REDUCED TILLAGE USING HERBICIDES IN A CONTINUOUS WINTER WHEAT CROPPING SYSTEM

By

DOUGLAS W. RUSHING

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North Carolina State University at Raleigh

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Thesis Approved:

Thomas F Peeper

Thesis Adviser

Howard D L Greer

Eddie Basler

Norman N. Durham

Dean of Graduate College

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CHAPTER I

INTRODUCTION

Interest in reduced tillage in wheat production is growing rapidly among Oklahoma wheat producers because of the potential it offers for reduced fuel consumption, increased soil conservation, and increased soil moisture storage during the summer fallow period. Two of the major hinderances to successful reduced tillage and no-tillage programs in the past were failure to obtain uniform stands and inability to adequately control weeds. During the past few years researchers have worked to develop reduced tillage and no-tillage systems. With the recent developments in seeding equipment suitable for use in heavy straw cover and more effective herbicides, the concept of reduced tillage wheat production is becoming more feasible (26).

The land area used for row crops and forage crops grown under no-tillage systems has increased rapidly during the past 15 years. In 1974, the USDA estimated that the amount of cropland in the U.S. under no-tillage cultivation was 2.23 million hectares, and that 62 million hectares or 45 percent of the total U.S. cropland will be under no-tillage systems by 2000 (4). Winter wheat is adapted throughout Oklahoma, with over 2.8 million hectares planted in 1978, and about 2 million hectares harvested (12). If the planted acreage remains unchanged, approximately 1.26 million hectares of Oklahoma wheat will be grown under no-till conditions within 20 years (39).

In the Great Plains area, where residue conservation is needed to control wind erosion, elimination of mechanical tillage operations by substituting herbicides for weed control has enormous potential (55). Chemical fallow would offer weed control with the least possible destruction of plant residue (55, 5). With increasing costs and improving technology, a shift away from tillage toward reduced tillage wheat production in Oklahoma is presently occurring.

The objectives of this research were to evaluate various herbicides and herbicide tillage combinations for weed control and moisture conservation during the period between crops in a continuous winter wheat cropping system common to Oklahoma.

CHAPTER II

LITERATURE REVIEW

Tillage System Definitions

Generations of farmers have developed various sequences of plowing, smoothing, stirring and leveling soil prior to planting. The ideal that multiple tillage operations were necessary became accepted, and hence the term "conventional tillage" was coined to describe systems using traditional repeated tillage operations for seedbed preparation (53). Chaffin (10) of Oklahoma defined "stubble mulching" as a system of managing plant residues in which harvesting, tilling, planting, and cultivating operations are performed with a view of keeping protective amounts of vegetative material on the surface. Under this system, a moldboard plow is not used. Minimum tillage and stubble mulching are terms frequently used interchangeably in Oklahoma. However, as defined by Greb (21) minimum tillage consists of using 2 to 4 tillage operations while substituting contact and/or preemergence herbicides for one or more tillages. Phillips and Young (38) defined no-tillage crop produc-ion as planting crops in previously unprepared soil by opening a narrow slot, trench, or band for seeding only of sufficient width and depth to obtain proper seed coverage. No other soil preparation is done. They also define summer fallowing as a cropping management system in which a period of time is allowed between harvested crops. In the Western Great Plains, most fallow periods consist of a wheat-fallow-wheat rotation or a wheat-sorghum-fallow rotation. During this fallow period, no crop is grown for 9 to 14 months. Burnside et al. (9) defined chemical fallow as the destruction of weeds during the fallow period with herbicides with the least possible destruction to plant residue.

Where annual precipitation exceeds approximately 61 cm, wheat can typically be planted every fall (39). Such cropping is called continuous wheat. In Oklahoma, continuous wheat is generally planted between September 15 and October 15, but the date varies widely depending on available moisture and grazing needs (30). The crop is typically harvested in June. Even though each summer the fields are not occupied by a crop for 90 to 120 days, this interval is not considered to be a true fallow period. The concept of substituting herbicides for summer tillage in continuous wheat systems has not been researched to the extent that use of herbicides in true fallow systems has. However, many of the advantages found in a chemical fallow program would be similar to those envisioned in programs where herbicides are used instead of summer tillage in a continuous wheat program (39).

The potential benefits of no-till are impressive. According to Greb (21), the elimination of dust bowl threats of the Great Plains would be expected, as well as possible wheat yields of more than 35 hl/ha compared with current yields of 22 to 26 hl/ha with equivalent precipitation.

Factors Affecting Soil Moisture

Soil moisture is normally lost from the plant root zone by evaporation from the soil surface, as surface water runoff, transpiration by growing plants, and percolation to depths beyond the normal root zone (7).

Finnel (17) stated that on heavy soils in the Southern Great Plains 65.8 percent of rainfall evaporated, 13.5 percent ran off, 2.7 percent was lost during tillage operations, and 18 percent was stored in the soil. More recently published research from over 32 years at Bushland, Texas showed that 22 percent of the rainfall was stored in the soil between crops of continuous winter wheat (27). Grace (19) recognized that rainfall dictated the time of tillage between crops of spring cereals in eastern Colorado. If summer rains fell after harvest, early fall plowing was required to eliminate weeds that would use water from the soil. In central Oklahoma, one cultivation per month was required, depending on the amount of rainfall received. In drier seasons, less vegetative growth would require fewer cultivations (31).

The moisture conserving effects of surface vegetative residue were noted by Blevins et al. (7), who observed that soil moisture at a depth of 23 cm was consistently greater under chemically killed bluegrass (Poa Pratensis L.) sod (no-tillage) than under adjacent cultivated soil (conventional tillage). He also found that in the early part of the growing season under conventional tillage, evaporation accounts for a higher percentage of water loss. As the plant grows, a shading effect is produced that decreases evaporation.

Other studies (5, 1) have also shown that soil moisture content near the surface is greater for longer periods of time in a mulched soil than a nonmulched soil. During a recent chemical fallow investigation in Texas, Wiese and Army (53) observed that the soil surface of disced plots following a rain, dried much more rapidly than on plots where a straw mulch was maintained by using herbicides or a sweep plow for weed control. Delayed drying of the surface was particularily apparent where herbicides instead of tillage had been used. However, the effects of residues on moisture content decreased as depth from the soil surface approached 6 inches over a 10 day period.

A common practice in Oklahoma is to disc immediately following wheat harvest. However, Unger (46) suggests leaving the wheat straw on the soil surface in a no-tillage farming system because his research indicated that a straw mulch virtually eliminated wind erosion, controlled water erosion, increased soil moisture, and consequently improved the yield of subsequent crops. In investigations of the amount of straw required to conserve moisture at Bushland, Texas, it was found that when 30.5 cm of rain fell from July through October, only 2.3 cm of moisture were stored in a bare soil. With 0.45 metric ton/ha of wheat straw on the soil surface, 2.8 cm of moisture were stored, and with 5.44 metric ton/ha of wheat straw on the soil surface, 13.2 cm of moisture were stored in the soil profile.

Army et al. (5) observed in Texas that although differences in soil moisture content were normally apparent for at least one week after rain, the quantity of residue on the soil surface seemed to have little effect on soil moisture content at soil depths greater than 2 inches.

The role of straw mulches in water conservation was also investigated by Hanks and Woodruff (24) in Kansas who concluded that mulches conserve extra water during frequent rainy periods but have little effect during long dry periods. Soil water losses measured by solar distillation were reduced 16, 33, and 49 percent over a 20 day period at Akron, Colorado, with surface applications of 1.36, 2.7, and 4.0 metric tons of wheat straw per hectare, respectively (20).

Russel (40) concluded that mulches conserve moisture during periods of frequent rains by preventing evaporation, but have little value for moisture conservation during dry periods. During his studies, precipitation totaled 4.8 cm in May, June, and July. The majority of it evaporated before it could penetrate the surface.

Tucker (45) stated that for every 27.2 kg of wheat grain produced in Oklahoma, there would be 45.4 to 90.8 kg of straw residue left on the soil surface. With an average wheat crop of 26 hl/ha, there would be from 2.24 to 6.72 metric tons/ha of straw left on the soil surface.

Stubble orientation has been found to affect moisture loss. Work done by Army et al. (5) in Bushland, Texas indicated that most of the wheat stubble was upright on chemically treated fallow land. Sweep tillage knocked most of the residue down. Standing stubble would reduce air movement at the soil surface and consequently retard evaporation to a greater extent than stubble laid over by tillage implements.

In laboratory studies, Bond and Willis (8) determined that surface residues effectively reduce evaporation rates and concluded that the benefit from surface mulches is proportional to the number of times the soil is rewetted and moisture thus stored in the subsoil.

Thus the literature indicates that an average wheat crop in Oklahoma would leave residue capable of markedly reducing the rate of evaporation thereby increasing soil moisture storage, and soil moisture content, and that the residue would slow but not entirely prevent loss of moisture and drying of the soil under conditions of prolonged minimal rainfall.

Plant residue may determine other factors than soil moisture. The effects of plant residue on herbicide performance have been detailed by several authors. French (18) indicated that heavy straw may intercept part of the herbicide sprays and prevent it from reaching the soil surface. He suggested that such interference might necessitate higher herbicide rates and/or increased carrier volume for acceptable weed control in a reduced tillage system. However, Ervach (15) concluded that plant residue did not significantly affect weed control when herbicides were applied at recommended rates, but had an increased influence on control as herbicide rates were reduced. Mullins et al. (37) reported that weed control obtained with alachlor plus paraquat or linuron plus paraquat was better when wheat stubble was left 10 cm tall than when wheat stubble was left 46 cm tall. The author gave no explanation for such differences.

Stubble Mulching

Zingg (57) defined stubble mulch farming as a system of managing crop residues so that the soil surface is protected at all times against erosion hazards. This requires special tillage implements which will till the land and yet maintain a protective cover of residues on the surface. These requirements are best met by subsurface implements that cut vegetation roots and loosen the soil without major surface disturbance, or by disc and chisel implements that stir the soil without inversion. This has proven to be an effective practice in semi-arid and subhumid areas. However, in subhumid areas, yields have been lower under stubble mulch than under clean tillage. For example; at the former Wheatland Conservation Experiment Station in Cherokee, Oklahoma, stubble mulching reduced water runoff, had little effect on seeding time soil moisture, and decreased wheat yields (45). However, yield decreases were attributed to inadequate weed control and plant diseases. Sub-surface tillage destroys some stubble. Baker et al. (6) stated that each subsurface operation breaks up and buries about 20 percent of the trash remaining on the soil surface. Generally, more wheat stubble residue was conserved with tillage sequences using subsurface implements (8 foot V-sweep) exclusively than with those using one-way discs in combination with other implements (chisel and plain rodweeder) (16). Greb and Black (22) reported rerooting of undercut weeds when a sweep or one-way tillage was performed shortly before a rain or when soil moisture content was high. Zingg et al. (57) concluded that the degree of stirring, temperature, soil moisture, kind of weeds present, and stage of growth all influenced weed control attained with any implement. Wheat yields tend to be higher with stubble mulching than with plowing in semiarid to arid climates, and less than with plowing in humid to subhumid climates. Stubble mulch tillage is known to influence chemical and physical properties and microbial activities of the soil. One effect is the retardation of nitrification (33).

In comparing stubble mulching with no-tillage, Shear (41) stated one of the greatest beneficial effects to be derived from leaving the soil untilled after killing the sod appears to be the maintenance of changes in the physical structure of the soil resulting from the growth of the sod crop. Roots of grasses, particularly perennial ones, gradually bring about the aggregation of soil particles in the root zone. The aggregates tend to be broken down through tillage of the soil.

During 1966-1969, Davidson and Santelman (13) found that control of summer annual weeds in continuous winter wheat with residual herbicides was only partially successful. With propachlor (see Table I) at 4.48 kg/ha, only 70 percent weed control was obtained. Paraquat

TABLE I

COMMON AND CHEMICAL NAMES OF HERBICIDES

Common Name	Chemical Name
alachlor	2-chloro-2',6'-diethyl-N-(methoxymethyl) acentanilide
atrazine	2-chloro-4-(ethylamino)-6-(isopropylamine)-s-triazine
bromoxynil	3,5-dibromo-4-hydroxybenzonitrile
buthidazole	3-[5-(1,1-dimethylethy)-1,3,4-thiadiazol-2-yl]-4-hydroxy-1-methyl-2-imidazolidinone
cyanazine	2[[4-chloro-6-(ethylamino)-s-triazin-2-yl] amino]-2-methylpropionitrile
dalapon	2,2-dichloropropionic acid
dicamba	3,6-dichloro-o-anisic acid
DPX4189	2-chloro-N[(4-methoxy-6-methyl-1,3,5-triazin-2-yl)aminocarbonyl]benzenesulfonamide
glyphosate	N-(phosphonomethyl)glycine
linuron	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea
MCPA	[(4-chloro-o-tolyl)oxy]acetic acid
methazole	2-(3,4-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione
metribuzin	4-amino-6-tert-butyl-3-(methylthio)-as-triazine-5(4H)-one
metholachlor	2-chloro-N-(2-ethyl-6-methylphenyl)-N-(2-methoxy-1-methylethyl)acetamide
MSMA	monosodium methanearsonate
MON-097	2-chloro-N-ethoxymethyl-N-(N)2-ethyl-6-methyl-phenyl(N)-acetamide
oryzalin	3,5-dinitro-N^4,N^4-dipropylsulfanilamide
oxyfluorfen	2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(tri-fluomethyl)benzene

TABLE I (Continued)

Common Name	Chemical Name
paraquat	1,1'-dimethyl-4,4'-bipyridinium ion
pendimethalin	*N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine
propachlor	2-chloro-*N*-isopropylacetanilide
terbutryn	2-(*tert*-butylamino)-4-(ethylamino)-6-(methylthio)-*s*-triazine
2,4-D	(2,4-dichlorophenoxy)acetic acid

was relatively ineffective if the weeds were large. Cheat also became a problem in no-till plots because it often emerged after planting. However, it did not occur in conventional tillage plots. Weed species occurring in the chemically treated plots changed over time, as the perennial species became more prominent.

Soil Temperature

Soil temperature is affected by many factors, including air temperature, radiation, precipitation, soil water content and evaporation, and type and amount of soil cover. Since reducing the number of tillages directly influences many of these factors, it also directly influences soil temperature. Hay (25) observed that wheat straw mulches at the rates of 8 and 12 metric tons/ha substantially decreased soil temperatures at a depth of 10 cm. He also concluded that uncultivated soil covered by an insulating mulch of straw, had a higher moisture content and a higher bulk density than the loosened, plowed soil. These factors reduced the amplitude of daily temperature variation significantly. The author also observed that in winter wheat, the plant continues to grow at temperatures down to 0^{o} C, and at this temperature, the vegetative growth of the plant comes from stem apices in the soil surface. This growth may be complete before the average soil temperature exceeds 10^{o} C. Therefore every accumulated hour degree above 5^{o} C should be valuable for shoot growth. Until the crop canopy is able to modify the soil temperature, wheat growth may be faster in conventionally tilled ground than in no-tilled ground where stubble is left intact.

Similar results were observed in both growth chamber and field experiments by Smika and Ellis (43). Wheat plants grown with soil temperatures below 10° C for 50 days had 2 to 3 fewer tillers per plant and 0.5 to 1.2 fewer heads per plant than plants grown with soil temperatures below 10° C for only 15 days. He suggested increasing the seeding rate in order to compensate for the reduction in tillers and heads per plant. Soil temperature did not appear to affect weight per head or total plant weight.

Effects of Tillage on Erosion Control

Conventional tillage practices, which expose the bare soil during periods of potentially high runoff and evaporation, serve to deplete the soil moisture supply or reduce the possibilities for moisture recharge when it is most needed (47). McGregor et al. (34) stated that no-till conservation systems have the potential for controlling erosion on intensively cropped upland soils. The no-till systems greatly reduced soil losses from that for the conventional tillage systems. For continuous soybeans, they found about seven times more soil was lost with conventional tillage as compared with no-till. Wheat straw effectively reduced soil loss on sloping land also. Mulch rates of only 0.56 and 1.12 metric tons/ha reduced soil losses to less than one-third of those from unmulched areas during a series of intense rains. A mulch of 2.24 metric tons/ha decreased soil loss to only 18 percent of that from no mulch, whereas 4.48 and 8.96 metric tons/ha of mulch reduced soil loss to less than 5 percent (35). Anderson (3) observed that the elimination of tillage by total chemical summerfallow reduced the amount of soil erosion during the summerfallow season. He also concluded that conservation of crop residue was increased and soil temperature was equal or slightly higher under chemical fallow than under normal tillage. The author gave no explanation for the higher soil temperature under chemical fallow conditions.

Chemical Weed Control

One variation of no-till farming, as practiced currently on 10 to 15 million acres of corn in the Midwest, involves complete substitutes of all tillage (except for seedbed preparation prior to planting) with combinations of contact and preemergence herbicides. Problems include high cost of certain contact herbicides (glyphosate, paraquat), possible carryover of preemergence herbicide residues (atrazine, cyanazine) in sandy or high pH soils, and slow development of plant equipment for drilling into heavy stubble (7).

Weeds growing on fallow land use water intended for the subsequent winter wheat crop. Weeds should be killed as rapidly as possible since plants continue to use water until they are air dry (54). Naturally, there would be less soil water loss from young weeds than from more mature weeds. For example, Wiese (51) showed that tansy mustard (Descuraninia intermedia) see Table II, germinated in Texas in late October, and did not reduce soil water in excess of the amount of evaporation from bare soil until after March 15 when plants were 8-10 cm tall.

The concept of reducing tillage operations by substituting herbicides was first tested in California orchards in 1944 (32). In the Great Plains area, where residue conservation is needed to control wind erosion, elimination of mechanical tillage operations with herbicides has enormous potential. Recognizing this, T. S. Aasheim (6) started experiments with chemical fallow in 1948 to evaluate 2,4-D for weed control during the fallow period in Montana. He concluded that where

TABLE II

COMMON AND SCIENTIFIC NAMES OF PLANTS

Common Name	Scientific Name
barnyardgrass	*Echinochloa crus-galli* (L.) Beauv.
bermudagrass	*Cynodon dactylon* (L.) Pers.
bluegrass	*Poa pratensis* (L.)
carpetweed	*Mollugo verticillata* (L.)
cheat	*Bromus secalinus* (L.)
corn	*Zea mays* (L.)
downy brome	*Bromus tectorum* (L.)
fall witchgrass	*Panicum capillare* (L.)
henbit	*Lamium amplexicaule* (L.)
kochia	*Kochia scoparia* (L.) Roth
large crabgrass	*Digitaria sanguinalis* (L.) Scop.
musk thistle	*Carduus nutans* (L.)
prairie cupgrass	*Eriochloa contracts* Hitchc.
pigweed species	*Amaranthus* sp.
prostrate spurge	*Euphorbia supina* Raf.
red sprangletop	*Leptochloa filiformis* (L.) Beauv.
redroot pigweed	*Amaranthus retroflexus* (L.)
smallseed falseflax	*Camelina microcarpa* Andrz.
smooth pigweed	*Amaranthus hybridus* (L.)
sorghum	*Sorghum bicolor* (L.) Moench
soybeans	*Glycine max* (L.) Merr.
tansy mustard	*Descuraninia intermedia pinnata* (Walt)
tumble pigweed	*Amaranthus albus* (L.)
yellow foxtail	*Setaria glauca* (L.) Beauv.
yellow nutsedge	*Cyperus esculentus* (L.)
wheat	*Triticum aestivum* (L.)

chemical fallow controlled weeds, grain yields were comparable to yields from conventional tillage.

