CROP PRODUCTION AS AFFECTED BY CROPPING SEQUENCE
AND METHOD OF SEEDBED PREPARATION IN CONSERVATION TILLAGE

by

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TABLE OF CONTENTS

	Page
Acknowledgements	ii
List of Figures	iv
List of Tables	v
Introduction	1
Literature Review	2
Materials and Methods	16
Results and Discussion	22
Summary	92
References	94
Appendix	97

LIST OF FIGURES

Page

Figure 1. Plot design and distribution of soil types . . . 17

Figure 2. Effect of seedbed preparation on wheat yields in a continuous wheat cropping system in eight years. 23

Figure 3. Effect of seedbed preparation on wheat yields in a wheat-soybean crop rotation in eight years. 27

Figure 4. Effect of seedbed perparation on soybean yields in a soybean-wheat crop rotation in eight years. 40

Figure 5. Effect of seedbed preparation on soybean yields in a continuous soybean cropping system in eight years. 41

Figure 6. Effect of seedbed preparation on soybean yields in a soybean-grain sorghum crop rotation in eight years. 44

Figure 7. Effect of seedbed preparation on grain sorghum yields in a continuous grain sorghum cropping system in eight years. 58

Figure 8. Effect of seedbed preparation on grain sorghum yields in a grain sorghum-soybean crop rotation in eight years 60

LIST OF TABLES

Page

Table 1. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1975. 32

Table 2. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1976. 32

Table 3. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1977. 33

Table 4. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1978. 33

Table 5. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1979. 34

Table 6. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1980. 34

Table 7. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1981. 35

Table 8. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1982. 35

Table 9. Effect of cropping sequence and seedbed preparation on wheat test weight and grain moisture in 1981 36

Table 10. Effect of cropping sequence and seedbed preparation on wheat test weight and grain moisture in 1982 36

Table 11. Effect of cropping sequence and seedbed preparation on phosphorus and potassium content of the harvested wheat in 1981. 37

Table 12. Effect of treatments on nitrogen content of the harvested wheat in 1981. 37

Table 13. Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested wheat in 1982. 38

Table 14. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1975. 50

Table 15. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1976. 50

Page

Table 16.	Combined effect of cropping sequence and seedbed preparation on soybean yields in 1977.	51
Table 17.	Combined effect of cropping sequence and seedbed preparation on soybean yields in 1978.	51
Table 18.	Combined effect of cropping sequence and seedbed preparation on soybean yields in 1979.	52
Table 19.	Combined effect of cropping sequence and seedbed preparation on soybean yields in 1980.	52
Table 20.	Combined effect of cropping sequence and seedbed preparation on soybean yields in 1981.	53
Table 21.	Combined effect of cropping sequence and seedbed preparation on soybean yields in 1982.	53
Table 22.	Effect of cropping sequence and seedbed preparation on soybean plant height and seed weight in 1981	54
Table 23.	Effect of treatments on soybean grain moisture content in 1981.	54
Table 24.	Effect of cropping sequence and seedbed preparation on soybean grain moisture, plant height, and seed weight in 1982.	55
Table 25.	Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested soybeans in 1981	56
Table 26.	Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested soybeans in 1982	56
Table 27.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1975. . .	66
Table 28.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1976. . .	66
Table 29.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1977. . .	67
Table 30.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1978. . .	67

		Page
Table 31.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1979. . .	68
Table 32.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1980. . .	68
Table 33.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1981. . .	69
Table 34.	Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1982. . .	69
Table 35.	Effect of cropping sequence and seedbed preparation on grain sorghum test weight, grain moisture and plant height in 1981	70
Table 36.	Effect of cropping sequence and seedbed preparation on grain sorghum test weight and grain moisture in 1982	70
Table 37.	Effect of treatments on grain sorghum plant height in 1982	71
Table 38.	Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested grain sorghum in 1981. . .	71
Table 39.	Effect of cropping sequence and seedbed preparation on phosphorus and potassium content of the harvested grain sorghum in 1982.	72
Table 40.	Effect of treatments on nitrogen content of the harvested grain sorghum in 1982.	72
Table 41.	Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-5 cm soil layer of the wheat plots in 1981 . .	80
Table 42.	Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-2 cm soil layer of the wheat plots in 1982 . .	80
Table 43.	Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-5 cm soil layer of the soybean plots in 1981 .	81
Table 44.	Effect of treatments on available phosphorus concentration in the 0-2 cm soil layer of the soybean plots in 1982.	81

Page

Table 45. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-5 cm soil layer of the grain sorghum plots in 1981. . . . 82

Table 46. Effect of treatments on available phosphorus concentration in the 0-2 cm soil layer in the grain sorghum plots in 1982. 82

Table 47. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-5 cm soil layer of the wheat plots in 1981 83

Table 48. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-2 cm soil layer of the wheat plots in 1982 83

Table 49. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-5 cm soil layer of the soybean plots in 1981 84

Table 50. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-2 cm soil layer of the soybean plots in 1982 84

Table 51. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-5 cm soil layer of the grain sorghum plots in 1981 . . 85

Table 52. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-2 cm soil layer of the grain sorghum plots in 1982 . . 85

Table 53. Effect of cropping sequence and seed preparation on organic matter in the 0-5 cm soil layer of the wheat plots in 1981. 86

Table 54. Effect of treatments on organic matter in the 0-2 cm soil layer of the wheat plots in 1982 86

Table 55. Effect of treatments on organic matter in the 0-5 cm soil layer of the soybean plots in 1981 87

Table 56. Effect of cropping sequence and seedbed preparation on organic matter in the 0-2 cm soil layer of the soybean plots in 1982. 87

Page

Table 57. Effect of cropping sequence and seedbed preparation on organic matter in the 0-5 cm soil layer of the grain sorghum plots in 1981. 88

Table 58. Effect of cropping sequence and seedbed preparation on organic matter in the 0-2 cm soil layer of the grain sorghum plots in 1982. 88

Table 59. Effect of cropping sequence and seedbed preparation on soil pH in the 0-5 cm soil layer of the wheat plots in 1981. 89

Table 60. Effect of treatments on soil pH in the 0-2 cm soil layer of the wheat plots in 1982 89

Table 61. Effect of cropping sequence and seedbed preparation on soil pH in the 0-5 cm soil layer of the soybean plots in 1981. 90

Table 62. Effect of cropping sequence and seedbed preparation on soil pH in the 0-2 cm soil layer of the soybean plots in 1982. 90

Table 63. Effect of cropping sequence and seedbed preparation on soil pH in the 0-5 cm soil layer of the grain sorghum plots in 1981. 91

Table 64. Effect of cropping sequence and seedbed preparation on soil pH in the 0-2 cm soil layer of the grain sorghum plots in 1982. 91

<u>Appendix</u>

Table 65. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1981.

Table 66. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 67. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 68. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1982.

Table 69. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 70. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 71. Effect of cropping sequence and seedbed preparation on organic matter in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1981.

Table 72. Effect of treatments on organic matter in the 25-30 cm soil layer of the wheat plots at Manhattan, Kansas in 1981.

Table 73. Effect of cropping sequence and seedbed preparation on organic matter in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 74. Effect of cropping sequence and seedbed preparation on organic matter in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 75. Effect of cropping sequence and seedbed preparation on soil pH in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1981.

Table 76. Effect of cropping sequence and seedbed preparation on soil pH in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 77. Effect of cropping sequence and seedbed preparation on soil pH in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 78. Analysis of Variance of the effect of year, cropping sequence, and seedbed preparation on wheat yields at Manhattan, Kansas.

Table 79. Analysis of Variance of the effect of year, cropping sequence, and seedbed preparation on soybean yields in Manhattan, Kansas.

Table 80. Analysis of Variance of the effect of year, cropping sequence, and seedbed preparation on grain sorghum yields at Manhattan, Kansas.

Table 81. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture and test weight of the winter wheat at Manhattan, Kansas in 1981.

Table 82. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture and test weight of the winter wheat at Manhattan, Kansas in 1982.

Table 83. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height, and seed weight of the soybeans at Manhattan, Kansas in 1981.

Table 84. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height, and seed weight of the soybeans at Manhattan, Kansas in 1982.

Table 85. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height and test weight of the grain sorghum at Manhattan, Kansas in 1981.

Table 86. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height and test weight of the grain sorghum at Manhattan, Kansas in 1982.

Table 87. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K) content of the grain harvested from the wheat plots at Manhattan, Kansas in 1981.

Table 88. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K) content of the grain harvested from the wheat plots at Manhattan, Kansas in 1982.

Table 89. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K), content of the grain harvested from the soybean plots at Manhattan, Kansas in 1981.

Table 90. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K), content of the grain harvested from the soybean plots at Manhattan, Kansas in 1982.

Table 91. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P), and potassium (K) content of the grain harvested from the grain sorghum plots at Manhattan, Kansas in 1981.

Table 92. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P), and potassium (K) content of the grain harvested from the grain sorghum plots at Manhattan, Kansas in 1982.

Table 93. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the available phosphorus concentration in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Table 94. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the available phosphorus concentration in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 95. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the available phosphorus concentration in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 96. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the exchangeable potassium concentration in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Table 97. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the exchangeable potassium content in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 98. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the exchangeable potassium concentration in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 99. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Table 100. Analysis of Variance of the effects of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 101. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 102. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the organic matter content in the different layers of the wheat plots at Manhattan, Kansas in 1981.

Table 103. Analysis of Variance of the effect of cropping sequence and seedbed preparation on soil pH in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Table 104. Analysis of Variance of the effect of cropping sequence and seedbed preparation on soil pH in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Table 105. Analysis of Variance of the effect of cropping sequence and seedbed preparation on available phosphorus, exchangeable potassium, organic matter and soil pH of the 0-2 cm layer of the soil in the wheat plots at Manhattan, Kansas in 1982.

Table 106. Analysis of Variance of the effect of cropping sequence and seedbed preparation on available phosphorus, exchangeable potassium, organic matter and soil pH of the 0-2 cm layer of the soil in the soybean plots at Manhattan, Kansas in 1982.

Table 107. Analysis of Variance of the effect of cropping sequence and seedbed preparation on available phosphorus exchangeable potassium, organic matter and soil pH of the 0-2 cm layer of the soil in the grain sorghum plots at Manhattan, Kansas in 1982.

INTRODUCTION

In recent years an increased interest in conservation tillage has developed. Several advantages of the conservation tillage system compared to the conventional tillage system have enhanced its popularity. With proper management of the surface residues, one can expect an increase in water infiltration and conservation, a decrease in water evaporation, lower equipment and labor requirements, and perhaps most importantly for the future of agriculture, a decrease in soil erosion. However, some disadvantages of the conservation tillage system need to be considered also. Proper equipment is not always available to plant in the heavy residues; low soil temperatures may complicate plant growth; and herbicides for weed control may be needed.

The performance and effects of no-tillage corn production have been researched rather thoroughly in the eastern half of the United States where wetter conditions prevail. However, due to lower rainfall, corn production is usually not feasible in the dryland crop-producing areas of Kansas. Therefore, this study was initiated to investigate the effects and feasibility of several alternative conservation tillage systems in eastern Kansas.

The objectives of this experiment were to determine the effects of cropping sequence and seedbed preparation on the yields of wheat (*Triticum aestivum* L.), soybeans (*Glycine max* (L.) Merrill), and grain sorghum (*Sorghum bicolor* (L.) Moench), to monitor the change in weed population and to determine the fertility patterns that develop under the various cropping systems.

LITERATURE REVIEW

VanDoren, Triplett, and Henry (30) stated that soil tillage as developed over centuries has enabled farmers to kill weeds, loosen and mix the soil, and more recently to prepare the soil to accept mechanical planting devices. In 1972 Larson (12) noted that the trend 25 years ago was to increase the amount of tillage of the soil, both in number and intensity of operations. Researchers were wondering if all the trips over the field were necessary, whether better tillage methods could be developed to prevent soil erosion, and whether undue soil erosion was occurring.

Willis and Amemiya (33) gave the following reasons for tilling agricultural lands: (a) to establish a soil surface that prevents water and wind erosion, thus conserving both soil and water; (b) to manipulate plant residues; (c) to manage water; (d) to prepare a seedbed; or (e) to control weeds. If weeds are controlled and adequate plant populations can be established, the remaining objectives are fulfilled when conservation tillage methods are utilized. Therefore as Witmuss, Triplett, and Greb (35) noted, the development of modern herbicides reduced the need for frequent and complete stirring of the soil for weed control and made development of some newer conservation tillage methods possible.

Witmuss, Triplett, and Greb (35) defined conservation tillage as tillage systems that create as good an environment as possible for the growing crop, and that optimize conservation of our soil and water resources, consistent with sound economic practices. With the recognition that all the tillage operations utilized in conventional tillage may not be necessary, Larson (12) noted that there has been a general decrease in the number of tillage operations and an awareness that over-tillage is costly and may have harmful effects. Larson and Gill (13) observed that recent changes in tillage systems have been motivated largely by the desire to decrease the number of trips of machinery over the soil and to reduce the amount of soil working and thereby reduce costs.

Several factors need to be considered when the conversion from conventional tillage to reduced or no-tillage cropping systems is made. The most important factor the producer considers is the effect on yields. Numerous studies have compared the yields of corn grown with conventional tillage to that of corn grown with the no-tillage system. VanDoren, Triplett, and Henry (30) indicate that corn yields for intermediate to long term studies have been remarkably insensitive to tillage, except where grown continuously on poorly drained soils. Likewise, Fink and Wesley (8) also found that yields were similar with conventional and zero tillage systems.

Jones et al. (11) reported that yields from no-tillage corn during a six-year period were comparable to or above yields from conventional turnplow tillage. In similar studies Shear and Moschler (21), as well as Daniel et al. (6) reported that corn yields were equivalent or greater where tillage was reduced than where conventional tillage was used. Research by Bennet, Mathias, and Lundberg (2) indicated that the average yields of corn silage and grain were higher where corn was sod planted rather than under conventional tillage. Blevins et al. (3) also found that increased corn yields were achieved on no-tillage plots.

Hovermale, Camper, and Alexander (10) found no-till soybeans double-cropped following wheat had higher yields than conventional tilled soybeans. Sanford, Myhre, and Merwine (20) reported lower no-till soybean and sorghum yields due to lack of perennial weed control without tillage.

However, when the weeds were hand hoed, yields of both soybeans and sorghum were higher with no-tillage crop production than with conventional tillage. Nearly all research has been focused on no-till corn production and the literature is limited on the performance of no-till soybeans, grain sorghum, and wheat.

Where yields of no-tillage plots were equal or exceeded yields of conventional tillage, the plots were closely monitored with timely operations, and any problems that occurred could be given immediate attention.

Management

The key to successful crop production in any tillage system is good management, and this is even more critical in reduced tillage systems. Sanford, Myhre, and Merwine (20) stated that no-tillage systems require a high level of management and continuous supervision to anticipate unusual problems, and to perform each operation at the most appropriate time. They go on to say that unsatisfactory results where no-tillage methods are used, are usually related to poor weed control, poor management, or lack of the complete technology of production. Walker and Triplett (31) give several rules that need to be followed to be successful with reduced tillage. Proper equipment and skills are important for crop establishment along with timing and good weed management. They conclude that with good management, yields of crops produced with reduced tillage equal those produced with conventional tillage.

Equipment

One of the problems with conservation tillage has been the lack of adequate equipment. Mock and Erbach (14) indicate that plant residues on the soil surface could cause equipment used for tillage, planting, and cultivation to perform improperly. Likewise, Walker and Triplett (31) noted that planting into untilled soil covered with residue requires proper equipment. Development in this area has lagged because increased use of no-till crop production would reduce the demand for large tractors and heavy equipment produced by the large equipment manufacturers. However, with the help of university engineers and small independent manufacturers, advances have been made and are continuing to be made in reduced tillage equipment.

Pest Management

As with any tillage system, pest control is important in a conservation tillage system. Musick and Petty (16) reported that no-tillage agriculture will change the microenvironment of insects, weeds, and plant diseases. Minor pests in conventional tillage may suddenly become serious, while major pests may decrease in importance.

Weeds.