In 1948, Klingman (29) attempted no-tillage practices in North Carolina with 2,4-D in corn. This did not prove successful because of inadequate vegetation control. Chemical fallow or no-till studies were started in the Great Plains in the 1950's. In these studies herbicides were substituted for tillage to control weeds during fallow. Early results showed that chemical weed control was better than tillage for increasing water storage and dryland grain yields in the Central Great Plains, but not in the Southern Great Plains (49). Later studies by Greb (20) suggested that a major reason for low water storage during fallow after dryland crops was the low residue production by these crops. In 1963, paraquat was introduced, and as a result more intensive research and interest developed in no-tillage crop production. Molberg and Hay (36) evaluated the use of paraquat for weed control on summer-fallowed land in semi-arid regions of Western Canada, and found that 3 to 4 applications at 1 kg/ha gave weed control equal to cultivation. Such chemical summerfallow conserved 91 percent of original crop residues compared to 24 percent for cultivated summerfallow. However, they concluded that the paraquat based program was not economically feasible.

Wiese (52) compared glyphosate with other herbicides for control of vegetation prior to minimum tillage plantings in the Texas panhandle. He concluded that glyphosate (0.6 to 4.5 kg/ha) gave better control of volunteer wheat, volunteer sorghum, and pigweed than did paraquat (0.3 to 3.4 kg/ha), or MSMA (3.4 to 10 kg/ha). Paraquat and methazole more effectively controlled volunteer corn than glyphosate.

In a non-till continuous winter wheat system, herbicides are needed to control weeds for a 2 to 3 month period wihtout leaving residues phytotoxic to wheat seedlings (2).

Stahlman (44) reported that a 2:1 mixture of cyanazine plus atrazine (3.4 + 1.7 kg/ha) broadcast at the soft dough or mature stages of wheat or postharvest adequately controlled pigweed in a wheat-fallow-wheat system the first summer after wheat harvest without reducing the yields of treated wheat. He also stated that buthidazole (0.8 kg/ha) and oryzalin (2.2 kg/ha) applied to wheat at the prejointing stage adequately controlled pigweed, but oryzalin caused severe lodging of the wheat, and buthidazole caused severe stem breakage. Weed control with wettable powder formulations of cyanazine after harvest was considerably better than similar treatments using granular formulations, probably because of dry conditions and more uniform distribution of the wettable powder formulations.

Addison et al. (2) reported excellent summerlong control of annual grasses and small seeded broadleaf weeds with oryzalin (0.9 to 1.1 kg/ha) applied to jointing wheat in Florida, Georgia, North Carolina, and Virginia. Some slight root injury was noticed with applications made at the fully tillered stage, but none was evident with the jointing or boot stage applications. By using a preharvest treatment such as this, control of summer annuals is feasible with only a preemergence herbicide, thus eliminating the need for a postemergence herbicide, typically necessary by the time wheat is harvested. Cleary and Peeper (11) of Oklahoma found that an April application of oryzalin plus bromoxnil (2.2 + 0.3 kg/ha) to jointing wheat provided good pigweed control until fall planting time without yield reduction of the treated crop or the subsequent crop.

The lack of available herbicides labeled for chemical fallow use is currently a limiting factor in its adoption in the Great Plains region. Currently, only 2,4-D, paraquat, glyphosate, dicamba, and cyanazine are labeled for use between wheat crops in Oklahoma. Oryzalin has an experimental use permit for application during the jointing stage of wheat growth.

Energy Conservation

Reduced tillage has the potential for saving substantial amounts of fuel, particularily in times of high seasonal demand for fuel oil products. As an industry, agriculture yields more energy than it consumes. Total U.S. energy use in 1970 was 32.5 million barrels of oil equivalent per day. This was broken down into industrial (41.2%), transportation (25.2%), residential (19.2%) and commercial uses (14.4%). Energy use by agriculture, some of which was included in each of the industrial, residential, and transportation categories, amounted to 2.3 percent of the U.S. Total (56).

Wittmus et al. (56) reported that substantial fuel savings are possible nationally by using reduced tillage practices for crop production. He stated that all regions of the U.S. should analyze their crop production practices in terms of fuel needs and potential fuel savings by adopting reduced tillage practices.

Slack et al. (42) looked at the advantages of reduced tillage from another viewpoint. He concluded that some pesticides are degraded to harmless components in the soil in a shorter period of time under no-tillage than under conventional tillage. Thus, he expressed the opinion that although more pesticides are used for the no-tillage system, it appears that the potential for pollution is no greater, and may be less, than for conventional tillage.

One primary reason for increasing interest in reducing the tillage requirement for wheat production in Oklahoma is increased costs of traditional tillage operations. The cost of conducting common tillage operations in Oklahoma are detailed in Table III (27). In the past decade variable costs such as fuel and oil have increased faster than the cost of pesticides, thus providing a desire to move toward reducing the number of tillage operations by substituting herbicides for weed control (50).

TABLE III

TOTAL COST FOR TILLAGE IN NORTH CENTRAL OKLAHOMA

Tillage	Labor ($5/hr)	Variable	Fixed	Total/A
Moldboard plow	1.74	4.81	4.53	11.08
Sweep	.48	1.07	1.22	2.77
Chisel	1.09	2.13	3.32	6.54
Offset Disc	.55	1.19	2.76	4.50

Source: OSU Ag Expt. Sta. Res. Report P-790 Aug-79

CHAPTER III

METHODS AND MATERIALS

Field studies were conducted at five locations in Oklahoma to evaluate the feasibility of substituting herbicides for all or part of the tillage typically used in a continuous winter wheat cropping system.

All herbicide treatments were applied by use of a tractor mounted compressed air plot sprayer with water carrier and total spray volume of 280 l/ha, unless otherwise stated. Granular treatments were applied with a cone type small plot granular applicator.

All experimental data was analyzed statistically. Treatment effects were compared using L.S.D.'s at the 0.05 level of significance unless otherwise stated. Visual ratings of crop injury or weed control were based on either a 0-100 scale, with 0 equal to no effect and 100 equal to complete plant kill, or percent ground cover.

Herbicide-Tillage Combinations in a Reduced Tillage System

An experiment was initiated in 1979 at the North Central Research Station on a Bethany silt loam (Pachic Paleustolls) to examine the effects of selected herbicides and herbicide-tillage combinations on summer annual weed control, soil moisture content at seeding and influence on weed species populations. On July 2, 1979, immediately following wheat harvest, four tillage treatments were applied. Equipment used to carry out the tillage programs included a 2.4 m Noble blade sweep, a 3.7 m offset disc, and a Graham-Hamey chisel with 30.5 cm sweeps. Each tillage operation consisted of one pass through the treatment. The following day thirteen herbicide treatments were applied across the tillages utilizing a split plot in strips experimental design, with tillage treatment as main plot treatments and herbicide treatment as the subplot treatments. Each plot measured 3 by 7.5 meters and each treatment was replicated three times. One of the tillage treatments were designated no-till in which the soil was left untilled after harvest with a stubble height of approximately 30 cm. Glyphosate was tank mixed with all herbicide treatments at 1.1 kg/ha to control any existing weeds in the no-till plots. Large crabgrass seedlings were present at the time of treatment ($21/m^2$) along with kochia ($21/m^2$) and various Amaranthus species ($43/m^2$).

Volunteer wheat became a problem during the summer, therefore it was deemed necessary to perform a second tillage operation. On August 7, 1979, tillage treatment 1 (chisel with 35 cm sweeps after harvest) was retilled with the same tool. Tillage treatments 2 and 3 were retilled with the 2.4 m blade. Tillage treatment 4 was retreated with glyphosate at 1.1 kg/ha with a carrier volume of 280 l/ha.

Visual ratings for 1979 summer annual weed control and wheat injury were taken 25, 79, and 123 days after application of herbicide treatments (DAT).

Soil cores were taken from the top 92 cm of the soil profile from each plot and moisture percentages were determined. Cores were extracted with a hydraulic soil probe and divided into 0-46 cm and 47-92 cm depths. Cores were taken on October 4, 1979 and placed in sealed vinyl bags and moist weight determined within 8 hours. Samples were placed in an oven at 49° C until dry. The samples were determined to be dry when they reached a constant weight. Soil moisture content of the samples were obtained by subtracting the dry weight from the moist weight resulting in the amount of water present. The water weight was then divided by the dry weight of the soil, thus determining the soil moisture percentage of each sample.

On November 5, 1979, the plot area was planted with TAM W-101 hard red winter wheat at 88.5 kg/ha using a model LZ1010 hoe type drill with 25.4 cm spacing converted to a no-till drill by lengthening the frame to accomodate two tool bars so that rolling coulters (50.9 cm diameter) and weights could be added. Specially designed narrow boots were also added for easier penetration of the soil. The rolling coulters were staggered on the two tool bars to permit greater trash clearance. Ammonium phosphate at 93 kg/ha was banded with the seed. A visual rating of crop injury to the fall sown wheat was made on December 16, 1979, 41 days after planting (DAP). Wheat yields were taken from a 1.5 by 6.7 m area of each plot on June 27, 1980.

All plots were retreated on June 27, 1980, except that since no weeds were present after harvest, glyphosate was not applied. The same equipment was used for the 1980 tillage operations. On October 24, 1980, a sweep tillage was applied to all plots to remove weed escapes and volunteer wheat prior to fall planting. Visual ratings for summer annual weed control were taken 70 DAT. Soil moisture cores were taken on October 6, 1980. TAM W-101 wheat was planted on October 28, 1980. Ammonium nitrate was banded with the seed at 112 kg/ha. Visual ratings on the fall sown wheat were made on December 17, 1980 (51 DAP). Wheat yields were determined by harvesting each plot on June 19, 1981.

A similar experiment was initiated in 1979 at the Agronomy Research Station near Perkins, Oklahoma on a Teller sandy clay loam (Udic Argiustolls). The experiment was also conducted over a 2 year period in the same location with each plot receiving the same treatment both years. The four tillage treatments were applied immediately following wheat harvest on July 12, 1979 and June 25, 1980. The thirteen herbicide treatments were applied across the tillages on the following day (July 13, 1979 and June 26, 1980). The tillage treatment designated as no-tillage had a 15 cm stubble height. Large crabgrass was present ($32/m^2$) (0 - 10 cm tall) in no-till plots after harvest both years.

Equipment used to carry out tillage programs included a 3.7 m Sunflower sweep operated at a depth of 10 cm, a 4.3 m offset disc operated at a depth 10 cm, and a 1.8 cm chisel with 30.5 cm sweeps operated 15 cm deep. All tillage treatments consisted of one pass through the plots.

Visual ratings for 1979 summer annual weed control were made September 4, 1979, 53 DAT, on the basis of percentage of groundcover. Due to heavy populations of Volunteer wheat, barnyardgrass, large crabgrass, and fall witchgrass, a second tillage operation was repeated on each respective tillage treatment on September 14, 1979. Glyphosate was applied at 1.1 kg/ha to all no-tillage main plots.

On September 13, 1979, 28-28-0 fertilizer were broadcast at 121 kg/ha. TAM W-101 wheat was planted October 23, 1979, at 87 kg/ha using the previously described drill. Crop injury on the fall sown wheat was evaluated on December 3, 1979, (40 DAP), and April 7, 1980 (167 DAP) on a 0 - 10 scale where 0 equals no visible wheat injury. Wheat yields were obtained from a 1.5 by 6.1 m area of each plot on June 25, 1980. Plot yields and test weights were recorded in the field.

Visual ratings of weed control were taken September 30, 1980 (96 DAT). Since volunteer wheat (20 cm) and bermuda grass were present prior to fall planting, all plots were tilled with the 1.8 m chisel with 30.5 cm sweeps on October 29, 1980. TAM W-101 was planted October 31, 1980, at 100 kg/ha. Visual injury ratings on the 1980-81 wheat crop were obtained on November 28, 1980 (28 DAP) and February 26, 1981. The number of heads per one meter of row was recorded from two randomly selected rows of all plots on April 22, 1981. Wheat yields were obtained on June 16, 1981. All 1981 wheat yields were recorded as combine yield (uncleaned) which was taken in the field, and clean grain weight after recleaning the grain with a small seed cleaner. Dockage percentages were determined from the amount of weed seed and debris cleaned from each sample.

On September 27, 1979 and October 9, 1980, soil cores were extracted with a hydraulic soil probe from the upper 92 cm of the soil profile, and moisture percentages were determined.

Comparison of Granular Versus Sprayed Herbicides in a Reduced Tillage System

Experiments were established in 1979 and 1980 at the Agronomy Research Station, Stillwater, Oklahoma on a Port clay loam (Cumulic Haplustolls) to evaluate granular versus liquid formulations of herbicides for control of summer annual weeds between wheat harvest and fall planting.

Following wheat harvest, the experimental area was tilled once with a sweep plow operated at a 10 cm depth. Thirteen herbicide treatments were applied the following day (July 3, 1979 and July 7, 1980). Each plot measured 1.7 by 7.6 m and herbicide treatments were replicated four times in a completely randomized block design.

TAM W-101 wheat was seeded October 26, 1979, at 87 kg/ha and October 31, 1980, at 102 kg/ha. Ammonium nitrate was applied on February 25, 1981, at 118 kg/ha. The experimental area was tilled with a 1.8 m V-sweep on October 10, 1979 and October 20, 1980, to control weed escapes and volunteer wheat.

Visual ratings for 1979 summer weed control were made on August 6, 1979 (34 DAT). Weed control ratings in 1980 were made on September 23, 1980 (78 DAT). Crop injury ratings were taken November 28, 1980 (29 DAP) and March 25, 1981 (117 DAP). Wheat yields were obtained from a 1.5 by 7 m area with a small plot combine on June 30, 1980 and June 12, 1981. The 1980 plot yield and test weight were determined in the field. The 1981 samples were bagged in the field, then later weighed, cleaned, and reweighed in order to determine percent dockage and actual grain yield.

A similar experiment was established at the Agronomy Research Station near Perkins, Oklahoma on a Teller sandy clay loam (Udic Argiustolls). Following wheat harvest, the experimental area was disced with a tandem disc 8 - 13 cm deep on July 12, 1979. Herbicide treatments were applied July 13, 1979. Each plot measured 1.8 by 7.6 m and four replications were used. Visual weed control ratings were taken September 7, 1979 (56 DAT) on the basis of percentage groundcover. The experimental area was fertilized with ammonium phosphate on September 6, 1979, at 121 kg/ha. TAM W-101 wheat was planted on October 23, 1979, at

87 kg/ha. Wheat yields were obtained from a 1.5 by 7.6 m area with a small plot combine on June 28, 1980.

Evaluation of Herbicides Applied Preharvest
for Summer Weed Control

Similar studies were initiated at the North Central Research Station, Lahoma, Oklahoma on a Pond Creek silt loam (Pachic Argiustolls) and at the Southern Great Plains Field Station, Woodward, Oklahoma on a Carey silt loam (Typic Argiustolls) to evaluate preharvest herbicide applications for summer weed control. A completely randomized block design was used at each location with four replications. Plots measured 2.7 by 6 m at Lahoma and 3 by 7.6 m at Woodward.

On April 4, 1980 at Lahoma, fifteen herbicide treatments were applied to TAM W-101 wheat (12 cm tall) in the 4-6 tiller stage. Weeds present at that time were henbit and kochia in the seedling to 2 leaf stage ($21/m^2$). On April 29, 1980, when the wheat was 38 cm tall and in the 2nd node, six additional treatments were applied. Weed growth had progressed considerably from the first application date. Weeds present included kochia, .6 to 1.3 cm tall ($54/m^2$); smallseed falseflax, 38 cm tall ($22/m^2$); seedling pigweed ($22/m^2$); and prairie cupgrass, 1.3 cm tall ($65/m^2$).

Visual ratings of crop vigor were made on April 29, 1980. Wheat was harvested on June 27, 1980 from a 1.5 by 6 m area of each plot. The stubble was left undisturbed following wheat harvest and the percent groundcover of each species present was estimated visually on June 5, 1980 (38 DAT), August 19, 1980 (111 DAT), and September 6, 1980 (129 DAT).

Ammonium nitrate was applied at 112 kg/ha on September 5, 1980. TAM W-101 wheat was planted at 69 kg/ha on October 28, 1980, using the previously described drill. Ammonium phosphate was banded through the drill at 112 kg/ha. Crop injury ratings were recorded December 17, 1980 (50 DAP).

At Woodward, the same 15 treatments were applied on Vona wheat (10 cm tall) in the 4-8 tiller stage of growth on April 4, 1980. Downy brome was present in the 3 leaf to 4 tiller stage (54-323/m^2). Six additional treatments were applied on April 29, 1980 when the wheat was 38 cm tall and in the 2nd node stage of growth. Visual ratings of crop injury were made April 29, 1980. Wheat was harvested on June 20, 1980, from a 1.5 by 7.6 m area of each plot. Visual ratings of weed control were recorded on August 27, 1980 (119 DAT).

TAM W-101 wheat was planted at Woodward on October 20, 1980, at 78 kg/ha and ammonium phosphate was banded with the seed at 112 kg/ha. Crop injury ratings were made on December 17, 1980 (58 DAP) and 73 days later on February 28, 1981.

There was a severe downy brome problem at the Woodward location both years. Therefore on January 28, 1981, metribuzin (.42 kg/ha) was reapplied for downy brome control. In 1981 the plots were harvested on June 19, 1981 (Lahoma) and June 11, 1981 (Woodward). Yield data represents combine yield (uncleaned), and clean grain weight after recleaning with small seed cleaners. Material removed by the cleaning process was considered dockage.

Reduced Tillage Using Herbicides

Applied Postharvest

Experiments were conducted at two locations to examine the effects on summer annual weed populations of 25 selected herbicide treatments applied to 30 cm tall wheat stubble immediately following wheat harvest. The first study was on a Carey silt loam (Typic Argiustolls) at the Southern Great Plains Field Station near Woodward, Oklahoma and the second was on a Port loam soil (Cumulic Haplustoll) at the Lake Carl Blackwell Research area, Payne County, Oklahoma. Treatment dates were June 20, 1980, at Woodward and July 2, 1980, at Lake Blackwell. A completely randomized block design was used with a plot size of 3 by 7.6 m at each site.