Triplett and Lytle (26) indicated that tillage has little influence on crop yield in the absence of weeds. Therefore, as VanDoren, Triplett, and Henry (30) reported, the development of 2,4-D in the 1940's and of additional herbicides since then has significantly reduced the need for tillage. The first attempts at eliminating tillage were evaluated in California orchards in 1944. The earliest attempts to exclude tillage from cropland were made in the western areas of the country. Chemicals replaced tillage for weed control during the fallow period, thus reducing moisture loss due to tillage. Wiese and Staniforth (32) reported that this practice, called chemical fallow, was viewed as an additional opportunity beyond stubble mulch to conserve soil moisture and reduce soil erosion. Grain yields were comparable to yields from conventional tillage where the chemical fallow treatment controlled weeds.

With the introduction of the triazine herbicides and atrazine in particular, reduced tillage systems became more practical due to the residual activity these herbicides exhibited. With these advances in chemical weed control, no-tillage research was initiated in the late 1950's and early 1960's in several midwestern and southeastern states.

Research on chemical weed control in no-tillage systems has been studied by several individuals. Ross and Williams (19) found that herbicide treatments on no-till systems where vegetation is usually present at planting time, need to kill established plants, control later germinating annual species, and not injure the crop. Combinations of herbicides have proven superior to single chemicals for this purpose. Research by Triplett (25) indicated that a foliar herbicide along with a residual herbicide treatment provided the best weed control and promoted the highest yields. The foliar herbicides were necessary to control the weed vegetation present at planting time and to reduce competition during the first part of the growing season. The residual herbicide controlled weed seed germinations following planting to prevent later competition.

Although post-emergent applications of herbicides are less effective than pre-emergent applications, they may become necessary if the pre-emergent treatment is rendered ineffective due to environmental conditions allowing weed escapes. If post-emergent applications are used, Robison and Witmuss (18) found that timeliness is critical to the success of post-emergent herbicides and can be risky due to a possible delay caused by unfavorable weather conditions.

In addition to weed control during the cropping season, Hoefer, Wicks, and Burnside (9) found that weeds must also be controlled between growing seasons to reduce water uptake and moisture loss during this period. This control can be accomplished with the use of short term residual herbicides, non-selective foliar herbicides, or a combination of the two.

A major concern when the conversion to reduced tillage is made is the shift in weed populations that may occur due to greater reliance on herbicides. Erbach and Lovely (7) stated that because reduced tillage and increased plant residue alter the moisture-temperature conditions of soil and the distribution of weed seeds in the soil, the spectrum of problem weed species probably will change with a switch from conventional to conservation tillage. Inevitably there are weed species that adapt to the crop production system. Triplett and Lytle (26) found that populations of annual weeds changed rapidly with various herbicide treatments, and usually one or more species dominated within one or two years where a specific chemical was used.

Along with a change in the annual weed spectrum, perennial weeds will become more of a problem as many perennial weeds are tolerant to herbicides. Robertson et al. (17) observed that after three years of continuous no-tillage corn, perennial weeds were beginning to appear, while few perennial weeds were observed in the conventionally planted corn. Triplett and Lytle (26) found a perennial weed problem of common milkweed (*Asclepias syriaca* L.) and hemp dogbane (*Apocynum cannabinum* L.) in the chemical plots that could not be controlled without tillage. They concluded that once established, perennial weed populations may require spot treatment with effective herbicides or tillage to control them.

One of the most effective means of controlling problem weeds is to change the environment by rotating crops. This cultural practice may become more important in reduced tillage systems. The weed control problem in conservation tillage is still not completely understood. Wiese and Staniforth (32) stated that with many cropping sequences, weeds can be controlled at critical times, and limited or no-till farming is practical; however, we do not as yet have the necessary herbicides for all cropping situations.

Insects and Plant Diseases.

Insects and plant diseases may be greatly affected by a switch from conventional tillage to conservation tillage. In many instances the best method of cultural control is tillage and burial of surface residue.

Musick and Petty (16) indicated that when examined closely, the microenvironment of the no-tillage system is conducive to insect activity. Pests formerly of minor importance may assume economic status, and no insect is less important in the no-tillage system. Not only could the change in environment enhance pest populations, but it could also be beneficial to many of the pest's natural enemies. Reduced tillage will alter the usual pattern of insect problems, but the overall picture is not yet understood.

The same is true of plant diseases. Boosalis and Cook (5) stated that conservation tillage as it relates to the management of surface residues is an important cultural practice that may greatly affect the onset and development of plant diseases. A continual supply of surface residue resulting from conservation tillage and a monoculture system of cropping as practiced in many areas, may maintain a high enough level of innoculum of the pathogen to initiate severe disease outbreaks.

One example of a disease associated with conservation tillage is take-all of wheat. Take-all is caused by a fungus (Ophiobolus graminis) that does not survive well on plant residue that has been buried in the soil, but is very persistent on residue which remains on the surface of the soil. Therefore take-all can be a serious problem where continuous wheat is grown with minimum tillage.

As is the case with weed control, one of the most effective measures of controlling insects and plant diseases is by rotating crops and creating an unfavorable environment for growth of the pests. As Wiese and Staniforth (32) noted, with our present technology, insects and plant disease problems may dictate that certain cultural practices be employed.

Soil Environment

One of the biggest advantages of a conservation tillage system is the reduction in soil erosion. Wischmeier (34) reported that conservation tillage practices can be highly effective for control of erosion and sediment from cropland. The dominant factor in determining effectiveness is the amount and distribution of crop residues remaining on the soil surface. Therefore, Jones et al. (11) stated that the no-tillage principle for row crops offers the best natural resistance to erosion because it retains the existing vegetative cover on the land. Because surface soil erosion is reduced, Daniel et al. (6) concluded that the pollution potential is also reduced in conservation tillage systems even though the concentration of nutrients is greater near the soil surface due to surface application.

The better erosion control results mainly from reduced surface runoff and better infiltration at the soil surface. Hovermale, Camper and Alexander (10) found that surface mulch in reduced tillage systems protects the soil from raindrop impact and erosion, while enhancing water infiltration. Along with enhancing water infiltration, the surface mulch in conservation tillage also reduces water evaporation from the soil. This leads to better water conservation as well as soil conservation. In most cases in which yields in the no-till system exceeded those of conventional tillage, the difference was attributed to more favorable moisture conditions in the no-till system.

Bennet, Mathias, and Lundberg (2) reported that reduced evapotranspiration rates in the no-till plots along with reduced runoff resulted in a significantly greater amount of available soil water for plant growth. Blevins et al. (3) indicated that the higher soil moisture content was attributed to decreased evaporation especially just after planting, and a greater ability to store water. Unger and Phillips (29) described the situation by saying that conservation tillage, through the utilization of crop residues, reduces evaporation primarily by reducing the turbulent transfer of water vapor to the atmosphere, and by shielding the surface against the effects of solar radiation. Furthermore they stated that by reducing evaporation rates and lengthening first stage drying, plants can utilize some of the water in the surface layers, and the internal drainage of water can be enhanced, thus permitting storage at greater depths, where the water is less susceptible to evaporation. Blevins et al. (3) concluded that the additional amount of moisture stored under no-tillage conditions is capable of carrying crops through short term drought periods when conventionally tilled crops are stressed.

In addition to increasing soil moisture content, Willis and Amemiya (33) note that mulches of straw, corn stover, or other crop residues usually will decrease soil temperature by altering the amount of light energy reflected and the amount of net radiation. They go on to say that mulches also affect soil water storage and subsequent plant growth, and that water content affects thermal conductivity, thermal diffusity, and heat storage. Unger (28) also reported lower soil temperatures occurred under residue mulches due to shading and increased soil moisture. Bennet, Mathias, and Lundberg (2) found no-till sod reduced soil temperatures as much as 10°C compared to the conventional tillage plots. The more mulch remaining on the surface of the soil, the lower the soil temperature.

Reduced soil temperatures in the spring may necessitate a delay in planting date for crops sensitive to low soil temperatures, or result in slow germination and early seedling growth if planted at the same time as with conventional tillage. Beside affecting early growth, soil temperatures also affect transpiration, tillering, stomatal closure, growth of stems and roots, respiration, and uptake and availability of several plant nutrients. Willis and Amemiya (33) also indicate that generally soil temperature is more important for vegetative growth than air temperature. Therefore, a difference of 10°C could affect plant growth and development.

With a change in tillage systems comes a change in microbial populations. Sommers and Biederbeck (22) note that tillage alters the chemical and physical properties of soil, and therefore modifies the environment supporting microbial growth. In addition, the response of a soil to fluctuations in meterological and hydrological conditions is determined in part by tillage practices, which in turn influence the microbial populations. Sommers and Biederbeck (22) indicate that minimum tillage practices generally result in increased microbial populations compared to conventional tillage. The changes in microbial populations will alter rates of decomposition and degradation processes, but the overall effect of the shift in microbial populations is not known.

Soil Fertility

Stanford, Bennet, and Power (23) reported that an important factor contributing to the success thus far achieved with reduced tillage practices has been the supplemental use of plant nutrients. The fertility patterns are different in conservation tillage not only because of the different environment that is created, but also due to different forms of fertilizer applications. Stanford, Bennet, and Power (23) noted that in a continuous no-till system, substantial amounts of fertilizer must be topdressed, rather than mixed with the soil. This could create differences as well as problems with nutrient availability and soil acidity.

Nitrogen is the nutrient absorbed by the plant in largest quantities and generally applied to the soil in the largest amounts. Unlike phosphorus and potassium, nitrogen is a mobile element that is easily moved through the soil. This movement can be an advantage or a disadvantage depending on the conditions. Triplett and VanDoren (27) observed that since nitrogen is a mobile element, it easily moves down through the soil profile and thus uptake is not a problem. However if large amounts of rainfall are received, Thomas et al. (24) found that nitrate levels were significantly lower in the no-till plots than conventional plots due to increased leaching.

Several studies have found greater amounts of mineral and total nitrogen under conservation tillage than conventional tillage. Stanford, Bennet, and Powers (23) believed this occurred because more mineralizable organic nitrogen is present and the soil moisture is more favorable for the biological processes involved in converting organic to mineral forms of nitrogen.

Bandel et al. (1) reported that at suboptimum levels of applied nitrogen fertilizer, nitrogen deficiency symptoms were accentuated with no-tillage. This was attributed to more early growth in the no-till plots due to more favorable moisture conditions. It has been shown that a greater amount of applied fertilizer nitrogen is tied up early in the growing season by the increased quantities of residue and organic matter in conservation tillage systems. For this reason some researchers believe larger nitrogen fertilizer applications are required when a no-till system is initiated. However, in time, this will be re-leased back into the soil in the form of mineralized nitrogen.

Bandel et al. (1) postulated that the nitrogen status of soils will gradually increase under no-tillage, and gradually decline under continued conventional tillage. However, due to the fact that conserva-tion tillage is a relatively new idea, long term effects are still not understood.

Phosphorus is an immobile element that tends to stay in the area where it is applied. Triplett and VanDoren (27) reported that when phosphorus was surface broadcast, most of it remained in the surface 2.5 cm. Likewise, Fink and Wesley (8) found that movement of surface applied phosphorus was slow, but was sufficient to provide adequate nutrition for the plants. Triplett and VanDoren (27) postulated that the surface nutrients were more available in the no-till system be-cause the surface residue keeps the soil moist because of better in-filtration and less evaporation, promoting greater root exploration and nutrient absorption.

Shear and Moschler (21) found an increase in total available phosphorus in the no-till plots as compared to conventional tillage. They believed this was due to less phosphorus fixation from a surface application than when the fertilizer is mixed into the soil. Although the literature indicates that phosphorus is just as available under no-till conditions, this research was completed under wetter conditions than usually occur in Kansas. There are still some questions about phosphorus availability from surface applications when dry conditions exist.

Potassium is similar to phosphorus in terms of mobility, and therefore reacts in much the same way in conservation tillage systems. Research by Fink and Wesley (8) indicated that downward movement of potassium was slow, but sufficient to provide adequate nutrition for corn plants. They also indicated that the potassium movement was greater than that of phosphorus. Research by Moschler and Martens (15) also indicated that surface application of potassium on no-till plots supplied the crop needs sufficiently, plus resulted in higher fertilizer use efficiency than conventional methods. Stanford, Bennet, and Power (23) concluded that reduced tillage has little effect on potassium availability, uptake, or content of the soil.

With surface applications of nitrogen fertilizer, low soil pH may become a problem with no-till systems. Stanford, Bennet and Powers (23) noted a gradual increase in soil acidity accompanies the use of nitrogen fertilizers of the types most commonly applied. Blevins, Thomas, and Cornelius (4) observed that soil pH was significantly lower for no-tillage as compared to conventional tillage in the upper 0-5 cm soil layer. A low pH at the soil surface could be detrimental to crop growth as well as weed control. Many herbicides, and particularly atrazine exhibit reduced activity and weed control at a low pH. Therefore, Shear and Moschler (21) suggested more frequent liming of the soil may be necessary to maintain pH and promote optimum crop growth in reduced tillage systems.

MATERIALS AND METHODS

Field experiments were initiated in 1974 at the Ashland Agronomy Farm near Manhattan, Kansas, to evaluate the effects and feasibility of several conservation tillage systems in eastern Kansas.

The plot area where the experiment was carried out consisted of two soil types. Most of the plot area was a Muir silt loam (Cumulic haplustoll, fine-silty, mixed, mesic), while one corner of the plot area was a Reading silt loam (Typic arguidoll, fine, mixed, mesic). In addition water drainage occurred across the Reading silt loam soil when large amounts of rainfall occurred during a short time period. The different soil types and drainage problems were not known when the study was initiated. The approximate distribution of soil types is illustrated on the map of the plot area in Figure 1.

The study was designed as a split block design with four replications. The main plots consisted of cropping sequence. There were three crops, wheat, grain sorghum, and soybeans. Each crop was grown continuously and in a soybean-wheat rotation and a soybean-grain sorghum rotation. The subplots consisted of three methods of seedbed preparation, and were randomized within each cropping sequence. The three methods of seedbed preparation were chemical, chemical/mechanical, and mechanical. The chemically prepared seedbeds were not tilled and relied totally on herbicides for weed control. The chemically/mechanically prepared seedbeds relied on a combination of tillage and herbicides for weed control before planting, with chemical weed control after planting. The mechanically prepared seedbeds relied on tillage for weed control until planting, and chemical weed control after planting. The plots were 6.1 meters wide and 18.3 meters long. A map of the plot design is represented

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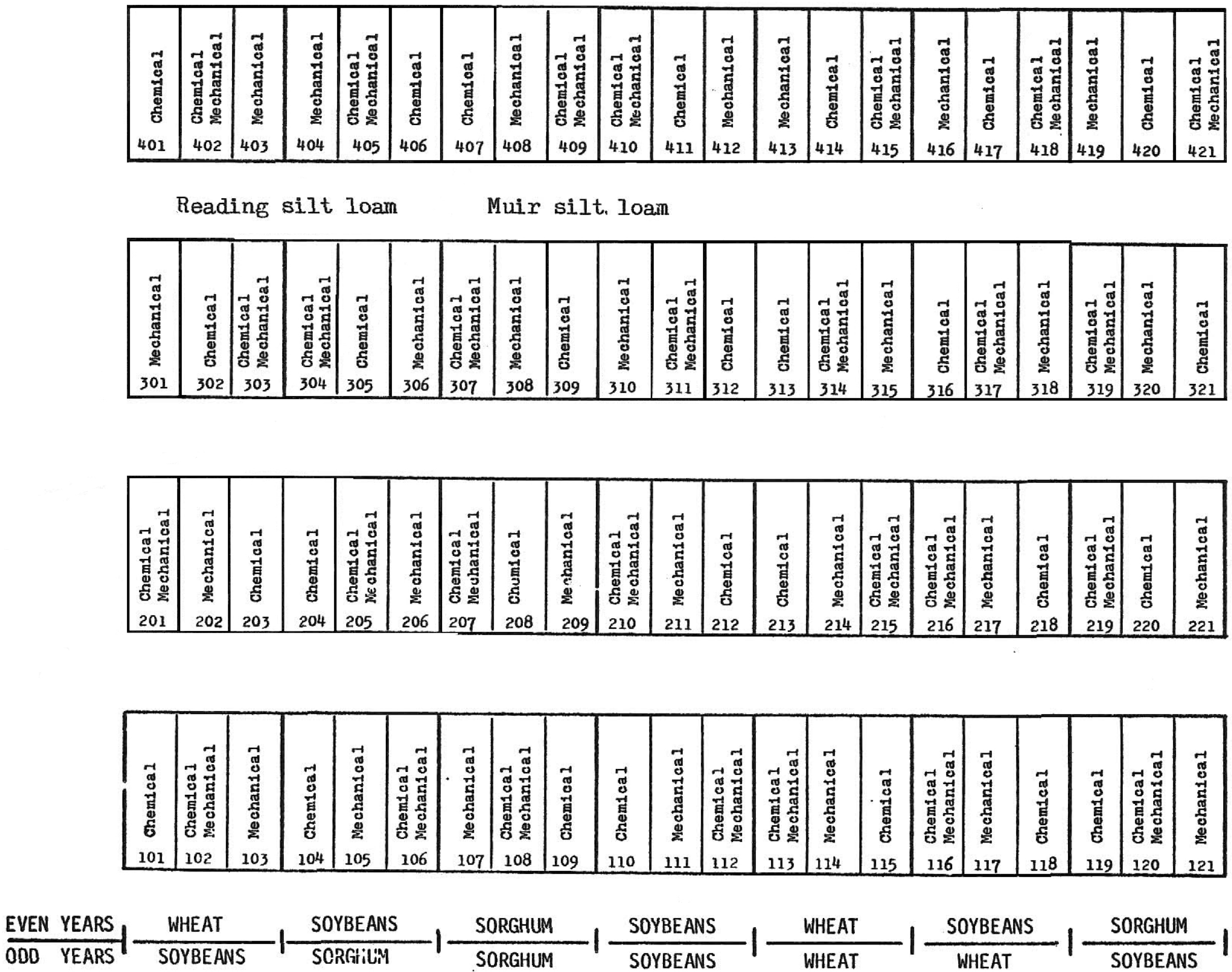

Figure 1. Plot design and distribution of soil types.

in Figure 1.