There was a heavy infestation of downy brome in the previous 1980 wheat crop at Woodward, but a few musk thistles were the only weeds growing when the herbicides were applied. The Lake Blackwell location had small amounts of carpetweed (7 cm diameter), smooth pigweed (25 cm tall), and red sprangletop (1 - 13 cm). All treatments were applied with a spray volume of 280 l/ha with the exception of four glyphosate-oryzalin tank mix treatments applied at 94 l/ha.

Visual ratings of weed control were made at Woodward on August 27, 1980 (58 DAT). No significant rainfall was received at the Lake Blackwell location for 47 days after the herbicide treatments were applied, therefore visual ratings were not taken until October 8, 1980 (98 DAT). By late August there was a heavy infestation of tumble pigweed and prostrate spurge ($6/m^2$) throughout the experiment at Woodward. Therefore, a tractor mounted "Bobar" ropewick applicator containing a 4:1:8 mixture of glyphosate, dicamba and water, respectively, was used on August 27, 1980, to clean up weed escapes. The tractor was operated at 3 mph and two passes were made over the plots in opposite directions. Visual ratings for weed control were made on September 6, 1980 (13 DAT). A 1.8 m V-sweep was used over the entire experimental area on October 10, 1980, to control existing weed escapes and volunteer wheat.

TAM W-101 wheat was seeded at 78 kg/ha at Woodward on October 20, 1980 and at Lake Blackwell on October 14, 1980. Visual ratings for herbicide injury on wheat was recorded at Woodward on December 17, 1980 (58 DAP) and on January 28, 1981 (100 DAP), and at Lake Blackwell on November 28, 1980 (45 DAP), and February 18, 1981 (127 DAP).

Metribuzin (.42 kg/ha) was applied on January 28, 1981 to control a severe infestation of downy brome ($1075/m^2$) at the Woodward location. At Woodward, harvest data was obtained by combining a 1.5 by 7.6 m area from each plot on June 11, 1981. Samples were recorded as combine yield (uncleaned), clean weight (after cleaning seed in a small seed cleaner), and dockage percentage. Harvest data was obtained from a 1.5 by 12.2 m plot at Lake Blackwell on June 2, 1980. Plot yield and test weight were determined in the field.

Comparison of Boom Placement on a Sweep Plow for Herbicide Application

On July 3, 1980, at the Lake Carl Blackwell Research Area, Payne County, Oklahoma, a field study was established on a Port loam soil (Cumulic Haplustoll) to evaluate spray boom position in relation to blade location during a simultaneous sweep tillage-herbicide application operation with a spray boom mounted at three different positions on a 1.8 m V-sweep. The boom positions evaluated were; boom in front of the sweep, boom behind the sweep, and boom mounted in a V shape over the sweep, blade with the spray pattern directed at the rear edge of the blade. A compressed air sprayer was mounted on top of the sweep. Heavy wheat stubble (35 cm tall) was present at the time of treatment. A completely randomized block design was used with a plot size of 2 by 12 m replicated four times.

The area received no appreciable rainfall for 47 days after the treatments were applied. Visual ratings were made 97 days after herbicide application on October 8, 1980. Only one visual rating was made due to the lack of weed growth. TAM W-101 wheat was seeded on October 14, 1980, at 78 kg/ha. A topdressing of ammonium nitrate was applied at 220 kg/ha on March 3, 1980. Visual ratings of wheat injury were made on November 28, 1980 (45 DAP) and February 18, 1981 (127 DAP).

Wheat yields were obtained from a 1.5 by 7 m area of each plot with a small plot combine on June 3, 1981. Plot yield and test weight were determined in the field.

CHAPTER IV

RESULTS AND DISCUSSION

Comparison of Herbicide-Tillage Combinations

Bethany Silt Loam (Lahoma)

In 1979, the herbicide treatments were activated by 3.3 cm of rainfall received one day after application. Since glyphosate was tank mixed with all herbicide treatments, initial control of all existing vegetation, primarily large crabgrass seedlings, kochia, and various Amaranthus species was obtained. By 25 days after treatment (DAT), a heavy population of volunteer wheat had emerged (Table IV). When averaged over all four tillage systems, the herbicide treatments providing the best volunteer wheat control were cyanazine plus glyphosate and metribuzin plus glyphosate with 13 and 15 percent groundcover, respectively.

Averaged over tillage treatments, plots treated with oryzalin plus glyphosate had 21 percent groundcover. However, in combination with the no-tillage main plot treatment, there was only 4 percent groundcover of volunteer wheat with this herbicide combination. With all herbicide treatments except those containing metribuzin or cyanazine, the control of volunteer wheat was generally superior under no-till conditions. Tillage prior to herbicide application did not influence the ability of metribuzin or cyanazine to control volunteer wheat.

TABLE IV

EFFECTS OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS ON VOLUNTEER WHEAT DENSITY BETHANY SILT LOAM (LAHOMA) 1979

Treatment	Rate (kg/ha)	Visual Ratings 7-30-79 (% groundcover)				
		Disc(1)	Sweep	Chisel	No-Till	Mean(2)
1. Alachlor + glyphosate	2.2 + 1	43	55	45	35	45
2.	3.3 + 1	54	73	48	30	51
3. DPX4189 + glyphosate	0.14+ 1	43	47	32	25	37
4.	0.28+ 1	30	38	29	27	31
5. Cyanazine + glyphosate	2.8 + 1	12	14	18	10	13
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.0	25	32	26	23	27
7. Linuron + glyphosate	1.1 + 1.1	57	47	40	19	41
8.	2.2 + 1.1	35	31	27	12	26
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	48	48	38	20	39
10. Metribuzin + glyphosate	0.81+ 1.1	18	12	15	16	15
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	28	30	22	16	24
12. Oryzalin + glyphosate	1.1 + 1.1	27	25	30	4	21

TABLE IV (Continued)

Treatment	Rate (kg/ha)	Visual Ratings 7-30-79 (% groundcover)				
		Disc(1)	Sweep	Chisel	No-Till	Mean(2)
13. Glyphosate	1.1	57	55	32	20	41
Mean (3)		37	39	31	20	

(1) The LSD 0.05 for comparing values for volunteer wheat in any herbicide or tillage treatment = 12.7 (C.V. = 24%).
(2) The LSD 0.05 for comparing herbicide treatment means averaged across tillage treatments = 11.3 (C.V. = 24%).
(3) The LSD 0.05 for comparing two tillage means averaged across herbicide treatments = 7.7 (C.V. = 24%).

By August, the weed population increased to the point that additional weed control was considered necessary. On August 7, 1979, the chisel tillage main plot received a second chisel operation while the sweep and disc tillage main plots were swept with a 2.4 meter V-sweep. Reapplication of glyphosate (1.12 kg/ha) controlled all vegetation in the no-till main plot treatment. Forty-six days later, on September 22, the most prominent weed species were volunteer wheat, redroot pigweed, large crabgrass and carpetweed (Table V). Although the density of volunteer wheat was less than earlier in the summer, analysis of groundcover data again revealed significant herbicide by tillage interactions. In contrast to the previous evaluation, control of volunteer wheat did not vary with tillage in the oryzalin plus glyphosate treatment. The volunteer wheat control with metribuzin or cyanazine was less with no-tillage or sweep tillage than where the disc or chisel was used. Populations of other species probably account for the lower populations of volunteer wheat in the glyphosate alone herbicide treatment.

Analysis of the tillage means revealed that the no-tillage and sweep tillage main plot treatments had higher volunteer wheat populations than the disc and chisel main plot treatments. This may indicate that germination of volunteer wheat occurred later in the summer under no-till conditions.

Redroot pigweed populations varied with herbicide treatments, but the tillage systems had no significant effect. Both treatments of DPX4189 plus glyphosate completely controlled redroot pigweed. Cyanazine plus glyphosate appeared particularly weak in control of this species.

Significant herbicide by tillage interactions occurred in the data

TABLE V

WEED POPULATIONS 46 DAYS AFTER THE SECOND WEED CONTROL OPERATION IN THE POSTHARVEST HERBICIDE-TILLAGE EXPERIMENT BETHANY SILT LOAM (LAHOMA) 1979

		Visual Ratings 9-22-79 (% groundcover)																
Initial Treatment	Rate (kg/ha)	Disc				Sweep				Chisel				No-Till				Mean
		VW(1)	CR(2)	CW(3)	RPW	VW	CR	CW	RPW	VW	CR	CW	RPW	VW	CR	CW	RPW	RPW(4)
1. Alachlor + glyphosate	2.2 + 1.1	6	0	12	0	13	15	13	1	5	3	5	3	13	0	1	0	0.8
2.	3.3 + 1.1	6	0	9	2	11	0	7	1	5	2	20	3	6	0	0	0	1.8
3. DPX4189 + glyphosate	0.14+ 1.1	8	7	1	0	14	0	6	0	6	4	14	0	8	0	0	0	0
4.	0.28+ 1.1	9	1	5	0	17	0	4	0	8	1	8	0	16	0	0	0	0
5. Cyanazine + glyphosate	2.8 + 1.1	8	1	6	4	15	2	6	7	7	1	10	10	14	0	0	2	7.6
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	6	0	8	2	19	1	8	2	5	1	18	9	12	0	0	1	4.0
7. Linuron + glyphosate	1.1 + 1.1	7	9	8	1	17	2	7	1	5	7	17	7	24	0	0	1	2.7
8.	2.2 + 1.1	3	25	5	1	14	9	9	2	5	10	16	4	11	0	1	1	1.9
9. Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	5	2	10	3	14	9	6	3	4	3	15	4	14	0	1	0	3.1
10. Metribuzin + glyphosate	0.84+ 1.1	8	2	6	1	21	3	5	2	5	3	15	3	24	0	0	0	2.0
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	11	0	6	2	21	0	4	2	18	0	15	8	20	0	0	1	4.0
12. Oryzalin + glyphosate	1.1 + 1.1	5	0	2	2	9	0	2	1	5	0	3	7	3	0	0	0	2.7
13. Glyphosate	1.1	3	23	5	3	6	23	2	3	4	15	13	5	10	0	0	0	2.8
Mean (5, 6, 7)		6.6	4.8	6.9	2.0	14.3	4.6	6.0	2.7	5.5	3.8	12.9	5.2	13.5	0	0.2	0.3	
Total Mean (8)		20.3				27.6				27.4				14.0				

(1) The LSD 0.05 for comparing populations of volunteer wheat in any herbicide or tillage treatment = 6.4 (C.V. = 39%).
(2) No significant differences in large crabgrass control were observed (C.V. = 213%).
(3) The LSD 0.05 for comparing populations of carpetweed among herbicide or tillage treatments = 5.2 (C.V. = 49%).
(4) The LSD 0.05 for comparing herbicide treatment means for redroot pigweed averaged across tillage systems = 2.8 (C.V. = 101%).
(5) The LSD 0.05 for comparing tillage means for volunteer wheat averaged across herbicide treatments = 5.6 (C.V. = 39%).
(6) The LSD 0.05 for comparing tillage means for redroot pigweed averaged across herbicide treatments = 3.1 (C.V. = 101%).
(7) The LSD 0.05 for comparing tillage means for carpetweed averaged across herbicide treatments = 1.8 (C.V. = 49%).
(8) Total mean represents the sum of all weed species when averaged over all herbicide treatments.

for carpetweed groundcover. Oryzalin provided good control regardless of the tillage operation. Carpetweed populations were lower in the no-tillage main plots (0.2%) than the other tillage treatments. The highest populations occurred in the chisel treatments (12.9%).

No significant differences were observed in large crabgrass control, however, the data indicated that there was extreme variability present. There was 15 to 23 percent groundcover of large crabgrass present in the glyphosate treated checks for the three tillage treatments. In the no-tillage treatments, no large crabgrass was present in any of the herbicide treatments.

Since no additional weed control procedures were applied prior to planting TAM W-101 wheat on November 5, 1979, volunteer wheat became a problem early in the growing season as it competed with the young seeded wheat. At planting the volunteer wheat population averaged over all herbicide treatments was still higher than in the disc and chisel tillage main plots (Table VI). Oryzalin plus glyphosate with no-tillage was more effect in controlling volunteer wheat through planting than any other treatment.

Visual ratings of crop vigor 41 days after planting (DAP) revealed no injury to wheat seedlings from any herbicide treatments. Analysis of June 22 yield data indicated no differences among herbicide treatment means averaged across tillage programs (Table VI). However, averaged over all herbicide treatments, the no-till main plot treatments had significantly lower yields. High populations of volunteer wheat and downy brome in the no-tillage plots, which were severe in the second and third replication of the experiment, undoubtedly contributed to low yields.

Following wheat harvest, the tillage and herbicide treatments were

TABLE VI

EFFECT OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS ON VOLUNTEER WHEAT DENSITY AT PLANTING AND WHEAT PRODUCTION BETHANY SILT LOAM (LAHOMA) 1979-80

Treatments	Rate (kg/ha)	Volunteer Wheat Population (11-5-79) % groundcover				Wheat Yield (6-22-80) (kg/ha)			
		Disc	Sweep	Chisel	No-Till(1)	Disc	Sweep	Chisel	No-Till(2)
1. Alachlor + glyphosate	2.2 + 1.1	15	25	15	27	874.3	673.1	943.9	541.6
2.	3.3 + 1.1	13	23	9	25	1214.7	742.8	742.8	472.0
3. DPX4189 + glyphosate	0.14+ 1.1	13	23	7	23	1005.8	804.7	943.9	804.7
4.	0.28+ 1.1	18	38	8	48	943.9	804.7	1075.5	673.1
5. Cyanazine + glyphosate	2.8 + 1.1	33	53	37	45	874.3	742.8	673.1	541.6
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	22	48	28	35	1075.4	1145.1	804.7	541.6
7. Linuron + glyphosate	1.1 + 1.1	13	34	11	72	1005.8	1145.1	804.7	472.0
8.	2.2 + 1.1	8	43	9	45	1005.8	603.5	874.3	472.0
9. Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	11	37	10	47	1005.8	1075.5	943.9	472.0
10. Metribuzin + glyphosate	0.84+ 1.1	25	53	8	57	874.3	874.3	603.5	472.0
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	25	53	24	37	742.8	673.1	673.1	270.8
12. Oryzalin + glyphosate	1.1 + 1.1	8	20	17	5	1005.8	673.1	804.7	541.6
13. Glyphosate	1.1	7	23	6	22	1005.8	673.1	943.9	402.3
Mean (3)		16.2	35.7	14.5	37.5	894.5	817.8	833.2	513.6
					CV=	28.5%	21.2%	32.9%	26.4%

(1) The LSD 0.05 for comparing volunteer wheat populations among any herbicide or tillage treatment = 16.8 (C.V. = 40%).

(2) The LSD 0.05 for comparing tillage means = 252.7.

(3) The LSD 0.05 for comparing tillage means for volunteer wheat averaged across herbicide treatments = 14.1 (C.V. = 40%).

repeated on the same plots for the second year. There was no appreciable rainfall on the experimental area for 53 days after the herbicides were applied. Due to the low moisture conditions, very little vegetation appeared until a 9.4 cm rainfall. Populations of volunteer wheat, large crabgrass, carpetweed, and various Amaranthus species then began to appear. A visual rating was made on September 6, 1980 of the percent groundcover of the various species (Table VII).

Volunteer wheat was the most prominent weed species present. Averaged over all herbicide treatments, volunteer wheat populations in the no-till main plot treatments were twice as high as in the sweep and chisel main plots and four times higher than in the disc main plots. The volunteer wheat groundcover data revealed significant herbicide by tillage treatment interactions. In contrast to the previous year, oryzalin plus glyphosate provided good control of volunteer in all tillage systems. Conversely, the control obtained with metribuzin was very poor only under the no-till system, whereas it was similar in all tillage systems the previous year. The lack of rainfall did not appear to affect cyanazine activity since it provided good volunteer control in all tillage systems. The alachlor treatments were markedly less effective with no tillage before applications than when any of the three types of tillage operations had been performed.

Analysis of large crabgrass groundcover data revealed that there were no significant differences among tillage main plots or tillage system by herbicide treatment interactions, however, significant differences among herbicide treatments were found. There was essentially no large crabgrass present under no-tillage conditions whereas significant populations were present in some tilled plots. The only herbicide

TABLE VII

EFFECT OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS ON SUMMER ANNUAL WEED POPULATIONS BETHANY SILT LOAM (LAHOMA) 1980

Treatment	Rate (kg/ha)	Visual Ratings 9-6-80 (% groundcover) (1)																	
		Disc				Sweep				Chisel				No-Till				Mean	
		VW(2)	CR	CW	PW(3)	VW	CR	CW	PW	VW	CR	CW	PW	VW	CR	CW	PW	CR(4)	CW(5)
1. Alachlor + glyphosate	2.2 + 1.1	1.6	1.0	0.3	1.3	4.3	2.0	5.3	0	6.0	0	3.0	0.3	18.3	0	1.0	0	0.8	2.4
2.	3.3 + 1.1	4.3	1.0	1.0	0	6.0	0	1.3	0.6	6.6	0	1.6	0	36.6	0	0	0.3	0.3	1.0
3. DPX4189 + glyphosate	0.28+ 1.1	13.3	6.6	5.0	0	18.3	1.6	5.0	0	23.3	10.0	4.3	0	14.3	0.3	0.3	0	4.7	3.7
4.	0.14+ 1.1	6.6	0.6	1.6	0	21.6	0	0	0	19.1	1.0	3.0	0	5.0	0	0.6	0	0.4	1.3
5. Cyanazine + glyphosate	2.8 + 1.1	3.3	1.3	0.6	0	5.0	3.3	0.6	0	1.6	1.6	0	0	0	0	0	0	1.6	0.2
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	0	0.6	0.3	1.0	6.6	0.3	0	0	5.6	0	0	0	6.6	0	0	0	0.3	0.1
7. Linuron + glyphosate	1.1 + 1.1	6.0	20.0	6.6	0	20.0	8.3	9.3	1.6	7.6	18.3	7.6	0	53.3	0	0	0	11.7	5.9
8.	2.2 + 1.1	6.0	35.0	1.3	1.3	13.3	22.0	4.1	0.6	10.0	25.0	1.0	0	23.3	0	0	0	20.5	1.7
9. Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	6.6	5.0	3.0	0	11.6	6.6	4.0	1.6	9.3	6.6	3.3	0	60.0	0	0	0	4.6	2.6
10. Metribuzin + glyphosate	0.84+ 1.1	3.3	1.0	2.6	5.0	8.3	1.3	1.0	2.2	8.3	0.3	0.3	0	21.0	0	0	0	0.7	1.0
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	1.6	0.3	0.6	1.3	11.6	1.3	0.3	2.6	6.6	0.3	0.6	0	23.6	0	0	1.6	0.5	0.4
12. Oryzalin + glyphosate	1.1 + 1.1	1.6	2.6	0.6	2.0	4.3	0	0.6	1.3	2.0	0	0.3	0	0.6	0	0	3.6	0.6	0.4
13. Check	1.1	11.6	33.3	9.3	0	20.0	35.0	6.6	0	16.6	30.0	9.0	0	31.6	5.0	6.6	1.0	25.8	7.9
Mean (6, 7)		5.0	8.3	2.5	1.0	11.6	6.3	2.9	0.8	9.4	7.2	2.6	0	22.6	0.4	0.7	0.5		

(1) VW = volunteer wheat, CR = large crabgrass, CW = carpetweed, PW = tumble pigweed and redroot pigweed.
(2) The LSD 0.05 for comparing values of volunteer wheat among any herbicide or tillage treatment = 17.5 (C.V. = 86%).
(3) No significant difference among pigweed ratings for herbicides, tillages, or herbicide X tillage interactions was observed, (C.V. = 306%).
(4) The LSD 0.05 for comparing herbicide treatment means of large crabgrass averaged across four tillages = 16.2 (C.V. = 166%).
(5) The LSD 0.05 for comparing herbicide treatment means of carpetweed averaged across four tillages = 3.9 (C.V. = 126%).
(6) The LSD 0.05 for comparing tillage means for volunteer wheat averaged across herbicide treatments = 9.9 (C.V. = 86%).
(7) The LSD 0.05 for comparing tillage means for carpetweed averaged across herbicide treatments = 1.6 (C.V. = 126%).

treatments providing poor control of large crabgrass were linuron plus glyphosate and glyphosate alone. Linuron is primarily a broadleaf herbicide and grass control would not be expected (23).

Analysis of carpetweed groundcover evaluations revealed significant differences among herbicide treatments and tillage main plots, but no interactions. Averaged over all herbicide treatments, the no-tillage main plots had lower populations of carpetweed than the other tillage systems. When averaged across all tillage main plots, the data indicated that all herbicide treatments provided better control of carpetweed than the glyphosate treated check except linuron plus glyphosate at the lower rate.

On October 14, 1980, a sweep tillage operation using a 2.4 m V-blade was used on the entire experiment to control existing weeds. The area received 7.75 cm of rainfall during the next two days, thus the volunteer wheat was not controlled and the sweep operation was repeated on October 24, at which time volunteer wheat control was achieved. Possible crop injury due to herbicide carryover was anticipated because of late season activation of herbicide treatments, however, none was observed 51 DAP.

Analysis of yield data for the 1981 wheat crop (Table VIII) does not include the no-tillage program. The rear of the first replication and the front of the second replication were heavily infested with downy brome. This area of infestation was limited to the no-tillage treatments only. No-till plots in the third replication were not affected, however, the harvest data from the no-tillage plots was not included in the statistical analysis of yields and the tabulated data is from the third replication only. Harvest data included weight of the combine

TABLE VIII

EFFECT OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS OF WHEAT PRODUCTION BETHANY SILT LOAM (LAHOMA) 1981

		Harvest Data (6-19-81)															
		Yield (Combine Sample)				Yield (Recleaned)				Test Weight				Dockage			
Treatment	Rate (kg/ha)	Disc (kg/ha)	Swep	Chsl	Notl(1)	Disc (kg/ha)	Swep	Chsl	Notl	Disc (kg/ha)	Swep	Chsl	Notl	Disc (%)	Swep	Chsl	Notl
1. Alachlor + glyphosate	2.2 + 1.1	1851	1163	1731	1535	1823	1145	1701	1203	57	55	56	53	1.5	1.6	2.0	21.6
2.	3.3 + 1.1	2062	1383	1771	1438	2036	1329	1745	1308	57	57	56	56	1.2	5.7	1.5	8.9
3. DPX4189 + glyphosate	0.14+ 1.1	1575	1264	1644	2024	1556	1230	1607	1986	57	54	55	57	1.3	3.0	2.0	1.9
4.	0.28+ 1.1	2056	1440	1817	2272	2037	1409	1788	2233	57	56	56	56	0.9	2.4	1.8	1.7
5. Cyanazine + glyphosate	2.8 + 1.1	1534	1314	1995	1860	1513	1281	1972	1803	57	56	57	56	1.4	2.5	1.2	3.0
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	1861	1368	1835	1715	1835	1290	1897	1005	57	56	57	51	1.4	5.7	1.9	41.3
7. Linuron + glyphosate	1.1 + 1.1	1850	1189	1762	1246	1825	1156	1735	1182	57	55	58	52	1.4	2.9	1.6	5.1
8.	2.2 + 1.1	1525	1308	1785	1970	1504	1245	1755	1912	58	56	57	56	2.1	4.9	1.7	2.9
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	2009	1363	1800	1013	1989	1330	1771	959	57	55	56	52	1.0	2.4	1.6	4.9
10. Metribuzin + glyphosate	0.81+ 1.1	1723	928	1916	1269	1683	868	1891	1184	57	54	56	56	2.4	8.4	1.3	6.6
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	1497	1111	1748	1845	1471	1083	1720	1787	57	55	56	53	1.7	2.3	1.8	3.0
12. Oryzalin + glyphosate	1.1 + 1.1	1395	1897	1742	1950	1377	1840	1721	1908	57	56	56	54	1.5	2.7	1.3	2.3
13. Check	1.1	1512	1459	1676	1739	1489	1382	1654	1699	57	56	56	57	1.5	4.8	1.9	2.3
Mean (2)		1728	1322	1793	1683	1703	1276	1766	1551	57	55	56	55	1.5	3.8	1.7	7.8
(3) Herbicide		(a)27.7%				(b)28.5%				(c)1.9%				(d)173.0%			
Tillage		65.5%				66.4%				5.4%				113.1%			
Herb X Till		19.7%				20.1%				1.4%				91.2%			

(1) All harvest data for no-till operations represents only one replication and is not included in the statistical analysis.
(2) There were no significant differences among herbicide treatments or tillage treatments.
(3) C.V. percent is shown indicating the coefficient of variability among herbicides, tillages, and herbicide X tillage interactions for (a) combine yield, (b) clean yield, (c) test weight, and (d) dockage, respectively.

harvested sample, and weight of recleaned grain, test weight on the cleaned sample, and dockage. There were no differences among herbicides, tillages, or herbicide-tillage interactions in the harvest data.

The 1979 wheat crop produced approximately 3000 kg/ha of crop residue, which proved adequate to influence soil moisture. Analysis of the 1979 soil moisture data revealed that the no-till plots, averaged over all herbicide treatments contained more soil moisture in the upper 46 cm of the soil profile than the disc and chisel main plots (Table IX). Averaged across tillage main plots, oryzalin plus glyphosate (14.8%) and alachlor plus glyphosate (12.7%) significantly increased soil moisture in the upper 46 cm compared to the glyphosate treated check. From 47 to 92 cm in the soil profile, there were no differences in moisture.

In 1980, the experimental area averaged only 1200 kg/ha of crop residue after harvest. The no-tillage main plot treatments had additional residue from a heavy infestation of downy brome in the first two replications, which provided a heavy layer of residue on the surface of the no-till plots. No differences in soil moisture were found between tillage treatment main plots. Several herbicide treatments had significantly higher soil moisture content than the glyphosate treated check (10.5%). Those with the higher moisture content were cyanazine plus glyphosate (15.8%), alachlor plus cyanazine plus glyphosate (14.9%), and oryzalin plus glyphosate (14.9%).

Other treatments containing cyanazine tank mixed with additional herbicides had relatively more moisture, but late season volunteer wheat control with these treatments was not as good as with oryzalin. In 1980, treatments providing good weed control increased soil moisture 3 to 5 percent over that in the weedy check plots. The lack of rainfall

TABLE IX

PERCENT MOISTURE IN THE SOIL PROFILE AT 0 TO 46 CM AND 47 TO 92 CM DEPTH IN OCTOBER 1979 AND 1980 IN THE POSTHARVEST HERBICIDE-TILLAGE EXPERIMENT BETHANY SILT LOAM (LAHOMA) 1979-80

		Soil Moisture %																			
		Disc				Sweep				Chisel				No-Till				Mean			
	Rate	0-46 cm		47-92 cm		0-46 cm		47-92 cm		0-46 cm		47-92 cm		0-46		47-92 cm		0-46 cm		47-92 cm	
Treatment	(kg/ha)	79	80(1)	79	80	79	80	79	80	79	80	79	80	79	80	79	80	79(2)	80(3)	79	80
1. Alachlor + glyphosate	2.2 + 1.1	11.4	15.5	12.5	16.0	9.5	14.1	14.5	16.0	9.0	14.5	13.0	15.9	9.3	14.0	12.6	12.3	11.0	14.5	13.1	15.1
2.	3.3 + 1.1	11.7	15.3	13.0	16.8	13.1	14.1	15.0	16.5	10.8	14.7	13.1	14.5	15.4	11.6	14.5	13.4	12.7	13.9	11.4	15.3
3. DPX4189 + glyphosate	0.14+ 1.1	11.3	12.2	13.3	8.1	13.4	12.8	14.5	14.0	12.0	11.0	15.3	15.9	13.0	14.8	14.1	14.6	12.4	12.7	14.3	13.1
4.	0.23+ 1.1	10.1	13.1	11.1	14.3	12.7	13.5	12.1	16.0	11.0	14.8	13.8	16.2	13.9	16.1	14.1	14.5	11.9	14.4	12.8	15.3
5. Cyanazine + glyphosate	2.8 + 1.1	10.6	15.4	12.5	11.2	12.3	14.7	13.9	16.6	11.0	16.9	14.0	15.7	14.2	16.3	15.1	12.6	12.0	15.8	13.9	15.3
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	10.8	16.0	13.2	15.8	11.4	16.4	14.7	14.9	7.5	14.0	13.9	15.5	12.3	13.2	11.8	13.7	10.5	14.9	13.3	15.0
7. Linuron + glyphosate	1.1 + 1.1	9.1	14.6	12.1	15.4	12.1	14.6	15.0	13.7	10.0	10.1	13.6	13.1	16.3	7.4	14.8	13.1	11.9	11.7	13.7	9.5
8.	2.2 + 1.1	9.8	12.8	12.2	16.2	12.9	8.5	14.5	15.1	10.6	12.8	13.9	14.9	12.6	15.0	14.2	13.6	11.5	12.3	13.7	14.9
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	11.5	15.0	13.8	15.4	12.9	10.7	15.6	13.6	11.8	11.6	11.3	13.2	12.8	10.7	14.1	14.1	12.2	12.0	13.8	14.1
10. Metribuzin + glyphosate	0.81+1.1	10.6	14.6	13.3	16.0	8.7	14.8	12.8	16.3	9.7	13.7	13.5	14.6	12.8	12.1	13.8	12.4	10.4	13.8	13.4	14.8
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	9.1	14.0	13.5	14.1	11.2	13.1	13.5	14.9	12.9	14.5	13.2	15.1	11.4	11.5	14.3	13.7	11.2	13.3	13.6	14.5
12. Oryzalin + glyphosate	1.1 + 1.1	11.4	13.4	12.6	13.8	14.6	16.0	13.7	13.9	18.7	14.4	14.7	14.3	14.5	15.7	13.9	16.0	14.8	14.9	13.8	14.5
13. Glyphosate Check (4)	1.1	6.5	8.7	11.5	13.4	11.2	11.1	11.4	14.1	11.4	10.5	14.6	15.1	13.3	11.4	13.1	14.3	10.6	10.5	11.6	12.3
Mean (5)		10.3	13.9	12.6	13.4	12.0	13.4	14.0	15.0	11.3	13.3	13.7	14.9	13.6	13.0	13.8	13.7	11.8	13.4	13.3	14.3

(1) The LSD 0.05 for 1980 for herbicide X tillage interactions at the 0 to 46 cm level = 3.3%.
(2) The LSD 0.05 for 1979 for herbicide treatments averaged across tillage main plots at the 0 to 46 cm level = 2.1%.
(3) The LSD 0.05 for 1980 for herbicide treatments averaged across tillage main plots at the 0 to 46 cm level = 2.6%.
(4) Glyphosate was applied to the check plots in 1979 but not in 1980.
(5) The LSD 0.05 for 1979 for tillage main plots at the 0 to 46 cm level = 1.8%.

in the summer of 1980 resulted in less vegetative groundcover, therefore, no glyphosate was applied to the check plots. Higher moisture percentages were observed in 1980 than in 1979. This was attributed to a 2.5 cm rainfall within 10 days of the 1980 soil core extraction date. The only significant rainfall prior to the 1979 sampling date was 34 days earlier when the area received 6.9 cm.

Visual ratings made 17 days after the 1981 wheat harvest (375 days after application of the 1980 treatments) indicated that there were no changes in weed species since the experiment was initiated in 1979. The most common weed species present from 1979 to 1980 were carpetweed, tumble and smooth pigweed, large crabgrass, and prairie cupgrass. Volunteer wheat was beginning to emerge. The no-till plots had lower populations of all weed species compared to the other tillage treatments. Less prairie cupgrass and volunteer wheat were present in the no-till plots which had 6 percent groundcover than in the disc, sweep, and chisel plots which had 27, 24, and 32 percent, respectively. The 1981 crop residue was approximately 2000 kg/ha. It was observed that a heavy straw cover inhibited early summer weed growth, but often served to enhance it by late summer, possibly because of its moisture retention abilities. There were no differences among weed populations in the other three tillage operations.

At this location, residual herbicide treatment such as alachlor alone and in tank mixes with cyanazine, linuron, and metribuzin provided early control of grasses and small seeded broadleaves. Over time, the effectiveness of these treatments decreased and later in the summer, weeds such as carpetweed, pigweed and large crabgrass began to appear. The differences among plots observed in June, 1981, could not be attributed to herbicide phytotoxicity, since their residual effectiveness is not this prolonged with the rates used. Weed populations were also affected by tillage operations. In the no-tillage system, a heavy straw cover could inhibit an early germinating species such as was the case with carpetweed. By doing so, a later germinating species such as volunteer wheat emerged with little competition. This was indicated in the September visual ratings in 1979 and 1980. Volunteer wheat populations were much higher in no-tillage plots than other tillage operations. No herbicide combinations appeared to entirely prevent the weed species from producing seed.

Teller Sandy Clay Loam (Perkins)

Since several species of grasses were present when the 1979 wheat crop matured, glyphosate was tank mixed with all herbicide treatments to control these weeds in the no-till plots. Existing vegetation was controlled with the tillage operations in the other main plot treatments. The experimental area received 0.7 cm of rainfall 5 days after herbicide treatments were applied and 1 cm 19 days after treatment. Barnyardgrass, large crabgrass, and fall witchgrass appeared as the three most prominent weed species. Volunteer wheat appeared late in August following a 2.3 cm rainfall. Visual ratings made September 4, 1979, on the basis of percent groundcover (Table XI) indicated that there were no differences in weed control among any of the herbicide treatments. Analysis of the groundcover data for large crabgrass revealed significant differences between tillage main plot treatment means. Populations of large crabgrass were lower in the no-till main plot treatments than in

TABLE X

WEED SPECIES POPULATIONS ONE YEAR AFTER TREATMENTS IN
THE HERBICIDE-TILLAGE COMBINATIONS EXPERIMENT
BETHANY SILT LOAM (LAHOMA) 1981

		Visual Ratings 7-6-81 (% groundcover)											
		Species Population(1)											
	Rate	Disc			Sweep			Chisel			No-Till		
Treatment	(kg/ha)	CW	PW	GR	CW	PW	GR	CW	PW	GR	CW	PW	GR
1. Alachlor + glyphosate	2.2 + 1.1	24	10	17	8	7	22	37	8	17	4	2	6
2.	3.3 + 1.1	35	3	23	17	5	13	25	12	33	2	3	2
3. DPX4189 + glyphosate	0.14+ 1.1	14	2	45	12	1	17	17	3	6	7	1	8
4.	0.28+ 1.1	32	1	20	18	1	10	29	4	35	10	0	5
5. Cyanazine + glyphosate	2.8 + 1.1	11	13	12	9	8	17	33	11	28	4	4	7
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	11	10	12	11	5	23	37	11	22	3	6	6
7. Linuron + glyphosate	1.1 + 1.1	19	6	45	7	23	33	18	13	57	3	5	4
8.	2.2 + 1.1	20	13	30	15	20	28	23	10	42	3	4	8
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	25	5	43	13	13	42	21	14	53	4	5	5
10. Metribuzin + glyphosate	0.81+ 1.1	25	13	13	10	10	19	27	9	28	3	2	4
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	26	19	10	10	11	18	27	8	13	3	6	5
12. Oryzalin + glyphosate	1.1 + 1.1	11	6	24	6	6	7	3	7	10	6	8	8
13. Glyphosate	1.1	12	4	52	3	10	62	22	8	67	3	2	4
Mean (2, 3, 4)		20.2	8.1	26.6	10.7	9.2	23.9	24.5	9.1	31.6	4.2	3.7	5.5

(1) Visual ratings were recorded 373 days after herbicides were applied and based on % groundcover. CW = carpetweed, PW = tumble pigweed and smooth pigweed, GR = volunteer wheat, prairie cupgrass and large crabgrass.
(2) The LSD 0.05 for comparing tillage means for carpetweed averaged across herbicide treatments = 4.5.
(3) The LSD 0.05 for comparing tillage means for pigweed averaged across herbicide treatments = 2.1.
(4) The LSD 0.05 for comparing tillage means for grasses averaged across herbicide treatments = 8.9.

TABLE XI

EFFECT OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS ON SUMMER ANNUAL WEED CONTROL AND CROP INJURY TELLER SANDY CLAY LOAM (PERKINS) 1979-80

		Visual Ratings 9-4-79 (% groundcover)(1)																Wheat Injury 4-7-80 (0-100 Scale)				
		Disc				Sweep				Chisel				No-Till								
Treatment	Rate (kg/ha)	VW	BG	CR	FWG	VW	BG	CR	FWG	VW	BG	CR	FWG	VW	BG	CR	FWG	Disc	Sweep	Chisel	No-Till	Mean
1. Alachlor + glyphosate	2.2 + 1.1	22	2	1	2	27	0	0	0	24	0	0	0	17	0	0	0	7	3	0	5	3.8
2.	3.3 + 1.1	19	0	2	1	25	1	1	0	22	0	1	0	23	0	0	2	0	0	3	0	0.8
3. DPX4189 + glyphosate	0.14+ 1.1	17	1	1	2	27	0	0	1	22	0	1	1	13	0	0	0	0	0	0	5	1.3
4.	0.28+ 1.1	23	1	1	1	30	0	1	1	25	0	1	1	21	0	0	0	7	0	0	5	3.0
5. Cyanazine + glyphosate	2.8 + 1.1	13	1	3	3	22	0	0	1	23	0	1	1	10	0	0	0	0	0	0	5	1.3
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	15	1	0	2	22	0	1	1	28	0	1	0	19	0	1	1	0	0	0	5	1.3
7. Linuron + glyphosate	1.1 + 1.1	20	0	3	1	32	1	1	1	24	0	3	0	32	0	0	2	3	0	3	0	1.5
8.	2.2 + 1.1	20	2	1	2	21	0	1	0	24	0	1	0	19	0	0	3	0	0	0	0	0
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	22	1	1	1	27	1	1	1	27	1	1	0	29	1	0	3	3	3	0	5	2.8
10. Metribuzin + glyphosate	0.84+ 1.1	14	1	5	1	22	1	2	0	27	0	1	0	19	1	1	4	0	7	0	5	3.0
11. Metribuzin + alachlor + glyphosage	0.4 + 2.2 + 1.1	17	1	4	1	22	1	1	0	21	0	1	1	16	1	0	1	13	7	7	0	6.8
12. Oryzalin + glyphosate	1.1 + 1.1	10	1	1	1	17	0	0	1	16	0	1	0	16	0	0	0	40	40	20	1	25.3
13. Glyphosate	[illegible]	[illegible]	1	3	1	28	0	1	1	26	0	1	0	32	0	0	1	7	0	3	1	2.8
Mean (2, 3)		18	1	1.6	1	25	.2	.5	.3	24	0	.9	.3	21	.1	.1	1.2	6.2	4.6	2.8	2.8	

(1) VW = volunteer wheat, BG = barnyard grass, CR = large crabgrass, FWG = fall witchgrass
(2) The LSD 0.05 for comparing tillage means for large crabgrass averaged across herbicide treatments = 0.8 (C.V. = 193%)
(3) There was no significance for visual ratings of volunteer wheat, barnyard grass, or fall witchgrass among herbicides, tillages, or herbicide X tillage interactions.

the chiseled or disced main plots. This could be due to the crop residue serving as a mulch, thereby preventing seedling emergence. No other differences were noted among tillage main plot treatments for the other weed species.