The wheat variety "Cloud" was seeded the first two years of the study, but due to its susceptibility to soilborne mosaic (Marmor tritici) it was no longer used. "Newton" wheat was planted after public release in 1976 because of its resistance to soilborne mosaic. "Newton" is a high yielding semidwarf wheat cultivar well adapted to Kansas conditions.

Wheat plots were planted with a Tye brand disc drill with 20 cm row spacings. Due to heavy residue and compacted soils in the chemically prepared seedbeds, the drill would not function properly during dry years, and adequate plant stands could not be established. Therefore, in 1980, 1981, and 1982, one tillage operation was performed prior to planting in the chemically prepared wheat seedbeds to reduce planting problems.

The soybean cultivar "Williams" was planted from 1975 to 1980, and the cultivar "Williams 79" was planted in 1981 and 1982. Both cultivars exhibit semi-indeterminate growth patterns with a group three maturity date and are well adapted to eastern Kansas growing conditions. Prior to planting, all soybean seeds were treated with Captan fungicide to prevent fungal infection.

The grain sorghum cultivar "Pioneer 8626" was used from 1975 to 1980. "DeKalb DK57" safened seed was used in 1981, and "Funk's 623GBR" safened seed was used in 1982. All three grain sorghum cultivars have a medium maturity lifespan and are well adapted to eastern Kansas growing conditions. Safened seed was planted in 1981 and 1982 to permit the use of acetanilide herbicides for annual grass control. Furadan 10G granular insecticide was applied at a rate of 14.6 kg/ha in the grain sorghum furrow to reduce greenbug (Schizaphis graminum) and chinch bug (Blissus leusopterus Say) injury.

Soybean and grain sorghum plots were planted with a Buffalo no-till planter the first five years of the study, and with a John Deere Max Emerge planter the last three years. The plots were eight rows wide with 76.2 cm row spacings.

All plots received a surface broadcast fertilizer application of 134 kg/ha of ammonium nitrate, and 123 kg/ha of ammonium phosphate before planting. This converts to 65 kg/ha of actual nitrogen and 59 kg/ha of phosphate. After application, the fertilizer was incorporated in the soil in the mechanically prepared seedbed prior to planting, but not in the chemically and chemically/mechanically prepared seedbeds.

Herbicide and tillage treatments were not the same each year, but a similar pattern of treatments was followed.

All herbicide treatments were applied with a compressed-air tractor-mounted plot sprayer.

The primary tillage tool in the continuous wheat seedbeds was the chisel. The mechanically and chemically/mechanically prepared seedbed plots were chiseled following wheat harvest in June. Thereafter the mechanically prepared seedbeds were tilled as needed through the summer for weed control using a disk, field cultivator, spring tooth, and a power-driven rotary tiller. The chemically and chemically/mechanically prepared seedbed plots received an early summer 2,4-D application to control broadleaves, and a late summer nonselective foliar treatment to kill volunteer wheat and any remaining broadleaves or grasses. During the first part of October, the plots were fertilized, tilled with a power-driven rotary tiller, and planted.

In the wheat-soybean rotation, fertilizer was broadcast over all the plots following soybean harvest. Then the mechanically and chemically/mechanically prepared seedbeds were disked to incorporate the fertilizer. All the plots were then tilled with a power driven rotary tiller, and planted.

After harvest in the fall, all mechanically and chemically/mechanically prepared seedbeds of soybeans and grain sorghum were furrowed for the winter. Early in the spring, the furrows were knocked down. Thereafter, the mechanically prepared seedbed plots were tilled as needed for weed control. The chemically and chemically/mechanically prepared seedbed plots received an early treatment of a residual grass herbicide and a residual broadleaf herbicide. Prior to planting, all plots received a fertilizer application, and the mechanically prepared seedbed plots were tilled to incorporate the fertilizer. All the soybean and grain sorghum plots were then planted, and both crops were treated with a residual grass herbicide and a residual broadleaf herbicide. If any vegetation was present at planting, a nonselective foliar herbicide was also included in the application.

The herbicide and tillage treatments did not follow a strict guideline and varied from year to year depending upon environmental conditions or any particular problems that occurred.

The crops were harvested with a modified plot combine. Wheat yields were computed from a 1.83 m swath harvested through the middle of the plots. Soybean and grain sorghum yields were computed from samples harvested from the fifth and sixth rows of the soybean and grain sorghum plots.

Soil samples were taken in 1981 and 1982 to evaluate soil fertility patterns. Samples were taken to a depth of 30 cm from each plot in 1981, and divided into 5 cm increments: 0-5, 5-10, 10-15, 15-20, 20-25, and 25-30 cm. Each increment was then analyzed for available phosphorus, exchangeable potassium, organic matter, and soil pH at the Kansas State University Soils Testing Laboratory.

In 1982, soil samples from each plot were taken in the surface 0-2 cm layer and again analyzed for available phosphorus, exchangeable potassium, organic matter, and soil pH at the K.S.U. Soils Testing Laboratory.

Data collected from all plots in 1981 and 1982 included grain weight, test weight, percent moisture, and grain analysis for nitrogen, phosphorus, and potassium content. In addition, soybean weight per 100 seeds, and soybean and grain sorghum plant height at maturity were recorded.

All data was analyzed, by crop, using analysis of variance procedures. Least significant differences were computed at the five percent alpha level.

Yield data was analyzed as a split, split block design, utilizing the year as the whole plot, cropping sequence as the sub-plot, and method of seedbed preparation as the sub-sub-plot. All other data was analyzed as a split block design, with the cropping sequence being the whole plot, and method of seedbed preparation the sub-plot.

RESULTS AND DISCUSSION

Wheat

Wheat Yields in a Continuous Wheat System.

Because of a significant interaction between year, cropping sequence, and method of seedbed preparation, LSD values can be computed comparing the three methods of seedbed preparation, in each cropping sequence, for each year. A graph representing continuous wheat yields is presented in Figure 2, and will be referred to throughout the continuous wheat section.

Wheat plots were first established in the fall of 1974, and adequate stands were obtained with all three methods of seedbed preparation. No significant differences in wheat yields resulted because of method of seedbed preparation in the continuous wheat system in 1975.

In 1976, downy brome was starting to infest the chemically prepared seedbed where wheat was grown continuously, and would continue to be a serious problem in these plots during the remainder of the study. The downy brome provided severe competition and resulted in lower wheat yields from the chemically prepared seedbed the second year of the study.

The heavy residue left by the downy brome plants, along with a firm seedbed in the chemically prepared seedbeds where wheat was grown continuously resulted in planting difficulties. Consequently, plant stand establishment also became a problem in these plots.

Wheat yields were again significantly lower in the chemically prepared seedbed of continuous wheat in 1977, due to the downy brome competition and planting problems. Yields from the chemically/mechanically prepared seedbeds were significantly higher than the yields from the mechanically prepared seedbeds, perhaps due to more available moisture.

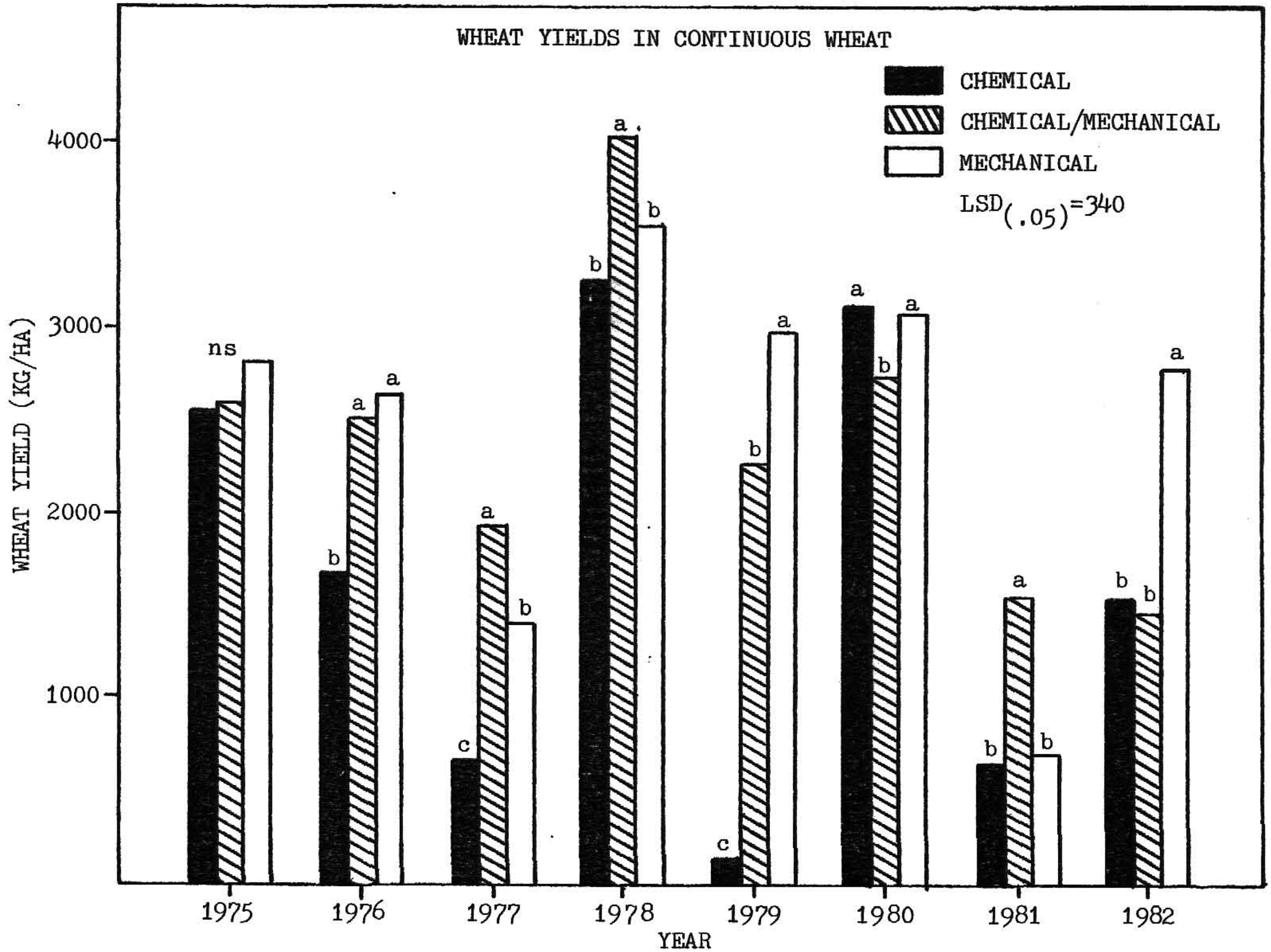

Figure 2. Effect of seedbed preparation on wheat yields in a continuous wheat cropping system in eight years.

Large amounts of precipitation occurred in the spring of 1978, and the wheat performed well in all three tillage systems. Yields were the highest from the chemically/mechanically prepared seedbed plots, with no significant difference between the mechanical and chemical methods of seedbed preparation. Apparently rainfall was adequate to promote optimum growth of both the wheat and the downy brome in the chemically prepared seedbeds.

By 1979, the downy brome infestations were spreading from the chemically prepared seedbeds to the chemically/mechanically prepared seedbeds. The populations were not as heavy, but were present. The mechanically prepared seedbeds remained relatively clean throughout the study, indicating that the increased tillage was controlling the downy brome.

As the yields indicate, a marginal level of rain fell in 1979. Yields in the chemically prepared seedbed were extremely low. The mechanically prepared seedbed promoted the highest yields, with wheat yields from the chemically/mechanically prepared seedbed in between. The wheat yields appeared to be directly related to the level of downy brome competition.

As stated in the materials and methods section, to reduce planting problems, one tillage operation was performed prior to planting in the chemically prepared seedbeds starting in the fall of 1979. This practice, along with late germinating volunteer wheat, resulted in thick plant stands for the 1980 crop. As was the case in 1978, sufficient precipitation in the spring provided adequate moisture for both the wheat and the downy brome. Consequently wheat yields in the chemically prepared seedbed were comparable to the wheat yields in the mechanically prepared a seedbed. The chemically/mechanically prepared seedbed plots had slightly lower yields.

The summer of 1980 was extremely hot and dry, with below normal precipitation continuing through the 1981 growing season. Consequently, wheat yields were low. Wheat yields were significantly higher from the chemically/mechanically prepared seedbed than the other two. This may have been due to higher levels of available moisture. There could have been less moisture available to the plant in the chemically prepared seedbeds due to the downy brome competition, and less available moisture in the mechanically prepared seedbeds because of more evaporation from the preplant tillage.

Spring treatments of .42 kg/ha metribuzin were applied in 1981 and 1982 in an attempt to control the downy brome. However, these treatments were ineffective, not reducing the downy brome pressure noticeably.

A new problem possibly associated with reduced tillage arose in 1982. Take-all, a fungal wheat disease associated with moist conditions and surface residue was observed in the chemically and chemically/mechanically prepared seedbed plots. Take-all restricts nutrient and water flow in the plant stem from the roots to the head. Eventually, the wheat stem dies before the plant is mature, and the head does not fill properly. Infection by take-all, and competition from the downy brome in the chemically and chemically/mechanically prepared seedbeds resulted in significantly lower yields than those harvested from the mechanically prepared seedbed. Take-all may become a problem where wheat is grown continuously using conservation tillage methods.

It appears that continuous wheat can be produced with the mechanical or the chemical/mechanical methods of seedbed preparation without much variation in yields. There is a greater possibility of take-all infection in the chemically/mechanically prepared seedbeds, but this method could also provide better water and soil conservation than the mechanically prepared seedbed. The chemical method of seedbed preparation proved to be inferior to the mechanical and chemical/mechanical methods of seedbed preparation. Planting problems, disease problems, and annual grass populations that could not be controlled with the herbicides available resulted in significantly lower yields than in plots where tillage was included in the seedbed preparation.

Wheat Yields in a Wheat-Soybean Rotation.