In order to kill existing weeds prior to planting, a second tillage operation was repeated on each respective tillage treatment. Glyphosate was applied to control the existing vegetation in the no-till main plot treatments. The plots remained free of weeds until the wheat crop was planted due to lack of rainfall. The area received 2.9 cm of rainfall in late October after the wheat was planted.

Visual evaluation of wheat injury on April 7, 1980, when the wheat was jointing, indicated that oryzalin plus glyphosate was stunting the wheat in the disc and sweep main plot treatments (Table XI). This was evident to a lesser extent in the chisel main plot. There was no crop injury from this treatment in the no-till main plot. Wheat in the alachlor plus metribuzin treatment was slightly stunted with stand reduction in the disc, sweep and chisel treatments, however, no injury was noted in the no-till main plot treatments. However, analysis of the 1980 harvest data indicated no significant differences among herbicide treatments, tillages, or herbicide by tillage interactions (Table XII). High populations of volunteer grain lowered wheat yields and caused dockage to be between 20 and 40 percent although no significant differences were noted.

Each treatment was reapplied June 26, 1980. Glyphosate was included in each tank mix and all existing weeds were controlled. Thereafter the experimental area went 56 days without a substantial rainfall. Therefore, virtually no weeds appeared until late August. The same weed

TABLE XII

EFFECT OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS ON WHEAT PRODUCTION
TELLER SANDY CLAY LOAM (PERKINS) 1980

	Treatment	Rate (kg/ha)	Yield 6-25-80 (kg/ha) Disc	Sweep	Chisel	No-Till	Dockage (%) Disc	Sweep	Chisel	No-Till
1.	Alachlor + glyphosate	2.2 + 1.1	1207	1416	1346	1207	36	38	26	32
2.		3.3 + 1.1	1076	1277	1416	1346	35	34	23	33
3.	DPX4189 + glyphosate	0.14+ 1.1	1145	1277	1346	1137	38	42	23	32
4.		0.28+ 1.1	1045	1145	1346	1045	35	33	27	25
5.	Cyanazine + glyphosate	2.8 + 1.1	1207	1207	1478	1346	36	36	22	24
6.	Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	944	1346	1277	1207	44	35	25	28
7.	Linuron + glyphosate	1.1 + 1.1	1207	1416	1277	1075	39	39	23	30
8.		2.2 + 1.1	1145	1277	1416	1416	40	37	20	28
9.	Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	1075	1145	1145	944	43	39	26	32
10.	Metribuzin + glyphosate	0.84+ 1.1	1346	1346	1346	1276	32	30	35	27
11.	Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	1416	1277	1346	1277	31	37	26	27
12.	Oryzalin + glyphosate	1.1 + 1.1	1207	1277	1346	1416	39	34	22	22
13.	Glyphosate	1.1	1145	1145	1207	944	37	33	24	40
	Mean		1167	1273	1330	1203	37	36	25	29
	LSD 0.05 =		NS	NS	NS	NS	NS	NS	NS	NS
	C.V.% =		39%	25%	23%	25%	19%	22%	20%	30%

species were present in 1980, however, there was an increase in Amaranthus species throughout the experimental area. Visual ratings taken 96 DAT on September 30, 1980, revealed that volunteer wheat and large crabgrass were the dominant weed species (Table XIII).

Under no-till conditions, cyanazine plus glyphosate and oryzalin plus glyphosate had lower populations of volunteer wheat than treatments containing alachlor or linuron. Cyanazine plus glyphosate provided significantly high volunteer wheat control than the glyphosate treated check in the disc, sweep, and no-tillage main plot treatments. Oryzalin plus glyphosate gave better volunteer wheat control than the glyphosate treated check in the sweep and no-tillage main plot treatments. Analysis of tillage means revealed higher populations of volunteer wheat in the sweep and no-tillage main plot treatments than in the disc and chisel main plots.

There were higher populations of large crabgrass in the glyphosate treated check in the disced plots than the other tillage plots. Within the disced main plot treatments, all herbicide treatments except linuron at the low rate reduced large crabgrass populations compared to the glyphosate treated check. Cyanazine plus glyphosate provided higher control than the glyphosate treated check in the disc, chisel, and no-tillage main plot treatments.

No herbicide by tillage interaction was observed for tumble pigweed populations. However, analysis of herbicide treatment means revealed that tumble pigweed populations were lower in all herbicide treatments except oryzalin plus glyphosate and the low rates of alachlor plus glyphosate and linuron plus glyphosate than in the glyphosate treated check.

TABLE XIII

WEED POPULATIONS 96 DAYS AFTER TREATMENT IN THE POSTHARVEST HERBICIDE-TILLAGE COMBINATION EXPERIMENT TELLER SANDY CLAY LOAM (PERKINS) 1980

Treatment	Rate (kg/ha)	Visual Ratings 9-30-80 (% groundcover)(1) Disc VW(2)	CR(3)	FWG(4)	TP(5)	Sweep VW	CR	FWG	TP	Chisel VW	CR	FWG	TP	No-Till VW	CR	FWG	TP	Mean TP(5)
1. Alachlor + glyphosate	2.2 + 1.1	17	2	1	3	23	1	15	1	17	5	5	0	47	3	0	10	3.5
2.	3.3 + 1.1	15	8	1	1	30	1	8	1	18	3	9	0	39	3	0	3	1.3
3. DPX4189 + glyphosate	0.14+ 1.1	14	6	1	3	18	2	1	0	14	8	1	0	35	3	0	0	0.7
4.	0.28+ 1.1	11	5	0	0	22	2	1	0	14	1	1	0	15	1	0	0	0
5. Cyanazine + glyphosate	2.8 + 1.1	5	6	1	2	10	1	2	0	9	2	3	1	7	2	0	0	0.6
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	12	3	0	0	22	3	2	0	14	2	1	0	24	1	1	1	0.1
7. Linuron + glyphosate	1.1 + 1.1	19	10	0	0	47	0	0	3	15	14	8	3	48	2	1	2	2.1
8.	2.2 + 1.1	19	4	1	0	32	1	1	0	19	5	1	0	50	1	0	3	0
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	22	1	0	0	40	0	2	1	20	3	0	0	50	2	0	1	0.6
10. Metribuzin + glyphosate	0.84+ 1.1	7	6	2	0	17	6	16	0	11	6	3	1	18	10	4	3	1.0
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	15	8	1	0	24	4	7	1	12	4	1	0	28	3	1	2	0.5
12. Oryzalin + glyphosate	1.1 + 1.1	7	3	1	2	8	4	1	3	7	3	2	6	5	4	1	10	5.4
13. Glyphosate	1.1	19	14	3	5	37	5	1	2	18	8	0	6	45	8	2	11	5.1
Mean (6)		14.0	5.8	0.9	1.2	25.4	2.3	4.4	0.9	14.5	4.9	2.9	1.3	31.6	3.3	0.8	3.4	

(1) VW = volunteer wheat, CR = large crabgrass, FWG = fall witchgrass, TP = tumble pigweed.
(2) The LSD 0.05 for comparing populations of volunteer wheat among herbicide or tillage treatments = 13.6 (C.V. = 39%).
(3) The LSD 0.05 for comparing populations of large crabgrass among herbicide or tillage treatments = 5.5 (C.V. = 82%).
(4) No significant differences among fall witchgrass populations was observed.
(5) The LSD 0.05 for comparing herbicide treatment means for tumble pigweed averaged across tillage treatments = 3.8 (C.V. = 190%).
(6) The LSD 0.05 for comparing tillage means for volunteer wheat averaged across herbicide treatments = 7.5 (C.V. = 39%).

The entire experimental area was tilled with a 1.5 m V-sweep which controlled the weeds present including volunteer wheat. However, the volunteer wheat continued to emerge after this tillage operation. Visual ratings of crop vigor made 28 and 110 days after the 1980 planting revealed no injury from herbicide residues.

No treatments significantly affected heads per meter of row (Table XIV). However, when examining treatment means it appeared that the oryzalin plus glyphosate plots had a higher number of heads per row than the other treatments. This would have been understandable due to the superior late season volunteer wheat control which enabled the young wheat plants to grow with less competition.

Analysis of harvest data indicated significant differences between herbicide treatments in the combine yield (before cleaning), and recleaned yield but no differences between tillage treatments or herbicide X tillage interactions (Table XV). The two treatments with significantly higher yields than the glyphosate treated check both before and after cleaning were cyanazine plus glyphosate and alachlor plus metribuzin plus glyphosate. Analysis of the test weight data indicated oryzalin plus glyphosate and rate of DPX4189 plus glyphosate increased test weight over that in the glyphosate treated check within the disc and sweep tillage main plot operations. No differences were observed for the no-till and chisel treatments.

Analysis of the 1979 soil moisture data indicated no significant differences between herbicide treatments. Averaged over all herbicide treatments, the no-tillage treatment had less soil moisture than other main plot treatments. Apparently, there was not enough residue to shade the soil surface to prevent evaporation. Without a tillage operation

TABLE XIV

WHEAT HEADS PER ONE METER OF ROW IN THE HERBICIDE-TILLAGE COMBINATION EXPERIMENT TELLER SANDY CLAY LOAM (PERKINS) 1981

Treatment	Rate (kg/ha)	Heads/Meter of Row (4-22-81) Disc	Sweep	Chisel	No-Till	Mean
1. Alachlor + glyphosate	2.2 + 1.1	84	80	94	98	89
2.	3.3 + 1.1	88	81	89	94	88
3. DPX4189 + glyphosate	0.14+ 1.1	92	81	90	98	90
4.	0.28+ 1.1	103	95	90	94	95
5. Cyanazine + glyphosate	2.8 + 1.1	91	103	96	92	96
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	92	92	101	90	94
7. Linuron + glyphosate	1.1 + 1.1	96	88	82	84	88
8.	2.2 + 1.1	103	88	92	76	90
9. Alachlor + linuron + glyphosate	1.1 + 1.1 + 1.1	101	90	94	84	92
10. Metribuzin + glyphosate	0.84+ 1.1	109	84	88	75	89
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	101	106	102	93	100
12. Oryzalin + glyphosate	1.1 + 1.1	106	114	99	96	104
13. Glyphosate	1.1	87	105	80	87	90
Mean		96	93	92	89	(1)

(1) No significant differences were observed within herbicide treatments, tillages or herbicide X tillage interactions. (C.V.% for herbicide variable = 18.5%, tillage variable = 24.4%, herbicide X tillage interaction = 14.8%.)

TABLE XV

EFFECT OF POSTHARVEST HERBICIDE-TILLAGE COMBINATIONS ON WHEAT PRODUCTION
TELLER SANDY CLAY LOAM (PERKINS) 1981

		Harvest Data 6-16-81																	
		Yield (Combine Sample) (kg/ha) (1)					Yield (Recleaned) (kg/ha) (2)					Test Weight (kg/ha) (3)				Dockage (%) (4)			
Treatment	Rate (kg/ha)	Disc	Swep	Chsl	Notl	Mean	Disc	Swep	Chsl	Notl	Mean	Disc	Swep	Chsl	Notl	Disc	Swep	Chsl	Notl
1. Alachlor + glyphosate	2.2 + 1.1	1834	1633	1648	1718	1702	1764	1547	1509	1679	1632	69.6	69.6	67.0	69.6	3.8	2.5	10.0	2.5
2.	3.3 + 1.1	1934	1578	1671	1594	1694	1872	1540	1633	1547	1648	68.3	68.3	68.3	68.3	3.3	2.6	2.5	3.2
3. DPX4189 + glyphosate	0.14+ 1.1	1919	1741	1702	1687	1764	1872	1710	1656	1633	1717	69.6	69.6	69.6	68.3	2.4	1.7	2.6	3.5
4.	0.28+ 1.1	1986	1640	1756	1687	1764	1950	1639	1710	1640	1725	70.8	69.6	69.6	69.6	2.1	2.1	2.4	2.8
5. Cyanazine + glyphosate	2.8 + 1.1	2012	1803	1811	1950	1895	1965	1764	1764	1880	1849	69.6	69.6	69.6	68.3	2.2	2.1	2.7	3.2
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	1857	1764	1671	1725	1756	1818	1710	1625	1671	1709	69.6	69.6	68.3	68.3	2.2	3.1	2.9	3.0
7. Linuron + glyphosate	1.1 + 1.1	1540	1462	1602	1424	1508	1509	1416	1547	1385	1462	69.6	68.3	68.3	69.6	2.3	3.2	3.0	2.7
8.	2.2 + 1.1	1834	1671	1772	1718	1748	1795	1625	1725	1679	1709	69.6	68.3	69.6	68.3	1.9	2.7	2.7	2.5
9. Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	1872	1501	1633	1656	1663	1826	1462	1586	1602	1617	69.6	69.6	68.3	68.3	2.5	2.9	2.8	3.2
10. Metribuzin + glyphosate	0.84+ 1.1	1919	1771	1617	1795	1771	1764	1747	1586	1749	1702	69.6	68.3	69.6	69.6	7.3	2.2	2.0	2.5
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	1725	1795	2050	1849	1856	1679	1718	1989	1800	1787	69.6	68.3	69.6	68.3	2.7	4.3	3.1	3.6
12. Oryzalin + glyphosate	1.1 + 1.1	1826	1671	1687	1826	1756	1764	1648	1648	1799	1709	69.6	69.6	69.6	69.6	3.5	1.6	2.5	2.7
13. Glyphosate	1.1	1664	1640	1602	1664	1640	1617	1594	1563	1602	1593	68.3	68.3	69.6	69.6	2.7	2.9	2.3	3.4
Mean		1841	1671	1710	1710		1780	1625	1656	1664		69.4	69.0	68.9	68.9	3.0	2.6	3.2	3.0

(1) The LSD 0.05 for comparing herbicide treatment means for combine yield averaged across tillage treatments = 155 (C.V. = 10.6%).
(2) The LSD 0.05 for comparing herbicide treatment means for cleaned yield averaged across tillage treatments = 160 (C.V. = 11.3%).
(3) The LSD 0.10 for comparing test weights among herbicide or tillage treatments = 1.2 (C.V. = 1.3%).
(4) There were no significant differences among the dockage data for any variables. (C.V. for tillage main plot treatments = 10%, herbicides = 77%, herbicide X tillage interaction = 76%.)

TABLE XVI

PERCENT MOISTURE IN THE SOIL PROFILE AT 0 TO 46 AND 47 TO 92 CM DEPTH IN OCTOBER 1979 AND 1980 IN THE POSTHARVEST HERBICIDE-TILLAGE EXPERIMENT TELLER SANDY LOAM (PERKINS) 1979-81

		% Soil Moisture 1979-80																
		Disc				Sweep				Chisel				No-Till				Mean
	Rate	0-46 cm		47-92 cm		0-46 cm		47-92 cm		0-46 cm		47-92 cm		0-46 cm		47-92 cm		0-46 cm
Treatment	(kg/ha)	79(1)	80	79	80	79	80	79	80	79	80	79	80	79	80	79	80	1980(2)
1. Alachlor + glyphosate	2.2 + 1.1	10.6	9.5	10.0	10.9	9.7	9.9	11.1	10.9	9.3	11.4	16.0	11.5	10.1	9.4	8.3	12.2	10.0
2.	3.3 + 1.1	9.5	11.6	9.6	12.3	9.8	7.8	9.8	11.1	11.3	10.0	17.0	12.1	8.0	8.8	10.3	13.2	9.5
3. DPX4189 + glyphosate	0.14+ 1.1	9.3	11.2	11.1	12.3	11.4	10.9	10.6	12.5	11.2	11.5	12.4	11.4	9.0	9.4	21.8	13.7	10.7
4.	0.28+ 1.1	10.5	12.1	11.9	12.6	12.2	10.2	12.2	11.6	14.2	11.2	10.6	11.8	7.2	10.9	9.1	12.1	11.1
5. Cyanazine + glyphosate	2.8 + 1.1	10.8	10.7	11.5	12.4	11.7	11.1	12.3	11.6	12.1	10.6	13.2	13.0	9.2	11.7	10.5	13.0	11.0
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	10.4	11.7	12.1	11.6	12.2	9.7	12.4	12.5	11.2	10.2	22.0	11.6	7.6	10.7	11.7	12.5	10.5
7. Linuron + glyphosate	1.1 + 1.1	10.9	10.5	11.8	12.2	11.3	8.0	11.9	11.8	11.6	10.9	18.8	11.4	6.5	8.5	10.6	10.9	9.4
8.	2.2 + 1.1	10.8	10.3	11.7	12.4	11.7	11.4	11.8	13.1	18.4	10.0	9.7	11.4	9.5	9.1	14.3	12.8	10.2
9. Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	10.7	10.3	11.6	11.8	10.6	9.5	12.2	10.3	13.1	10.1	12.7	12.1	6.6	9.6	12.3	10.7	9.9
10. Metribuzin + glyphosate	0.84+ 1.1	11.6	11.5	11.9	16.3	10.6	11.2	11.0	12.3	9.4	10.5	15.2	12.5	9.6	10.6	9.7	16.5	11.0
11. Metribuzin + alachlor + glyphosate	0.4 + 2.2 + 1.1	11.3	11.7	10.2	12.5	10.4	9.9	10.4	11.8	18.9	11.9	21.3	12.6	5.0	9.1	9.9	12.5	10.6
12. Oryzalin + glyphosate	1.1 + 1.1	11.1	11.6	11.9	11.1	11.3	12.4	10.9	12.3	13.0	10.7	12.3	11.5	9.8	11.6	11.2	10.5	11.6
13. Glyphosate	1.1	11.2	10.0	12.1	11.7	11.2	9.0	14.2	10.2	11.5	10.5	12.4	12.0	8.6	8.9	25.4	12.1	9.6
Mean (3)		10.7	11.0	11.3	12.3	11.1	10.1	11.6	11.7	12.7	10.7	14.9	11.9	8.2	9.9	12.7	12.5	

(1) The LSD 0.05 for comparing values of % moisture in 1979 at the 0 to 46 cm level among herbicide or tillage treatments = 0.3 (C.V. = 13%).
(2) The LSD 0.05 for comparing herbicide treatment means at the 0 to 46 cm level in 1980 when averaged across four tillage main plot treatments = 1.2 (C.V. = 11.5%).
(3) The LSD 0.05 for comparing tillage means when averaged across herbicide treatments in 1979 = 1.5 (C.V. = 13%).

to break up the soil crust, intense rainfall was more susceptible to runoff. There were no differences in moisture between the upper and lower 46 cm of the soil profile.

The 1980 wheat yield averaged approximately 1500 kg/ha and after harvest approximately 1800 kg/ha of crop residue remained. The straw ejected from the rear of the combine was placed back in each plot to insure a more uniform straw cover for no-tillage plots than in 1979. Analysis of herbicide treatment means revealed that in the top 46 cm of the soil profile the high rate of DPX4189 plus glyphosate, cyanazine plus glyphosate, and oryzalin plus glyphosate all had higher soil moisture than the glyphosate treated check. These treatments had provided the best summer weed control. There were no differences among tillage main plots and no interaction.

Species population visual ratings recorded on July 6, 1981 (374 days after herbicide treatment) indicated no significant differences among tillage main plots, herbicide treatments, or interactions. Carpetweed was the most notable weed species. It was not present when the experiment was initiated in 1979, however it became a prominent species in spite of herbicide applications. One reason for its appearance in 1981 could be due to long life of the seed. In the plots where there was a reduction of carpetweed, a heavy infestation of large crabgrass was present. Large crabgrass began to appear earlier in the summer than carpetweed and could have inhibited its growth.

TABLE XVII

WEED SPECIES POPULATIONS ONE YEAR AFTER TREATMENTS
IN THE HERBICIDE-TILLAGE EXPERIMENT
TELLER SANDY LOAM (PERKINS) 1981

Treatment	Rate (kg/ha)	Visual Ratings 7-6-81 (% groundcover) Species Population (1; 2) Disc CW	Disc GR	Disc PW	Sweep CW	Sweep GR	Sweep PW	Chisel CW	Chisel GR	Chisel PW	No-Till CW	No-Till GR	No-Till PW
1. Alachlor + glyphosate	2.2 + 1.1	100	60	30	100	37	23	100	47	40	100	57	37
2.	3.3 + 1.1	100	70	10	100	50	13	100	33	37	100	57	20
3. DPX 4189 + glyphosate	0.14+ 1.1	100	57	13	100	27	0	100	40	3	100	27	0
4.	0.28+ 1.1	93	53	13	100	43	0	100	23	0	100	30	0
5. Cyanazine + glyphosate	2.8 + 1.1	100	84	10	100	28	20	100	20	13	100	33	33
6. Cyanazine + alachlor + glyphosate	1.3 + 2.2 + 1.1	100	24	24	100	33	17	100	57	33	100	43	3
7. Linuron + glyphosate	1.1 + 1.1	100	70	27	100	30	33	100	97	20	100	57	27
8.	2.2 + 1.1	100	73	30	100	40	7	83	47	43	100	50	7
9. Linuron + alachlor + glyphosate	1.1 + 1.1 + 1.1	100	50	37	100	27	17	100	53	10	100	50	30
10. Metribuzin + glyphosate	0.84+ 1.1	83	90	0	100	64	20	100	73	20	100	80	23
11. Metribuzin + alachlor + glyphosate	0.4 + 1.1	100	67	7	100	50	10	90	50	33	100	73	10
12. Oryzalin + glyphosate	1.1 + 1.1	77	37	57	100	47	10	100	43	57	67	80	33
13. Glyphosate	1.1	67	57	23	100	50	13	73	73	33	100	83	17
Mean		94	60	22	100	40	14	94	50	26	97	55	19

(1) Visual ratings were recorded 375 days after treatments were applied and based on % groundcover. CW = carpetweed, GR = large crabgrass, PW = smooth pigweed.
(2) There were no significant differences among species populations for herbicide treatment, tillages, or herbicide X tillage interaction.

Comparison of Granular Versus Sprayed Herbicides in a Reduced Tillage System

Port Silty Clay Loam (Stillwater)

Visual ratings made 34 DAT revealed that smooth pigweed populations were higher in plots treated with the low rate of metribuzin granules than where the same rate of metribuzin was applied as a wettable powder (Table XVIII). No significant differences were observed with control of the other weed species.

Analysis of the 1980 harvest data indicated that plots treated with alachlor 4 EC (2.2 kg/ha) produced a higher yield than plots treated with alachlor granules at the same rate. Plots treated with the wettable powder formulation of metribuzin (1.1 kg/ha) produced higher wheat yields than plots treated with either rate of metribuzin granules. The increases in yield could be related to the summer weed control, as was the case with the two formulations of metribuzin.

The 1980 herbicide treatments were not activated until 5.6 cm rainfall occurred on August 18, 1980 (42 DAT). This was in sharp contrast with 1979 when the experimental area received 8.3 cm within two days of herbicide application. This difference in time between application and rainfall may explain why alachlor granules at high rate provided better weed control in 1980 than the same rate applied as an EC formulation, while in 1979 such differences were not found (Table XIX).

Visual ratings made on the 1981 wheat crop 29 DAP indicated that slight stand reduction occurred in the alachlor EC (2.2 kg/ha) and metribuzin 2 G (1.1 kg/ha) treatments (Table XVIII). A second crop vigor rating on March 25, 1981 (145 DAP) showed no significant injury to

TABLE XVIII

EFFECT OF GRANULAR VERSUS SPRAYED HERBICIDE TREATMENTS ON WEED POPULATIONS AND WHEAT PRODUCTION, PORT SILTY CLAY LOAM (STILLWATER) 1979-1980

			Visual Ratings					
			% (groundcover) 8-6-79 (1)				Wheat Yield 6-30-80	
	Treatment	Rate (kg/ha)	PC	PW	NS	FWG	Yield (kg/ha)	Test Wt. (kg/hl)
1.	Alachlor 4EC	2.2	9	1	3	7	1417	68
2.		3.4	9	1	17	2	1202	66
3.	Alachlor 10G	2.2	12	1	2	4	977	65
4.		3.4	7	1	1	1	1544	70
5.	Cyanazine 80WP	2.2	1	1	4	2	1681	67
6.		3.4	0	0	2	1	1554	66
7.	Cyanazine 15G	2.2	2	1	8	5	1593	69
8.		3.4	0	1	2	2	1535	67
9.	Metribuzin 75WP	.56	1	1	2	1	1759	66
10.		1.12	0	0	2	0	2082	68
11.	Metribuzin 2G	.56	1	11	6	2	1378	65
12.		1.12	0	1	4	8	1407	68
13.	Untreated	--	0	9	10	5	1271	67
	LSD 0.05 =		NS	4.2	NS	NS	420	NS
	C.V.% =		216	148	106	138	19.6	4.4

(1) Visual ratings recorded 34 DAT - PC = Prairie cupgrass, PW = smooth pigweed, NS = yellow nutsedge, FWG = fall witchgrass.

TABLE XIX

EFFECT OF GRANULAR VERSUS SPRAYED HERBICIDE TREATMENTS ON WEED POPULATIONS AND WHEAT PRODUCTION, PORT SILTY CLAY LOAM (STILLWATER) 1980-1981

Treatment	Rate (kg/ha)	Visual Ratings (0-100 scale) 9-23-80(1) %	11-28-80(2) WH	3-25-80(3) VW	3-25-80(3) WH	3-25-80(3) HN	Harvest Data Yield (6-12-81) Com. Samp. (kg/ha)	Recln. Gr. (kg/ha)	Test Wt. (kg/hl)	Dockage (%)
1. Alachlor 4EC	2.2	60	20	70	38	44	1033	924	64	13.7
2.	3.4	64	0	85	18	85	1214	1115	65	9.3
3. Alachlor 10G	2.2	64	0	83	20	68	1159	1084	65	8.1
4.	3.4	35	10	75	23	63	1247	1161	65	7.3
5. Cyanazine 80WP	2.2	12	0	88	18	65	1219	1121	64	12.7
6.	3.4	9	0	73	8	60	1511	1379	66	11.2
7. Cyanazine 15G	2.2	46	10	75	15	78	1407	1312	66	7.4
8.	3.4	31	0	75	5	58	1257	1110	64	16.3
9. Metribuzin 75WP	0.56	18	0	63	13	43	1252	1152	65	12.5
10.	1.12	4	0	78	8	73	1377	1290	66	6.9
11. Metribuzin 2G	0.56	38	0	78	15	55	1336	1211	65	11.0
12.	1.12	10	20	78	20	53	1191	1059	64	13.0
13. MON-097 4EC	2.2	22	0	80	10	85	1089	970	64	12.7
14.	3.4	41	10	65	20	70	1330	1249	65	7.1
15. Untreated	---	38	0	68	13	83	1202	1121	65	7.2
LSD 0.05 =		23.6	12.7	NS	NS	NS	NS	NS	NS	NS
C.V.% =		46	298	84	25	36	20.8	22.8	3.1	57

(1) Visual ratings recorded 78 DAT based on % groundcover of prickly sida, prairie cupgrass, volunteer wheat, and smooth pigweed.
(2) Crop vigor ratings were recorded 29 DAP. WH = wheat
(3) Visual ratings recorded 145 DAP. VW = volunteer wheat, WH = wheat, HN = henbit

the fully tillered wheat. Analysis of the 1981 wheat harvest data revealed no differences among herbicide treatments (Table XIX).

Teller Sandy Clay Loam (Perkins)

Four days after application, the experiment received 0.7 cm of rain followed by 1 cm 2 weeks later. Lack of herbicide performance may have been due to application when the soil was very wet and insufficient moisture to move the herbicide into the soil prior to weed emergence. Analysis of visual ratings recorded 56 DAT did not reveal any significant differences among herbicide treatments or formulations (Table XX). No differences were observed in the 1980 harvest data.

Reduced Tillage Using Herbicides Applied Preharvest

Pond Creek Silt Loam (Lahoma)

Visual ratings 25 days after the April 4th treatment date indicated that none of the herbicides caused any significant injury to the jointing wheat (Table XXI). Treatments containing alachlor plus DPX4189 controlled prairie cupgrass better than oryzalin and DPX4189. The low rates of oryzalin plus DPX4189 were better than oryzalin alone. Oryzalin failed to control kochia when applied alone, however, good to excellent control was achieved when it was tank mixed with DPX4189. Alachlor plus DPX4189 also controlled the kochia. The low rates of oryzalin failed to provide any control of smallseed false flax. When oryzalin and alachlor were tank mixed with a postemergence herbicide, good control was achieved.

TABLE XX

EFFECTS OF GRANULAR VERSUS SPRAYED HERBICIDE TREATMENTS ON WEED CONTROL AND WHEAT PRODUCTION, TELLER SANDY CLAY LOAM (PERKINS) 1979-80

Treatment	Rate (kg/ha)	Visual Ratings 9-7-79 (%groundcover) VW	CR	FWG	Total	Wheat Yield 6-28-80 (kg/ha)
1. Alachlor 4EC	2.2	8	6	8	22	2150
2.	3.4	11	4	6	21	2053
3. Alachlor 10G	2.2	13	6	19	38	2062
4.	3.4	8	8	21	37	2199
5. Cyanazine 80WP	2.2	8	6	18	32	2199
6.	3.4	6	10	13	29	2434
7. Cyanazine 15G	2.2	7	1	23	31	2073
8.	3.4	21	11	12	44	2199
9. Metribuzin 75WP	.56	35	4	8	47	2297
10.	1.12	10	6	8	24	2062
11. Metribuzin 2G	.56	18	3	9	30	2170
12.	1.12	7	5	8	20	2189
13. Untreated	--	12	22	11	45	2180
LSD 0.05 =		NS	NS	NS	NS	NS
CV% =		90	131	100	88	16.7

(1)VW = volunteer wheat, CR = large crabgrass, FWG = fall witchgrass

TABLE XXI

EFFECT OF PREHARVEST HERBICIDE APPLICATIONS TO WHEAT ON WEED CONTROL AND WHEAT PRODUCTION POND CREEK SILT LOAM (LAHOMA) 1980

	Treatment	Rate (kg/ha)	Stage	Weed Control (%) (1) 4-30-80 WH	GR	KOZ	FLX	6-5-80 WH	CH	Harvest Data 6-27-80 Yield (kg/ha)	Test Wt. (kg/hl)	Dockage (%)	Protein (%)
1.	Oryzalin	1.1	4-4-80	5	0	8	0	10	13	1238	68	10.8	16.4
2.		1.4	"	3	20	15	0	0	20	1230	68	8.8	16.0
3.		2.2	"	5	53	5	35	5	10	1130	68	10.9	16.4
4.		2.8	"	15	40	40	65	3	20	1369	70	10.3	16.2
5.	Oryzalin + MCPA ester	1.1 + 0.6	"	3	40	98	95	0	10	1416	69	9.1	16.2
6.	Oryzalin + DPX4189	1.1 + 0.02	"	3	65	95	100	3	3	1106	69	12.5	16.4
7.		1.1 + 0.04	"	10	53	100	100	3	0	1253	70	12.3	16.4
8.		1.1 + 0.07	"	8	40	100	100	10	3	1176	70	10.1	16.2
9.		1.1 + 0.14	"	8	43	75	75	10	10	1215	70	6.9	16.2
10.	Alachlor + DPX4189	2.2 + 0.02	"	5	95	100	100	0	5	1257	68	10.3	16.4
11.		2.2 + 0.04	"	3	93	100	100	3	20	1393	70	8.7	16.5
12.		2.2 + 0.07	"	3	88	100	100	3	10	1269	70	8.4	16.6
13.		2.2 + 0.14	"	10	90	100	100	3	15	1308	70	7.7	16.3
14.	Alachlor + metribuzin	2.2 + 0.4	"	20	88	98	98	10	60	1006	68	6.3	16.5
15.	Oryzalin + bromoxynil	1.4 + 0.28	4-29-80	--	--	--	--	3	5	1292	68	7.4	16.3
16.	Alachlor + bromoxynil	2.2 + 0.28	"	--	--	--	--	0	10	1308	66	8.4	16.6
17.	Oryzalin	1.1	"	--	--	--	--	0	0	1292	68	10.6	16.5
18.		1.4	"	--	--	--	--	0	3	1199	68	12.1	16.6
19.		2.2	"	--	--	--	--	0	13	1284	68	12.9	16.3
20.		2.8	"	--	--	--	--	3	10	1308	68	13.5	16.5
21.	Untreated	--	--	0	0	0	0	0	0	1083	67	25.1	16.7
	LSD 0.05 =			NS	38	28	37	NS	17	NS	2.0	2.3	NS
	C.V.% =			149	53	30	39	164	118	13.8	1.5	46.0	1.8

(1) WH = wheat, GR = prairie cupgrass, KOZ = kochia, FLX = smallseed falseflax, CH = cheat

No significant crop injury was observed on June 5th. The only treatment expected to provide some cheat control was alachlor plus metribuzin which provided 60 percent control of the species.

Due to the heavy infestation of cheat, wheat yields were relatively low throughout the experiment (Table XXI). No differences were observed in the yield data, however, herbicide treatments providing good control of weeds prior to harvest had higher test weights. There was 6.3 percent dockage in the alachlor plus metribuzin treatment, compared to 25.1 percent in the untreated check. This was probably due to a reduction in the cheat population. All of the treatments had less dockage compared to the untreated check. In plots where summer annual weed populations were controlled, less dockage was present at wheat harvest. There were high weed populations in the untreated check resulting in higher dockage.

Visual ratings on August 19, 1980 also illustrated that oryzalin failed to control the early emerging kochia when applied alone (Table XXII). When oryzalin was tank mixed with DPX4189, excellent control was observed at all rates. Kochia control with oryzalin applied April 29 was significantly less than the same treatments applied April 4, indicating that emergence of kochia continued in the interval between applications. When oryzalin was tank mixed with bromoxynil on April 29, kochia control was better than with oryzalin alone. The combination of oryzalin plus MCPA ester, applied April 4 was less effective than the oryzalin plus bromoxynil tank mix applied April 29. This could be due to either the compatibility problem which was found between MCPA ester and oryzalin wettable powder or simple inability of the herbicides to control kochia. An oily residue was found inside the spray tanks after application of MCPA ester plus oryzalin WP.

TABLE XXII

EFFECT OF PREHARVEST HERBICIDE APPLICATIONS TO WHEAT ON WEED CONTROL AND WHEAT PRODUCTION POND CREEK SILT LOAM (LAHOMA) 1980-81

Treatment	Rate (kg/ha)	Stage	Weed Control (%) (1) 8-19-80 KOZ	TP	CW	FOX	GR	9-6-80 KOZ	TP	CW	FOX	VW	Harvest Data 6-19-81 Com.Samp. (kg/ha)	Recln.Gr. (kg/ha)	Test Wt(2) (kg/hl)	Dockage (%)
1. Oryzalin	1.1	4-4-80	57	100	100	100	100	40	75	100	100	90	1586	1465	70.8	7.9
2.	1.4	"	30	100	100	75	100	33	100	100	95	60	1640	1555	71.8	5.3
3.	2.2	"	35	100	100	95	100	25	100	100	100	80	1903	1810	72.5	4.8
4.	2.8	"	63	100	100	100	100	58	98	100	100	97	2012	1934	72.8	4.0
5. Oryzalin + MCPA ester	1.1 + 0.6	"	65	100	98	83	100	78	100	88	93	100	2004	1911	72.8	4.5
6. Oryzalin + DPX4189	1.1 + 0.02	"	95	100	88	100	100	98	100	95	98	73	2058	1981	73.8	3.9
7.	1.1 + 0.04	"	100	100	100	100	96	100	100	83	100	30	2012	1911	71.2	5.6
8.	1.1 + 0.07	"	100	100	100	100	100	100	100	93	100	63	1841	1779	72.2	3.3
9.	1.1 + 0.14	"	100	100	100	100	100	100	100	95	100	83	2012	1926	73.1	4.5
10. Alachlor + DPX4189	2.2 + 0.02	"	100	100	5	90	50	100	100	0	80	0	1238	1161	70.9	6.7
11.	2.2 + 0.04	"	100	100	38	67	50	100	100	0	75	70	1207	1122	70.9	6.8
12.	2.2 + 0.07	"	100	100	18	85	60	100	100	0	98	33	1253	1176	71.8	6.4
13.	2.2 + 0.14	"	100	100	13	10	10	100	100	3	68	18	1408	1338	71.5	5.5
14. Alachlor + metribuzin	2.2 + 0.4	"	100	23	5	50	66	100	18	0	75	33	1308	1222	70.9	7.4
15. Oryzalin + bromoxynil	1.4 + 0.28	4-29-80	85	75	75	100	100	95	100	98	100	68	2259	2182	72.8	3.5
16. Alachlor + bromoxynil	2.2 + 0.28	"	93	46	33	95	100	73	27	0	83	0	1037	936	69.3	10.0
17. Oryzalin	1.1	"	20	98	75	100	100	3	98	100	100	100	1671	1609	73.4	3.4
18.	1.4	"	13	98	96	100	100	10	100	100	100	100	1826	1749	72.5	4.2
19.	2.2	"	36	100	67	100	100	33	100	100	100	100	2004	1950	72.8	4.2
20.	2.8	"	20	100	100	100	100	8	100	100	100	100	2027	1911	71.5	5.9
21. Untreated	--	--	0	20	18	0	0	0	0	0	50	33	743	689	--	6.4
LSD 0.05 =			30	26	38	NS	31	31	20	12	NS	48	387	391	NS	NS
C.V.% =			33	21	40	20	24	34	17	13	26	55	16.4	17.4	2.3	48

(1) KOZ = kochia, TP = tumble pigweed, CW = carpetweed, FOX = yellow foxtail, GR = prairie cupgrass, VW = volunteer wheat
(2) (--) Denotes that there was not enough grain to determine test weight.