A graph representing wheat yields when grown in a wheat-soybean rotation is presented in Figure 3.

No significant differences in wheat yields occurred between the three methods of seedbed preparation when grown in the wheat-soybean rotation in the first seven years of the study. In 1982, yields were highest with the mechanical method of seedbed preparation, followed by the chemical method of seedbed preparation, with the chemical/mechanical method of seedbed preparation having the lowest yields.

Planting in the chemically prepared seedbeds was difficult in the dry years. However, the wheat compensated by increased tillering, and yields were not adversely affected.

No unusual weed problems occurred in any of the plots. Unlike the continuous wheat system, downy brome populations could not become established in the chemically prepared seedbeds, due to the unfavorable environment created by the crop rotation.

Yields varied from year to year depending upon the growing conditions. In 1978 and 1980 when levels of precipitation were high and growing conditions were good, high yields resulted. In 1977 and 1981 when poor growing conditions existed, low wheat yields occurred in all

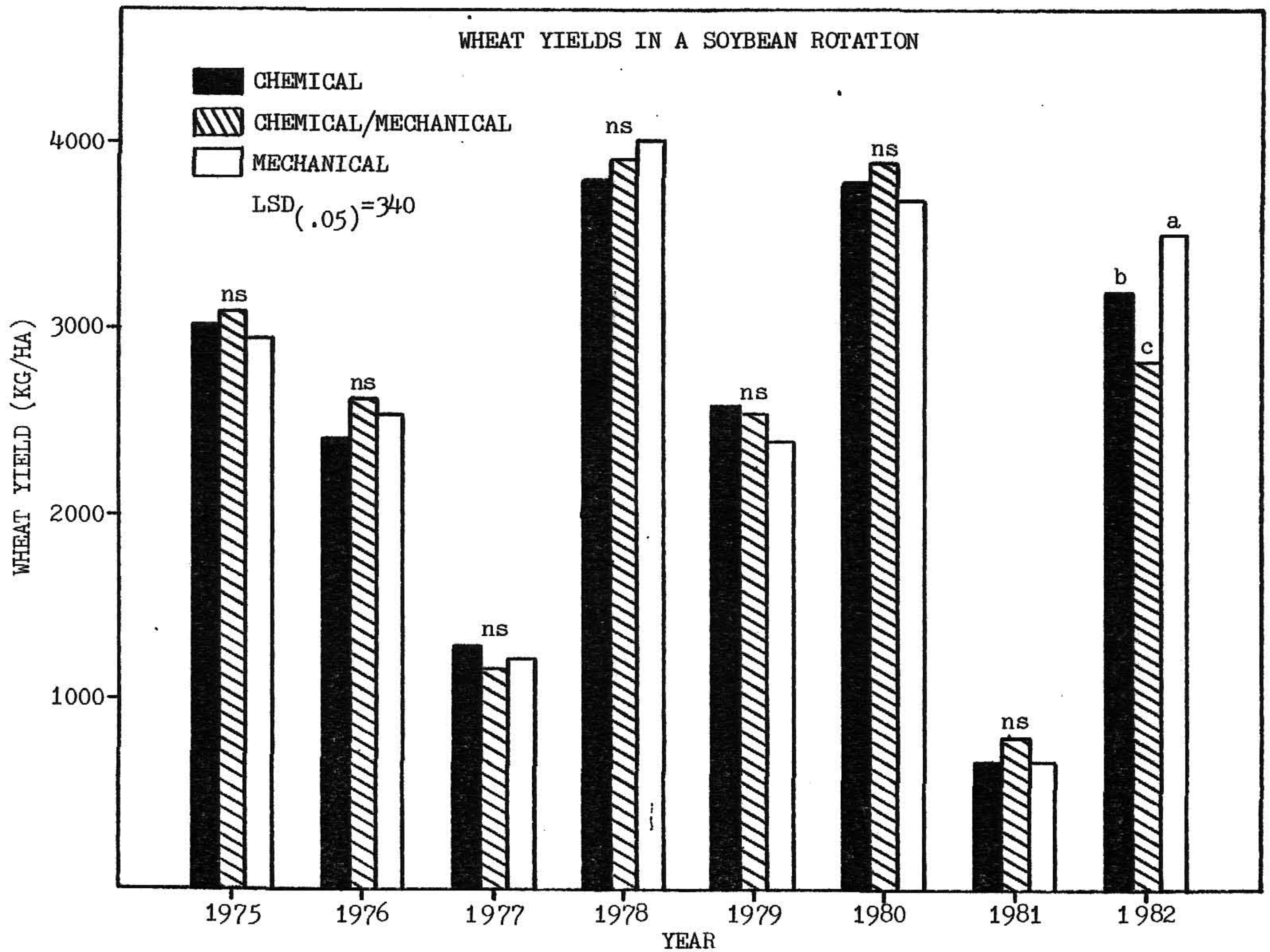

Figure 3. Effect of seedbed preparation on wheat yields in a wheat-soybean crop rotation in eight years.

the plots.

Regardless of the environmental conditions, wheat yields were similar from all three methods of seedbed preparation. Therefore, it appears that wheat can be produced in a wheat-soybean rotation with little variation in yields due to method of seedbed preparation.

Comparisons of All Wheat Production Systems.

Least significant differences can also be computed to compare the yields of each treatment for each year. Wheat yield data is presented in Tables 1 through 8.

In 1975, the wheat yields from all three methods of seedbed preparation in the wheat-soybean rotation were significantly higher than the wheat yields of the chemically/mechanically and chemically prepared seedbeds where wheat was grown continuously. Yields from the mechanically prepared seedbed in a continuous wheat system were not significantly different from any of the other treatments. At this point in the study, it appeared that wheat yields might be higher when grown in the soybean rotation than when grown continuously.

By 1976, downy brome had infested the chemically prepared seedbed where wheat was grown continuously and provided enough competition to decrease the yields compared to the other treatments. However, there were no differences between the remaining cropping systems.

Dry conditions existed in the spring of 1977 and lower wheat yields resulted. Yields were highest in the chemically/mechanically prepared seedbed of continuous wheat, and lowest in the chemically prepared seedbed of continuous wheat. The wheat-soybean rotation did not perform as well as the chemically/mechanically prepared seedbed of continuous wheat, possibly due to less available moisture in the soil profile. In a continuous wheat system, the soil can collect water through the summer when no crops are growing and build up a reservoir. Meanwhile in the wheat-soybean rotation, soybeans are depleting the soil of any available moisture during the summer, so that less is available when the wheat is planted in the fall. If dry conditions persist, wheat in the wheat-soybean rotation runs out of water more quickly.

In 1978, yields from the chemically prepared seedbed of continuous wheat were again significantly lower than all treatments, except the mechanically prepared seedbed where wheat was grown continuously. Wheat yields were highest in the mechanically and chemically/mechanically prepared seedbeds where wheat was grown in the wheat-soybean rotation, and in the chemically/mechanically prepared seedbed where wheat was grown continuously.

In 1979, heavy downy brome infestations, planting problems, and dry conditions again resulted in low yields in the chemically prepared seedbed where wheat was grown continuously. Yields were highest in the mechanically prepared seedbed in a continuous wheat cropping system.

Better growing conditions occurred in 1980, and consequently wheat yields were significantly higher from the wheat-soybean rotation than from the wheat grown continuously. Perhaps the additional amount of nitrogen provided in the soybean rotation stimulates wheat growth when adequate moisture is available.

As in 1977, dry conditions occurred in 1981 and wheat yields were significantly higher in the chemically/mechanically prepared seedbed where wheat was grown continuously than from any of the other treatments. Apparently this system of wheat production provides the best water conservation properties under dry conditions.

Wheat yields in the wheat-soybean rotation were higher in 1982 than wheat yields in the continuous wheat systems. Above average rainfall was received in the spring of 1982 and promoted increased yields in the wheat-soybean rotation. Disease problems developed in the reduced tillage systems where wheat was grown continuously, causing a decrease in production.

No system clearly outperformed the others. One advantage of the wheat-soybean rotation is the absence of significant weed problems. Wheat yields generally were better in the wheat-soybean rotation than in the continuous wheat system, provided adequate amounts of rainfall were received. However, in dry years, wheat grown in the soybean rotation ran out of water sooner than wheat grown continuously. Continuous wheat grown with the chemical/mechanical method of seedbed preparation proved to be superior under dry conditions because of better water conservation properties. Wheat production in the chemically prepared seedbed of continuous wheat was unsatisfactory due to heavy downy brome infestations, planting difficulties, and disease problems.

In addition to yield data, in 1981 and 1982 test weight, moisture, and grain content of nitrogen, phosphorus, and potassium were also determined. This data is presented in Tables 9 through 13.

No significant differences in test weight or moisture occurred due to cropping sequence in 1981 or 1982. In 1981, higher test weight values occurred for the wheat grown in the chemically/mechanically prepared seedbeds than where wheat was grown with the chemical or mechanical methods of seedbed preparation. This could be related to the higher wheat yields in these plots. Perhaps better water conservation and less moisture stress resulted in increased yields and higher test weights in these plots. Otherwise there were no significant differences in test weight in 1982 or moisture content in 1981 and 1982 due to method of seedbed preparation.

When the 1981 grain nutrient levels were examined, the nitrogen and phosphorus content of the grain was unusually high from all treatments due to shriveled grain, which resulted from severe moisture stress. It appeared the nitrogen, phosphorus, and potassium content of the grain was higher when the wheat was grown in the wheat-soybean rotation than when grown continuously. Phosphorus and potassium content tended to be higher with increased tillage. This might indicate greater absorption from the tillage plots. The nitrogen content of the continuous wheat grown in the chemically/mechanically prepared seedbed was lower than in all other treatments. Since wheat yields and test weights were highest from these plots, this difference could be attributed to a dilution of the nitrogen through an increased quantity of grain.

In 1982, there were no significant differences in grain nutrient content in any situation.

WHEAT

Table 1. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1975.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Soybeans	Chem/Mech	3140
Wheat-Soybeans	Chemical	3060
Wheat-Soybeans	Mechanical	3000
Wheat-Wheat	Mechanical	2840
Wheat-Wheat	Chem/Mech	2590
Wheat-Wheat	Chemical	2570
LSD (.05)		400

Table 2. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1976.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Soybeans	Chem/Mech	2660
Wheat-Wheat	Mechanical	2660
Wheat-Soybeans	Mechanical	2570
Wheat-Wheat	Chem/Mech	2510
Wheat-Soybeans	Chemical	2440
Wheat-Wheat	Chemical	1710
LSD (.05)		400

Table 3. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1977.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Wheat	Chem/Mech	1950
Wheat-Wheat	Mechanical	1430
Wheat-Soybeans	Chemical	1260
Wheat-Soybeans	Mechanical	1230
Wheat-Soybeans	Chem/Mech	1190
Wheat-Wheat	Chemical	670
LSD (.05)		400

Table 4. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1978.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Soybeans	Mechanical	4040
Wheat-Soybeans	Chem/Mech	4000
Wheat-Wheat	Chem/Mech	4000
Wheat-Soybeans	Chemical	3870
Wheat-Wheat	Mechanical	3580
Wheat-Wheat	Chemical	3280
LSD (.05)		400

Table 5. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1979.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Wheat	Mechanical	2980
Wheat-Soybeans	Chemical	2630
Wheat-Soybeans	Chem/Mech	2570
Wheat-Soybeans	Mechanical	2420
Wheat-Wheat	Chem/Mech	2280
Wheat-Wheat	Chemical	140
LSD (.05)		400

Table 6. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1980.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Soybeans	Chem/Mech	3940
Wheat-Soybeans	Chemical	3840
Wheat-Soybeans	Mechanical	3760
Wheat-Wheat	Chemical	3150
Wheat-Wheat	Mechanical	3100
Wheat-Wheat	Chem/Mech	2760
LSD (.05)		400

Table 7. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1981.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Wheat	Chem/Mech	1590
Wheat-Soybeans	Chem/Mech	820
Wheat-Soybeans	Mechanical	730
Wheat-Wheat	Mechanical	720
Wheat-Soybeans	Chemical	710
Wheat-Wheat	Chemical	670
LSD (.05)		400

Table 8. Combined effect of cropping sequence and seedbed preparation on wheat yields in 1982.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Wheat-Soybeans	Mechanical	3580
Wheat-Soybeans	Chemical	3220
Wheat-Soybeans	Chem/Mech	2840
Wheat-Wheat	Mechanical	2780
Wheat-Wheat	Chemical	1530
Wheat-Wheat	Chem/Mech	1480
LSD (.05)		400

Table 9. Effect of cropping sequence and seedbed preparation on wheat test weight and grain moisture in 1981.

	Test Weight (kg/hl)	Moisture (%)
Cropping Sequence		
Continous Wheat	68.8	10.4
Wheat-Soybean Rotation	68.9	10.5
LSD (.05)	NS	NS
Method of Seedbed Preparation		
Chemical	68.0	10.3
Chemical/Mechanical	70.7	10.6
Mechanical	67.7	10.3
LSD (.05)	2.2	NS

Table 10. Effect of cropping sequence and seedbed preparation on wheat test weight and grain moisture in 1982.

	Test Weight (kg/hl)	Moisture (%)
Cropping Sequence		
Continuous Wheat	70.1	11.0
Wheat-Soybean Rotation	71.1	11.1
LSD (.05)	NS	NS
Method of Seedbed Preparation		
Chemical	69.9	11.0
Chemical/Mechanical	70.1	11.1
Mechanical	71.7	11.0
LSD (.05)	NS	NS

Table 11. Effect of cropping sequence and seedbed preparation on phosphorus and potassium content of the harvested wheat in 1981.

Cropping Sequence	P (%)	K (%)
Continuous Wheat	.578	.50
Wheat-Soybeans	.650	.56
LSD (.05)	.055	.04
Seedbed Preparation		
Chemical	.587	.49
Chemical/Mechanical	.623	.53
Mechanical	.632	.56
LSD (.05)	NS	.06

Table 12. Effect of treatments on nitrogen content of the harvested wheat in 1981.

Treatment	N (%)
Continuous Wheat	
Chemical	3.26
Chemical/Mechanical	2.99
Mechanical	3.53
Wheat-Soybeans	
Chemical	3.45
Chemical/Mechanical	3.60
Mechanical	3.57

LSD (.05) Within a Cropping Sequence = .24
LSD (.05) Between All Treatments = .44

Table 13. Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested wheat in 1982.

	N	P	K
Cropping Sequence	(%)	(%)	(%)
Continuous Wheat	2.28	.444	.41
Wheat-Soybeans	2.24	.444	.40
LSD (.05)	NS	NS	NS
Method of Seedbed Preparation			
Chemical	2.29	.450	.41
Chemical/Mechanical	2.23	.442	.42
Mechanical	2.25	.439	.39
LSD (.05)	NS	NS	NS

Soybeans

A significant three-way interaction also was noted when the soybean yield data was analyzed. Therefore, LSD values can be computed to compare the three methods of seedbed preparation in each of the cropping sequences and years.

Soybean Yields in a Soybean-Wheat Rotation.

A graph representing soybean yields in a soybean-wheat rotation presented in Figure 4 will be referred to throughout the soybean-wheat section.

There were no significant differences in soybean yields in the soybean-wheat rotation due to method of seedbed preparation in any year, except 1977. In 1977, the yields from the chemical/mechanical method of seedbed preparation were significantly higher than soybean yields from the chemically prepared seedbeds, but the difference barely exceeded the LSD value.

Soybean yields from the soybean-wheat rotation varied from year to year depending on growing conditions, but did not vary due to method of seedbed preparation. Therefore, it appears that soybeans can be grown in a soybean-wheat rotation with all three methods of seedbed preparation with equal success.

Soybean Yields in a Continuous Soybean System.

A graph comparing yields from the three methods of seedbed preparation where soybeans were grown continuously is presented in Figure 5.

High soybean yields occurred in 1975, and low soybean yields occurred in 1976. In both years, yields were significantly higher in

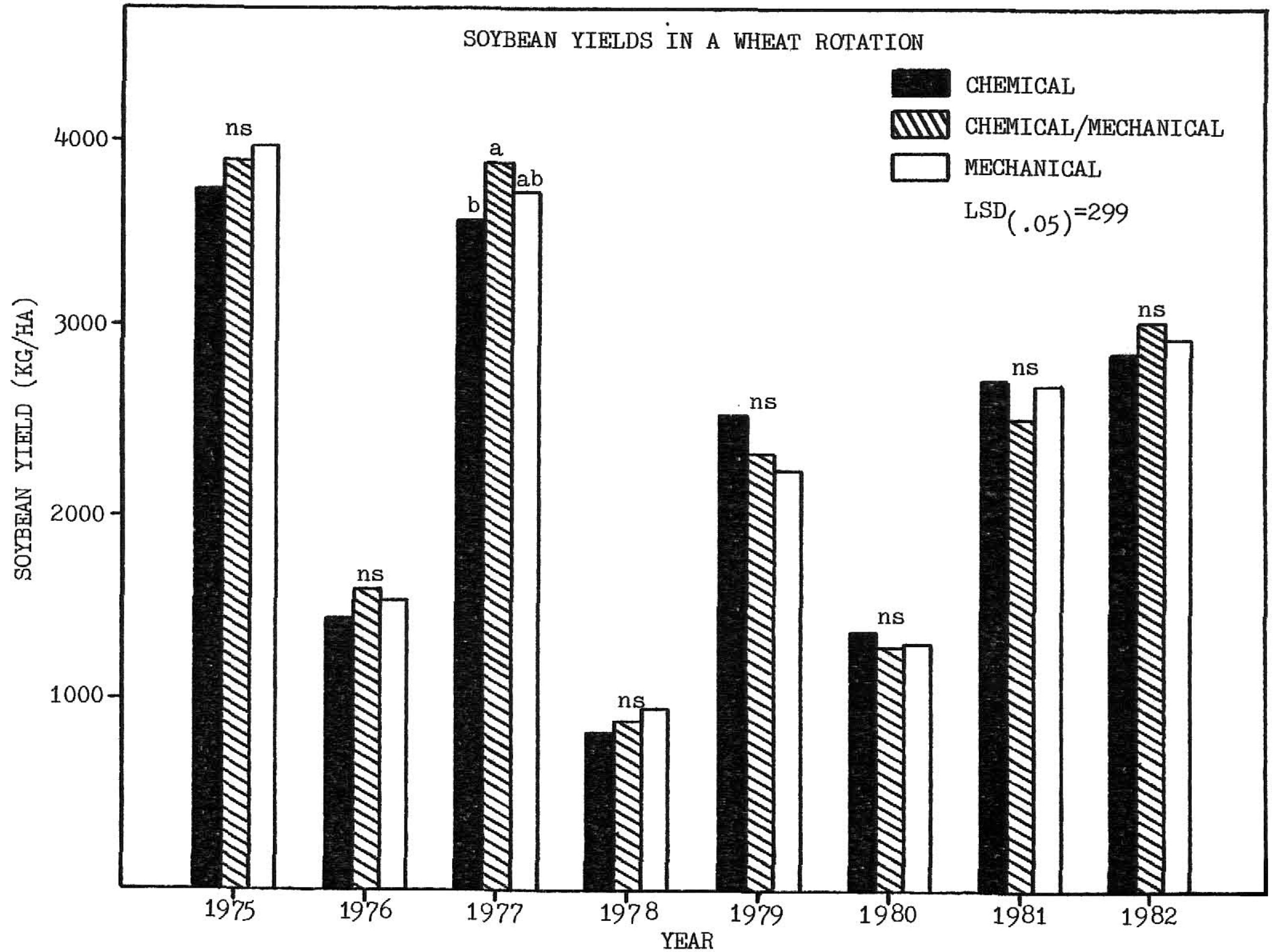

Figure 4. Effect of seedbed preparation on soybean yields in a soybean-wheat crop rotation in eight years.

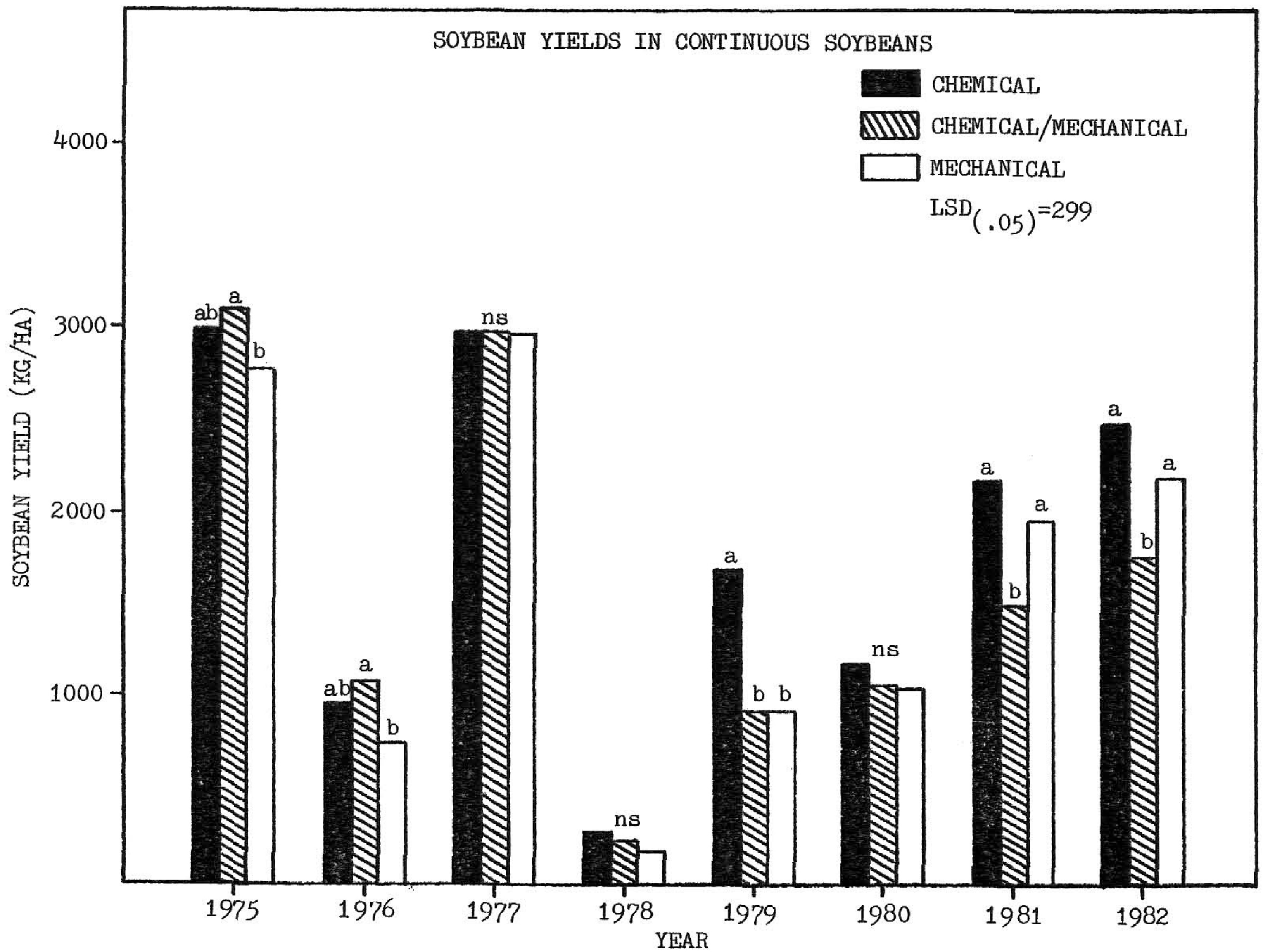

Figure 5. Effect of seedbed preparation on soybean yields in a continuous soybean cropping system in eight years.

the chemically/mechanically prepared seedbed than in the mechanically prepared seedbed. However, the differences were small in both years.

No significant differences were shown in soybean yields in 1977 or 1978, even though a great difference in yields was apparent between the two years. Soybean yields were high in 1977 and low in 1978, but the yields were similar with all three methods of seedbed preparation in each year.

In 1979, soybean yields were significantly higher in the chemically prepared than in the tilled plots. The higher yield could be due to less evaporation and better water conservation with the chemical method of seedbed preparation.

Once again in 1980, there were no significant differences, but in 1981 and 1982 the chemical and mechanical methods of seedbed preparation outyielded the chemical/mechanical method of seedbed preparation. Yields in the chemically prepared seedbed were higher than soybean yields from the mechanically prepared seedbed, but the differences were not significant.

For the first four years of the study it appeared that the method of seedbed preparation had little effect on soybean yields in a continuous soybean system. Soybean yields were highest in the chemically prepared seedbed in the last four years of the study. However, this might be misleading because of two drouthy spots that were observed within the mechanically and chemically/mechanically prepared seedbed treatments in the first and second ranges. The soybeans in these plots appeared to dry up, but the symptoms were not consistent over the whole plots, and were not apparent in the third and fourth ranges. Therefore, we felt that this condition was not a result of the method of seedbed preparation, but was a condition present in the soil. Because of this problem, it can not be concluded that the chemically prepared seedbed was superior to the tillage plots in the continuous soybean system.

Soybean Yields in a Soybean-Grain Sorghum Rotation.

Soybean yields in the soybean-grain sorghum rotation are represented in the graph in Figure 6, and will be referred to throughout this section.

Soybean yields were high in 1975 and low in 1976, but no significant differences occurred due to method of seedbed preparation in either year.

In 1977, soybean yields were high in all plots once again. Yields were significantly higher in the chemically/mechanically prepared seedbed than in the mechanically prepared seedbed, but the difference was small.

Because of poor growing conditions, low soybean yields resulted in 1978, and again no significant differences were apparent due to method of seedbed preparation.

In 1979, soybean yields were highest in the chemically prepared seedbed and lowest in the mechanically prepared seedbed. Since 1979 was a marginal year for rainfall, the differences in yields might have been caused by a difference in available moisture levels. The greatest amount of surface evaporation would take place in the mechanically prepared seedbeds and the least amount in the chemically prepared seedbeds. If moisture was a limiting factor, plants in the mechanically prepared seedbeds would be stressed more quickly than the other treatments.

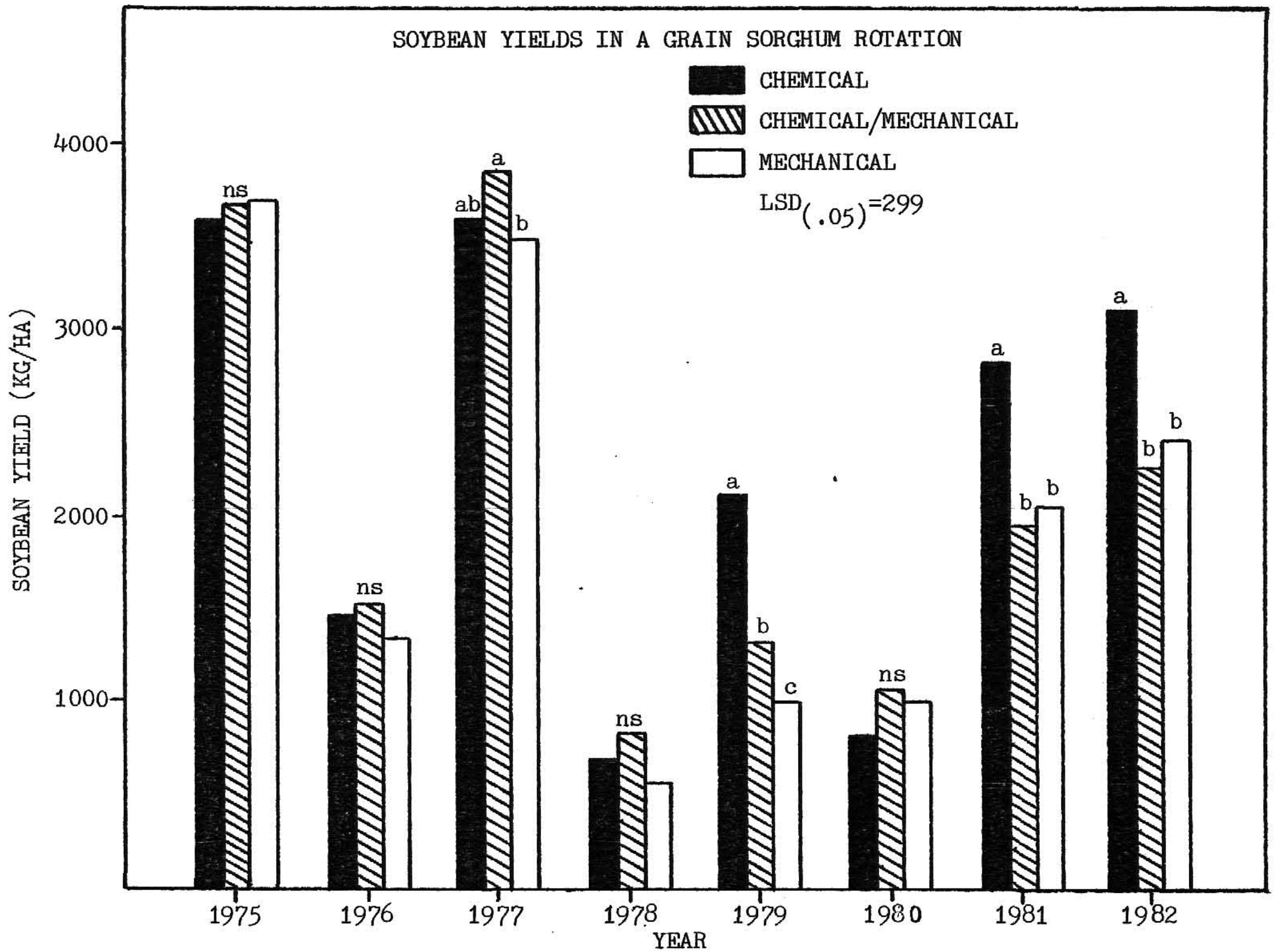

Figure 6. Effect of seedbed preparation on soybean yields in a soybean-grain sorghum crop rotation in eight years.

The summer of 1980 was extremely hot and dry. Consequently, all the soybeans were adversely affected and low soybean yields were harvested from all the plots.

As was the case in 1979, soybean yields from the chemically prepared seedbed plots were significantly higher than soybean yields from the tillage plots in both 1981 and 1982. Better water conservation in the chemically prepared seedbeds was probably the reason for the higher yields.

There was little or no difference in soybean yields from the soybean-grain sorghum rotation the first four years of the study. A different trend was observed in the last four years. In three of the last four years, soybean yields were significantly higher when grown with the chemical method of seedbed preparation than when grown with the use of preplant tillage. Better performance in the chemically prepared seedbed could be attributed to less evaporation and better water conservation in these plots.

Comparisons of All Soybean Production Systems.

Yields.

Least significant differences can also be computed to compare the soybean yields of each treatment within each year. The year by year soybean yield data is presented in Tables 14 through 21.

Soybean yields in the continuous soybean system were significantly lower than soybean yields from the soybean-wheat rotation or the soybean-grain sorghum rotation in 1975.

In 1976, yields were higher when soybeans were grown in either rotation than when grown continuously, although the differences were not significant in all situations. There were no significant differences between soybean yields from the soybean-grain sorghum rotation or the soybean-wheat rotation.

A similar trend in soybean performance occurred in 1977. Soybean yields from all tillage treatments in the continuous soybean system were significantly lower than yields from the soybean-wheat rotation or the soybean-sorghum rotation. Soybean yields from the chemically/mechanically prepared seedbed in the soybean-wheat rotation were significantly higher than yields from the mechanically prepared seedbed in the soybean-sorghum rotation. Otherwise, no significant differences in yields were apparent from the soybean-wheat rotation and the soybean-sorghum rotation.

Poor growing conditions existed in 1978 and soybean yields were low, but the same pattern of soybean yields was apparent. There were no significant differences in soybean yields in the soybean-wheat or soybean-sorghum rotations, with one exception. Soybean yields were significantly higher in the mechanically prepared seedbed of the soybean-wheat rotation than in the mechanically prepared seedbed of the soybean-sorghum rotation. Yields from the continuous soybean plots were lower than all other treatments, although yields from the mechanically prepared seedbed of the soybean-sorghum rotation were not significantly higher.