Since tumble pigweed had not emerged by April 4, excellent control of this species was achieved with all herbicide treatments except alachlor plus metribuzin. All April 29 treatments provided good tumble pigweed control except alachlor plus bromoxynil. All treatments gave good control of carpetweed except those combinations containing alachlor. Prairie cupgrass and volunteer wheat were controlled with all treatments except those containing alachlor in combination with DPX4189 or metribuzin. The lack of weed control by alachlor could be due to additional weed germination during the summer months and a decrease in residual effectiveness after six to ten weeks.

The experimental area received 14 cm of rainfall in late August. Visual ratings taken on September 6 (155 DAT) indicated that oryzalin plus DPX4189 was still providing good control on all weed species (Table XXII), but carpetweed control was diminishing and some volunteer wheat was appearing. Alachlor and oryzalin in combination with DPX4189 continued to provide excellent control of kochia and tumble pigweed. Oryzalin tank mixed with MCPA ester and bromoxynil also gave good control of kochia and tumble pigweed. Treatments containing alachlor failed to provide adequate control of carpetweed and volunteer wheat. Yellow foxtail and volunteer wheat were controlled with oryzalin applied alone and in tank mixes.

Wheat yields in 1981 were higher in treatments with good weed control during the previous summer than treatments with poor weed control or the weed check (Table XXII).

Carey Silt Loam (Woodward)

There was a heavy infestation of downy brome (1077/m^2, 2 leaf to 4 tillers) present when the first preharvest treatments were applied on April 4. Metribuzin did not significantly reduce the population because the rate of application was less than typically required for downy brome control and the date of application was later than optimum for control. Treatments applied April 4 had little if any effect on the tillering wheat and produced no significant differences in 1980 wheat yields (Table XXIII). High populations of downy brome resulted in dockage of 18 to 28 percent.

Weed control ratings 144 DAT on August 27, 1980, (Table XXIV), indicated that prostrate spurge control was not as good as tumble pigweed, carpetweed, or fall witchgrass. The experimental area received 4.5 cm of rainfall on April 24, therefore the prostrate spurge appeared to have been emerging before the April 4 treatments were activated. The erratic recorded rate response of prostrate spurge could be interpreted as being due to an erratic stand. However, since the stand was adequate for visual rating, the variable control may reflect only minor variation across the experiment in time of emergence of the species, which could have had a major influence on control obtained with oryzalin and alachlor, which are preemergence herbicides. Alachlor plus DPX4189 failed to give consistent control of carpetweed whereas oryzalin plus DPX4189 did. The experimental area received 2 cm of rainfall 9 days after the April 29 treatments were applied. All treatments containing oryzalin provided excellent control of tumble pigweed and fall witchgrass, indicating that these species did not emerge until after May 7. Visual ratings of treatments applied April 29 indicated that all species except prostrate spurge were completely controlled with oryzalin applied alone.

TABLE XXIII

EFFECT OF PREHARVEST HERBICIDE APPLICATIONS TO WHEAT
ON DOWNY BROME CONTROL AND WHEAT PRODUCTION
CAREY SILT LOAM (WOODWARD) 1980-81

	Treatment	Rate (kg/ha)	Date	Visual Rating(1) (0-100 scale) 4-29-80 WH	DB	Harvest Data 6-20-80 Yield (kg/ha)	Moisture (%)	Dockage (%)
1.	Oryzalin	1.1	4-4-80	10	20	572	20.6	28.5
2.		1.4	"	3	13	769	21.1	22.3
3.		2.2	"	3	10	765	21.5	21.8
4.		2.8	"	3	13	726	19.8	19.8
5.	Oryzalin + MCPA ester	1.1 + 0.56	"	5	18	693	20.3	28.3
6.	Oryzalin + DPX4189	1.1 + 0.02	"	13	15	672	20.6	24.5
7.		1.1 + 0.04	"	13	18	801	20.8	22.0
8.		1.1 + 0.07	"	8	3	1004	20.4	17.0
9.		1.1 + 0.14	"	10	14	719	18.9	23.0
10.	Alachlor + DPX4189	2.2 + 0.02	"	5	5	838	20.6	21.0
11.		2.2 + 0.04	"	13	25	695	21.2	26.3
12.		2.2 + 0.07	"	8	23	848	20.2	23.5
13.		2.2 + 0.14	"	5	14	896	20.4	18.8
14.	Alachlor + metribuzin	2.2 + 0.42	"	10	38	784	20.5	20.5
15.	Oryzalin + bromoxynil	1.4 + 0.28	4-29-80	--	--	819	19.4	23.3
16.	Alachlor + bromoxynil	2.2 + 0.28	"	--	--	657	18.4	25.8

TABLE XXIII (Continued)

	Treatment	Rate (kg/ha)	Date	Visual Rating(1) (0-100 scale) 4-29-80 WH	DB	Harvest Data 6-20-80 Yield (kg/ha)	Moisture (%)	Dockage (%)
17.	Oryzalin	1.1	4-29-80	--	--	689	18.8	20.3
18.		1.4	"	--	--	744	20.0	20.0
19.		2.2	"	--	--	875	20.8	25.5
20.		2.8	"	--	--	659	20.1	26.0
21.	Untreated	--	--	0	0	730	18.7	21.8
	LSD 0.05 =			NS	NS	NS	NS	NS
	C.V.% =			102	102	28	7.2	31.5

(1) Visual ratings were recorded on wheat injury (WH) and downy brome (DB) control 25 days after the 4-4-80 treatments.

TABLE XXIV

EFFECT OF PREHARVEST HERBICIDE APPLICATIONS TO WHEAT
ON SUMMER ANNUAL WEED CONTROL AND FALL SEEDED WHEAT
CAREY SILT LOAM (WOODWARD) 1980-81

				Weed Control(1) % 8-27-80				Harvest Data Yield 6-11-81			
	Treatment	Rate (kg/ha)	Stage	TP	PS	CW	FGW	Combine (kg/ha)	Recln. (kg/ha)	Test Wt(2) (kg/hl)	Dockage (%)
1.	Oryzalin	1.1	4-4-80	100	77	100	100	301	272	70.9	10.5
2.		1.4	"	93	75	100	100	278	247	70.3	11.6
3.		2.2	"	100	50	100	100	440	394	72.1	13.2
4.		2.8	"	100	75	100	100	587	526	70.9	10.8
5.	Oryzalin + MCPA ester	1.1 + 0.56	"	100	90	100	90	410	371	72.1	11.6
6.	Oryzalin + DPX4189	1.1 + 0.02	"	100	68	100	100	386	348	70.0	10.1
7.		1.1 + 0.04	"	100	50	100	100	371	332	71.2	12.3
8.		1.1 + 0.07	"	100	100	100	95	348	317	71.2	9.7
9.		1.1 + 0.14	"	100	75	100	95	394	355	70.3	10.9
10.	Alachlor + DPX4189	2.2 + 0.02	"	100	100	0	0	278	247	72.5	11.3
11.		2.2 + 0.04	"	100	63	90	50	325	278	71.5	13.7
12.		2.2 + 0.07	"	100	50	32	50	363	317	70.3	12.2
13.		2.2 + 0.14	"	100	100	90	90	340	294	71.5	16.0
14.	Alachlor + metribuzin	2.2 + 0.42	"	23	15	100	0	232	209	70.0	9.9
15.	Oryzalin + bromoxynil	1.4 + 0.28	4-29-80	100	82	100	100	479	433	71.2	9.0
16.	Alachlor + bromoxynil	2.2 + 0.28	"	90	42	90	50	301	270	71.8	10.0

TABLE XXIV (Continued)

	Treatment	Rate (kg/ha)	Stage	Weed Control(1) % 8-27-80 TP	PS	CW	FGW	Harvest Data Yield 6-11-81 Combine (kg/ha)	Recln. (kg/ha)	Test Wt(2) (kg/hl)	Dockage (%)
17.	Oryzalin	1.1	"	100	100	100	100	317	294	70.9	10.1
18.		1.4	"	100	88	100	100	440	394	71.5	9.9
19.		2.2	"	100	98	100	100	657	610	72.5	7.8
20.		2.8	"	100	73	100	100	626	580	71.5	8.1
21.	Untreated	--	--	0	0	0	0	93	85	--	14.5
	LSD 0.05 =			13	37	9	36	147	139	NS	4.0
	C.V.% =			10	39	7	29	27.1	28.8	1.8	25.3

(1) TP = tumble pigweed, PS = prostrate spurge, CW = carpetweed, FWG = fall witchgrass
(2) (--) Denotes that there was not enough grain harvested from the plot to determine test weights.

No tillage was performed prior to fall planting and a heavy population of downy brome appeared in November.

The application of metribuzin in January failed to give adequate control of the downy brome. This was attributed to insufficient rainfall to activate the herbicide. The resulting competition with the wheat for moisture in the winter and spring, reduced the 1981 wheat yield potential considerably (Table XXIV). Yields from all but one of the herbicide treatments were significantly higher than the untreated plot. The highest yields were obtained with the highest rate of oryzalin applied April 4 and the two highest rates applied April 29. Oryzalin has previously been found to control cheat when applied after harvest (11). The dockage data does not establish a clear relation but it appeared that the highest rates of oryzalin not only provided the best summer annual weed control but also reduced the downy brome population resulting in higher yields and lower dockage than most other treatments.

Reduced Tillage Using Herbicides Applied Postharvest

Carey Silt Loam (Woodward)

The experimental area received 3.4 cm of rainfall 3 days after treatment. There was not another rainfall for 56 days. On August 27, 1980, visual ratings were made on the existing vegetation. The most prominent weed species were tumble pigweed, carpetweed, and prostrate spurge.

The tumble pigweed and carpetweed were consistently controlled by most of the treatments except oxyfluorfen and oxyfluorfen plus alachlor (.42 + 2.2 kg/ha). Pendimethalin plus glyphosate was weak on carpetweed control and oryzalin plus glyphosate was variable. Prostrate spurge was the most prolific weed species with over 60 percent groundcover in the untreated plots. Only the higher rates of cyanazine in combination with 2,4-D, dalapon, or paraquat controlled prostrate spurge.

Other weed species present but not adequately distributed for visual ratings were kochia and redroot pigweed. Excellent control of smooth and redroot pigweed was obtained by use of the rearmounted ropewick applicator on all plots on August 27 (Table XXV). However, tumble pigweed and kochia control varied from 10 to 25 percent. Fifty to ninety percent suffered some chlorosis and necrosis, but they survived. The lack of control of these two species could be attributed to the large plant size, and the tendency for the rope to ride over the plants contacting only the outer branches. Application was made in the afternoon under hot and dry conditions. Much of the vegetation appeared under stress which hinders the effectiveness of glyphosate (49). Prostrate spurge and carpetweed were not controlled by the ropewick application due to their low growth habit.

At fall planting, difficulty in seed placement was encountered because the coulters could not be adjusted to cut deep enough to completely cut the straw. This occurred as a result of replacement of the original front gauge wheel with a larger wheel. This resulted in a relatively poor stand. A high downy brome (1077/m^2) population also competed with young wheat seedlings in the fall. Metribuzin was applied to the experimental area in January, but due to a lack of rainfall, the downy brome was not controlled and continued to interfere with crop

TABLE XXV

EFFECT OF POSTHARVEST HERBICIDE APPLICATIONS ON SUMMER ANNUAL WEED CONTROL AND WHEAT PRODUCTION CAREY SILT LOAM (WOODWARD) 1980-81

		Weed Control(1) (%) 8-27-80			Harvest Data Yield (6-11-81)			
Treatment	Rate (kg/ha)	TP	CW	PS	Com.Samp. (kg/ha)	Recln.Gr. (kg/ha)	Test Wt(2) (kg/hl)	Dockage (%)
1. Oxyfluorfen + X-77	0.42+ ½%	50	0	47	216	193	71.2	14.0
2.	0.56+ ½%	90	90	50	185	155	71.5	15.7
3. Oxyfluorfen + alachlor + X-77	0.42+ 2.2 + ½%	50	50	32	216	185	72.2	12.3
4.	0.56+ 1.1 + ½%	100	100	85	178	139	73.4	22.7
5.	0.56+ 2.2 + ½%	100	100	67	263	224	71.2	14.0
6. Terbutryn	1.8	100	100	27	170	147	71.2	16.1
7.	2.2	100	100	50	100	70	--	23.1
8. Terbutryn + Sun oil 11E	1.8 + 4.71/ha	100	100	85	139	108	--	22.5
9. Terbutryn + metolachlor	0.67+ 0.67	100	100	12	216	193	63.3	14.0
10.	1.3 + 1.3	100	100	45	147	131	73.1	11.9
11. Cyanazine + 2,4-D(LV)	1.8 + 1.1	100	100	85	185	155	70.5	16.0
12.	2.7 + 1.1	100	100	100	178	155	71.2	15.9
13.	3.6 + 1.1	100	100	100	170	131	70.9	23.7
14. Cyanazine + glyphosate + X-77	2.7 + 0.56 + ½%	100	100	82	185	155	73.4	15.3
15. Cyanazine + paraquat + X-77	2.7 + 0.28 + ¼%	100	100	100	240	209	72.1	15.7
16.	2.7 + 0.56 + ½%	100	100	100	325	294	71.8	10.3

TABLE XXV (Continued)

	Treatment	Rate (kg/ha)	Weed Control(1) (%) 8-27-80 TP	CW	PS	Harvest Data Yield (6-11-81) Com.Samp. (kg/ha)	Recln.Gr. (kg/ha)	Test Wt(2) (kg/hl)	Dockage (%)
17.	Oryzalin + glyphosate	1.1 + 0.56 + ½%	100	100	68	301	270	71.2	11.4
18.		1.4 + 0.56 + ½%	100	75	10	425	379	73.1	10.2
19.		2.2 + 0.56 ¼ ½%	100	100	48	695	649	72.2	6.7
20.		2.8 + 0.56 + ½%	90	90	50	518	479	70.2	10.1
21.	Propachlor + linuron	3.4 + 1.1	100	100	28	162	139	72.2	15.6
22.	Oryzalin + 2,4-D + dalapon + X-77	1.1 + 1.1 + 4.5	100	100	60	525	487	72.5	8.6
23.	Cyanazine + 2,4-D + dalapon + X-77	2.2 + 1.1 + 4.5	100	100	100	332	301	73.4	11.3
24.	Dicamba + glyphosate + X-77	0.56+ 0.28 + ½%	95	100	53	162	147	72.2	11.3
25.	Pendimethalin + glyphosate + X-77	0.84+ 0.56 + ½%	95	80	50	201	178	71.5	11.8
26.	Untreated	--	0	0	0	85	70	--	19.2
	LSD 0.05 =		23	26	42	179	172	NS	1.3(3)
	C.V.% =		18	20	48	51	55	2.5	46

(1) TP = tumble pigweed, CW = carpetweed, PS = prostrate spurge
(2) (--) Denotes that there was not enough grain harvested from the plots to determine a test weight.
(3) Analysis of the dockage data was calculated at the 0.10 level of significance.

development.

Analysis of the 1981 harvest data indicated that several treatments produced more wheat than the untreated plots (Table XXV). Treatments containing cyanazine or oryzalin tank mixed with 2,4-D plus dalapon and cyanazine plus paraquat had higher yields than the untreated check. The two highest rates of oryzalin plus glyphosate produced higher yields than any combination containing cyanazine. Tank mixes containing oryzalin resulted in significantly lower dockage than the untreated check. The lower dockage could be due to a reduction of downy brome populations, as was noted in the preharvest experiment at this location.

Port Loam (Lake Carl Blackwell)

The absence of rainfall for 47 days after treatment coupled with temperatures above 38° C during much of July and August combined to suppress weed growth. Weed pressure was too light to permit evaluation of weed control until October, at which time volunteer wheat and carpetweed were the major weed species present (Table XXVI). Control of these species was evaluated October 8, 1980.

Treatments containing glyphosate and paraquat controlled the existing amaranthus species and grasses. Tank mixed treatments containing 2,4-D provided control of the amaranthus species. By October 8 the population of Amaranthus species had been reduced due to a lack of rainfall, and therefore was not evaluated. The only treatments providing adequate control of volunteer wheat were oryzalin plus glyphosate and oryzalin tank mixed with 2,4-D (LV) plus dalapon. As the rate of oryzalin was increased to 2.8 kg/ha the volunteer wheat control increased to only 2 percent groundcover.