In 1979, soybean yields varied greatly with many significant differences between treatments. Basically, soybeans grown in the soybean-wheat rotation were higher yielding than all other treatments. These were followed by soybean yields from the chemically prepared seedbed of continuous soybeans. Soybean yields were lowest with the mechanical and chemical/mechanical methods of seedbed preparation in a continuous soybean system.

Due to hot and dry conditions in 1980, soybean yields were low in all plots. Again soybean yields were higher from the soybean-wheat rotation than from the other cropping sequences, but few significant differences occurred.

In 1981, soybean yields were highest in the chemically prepared seedbed of the soybean-sorghum rotation, along with all the soybeans grown in the soybean-wheat rotation. The lowest yields occurred in the mechanically and chemically/mechanically prepared seedbeds of the continuous soybeans and the soybean-sorghum rotation.

Soybean yields in 1982 were similar to those of 1981. Soybean yields were highest in the chemically prepared seedbed of the soybean-sorghum rotation and in the plots where soybeans were grown in the soybean-wheat rotation. Soybean yields were lower from the chemically/mechanically prepared seedbed of continuous soybeans than from all other treatments.

Generally, it appears that when soybeans are grown in a rotation, they perform better than when grown continuously. In most years soybean yields were highest when grown in the soybean-wheat rotation. Usually, soybean yields from the chemically prepared seedbed of the soybean-sorghum rotation were similar to the yields of the soybeans in the soybean-wheat rotation. Soybeans in the soybean-sorghum rotation where preplant tillage was performed generally had intermediate soybean yields. Soybean yields were lowest from the continuous soybean systems most of the time. Apparently there is an advantage to growing soybeans in a crop rotation.

Plant and Grain Characteristics for 1981 and 1982.

Several plant characteristics beside soybean yields were also collected in 1981 and 1982. Plant height, grain moisture, weight per 100 seeds, and nitrogen, phosphorus, and potassium content of the harvested grain were recorded and analyzed. This data is presented in Tables 22 through 26.

In 1981, plant height, seed weight, and grain moisture levels were higher for the soybeans grown in the soybean-wheat rotation than for the soybeans grown continuously or in the soybean-sorghum rotation. These differences can be correlated to the higher soybean yields that resulted from the soybean-wheat rotation. Plant height and seed weight levels were also higher in the chemically prepared seedbeds than where tillage was included in the seedbed preparation. Again these differences can be correlated to higher soybean yields in these plots.

When the nutrient content of the harvested soybeans was analyzed, the nitrogen levels were significantly lower from the soybean-wheat rotation and the chemically prepared seedbeds. This again can be associated to higher yields in these situations. Nitrogen content of grains are generally lower when high seed weights and high yields occur. Only small differences in phosphorus and potassium content of the soybeans resulted.

There were no significant differences in grain moisture due to cropping sequence or method of seedbed preparation in 1982. As in 1981, plant height, and seed weights were highest for the soybeans grown in the soybean-wheat rotation and the soybeans grown in the chemically prepared seedbeds. As before, these differences can be associated with the higher yields under these conditions.

No significant differences in grain nutrient levels occurred due to cropping sequence or method of seedbed preparation in 1982.

Soybeans

Table 14. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1975.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Wheat	Mechanical	4010
Soybean-Wheat	Chem/Mech	3920
Soybean-Wheat	Chemical	3830
Soybean-Sorghum	Mechanical	3670
Soybean-Sorghum	Chem/Mech	3660
Soybean-Sorghum	Chemical	3590
Soybean-Soybean	Chem/Mech	3120
Soybean-Soybean	Chemical	3020
Soybean-Soybean	Mechanical	2800
LSD (.05)		390

Table 15. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1976.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Sorghum	Chemical	1630
Soybean-Wheat	Chem/Mech	1600
Soybean-Wheat	Mechanical	1560
Soybean-Sorghum	Chem/Mech	1540
Soybean-Wheat	Chemical	1490
Soybean-Sorghum	Mechanical	1360
Soybean-Soybean	Chem/Mech	1110
Soybean-Soybean	Chemical	990
Soybean-Soybean	Mechanical	770
LSD (.05)		390

Table 16. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1977.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Wheat	Chem/Mech	3900
Soybean-Sorghum	Chem/Mech	3850
Soybean-Wheat	Mechanical	3740
Soybean-Sorghum	Chemical	3610
Soybean-Wheat	Chemical	3600
Soybean-Sorghum	Mechanical	3500
Soybean-Soybean	Chemical	2990
Soybean-Soybean	Chem/Mech	2990
Soybean-Soybean	Mechanical	2970
LSD (.05)		390

Table 17. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1978.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Wheat	Mechanical	960
Soybean-Wheat	Chemical	860
Soybean-Wheat	Chem/Mech	860
Soybean-Sorghum	Chem/Mech	820
Soybean-Sorghum	Chemical	720
Soybean-Sorghum	Mechanical	570
Soybean-Soybean	Chemical	260
Soybean-Soybean	Chem/Mech	210
Soybean-Soybean	Mechanical	180
LSD (.05)		390

Table 18. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1979.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Wheat	Chemical	2550
Soybean-Wheat	Chem/Mech	2340
Soybean-Wheat	Mechanical	2270
Soybean-Sorghum	Chemical	2090
Soybean-Soybean	Chemical	1690
Soybean-Sorghum	Chem/Mech	1320
Soybean-Sorghum	Mechanical	990
Soybean-Soybean	Chem/Mech	930
Soybean-Soybean	Mechanical	930
LSD (.05)		390

Table 19. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1980.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Wheat	Chemical	1400
Soybean-Wheat	Mechanical	1330
Soybean-Wheat	Chem/Mech	1290
Soybean-Soybean	Chemical	1200
Soybean-Soybean	Chem/Mech	1070
Soybean-Sorghum	Chem/Mech	1060
Soybean-Soybean	Mechanical	1050
Soybean-Sorghum	Mechanical	1000
Soybean-Sorghum	Chemical	840
LSD (.05)		390

Table 20. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1981.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Sorghum	Chemical	2820
Soybean-Wheat	Chemical	2750
Soybean-Wheat	Mechanical	2700
Soybean-Wheat	Chem/Mech	2510
Soybean-Soybean	Chemical	2180
Soybean-Sorghum	Mechanical	2050
Soybean-Soybean	Mechanical	1950
Soybean-Sorghum	Chem/Mech	1940
Soybean-Soybean	Chem/Mech	1520
LSD (.05)		390

Table 21. Combined effect of cropping sequence and seedbed preparation on soybean yields in 1982.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Soybean-Sorghum	Chemical	3100
Soybean-Wheat	Chem/Mech	3030
Soybean-Wheat	Mechanical	2930
Soybean-Wheat	Chemical	2890
Soybean-Soybean	Chemical	2500
Soybean-Sorghum	Mechanical	2420
Soybean-Sorghum	Chem/Mech	2240
Soybean-Soybean	Mechanical	2210
Soybean-Soybean	Chem/Mech	1760
LSD (.05)		390

Table 22. Effect of cropping sequence and seedbed preparation on soybean plant height and seed weight in 1981.

	Plant Height (cm)	Seed Weight (Gms/100 seeds)
Cropping Sequence		
Continuous Soybeans	96	13.25
Soybean-Wheat Rotation	107	16.48
Soybean-Sorghum Rotation	97	14.89
LSD (.05)	9	.59
Method of Seedbed Preparation		
Chemical	103	15.35
Chemical/Mechanical	97	14.55
Mechanical	100	14.73
LSD (.05)	4	61

Table 23. Effect of treatments on soybean grain moisture content in 1981.

Treatment	% Moisture
Continuous Soybeans	
Chemical	9.3
Chemical/Mechanical	9.4
Mechanical	9.4
Soybeans-Wheat	
Chemical	10.1
Chemical/Mechanical	9.7
Mechanical	9.6
Soybeans-Sorghum	
Chemical	9.3
Chemical/Mechanical	9.3
Mechanical	9.3

LSD (.05) Within a Cropping Sequence = .2

LSD (.05) Between All Treatments = .3

Table 24. Effect of cropping sequence and seedbed preparation on soybean grain moisture, plant height, and seed weight in 1982.

	Moisture (%)	Plant Height (cm)	Seed Wt. (Gms/100 sds)
Cropping Sequence			
Continuous Soybeans	11.6	92.8	15.64
Soybeans-Wheat	11.3	105.0	17.05
Soybeans-Sorghum	11.6	100.9	16.77
LSD (.05)	NS	6.9	NS
Method of Seedbed Preparation			
Chemical	11.5	104.0	17.57
Chemical/Mechanical	[illegible]	96.3	15.75
Mechanical	[illegible]	98.4	16.15
LSD (.05)	NS	4.9	1.07

Table 25. Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested soybeans in 1981.

Cropping Sequence	N (%)	P (%)	K (%)
Continuous Soybeans	6.26	.619	1.98
Soybeans-Wheat	5.89	.629	2.03
Soybeans-Sorghum	6.12	.628	2.01
LSD (.05)	.13	NS	.05
Method of Seedbed Preparation			
Chemical	6.01	.628	2.01
Chemical/Mechanical	6.13	.625	2.01
Mechanical	6.13	.622	2.00
LSD (.05)	.08	NS	NS

Table 26. Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested soybeans in 1982.

Cropping Sequence	N (%)	P (%)	K (%)
Continuous Soybeans	6.21	.646	1.90
Soybeans-Wheat	5.90	.664	1.96
Soybeans-Sorghum	5.89	.651	1.88
LSD (.05)	NS	NS	NS
Method of Seedbed Preparation			
Chemical	5.99	.664	1.94
Chemical/Mechanical	5.98	.641	1.88
Mechanical	6.03	.657	1.93
LSD (.05)	NS	NS	NS

Grain Sorghum

A significant three-way interaction also was revealed when the grain sorghum yields were analyzed. Therefore, LSD values can be computed to compare the three methods of seedbed preparation within each cropping sequence and year.

Grain Sorghum Yields in a Continuous Cropping System.

The continuous grain sorghum yield data is presented in Figure 7 and will be referred to throughout this section.

No significant differences in grain sorghum yields were apparent due to method of seedbed preparation the first three years of the study, even though yields varied greatly from year to year.

By 1978, an annual grass infestation of fall panicum and large crabgrass had developed in the chemically prepared seedbed of the continuous grain sorghum. Consequently, grain sorghum yields were significantly higher in the mechanically prepared seedbed than in the chemically prepared seedbed, probably due to competition from the annual grasses in the chemically prepared seedbeds.

In 1979, 1980, and 1981 no significant differences in grain sorghum yields occurred due to method of seedbed preparation.

Competition from fall panicum and large crabgrass was relieved in the chemically prepared seedbeds in 1981 and 1982 with the use of acetanilide herbicides and safened seed.

Grain sorghum yields were significantly higher in the chemically prepared seedbed than in the mechanically prepared seedbed in 1982. This difference could be associated with the improved grass control in conjunction with better water conservation in the chemically prepared seedbeds.

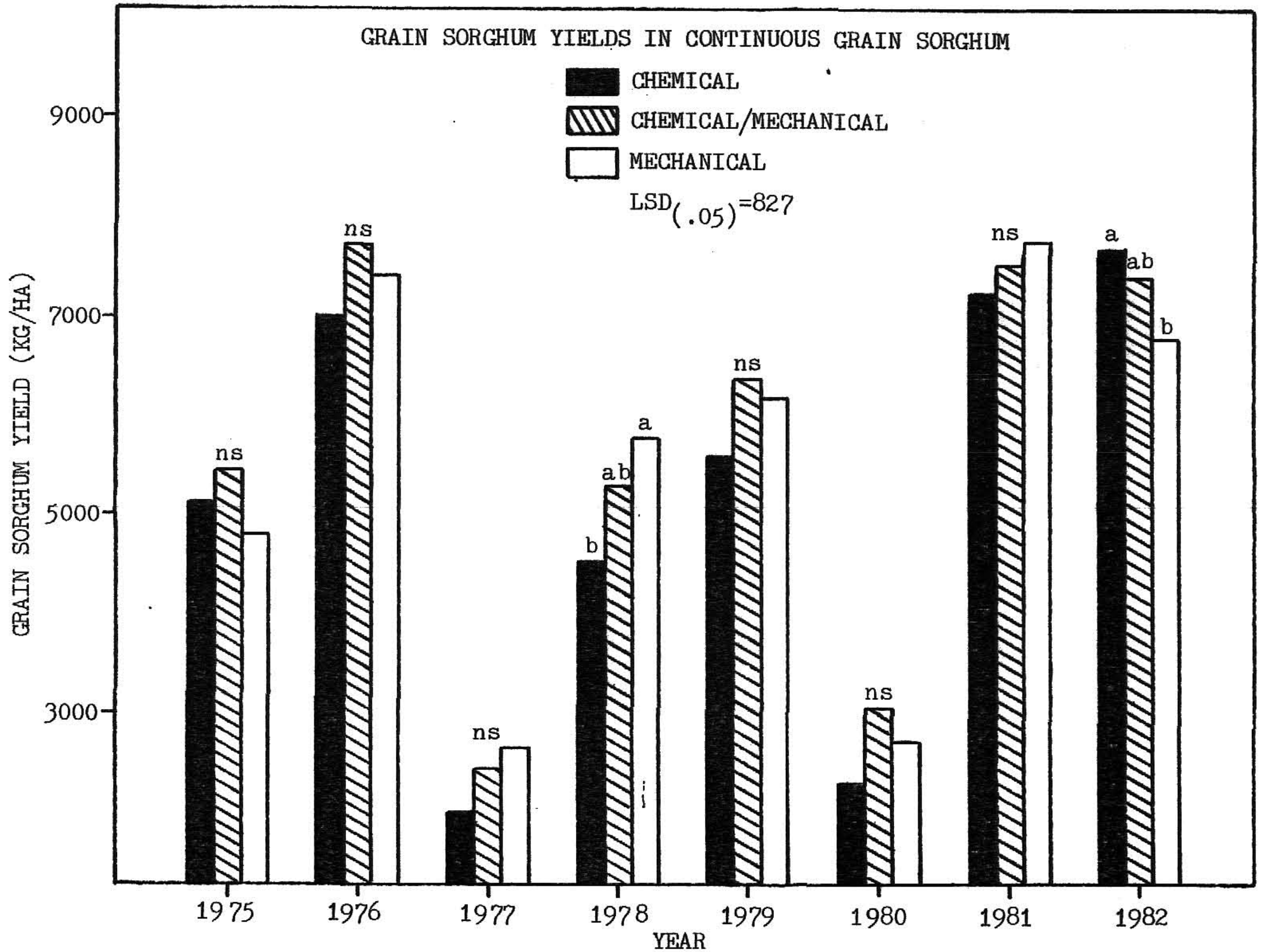

Figure 7. Effect of seedbed preparation on grain sorghum yields in a continuous grain sorghum cropping system in eight years.

For most of the study there were no significant differences in grain sorghum yields due to method of seedbed preparation in the continuously cropped grain sorghum. The annual grass problem that evolved in the chemically prepared seedbed resulted in significantly lower yields in only one year. Perhaps the competition from the annual grasses was offset by better water conservation in the chemically prepared seedbeds. With the use of more effective grass herbicides, higher grain sorghum yields might be possible in the chemically prepared seedbeds because of less competition and better moisture conservation.

Grain Sorghum Yields in a Grain Sorghum-Soybean Rotation.

Grain sorghum yields from the grain sorghum-soybean rotation are presented in Figure 8, and will be referred to throughout this section.

Grain sorghum yields were not significantly different in the first year of the study, but in 1976 grain sorghum yields were significantly higher from the chemically prepared seedbed than where preplant tillage was performed. This difference could be a result of better water conservation in the chemically prepared seedbed.

Due to a severe chinch bug infestation in grain sorghum plots in 1977, low yields occurred in all plots. Grain sorghum yields were not influenced by method of seedbed preparation.

In 1978, grain sorghum yields were significantly higher in the chemically and chemically/mechanically prepared seedbeds than in the mechanically prepared seedbeds.

Good growing conditions in 1979 resulted in higher grain sorghum yields. Hot and dry conditions in 1980 resulted in low grain sorghum yields. However, in both years, grain sorghum yields were signifi-

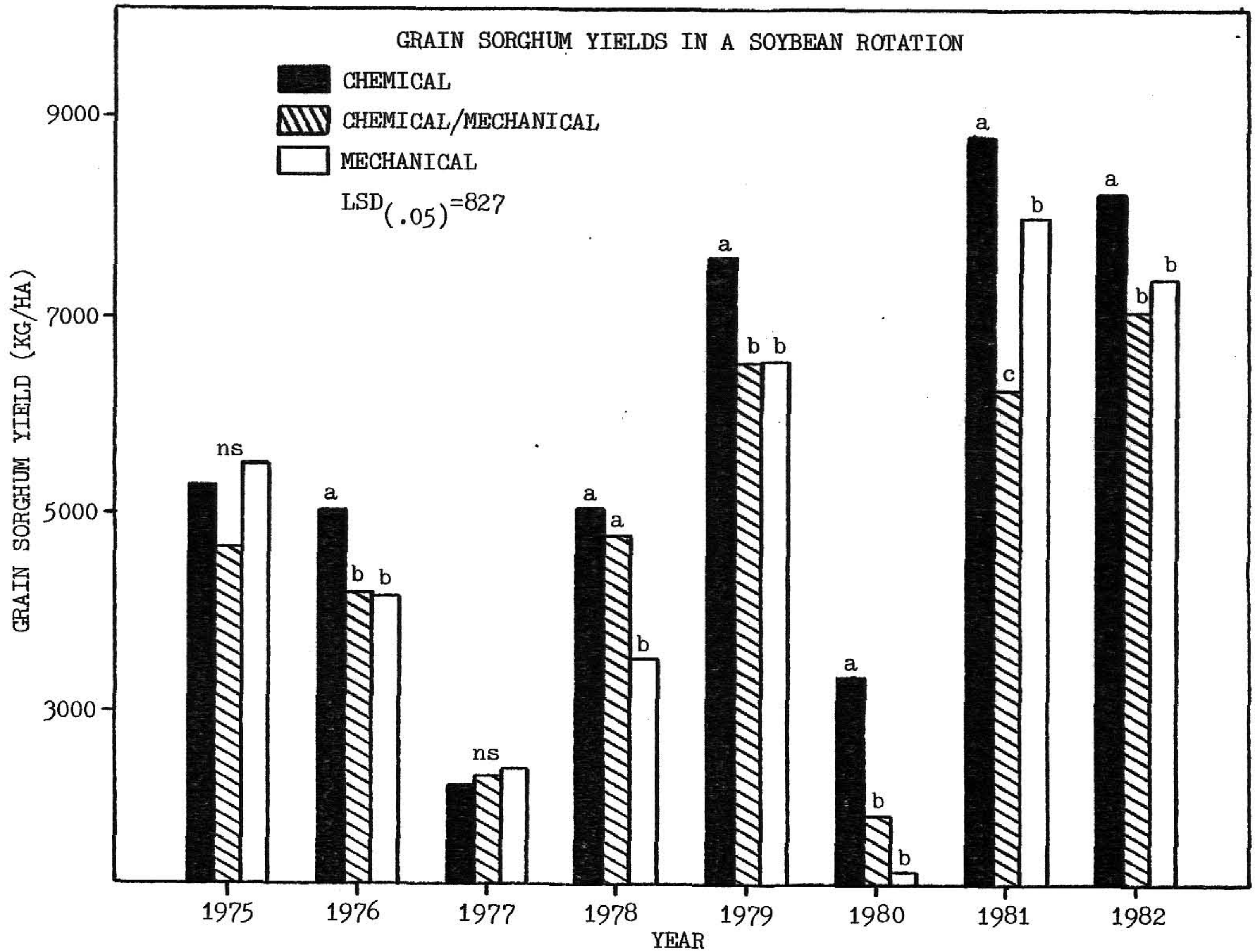

Figure 8. Effect of seedbed preparation on grain sorghum yields in a grain sorghum-soybean crop rotation in eight years.

cantly higher from the chemically prepared seedbeds than from the tilled plots.

A similar pattern of grain sorghum yields occurred in 1981 and 1982. Grain sorghum yields were significantly higher from the chemically prepared seedbed than where the mechanical or chemical/ mechanical methods of seedbed preparation were used.

In every year in which there were significant differences, grain sorghum yields in the grain sorghum-soybean rotation were highest with the chemical method of seedbed preparation. The increased yields were probably related to better water infiltration, reduced evaporation, and more available moisture in the chemically prepared seedbeds.

Comparisons of All Grain Sorghum Production Systems.

Yields.

Least significant difference values can be computed to compare grain sorghum yields of treatments in different cropping sequences in each year. Yield data of all grain sorghum treatments is presented in Tables 27 through 34, and will be referred to in this section.

In the initial year of the study no significant differences in grain sorghum yields resulted between any of the treatments.

In 1976, grain sorghum yields were significantly higher where the grain sorghum was grown continuously than where grown in the grain sorghum-soybean rotation. With the modest amount of nitrogen fertilizer applied to the plots, higher grain sorghum yields might be expected from the grain sorghum-soybean rotation due to the nitrogen fixing properties of soybeans. However, this did not occur.

Grain sorghum planted in the chemically prepared seedbeds often exhibited slower seed germination and less seedling vigor than the grain sorghum planted in the tillage plots. This difference in growth patterns was attributed to lower soil temperatures in the chemically prepared seedbeds. In certain years, a difference in flowering dates could be detected, but the grain sorghum was not delayed enough to prevent the plants from reaching full maturity.

A severe chinch bug infestation was a problem in all the grain sorghum plots in 1977. The insect pressure and injury appeared to be more severe in the chemically prepared seedbeds because of the smaller, more succulent plants. The less vigorous early season growth that resulted from the lower soil temperatures in the chemically prepared seedbeds could be detrimental to sorghum production under insect stress. Grain sorghum yields were lower in the chemically prepared seedbeds, but not significantly lower than the other treatments as all the yields were low because of the chinch bug injury.

In 1978, the continuous grain sorghum yields were higher than the yields from the grain sorghum-soybean rotation, except for the grain sorghum from the chemically prepared seedbed of the grain sorghum-soybean rotation. Yields from these plots were equivalent to those of the continuous grain sorghum.

Grain sorghum yields were significantly higher from the chemically prepared seedbed of the grain sorghum-soybean rotation than from all other treatments in 1979. The chemically prepared seedbed where grain sorghum was grown continuously had significantly lower yields than all the grain sorghum grown in the grain sorghum-soybean rotation. No significant differences were evident between any of the remaining treatments.

In 1980, yields were higher for the grain sorghum grown continuously and the chemically prepared seedbed of the grain sorghum-soybean rotation than for the grain sorghum grown in the grain sorghum-soybean rotation with the mechanical and chemical/mechanical methods of seedbed preparation.

As was the case in 1980, grain sorghum yields were highest in the chemically prepared seedbed of the grain sorghum-soybean rotation in both 1981 and 1982. Yields of the remaining treatments did not seem to follow any particular pattern.

In the early years of the study, grain sorghum yields were higher from the plots where grain sorghum was grown continuously. Grain sorghum yields were highest from the chemically prepared seedbed of the grain sorghum-soybean rotation each of the last four years. Yields may be enhanced in this system of sorghum production because of better water conservation compared to the tillage seedbeds, and lack of annual grass competition compared to the chemically prepared seedbed of continuous grain sorghum. There appeared to be little difference in performance of the remaining treatments.

1981 and 1982 Plant and Grain Characteristics.

Plant height, grain test weight, grain moisture, and grain content of nitrogen, phosphorus, and potassium were also collected from the grain sorghum plots in 1981 and 1982. The results are presented in Tables 35 through 40.

Test weight was not significantly influenced by cropping sequence in either 1981 or 1982. Due to method of seedbed preparation, the test weights were significantly higher in the mechanically prepared seedbeds than where tillage was reduced in both years.

The moisture content of the grain was significantly higher for the grain sorghum grown continuously than for the grain sorghum-soybean rotation in 1981 and 1982. The moisture content was also higher in both years for the grain sorghum grown in the chemically prepared seedbeds than where grown with tillage. This difference might indicate a delay in maturity in the chemically prepared seedbeds.

There were no significant differences in sorghum plant height in 1981. In 1982, the grain sorghum plants tended to be taller in the chemically prepared seedbeds, especially in the grain sorghum-soybean rotation.

Another phenomenon that was observed in both years, but was not recorded, was an increased number of tillers with reduced tillage. This was probably a result of lower soil temperatures in the chemically prepared seedbeds. It has been documented that lower soil temperatures enhanced tillering in grain sorghum.

When the nitrogen content of the grain was analyzed, the nitrogen content of the grain sorghum was significantly higher from grain sorghum grown in the grain sorghum-soybean rotation than when grown continuously. This might indicate a greater amount of available nitrogen and nitrogen uptake from the plots in the grain sorghum-soybean rotation. The modest level of nitrogen fertilizer applied to the plots may not be adequate to promote optimum growth of the grain sorghum under continuous sorghum production.

No significant differences in phosphorus content of the grain were evident due to cropping sequence in either year. The phosphorus content of the grain sorghum was higher where tillage was reduced than from the mechanically prepared seedbeds. There has been some question about the availability of surface applied phosphorus in reduced tillage systems. These results indicate that phosphorus was just as available or even more available from surface applications than where the fertilizer was incorporated.

The potassium studies were similar to the results with the phosphorus. Little difference in potassium content of grain was apparent due to cropping sequence in either year. However, the potassium content of the grain sorghum was significantly higher from the reduced tillage systems than from the mechanically prepared seedbeds. There appears to be no availability problem with potassium where grain sorghum is produced in reduced tillage systems.

Sorghum

Table 27. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1975.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum-Sorghum	Chem/Mech	5460
Sorghum-Soybeans	Chemical	5300
Sorghum-Sorghum	Chemical	5150
Sorghum-Soybeans	Mechanical	4890
Sorghum-Sorghum	Mechanical	4770
Sorghum-Soybeans	Chem/Mech	4710
LSD (.05)		NS

Table 28. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1976.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum-Sorghum	Chem/Mech	7770
Sorghum-Sorghum	Mechanical	7430
Sorghum-Sorghum	Chemical	7030
Sorghum-Soybeans	Chemical	5060
Sorghum-Soybeans	Chem/Mech	4180
Sorghum-Soybeans	Mechanical	4170
LSD (.05)		809

Table 29. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1977.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum-Sorghum	Mechanical	2550
Sorghum-Sorghum	Chem/Mech	2500
Sorghum-Soybeans	Mechanical	2400
Sorghum-Soybeans	Chem/Mech	2360
Sorghum-Soybeans	Chemical	2270
Sorghum-Sorghum	Chemical	1970
LSD (.05)		NS

Table 30. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1978.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum-Sorghum	Mechanical	5790
Sorghum-Sorghum	Chem/Mech	5240
Sorghum-Soybeans	Chemical	5120
Sorghum-Sorghum	Chemical	4510
Sorghum-Soybeans	Chem/Mech	4170
Sorghum-Soybeans	Mechanical	3520
LSD (.05)		809

Table 31. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1979.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum-Soybeans	Chemical	7620
Sorghum-Soybeans	Mechanical	6560
Sorghum-Soybeans	Chem/Mech	6540
Sorghum-Sorghum	Chem/Mech	6360
Sorghum-Sorghum	Mechanical	6240
Sorghum-Sorghum	Chemical	5600
LSD (.05)		809

Table 32. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1980.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum-Soybeans	Chemical	3360
Sorghum-Sorghum	Chem/Mech	3060
Sorghum-Sorghum	Mechanical	2720
Sorghum-Sorghum	Chemical	2350
Sorghum-Soybeans	Chem/Mech	1970
Sorghum-Soybeans	Mechanical	1350
LSD (.05)		809

Table 33. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1981.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum - Soybeans	Chemical	8860
Sorghum - Soybeans	Mechanical	7970
Sorghum - Sorghum	Mechanical	7660
Sorghum - Sorghum	Chem/Mech	7460
Sorghum - Sorghum	Chemical	7180
Sorghum - Soybeans	Chem/Mech	6300
LSD (.05)		809

Table 34. Combined effect of cropping sequence and seedbed preparation on grain sorghum yields in 1975.

Cropping Sequence	Seedbed Preparation	Yield (kg/ha)
Sorghum - Soybeans	Chemical	8230
Sorghum - Sorghum	Chemical	7610
Sorghum - Sorghum	Chem/Mech	7350
Sorghum - Soybeans	Mechanical	7300
Sorghum - Soybeans	Chem/Mech	7050
Sorghum - Sorghum	Mechanical	6740
LSD (.05)		809

Table 35. Effect of cropping sequence and seedbed preparation on grain sorghum test weight, grain moisture, and plant height in 1981.

	Test Weight (kg/hl)	Moisture (%)	Plant Height (cm)
Cropping Sequence			
Continuous Sorghum	75.7	18.8	131
Sorghum-Soybeans	76.6	17.9	131
LSD (.05)	NS	.7	NS
Method of Seedbed Preparation			
Chemical	75.5	19.1	130
Chemical/Mechanical	75.7	18.0	133
Mechanical	77.4	17.9	131
LSD (.05)	1.0	.9	NS

Table 36. Effect of cropping sequence and seedbed preparation on grain sorghum test weight and grain moisture in 1982.

	Test Weight (kg/hl)	Moisture (%)
Cropping Sequence		
Continuous Sorghum	74.7	15.4
Sorghum-Soybeans	75.9	14.1
LSD (.05)	NS	.3
Method of Seedbed Preparation		
Chemical	74.0	15.5
Chemical/Mechanical	75.8	14.4
Mechanical	76.0	14.2
LSD (.05)	1.1	.4

Table 37. Effect of treatments on grain sorghum plant height in 1982.

Treatment	Plant Height (cm)
Continuous Sorghum	
Chemical	133
Chemical/Mechanical	127
Mechanical	133
Sorghum-Soybeans	
Chemical	133
Chemical/Mechanical	128
Mechanical	126

LSD (.05) Within a Cropping Sequence = 4

LSD (.05) Between All Treatments = 6

Table 38. Effect of cropping sequence and seedbed preparation on nitrogen, phosphorus, and potassium content of the harvested grain sorghum in 1981.

Cropping Sequence	N (%)	P (%)	K (%)
Continuous Sorghum	1.43	.326	.40
Sorghum-Soybeans	1.70	.327	.37
LSD (.05)	.13	NS	.02
Method of Seedbed Preparation			
Chemical	1.54	.332	.40
Chemical/Mechanical	1.60	.339	.40
Mechanical	1.55	.309	.36
LSD (.05)	NS	.021	.03

Table 39. Effect of cropping sequence and seedbed preparation on phosphorusand potassium content of the harvested grain sorghum in 1982.

	P (%)	K (%)
Cropping Sequence		
Continuous Sorghum	.337	.38
Sorghum-Soybeans	.371	.38
LSD (.05)	NS	NS
Method of Seedbed Preparation		
Chemical	.352	.39
Chemical/Mechanical	.369	.39
Mechanical	.340	.36
LSD (.05)	.023	.01

Table 40. Effect of treatments on nitrogen content of the harvested grain sorghum in 1982.

Treatment	N (%)
Continuous Sorghum	
Chemical	1.24
Chemical/Mechanical	1.20
Mechanical	1.18
Sorghum-Soybeans	
Chemical	1.52
Chemical/Mechanical	1.71
Mechanical	1.71

LSD (.05) Within a Cropping Sequence = .13

LSD (.05) Between a Cropping Sequence = .16

Soil Fertility Patterns

Soil samples taken from each plot following harvest of each crop, were analyzed for phosphorus, potassium, organic matter, and soil pH. Statistical analysis for each element was made by crop, for the crop previously harvested from the individual plots. The data was analyzed in this manner because the soil samples were taken at different times of the year; fertility levels in the same cropping sequence may vary following the different crops and because the other data was also analyzed with this method.