TABLE XXVI

EFFECT OF POSTHARVEST HERBICIDE APPLICATIONS ON POPULATIONS OF VOLUNTEER WHEAT AND CARPETWEED AND WHEAT PRODUCTION PORT LOAM (LAKE BLACKWELL) 1980-81

Treatment	Rate (kg/ha)(2)	Visual Ratings(1) (% groundcover) 10-8-80 VW	CW	Harvest Data 6-2-81 Yield (kg/ha)	Test Wt. (kg/hl)	Moisture (%)
1. Oxyfluorfen + X-77	0.42+ ½%	78	0	1136	60	18.7
2.	0.56+ ½%	64	0	1431	57	20.1
3. Oxyfluorfen + alachlor + X-77	0.42+ 2.2 + ½%	76	0	1281	61	18.5
4.	0.56+ 1.1 + ½%	61	2	1504	59	20.2
5.	0.56+ 2.2 + ½%	53	1	1451	59	20.1
6. Terbutryn	1.8	71	0	1024	56	18.8
7.	2.2	56	0	1758	59	19.5
8. Terbutryn + Sun oil 11E	1.8 + 4.71/ha	53	0	1756	59	20.8
9. Terbutryn + metolachlor	0.67+ 0.67	53	0	1233	58	18.6
10.	1.34+ 1.34	56	0	1391	58	20.0
11. Cyanazine + 2,4-D(LV)	1.8 + 1.1	33	0	1740	60	19.9
12.	2.7 + 1.1	40	0	1969	62	20.9
13.	3.6 + 1.1	34	0	2106	60	22.0
14. Cyanazine + glyphosate + X-77	2.7 + 0.56 + ½%	33	0	1702	60	19.0
15. Cyanazine + paraquat + X-77	2.7 + 0.28 + ¼%	37	0	1800	60	21.9
16.	2.7 + 0.56 + ¼%	34	0	1756	59	20.5

TABLE XXVI (Continued)

Treatment	Rate (kg/ha)(2)	Visual Ratings(1) (% groundcover) 10-8-80 VW	CW	Harvest Data 6-2-91 Yield (kg/ha)	Test Wt. (kg/hl)	Moisture (%)
17. Oryzalin + glyphosate + X-77	1.1 + 0.56 + ½%	11	8	1909	59	22.2
18.	1.4 + 0.56 + ½%	11	7	1800	58	21.6
19. Oryzalin + glyphosate + X-77	2.2 + 0.56 + ½%	4	1	1641	54	22.8
20.	2.8 + 0.56 + ½%	2	6	1600	57	22.5
21. Propachlor + linuron	3.4 + 1.1	43	0	1555	57	19.5
22. Oryzalin + 2,4-D(LV) + dalapon + X-77	1.1 + 1.1 + 4.5 + ½%	10	15	1497	59	19.0
23. Cyanazine + 2,4-D(LV) + dalapon + X-77	2.2 + 1.1 + 4.5 + ½%	24	0	1503	54	17.9
24. Pendimethalin + glyphosate + X-77	0.84+ 0.56 + ½%	51	0	1391	60	18.4
25.	1.1 + 0.56 + ½%	53	0	1377	58	18.8
26. Untreated	----	54	45	1488	61	19.7
LSD 0.05 =		21.2	NS(3)	454	NS	2.3
C.V.% =		38	65	20	5.2	8

(1) VW = volunteer wheat, CW = carpetweed
(2) Terbutryn + metolachlor was a premixed formulation.
(3) Visual ratings on carpetweed are for two replications.

Treatments containing oryzalin or oxyfluorfen plus alachlor with surfactant were the only ones that did not completely control carpetweed. However, the carpetweed populations in these treatments were lower than the untreated which contained 45 percent groundcover of carpetweed. Oryzalin did not give consistent carpetweed control in any of the previous experiments.

All existing vegetation was controlled prior to fall planting with a 1.8 m V-sweep. Visual ratings for wheat vigor 45 and 127 DAP indicated no apparent injury from any treatments.

The only treatments producing yields significantly higher than the untreated were cyanazine at the two highest rates tank mixed with 2,4-D (Table XXVI). Terbutryn was applied alone and in combination with Sun oil and metalachlor. Plots treated with terbutryn at 1.8 kg/ha produced higher yields than plots treated with terbutryn plus metalachlor (1.3 kg/ha).

Grain moisture ranged from 18 to 23 percent at harvest time. These high readings were due to the early June harvest date and high relative humidity. Three of the four treatments containing oryzalin and glyphosate were the only treatments which increased grain moisture at harvest compared to the untreated check. The higher grain moisture indicated slower maturity, which could have resulted from either crop injury or the availability of more soil moisture during the growing season. The crop was under moisture stress much of the season and growth of volunteer was a major source of soil moisture loss prior to seeding.

Comparison of Boom Placement on a Sweep Plow for Herbicide Placement

Port Loam (Lake Carl Blackwell)

There was no appreciable rainfall on the experimental area for 47 days after the herbicides were applied. A heavy straw cover coupled with the lack of moisture resulted in a reduction of vegetation. Visual ratings based on percent groundcover made 97 DAT revealed that volunteer wheat was the dominant weed species present (Table XXVII).

There were no differences in weed control among herbicides applied with the front mounted boom. Both rates of oryzalin applied with the front mounted boom gave better volunteer wheat control than the high rates of cyanazine and oryzalin and the low rate of atrazine when applied with the middle mount. Oryzalin (1.4 kg/ha) provided better volunteer wheat control than all treatments except atrazine (1.7 kg/ha) when applied with the boom mounted in the middle. There were no differences among treatments applied with a rear mounted boom. All herbicide treatments increased volunteer wheat control compared to the untreated check.

None of the treatments caused any injury to the fall sown wheat. There were no differences in wheat yield due to boom position or herbicide treatments.

TABLE XXVII

EFFECTS OF HERBICIDE TREATMENTS APPLIED WITH VARIOUS BOOM POSITIONS ON A SWEEP PLOW ON VOLUNTEER WHEAT POPULATIONS AND WHEAT PRODUCITON PORT LOAM (LAKE CARL BLACKWELL) 1980-81

			Visual Ratings (% groundcover)	Harvest Data 6-3-81	
			10-8-80		
Treatment	Boom Mount	Rate (kg/ha)	VW(1)	Yield (kg/ha)	Test Wt. (kg/hl)
1. Cyanazine 80WP	Front	2.7	19	1332	55
2.	"	3.6	10	1575	56
3. Atrazine 90WP	"	1.7	14	1183	56
4.	"	2.2	10	1453	57
5. Oryzalin 75WP	"	1.1	5	1390	56
6.	"	1.4	6	1427	57
7. Cyanazine	Middle	2.7	27	1347	54
8.	"	3.6	19	1535	58
9. Atrazine	"	1.7	15	1152	60
10.	"	2.2	23	1455	60
11. Oryzalin	"	1.1	35	1324	56
12.	"	1.4	4	1200	53
13. Cyanazine	Rear	2.7	23	1435	55
14.	"	3.6	10	1471	54
15. Atrazine	"	1.7	24	1361	58
16.	"	2.2	12	1367	56

TABLE XXVII (Continued)

Treatment	Boom Mount	Rate (kg/ha)	Visual Ratings (% groundcover) 10-8-80 VW(1)	Harvest Data 6-3-81 Yield (kg/ha)	Test Wt. (kg/hl)
17. Oryzalin	Rear	1.1	18	1332	55
18.	"	1.4	15	1512	53
19. Untreated	--	--	53	1269	51
LSD 0.05 =			15	NS	NS
C.V.% =			60	19	7

(1) VW = volunteer wheat

CHAPTER V

SUMMARY AND CONCLUSIONS

Nine field experiments were conducted to evaluate herbicides applied before and after wheat harvest for summer weed control in continuous winter wheat. Of the treatments applied to tillering and jointing wheat, those containing oryzalin provided the best control of summer annual weeds, including kochia, tumble pigweed, and prostrate spurge. However, if broadleaf weeds had emerged before the herbicides were applied adequate weed control was obtained only if a postemergence broadleaf herbicide such as DPX4189 or bromoxynil was tank mixed with oryzalin. Alachlor failed to provide control comparable to oryzalin when tank mixed with DPX4189 or bromoxynil. Excellent carpetweed control was achieved at two locations with oryzalin applied alone and in combination with DPX4189. Oryzalin adequately controlled prairie cupgrass and fall witchgrass. Volunteer wheat control was better when oryzalin was applied in late April than early April. The late April treatments controlled the volunteer wheat through September. The weed control provided by alachlor did not last as long as that of oryzalin. None of the preharvest herbicide treatments had any effect on yield of the treated crop.

Of the 37 herbicide treatments applied after harvest, oryzalin provided the best overall weed control. Volunteer wheat was the major weed species in the postharvest experiments. It usually emerged in

August.

In the two herbicide-tillage combination experiments, volunteer wheat populations were higher in September in the no-till plots than in the plots tilled with a disc after harvest at both locations both years. Visual ratings in September indicated that volunteer wheat populations were higher in the no-till plots than the disc plots four out of four times. Oryzalin and cyanazine provided the best volunteer wheat control. A sweep tillage was used to control volunteer wheat populations prior to fall planting, which controlled all existing weeds except at Lahoma in 1980 when the experimental area received a rain the next day and the volunteer wheat rerooted, necessitating a repeat of the sweep tillage. The postharvest applied herbicide treatment did not injure the fall sown wheat.

As weed control and crop residue increased, soil moisture in the fall increased. Plots with poor weed control generally had lower soil moisture than plots with fewer weeds present.

In comparing granular versus liquid herbicide applications, the granular formulations were equal or inferior to sprayed formulations except in one instance where rainfall was not received for 42 days after treatment. In that instance, alachlor granules provided better weed control than alachlor EC.

Treatments providing good weed control had higher wheat yields compared to the weedy check. Failure to control summer weeds resulted in low wheat yields the following year.

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APPENDIXES

TABLE XXVIII

RAINFALL DATA, NORTH CENTRAL RESEARCH STATION, LAHOMA OKLAHOMA (JULY 1, 1979 - MAY 31, 1981)

Date	Centimeters	Date	Centimeters
July 6, 1979	3.3	Feb. 24	.6
July 13	.3	March 12	.6
July 17	4.6	March 24	3.0
July 24	1.1	March 27	.3
July 25	.8	March 28	.5
July 31	7.8	March 30	1.2
August 11	.4	April 3	1.3
August 15	.8	April 8	.3
August 23	.1	April 18	0.07
August 25	1.9	April 24	1.2
August 31	1.1	April 25	2.7
Sept. 1	6.4	April 26	6.8
Sept. 2	.5	May 1	.8
Sept. 7	.3	May 6	.4
Oct. 17	2.7	May 8	.7
Oct. 22	1.0	May 15	1.5
Oct. 30	.3	May 16	6.1
Oct. 31	3.3	May 18	1.4
Nov. 7	.2	May 21	1.7
Nov. 8	.6	May 27	2.8
Nov. 9	1.2	May 29	1.6
Nov. 20	1.9	May 30	0.03
Nov. 21	1.0	June 17	3.9
Dec. 28	1.3	June 18	2.4
Dec. 29	1.0	June 19	1.4
Jan. 3, 1980	.1	June 20	1.0
Jan. 20	2.0	June 22	.6
Jan. 21	1.1	July 25	.2
Feb. 8	1.3	August 18	9.4

TABLE XXVIII (Continued)

Date	Centimeters	Date	Centimeters
August 19, 1980	.6	March 2	.2
August 22	.7	March 3	.2
August 30	.2	March 4	1.4
Sept. 2	3.2	March 8	.8
Sept. 10	.3	March 15	2.2
Sept. 27	1.0	March 22	.2
Sept. 28	1.5	March 30	.9
Oct. 15	6.4	April 14	1.7
Oct. 16	1.4	April 16	.4
Oct. 27	.2	April 19	1.1
Nov. 14	.8	May 5	.6
Nov. 17	.2	May 8	.7
Dec. 8	3.6	May 9	.9
Jan. 19, 1981	.3	May 10	6.4
Jan. 20	0.08	May 17	.3
Jan. 31	.2	May 29	.4
Feb. 10	.7	May 30	2.9
Feb. 22	.4		

TABLE XXIX

RAINFALL DATA, AGRONOMY RESEARCH STATION, PERKINS OKLAHOMA (JULY 1, 1979 - MAY 30, 1981)

Date	Centimeters	Date	Centimeters
July 5, 1979	6.5	Mar. 29	.5
July 6	4.6	Mar. 30	0.05
July 17	.7	April 3	1.1
July 31	1.0	April 17	.4
August 10	1.5	April 24	3.1
August 21	.2	April 25	.5
August 23	2.3	April 26	5.2
August 31	.2	May 1	1.6
September 2	2.9	May 2	.7
Sept. 6	1.7	May 3	.3
Sept. 20	.3	May 8	0.05
October 16	.1	May 12	1.7
Oct. 22	1.0	May 15	.2
Oct. 31	1.9	May 16	4.0
Nov. 6	.2	May 18	2.3
Nov. 9	.5	May 21	.5
Nov. 18	1.7	May 22	.6
Nov. 19	2.8	May 27	6.2
Dec. 29	4.0	May 29	.8
Dec. 30	1.4	May 30	.3
Jan. 16, 1980	.2	June 17	6.5
Jan. 20	4.7	June 18	3.4
Jan. 21	.5	June 19	8.3
Feb. 8	2.0	June 20	3.5
Feb. 15	.2	June 22	.5
March 12	1.7	June 23	.2
March 21	.4	June 24	.1
March 23	1.2	July 27	.1
March 24	2.0	August 18	.3
March 28	.2	August 21	2.4

TABLE XXIX (Continued)

Date	Centimeters	Date	Centimeters
August 22, 1980	1.3	April 13	1.7
Sept. 2	1.9	April 18	.2
Sept. 3	.1	April 20	.7
Sept. 25	1.9	May 1	.1
Sept. 26	0.08	May 5	3.9
Sept. 27	1.9	May 9	1.7
Sept. 28	1.4	May 10	5.6
Oct. 15	.4	May 16	.3
Oct. 16	.2	May 17	0.08
Oct. 17	1.3	May 23	2.1
Oct. 24	.4	May 25	.3
Oct. 28	.4	May 29	3.2
Nov. 15	.1	May 30	.4
Nov. 17	.2	May 31	.1
Nov. 18	.9		
Nov. 23	.6		
Nov. 24	.1		
Dec. 8	3.3		
Dec. 9	0.07		
Dec. 16	.2		
Jan. 21, 1981	.1		
Feb. 1	.7		
Feb. 6	.2		
Feb. 10	1.2		
Feb. 11	.1		
Feb. 21	.1		
Feb. 28	.3		
March 3	0.07		
March 4	1.2		
March 15	1.5		
March 29	.4		
April 11	0.08		

TABLE XXX

RAINFALL DATA, AGRONOMY RESEARCH STATION, STILLWATER OKLAHOMA (JULY 1, 1979 - MAY 30, 1981)

Date	Centimeters	Date	Centimeters
July 5, 1979	1.3	Jan. 30	.3
July 6	5.6	Feb. 8	1.5
July 17	2.7	Mar. 12	1.4
July 18	0.05	Mar. 21	.4
July 25	.3	Mar. 23	1.0
July 31	.5	Mar. 24	3.4
Aug. 1	0.05	Mar. 27	.3
Aug. 11	1.9	Mar. 28	.4
Aug. 20	0.03	Mar. 29	.3
Aug. 21	2.3	Mar. 30	0.05
Aug. 22	3.3	April 3	1.2
Aug. 23	.2	April 8	0.07
Aug. 25	.3	April 18	.4
Aug. 26	1.0	April 24	3.8
Sept. 1	1.0	April 25	2.2
Sept. 2	1.7	April 26	5.9
Sept. 7	.5	May 1	1.1
Oct. 15	.2	May 2	.2
Oct. 22	1.5	May 4	1.1
Oct. 31	1.8	May 5	0.05
Nov. 8	.5	May 12	1.6
Nov. 9	1.2	May 16	4.4
Nov. 20	1.4	May 18	2.5
Nov. 21	3.7	May 21	.5
Dec. 28	3.5	May 27	4.9
Dec. 29	1.3	May 29	.9
Jan. 3, 1980	.3	June 17	4.0
Jan. 19	0.07	June 18	3.5
Jan. 20	1.7	June 19	7.6
Jan. 21	2.2	June 20	5.2

TABLE XXX (Continued)

Date	Centimeters	Date	Centimeters
June 22	.5	April 14	1.6
June 23	0.05	April 18	.1
July 26	.1	April 19	.4
August 12	.4	May 1	.2
Aug. 18	5.6	May 5	3.9
Aug. 21	2.2	May 9	1.3
Aug. 31	.1	May 10	4.1
September 25	1.4	May 16	.1
Sept. 27	.5	May 17	.3
Sept. 28	1.7	May 23	2.2
October 15	1.4	May 29	3.8
Oct. 16	.1	May 30	.4
Oct. 17	2.0		
Oct. 24	.4		
Oct. 27	.3		
November 14	.2		
Nov. 15	.2		
Nov. 17	.6		
December 8	3.9		
Dec. 16	.1		
January 20, 1981	.1		
Jan. 21	.1		
February 1	.7		
Feb. 7	.07		
Feb. 10	.5		
Feb. 11	.9		
Feb. 22	.5		
Feb. 28	0.08		
March 8	.9		
Mar. 15	2.7		
Mar. 29	2.0		
April 11	.2		

TABLE XXXI

RAINFALL DATA, SOUTHERN PLAINS RANGE RESEARCH STATION WOODWARD, OKLAHOMA (APRIL 1, 1980 - JUNE 30, 1981)

Date	Centimeters	Date	Centimeters
April 2, 1980	.1	Nov. 14	.5
April 3	1.5	Nov. 25	.3
April 24	4.5	Dec. 8	6.7
April 25	1.3	Dec. 9	.2
April 26	3.8	Jan. 17, 1981	0.03
April 30	0.08	Feb. 10	.2
May 1	.3	March 3	.5
May 5	.1	March 7	.6
May 7	2.0	March 8	1.6
May 8	.4	March 14	.2
May 15	1.1	March 15	2.2
May 16	3.5	March 25	0.05
May 18	1.2	March 29	.5
May 20	.7	April 3	0.08
May 21	.8	April 14	0.08
May 28	5.9	April 16	.5
May 29	.4	April 18	.3
June 5	.1	April 19	1.1
June 9	.3	April 30	.5
June 18	.2	May 1	.5
June 20	.7	May 8	.5
June 23	3.4	May 10	2.9
July 21	.6	May 17	.5
August 15	1.5	May 29	.2
August 16	.5	May 30	3.8
Sept. 8	0.05	June 2	1.1
Sept. 29	1.0	June 4	.2
Oct. 16	1.9	June 30	3.3
Oct. 27	2.0		

VITA

Douglas W. Rushing

Candidate for the Degree of

Master of Science

Thesis: REDUCED TILLAGE USING HERBICIDES IN A CONTINUOUS WINTER WHEAT CROPPING SYSTEM

Major Field: Agronomy

Biographical:

Personal Data: Born in Monroe, North Carolina, February 1, 1956, the son of Robert and Thelma Rushing.

Education: Graduated from Forest Hills High School, Marshville, N.C. in May 1974; received an Associate of Science degree from Wingate Junior College, Wingate, N.C. in May 1976; received the Bachelor of Science degree from North Carolina State University at Raleigh in May 1978; completed the requirements for the Master of Science degree in Agronomy at Oklahoma State University, Stillwater, Oklahoma, in December, 1981.

Professional Experience: Assistant Agricultural Extension Agent, N.C. Agricultural Extension Service, Salisbury, N.C., May 1978 - May 1979. Graduate Research Assistant, Oklahoma State University, May 1979 - August 1981.

Professional Organization: Southern Weed Science Society, Soil Science Society of America, American Society of Agronomy.