In 1981, soil samples were taken to a depth of 30 cm and divided into 5 cm increments. Most of the differences appeared in the 0-5 cm increment. Few differences appeared in the subsurface layers, and where they did, the differences were inconsistent.

Since the surface layer is the region of primary concern and this was the layer where most of the variation occurred in 1981, soil samples were taken from the 0-2 cm layer in 1982.

Each fertility aspect will be discussed separately. In most cases there was no significant interaction between cropping sequence and method of seedbed preparation; however, in some instances there was a significant interaction.

Phosphorus

When the phosphorus levels were examined in the suface 0-5 cm layer of the wheat plots in 1981 (Table 41), the available phosphorus levels were significantly higher where wheat had been grown in the wheat-soybean rotation than where wheat had been grown continuously. However, this difference did not hold up in 1982 (Table 42). In 1982, the phosphorus levels were significantly higher in the 0-2 cm layer where wheat was grown continuously than when grown in the wheat-soybean rotation. Since the soil samples from the wheat-soybean rotation were taken from a different set of plots in 1981 and 1982, this difference was probably due to a variation in phosphorus levels across the experimental area.

Due to the method of seedbed preparation, no significant differences appeared in available phosphorus in the surface 0-5 cm layer of the wheat plots in 1981. Phosphorus levels were significantly higher near the surface of the soil in the chemically prepared seedbeds than in the mechanically prepared seedbeds in 1982.

The available phosphorus levels appeared to be higher near the surface of the soil when soybeans were grown in rotation than when grown continuously in both 1981 and 1982 (Table 43 and 44).

Available phosphorus levels were also significantly higher in the soil surface layers where soybeans were grown with the chemical method of seedbed preparation than where grown with the mechanical method of seedbed preparation.

In the grain sorghum plots, available phosphorus levels were higher in the grain sorghum-soybean rotation than in continuous grain sorghum in both 1981 and 1982 (Table 45 and 46). This might indicate that phosphorus uptake was greater for the grain sorghum than the soybeans. However, the opposite appeared to be taking place when the soybean plots were analyzed; so no conclusions can be drawn on this subject.

Phosphorus levels in the grain sorghum plots were significantly higher near the surface of the soil in the chemically prepared seedbeds than in the mechanically prepared seedbeds both years of the study.

Because of the variation of phosphorus levels from one end of the study to the other, and conflicting results of phosphorus levels in the different crops, few conclusions can be made about how the phosphorus levels are affected by crops and cropping sequence. Phosphorus levels were highest near the soil surface in the chemically prepared seedbeds in all situations. The surface accumulation of phosphorus in chemically prepared seedbeds can be attributed to the surface application of phosphorus fertilizer and the immobility of phosphorus in the soil.

When the sub-surface layers were analyzed for phosphorus content in 1981, few differences appeared in any situations. The phosphorus levels did not appear to be higher at greater depths of the soil where the fertilizer was incorporated in the mechanically prepared seedbeds. Phosphorus levels in the sub-surface layers are presented in the appendix (Tables 65 to 67).

Potassium

In both 1981 and 1982, exchangeable potassium levels were significantly higher near the surface of the soil where wheat was grown continuously than where wheat was grown in the wheat-soybean rotation (Tables 47 and 48). This might indicate that soybeans absorb more potassium than wheat does.

The chemically prepared seedbeds of the wheat plots had higher potassium concentrations near the soil surface than the mechanically prepared seedbeds. The difference was significant in 1982, but not in 1981, possibly due to the different increments sampled. The results indicate an accumulation of exchangeable potassium near the surface of the soil in the chemically prepared seedbeds.

Results from the soybean plots (Tables 49 and 50) supported the findings from the wheat plots. Exchangeable potassium concentrations were significantly higher at the soil surface where the soybeans were grown in rotation than where grown continuously. This might be an indication that soybeans are an intense user of potassium.

When method of seedbed preparation was examined for the soybean plots, there were no significant differences in 1981; but the potassium concentration of the 0-2 cm layer was significantly higher in the chemically prepared seedbeds than in the mechanically prepared seedbeds in 1982.

Analysis of exchangeable potassium levels near the surface of the soil in the grain sorghum plots (Tables 51 and 52) indicated no significant differences due to cropping sequence or method of seedbed preparation.

It appears that potassium uptake might have been greater for soybeans than for wheat. Potassium concentrations were similar in the grain sorghum and soybean plots. The exchangeable potassium content tended to to be highest near the soil surface in the chemically prepared seedbeds when wheat and soybeans were grown. No significant differences in potassium content were apparent due to method of seedbed preparation in the grain sorghum plots. Surface accumulation of potassium may occur in no-till systems because of residual potassium deposits at the soil surface from decomposition of surface residue.

Tables of the potassium levels below the 0-5 cm range in 1981 are presented in the appendix.

Organic Matter

In 1981 or 1982, organic matter content of the soil surface layer of the wheat plots differed little due to cropping sequence (Tables 53 and 54). Organic matter levels were higher at the soil surface in the chemically prepared seedbeds than where tillage was performed in both years. This could be expected if the surface residue was not mixed into the soil.

Soybean organic matter levels (Tables 55 and 56) at the soil surface were higher in soybean-sorghum and soybean-wheat rotations than where soybeans were grown continuously. Soybeans do not produce as much residue as grain sorghum or wheat.

As was the case with wheat plots, organic matter levels in soybean plots were higher near the surface of the soil in the chemically prepared seedbeds than in the mechanically prepared seedbeds.

The organic matter content of the surface soil layer was not affected by cropping sequence in the grain sorghum plots (Tables 57 and 58). However, there was a higher level of organic matter in the soil surface layer in the chemically prepared seedbeds than where tillage was performed in the grain sorghum plots.

The organic matter content of the surface layer of the soil appeared to be higher where wheat and grain sorghum were grown than where soybeans were grown. Soybeans do not leave as much residue on the soil surface as wheat or grain sorghum.

Organic matter levels were significantly higher near the surface of the soil in the chemically prepared seedbeds than where tillage was performed. This difference would be expected since the surface residue is not mixed into the soil in the chemically prepared seedbeds.

High organic matter levels at the soil surface could affect herbicide use. With an increase in organic matter comes an increase in cation exchange capacity of the soil, which in turn reduces the activity and effectiveness of many herbicides. Consequently, soils high in organic matter require higher rates of some herbicides to achieve the same level of weed control.

Few differences in organic matter levels appeared in the subsurface layers of the soil in 1981. Tables containing this data are presented in the appendix.

Soil pH

Like organic matter, soil pH can also affect herbicide activity. Low soil pH's can transform certain herbicides into an inactive form and reduce their effectiveness.

Several researchers have found that soil pH decreased faster at the soil surface with no-till corn production than with conventionally tilled corn, due to the acidifying effect of surface applied nitrogen fertilizer. If soil pH is lowered more quickly with no-till crop production, it could require more frequent liming of the soil or complicate weed control.

The soil pH at the surface of the soil in the wheat plots tended to be slightly lower where wheat was grown continuously than where grown in the wheat-soybean rotation (Tables 59 and 60). There were no significant differences in soil pH due to method of seedbed preparation, except for the wheat-soybean rotation in 1982. In this case, the pH was higher in the chemically prepared seedbed than where tillage was performed. The higher pH in the chemically prepared seedbed was not expected and can not be explained.

No significant differences in soil pH of the surface layer of the soybean plots occurred in 1981 or 1982 due to cropping sequence or method of seedbed preparation (Tables 61 and 62).

In the grain sorghum plots no significant differences in surface soil pH resulted from cropping sequence in 1981 (Tables 63). In 1982 (Table 64), the pH was significantly lower in the soil surface layer where grain sorghum was grown in the grain sorghum-soybean rotation than in continuous sorghum.

Due to method of seedbed preparation, the pH in the soil surface layer of the grain sorghum plots was significantly lower in chemically prepared seedbeds than in mechanically prepared seedbeds in both years of the study.

Although some differences in soil pH were apparent between the three crops, few differences occurred when the data was analyzed by crop. The soil pH was slightly lower in the surface soil layer of the chemically prepared seedbeds in some instances, but not to the extent that was expected. Most of the previous research was conducted on no-till corn production where 150 to 225 kg/ha of nitrogen fertilizer was applied to the soil. Perhaps the smaller nitrogen fertilizer applications and the high buffering capacity of the soil reduced the drop in soil pH that is usually noted in no-till systems. A reduction in soil surface pH may not be as big a problem in these reduced tillage cropping systems as in no-till corn production.

Table 41. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-5 cm soil layer of the wheat plots in 1981.

	P (μgm/Gm of Soil)
Cropping Sequence	
Continuous Wheat	140
Wheat-Soybeans	168
LSD (.05)	22
Method of Seedbed Preparation	
Chemical	161
Chemical/Mechanical	143
Mechanical	158
LSD (.05)	NS

Table 42. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-2 cm soil layer of the wheat plots in 1982.

	P (μgm/Gm of Soil)
Cropping Sequence	
Continuous Wheat	128
Wheat-Soybeans	103
LSD (.05)	8
Method of Seedbed Preparation	
Chemical	139
Chemical/Mechanical	102
Mechanical	105
LSD (.05)	14

Table 43. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-5 cm soil layer of the soybean plots in 1981.

	P (μgm/Gm of Soil)
Cropping Sequence	
Continuous Soybeans	152
Soybeans-Sorghum	119
Soybeans-Wheat	159
LSD (.05)	23
Method of Seedbed Preparation	
Chemical	153
Chemical/Mechanical	145
Mechanical	131
LSD (.05)	18

Table 44. Effect of treatments on available phosphorus concentration in the 0-2 cm soil layer of the soybean plots in 1982.

	P (μgm/Gm of Soil)
Continuous Soybeans	
Chemical	143
Chemical/Mechanical	103
Mechanical	99
Soybeans-Sorghum	
Chemical	176
Chemical/Mechanical	104
Mechanical	103
Soybeans-Wheat	
Chemical	152
Chemical/Mechanical	153
Mechanical	127

LSD (.05) Between All Treatments = 17
LSD (.05) Within a Cropping Sequence = 14

Table 45. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the 0-5 cm soil layer of the grain sorghum plots in 1981.

	P (μgm/Gm of Soil)
Cropping Sequence	
Continuous Grain Sorghum	145
Grain Sorghum-Soybeans	154
LSD (.05)	4
Method of Seedbed Preparation	
Chemical	158
Chemical/Mechanical	140
Mechanical	125
LSD (.05)	26

Table 46. Effect of treatments on available phosphorus concentration in the 0-2 cm soil layer in the grain sorghum plots in 1982.

	P (μgm/Gm of Soil)
Continuous Grain Sorghum	
Chemical	168
Chemical/Mechanical	114
Mechanical	99
Grain Sorghum-Soybeans	
Chemical	168
Chemical/Mechanical	148
Mechanical	132

LSD (.05) Between All Treatments = 30
LSD (.05) Within a Cropping Sequence = 19

Table 47. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-5 cm soil layer of the wheat plots in 1981.

	K (μgm/Gm of Soil)
Cropping Sequence	
Continuous Wheat	609
Wheat-Soybeans	494
LSD (.05)	114
Method of Seedbed Preparation	
Chemical	567
Chemical/Mechanical	551
Mechanical	536
LSD (.05)	NS

Table 48. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-2 cm soil layer of the wheat plots in 1982.

	K (μgm/Gm of Soil)
Cropping Sequence	
Continuous Wheat	769
Wheat-Soybeans	627
LSD (.05)	127
Method of Seedbed Preparation	
Chemical	964
Chemical/Mechanical	608
Mechanical	522
LSD (.05)	143

Table 49. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-5 cm soil layer of the soybean plots in 1981.

	K (μgm/Gm of Soil)
Cropping Sequence	
Continuous Soybeans	360
Soybeans-Sorghum	447
Soybeans-Wheat	484
LSD (.05)	72
Method of Seedbed Preparation	
Chemical	431
Chemical/Mechanical	442
Mechanical	419
LSD (.05)	NS

Table 50. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-2 cm soil layer of the soybean plots in 1982.

	K (μgm/Gm of Soil)
Cropping Sequence	
Continuous Soybeans	499
Soybeans-Sorghum	625
Soybeans-Wheat	699
LSD (.05)	168
Method of Seedbed Preparation	
Chemical	643
Chemical/Mechanical	611
Mechanical	570
LSD (.05)	60

Table 51. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-5 cm soil layer of the grain sorghum plots in 1981.

	K (µgm/Gm of Soil)
Cropping Sequence	
Continuous Grain Sorghum	414
Grain Sorghum-Soybeans	438
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	421
Chemical/Mechanical	420
Mechanical	437
LSD (.05)	NS

Table 52. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the 0-2 cm soil layer of the grain sorghum plots in 1982.

	K (µgm/Gm of Soil)
Cropping Sequence	
Continuous Grain Sorghum	411
Grain Sorghum-Soybeans	465
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	404
Chemical/Mechanical	455
Mechanical	455
LSD (.05)	NS

Table 53. Effect of cropping sequence and seed preparation on organic matter in the 0-5 cm soil layer of the wheat plots in 1981.

	Organic Matter (%)
Cropping Sequence	
Continuous Wheat	2.5
Wheat-Soybeans	2.6
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	2.8
Chemical/Mechanical	2.5
Mechanical	2.4
LSD (.05)	.2

Table 54. Effect of treatments on organic matter in the 0-2 cm soil layer of the wheat plots in 1982.

	Organic Matter (%)
Continuous Wheat	
Chemical	5.5
Chemical/Mechanical	3.0
Mechanical	3.1
Wheat-Soybeans	
Chemical	3.6
Chemical/Mechanical	2.9
Mechanical	2.9

LSD (.05) Between All Treatments = .7

LSD (.05) Within a Cropping Sequence = .4

Table 55. Effect of treatments on organic matter in the 0-5 cm soil layer of the soybean plots in 1981.

	Organic Matter (%)
Continuous Soybeans	
Chemical	2.5
Chemical/Mechanical	2.4
Mechanical	2.1
Soybeans-Sorghum	
Chemical	2.9
Chemical/Mechanical	3.0
Mechanical	2.8
Soybeans-Wheat	
Chemical	2.8
Chemical/Mechanical	2.4
Mechanical	2.5

LSD (.05) Between All Treatments = .3
LSD (.05) Within A Cropping Sequence = .2

Table 56. Effect of cropping sequence and seedbed preparation on organic matter in the 0-2 cm soil layer of the soybean plots in 1982.

Cropping Sequence	Organic Matter (%)
Continuous Soybeans	2.3
Soybeans-Sorghum	2.9
Soybeans-Wheat	2.9
LSD (.05)	.2
Method of Seedbed Preparation	
Chemical	3.2
Chemical/Mechanical	2.5
Mechanical	2.4
LSD (.05)	.3

Table 57. Effect of cropping sequence and seedbed preparation on organic matter in the 0-5 cm soil layer of the grain sorghum plots in 1981.

	Organic Matter (%)
Cropping Sequence	
Continuous Grain Sorghum	2.9
Grain Sorghum-Soybeans	2.8
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	3.2
Chemical/Mechanical	2.8
Mechanical	2.6
LSD (.05)	.3

Table 58. Effect of cropping sequence and seedbed prepration on organic matter in the 0-2 cm soil layer of the grain sorghum plots in 1982.

	Organic Matter (%)
Cropping Sequence	
Continuous Grain Sorghum	2.9
Grain Sorghum-Soybeans	2.9
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	3.5
Chemical/Mechanical	2.6
Mechanical	2.6
LSD (.05)	.2

Table 59. Effect of cropping sequence and seedbed preparation on soil pH in the 0-5 cm soil layer of the wheat plots in 1981.

	Soil pH
Cropping Sequence	
Continuous Wheat	5.2
Wheat-Soybeans	5.4
LSD (.05)	.2
Method of Seedbed Preparation	
Chemical	5.3
Chemical/Mechanical	5.4
Mechanical	5.3
LSD (.05)	NS

Table 60. Effect of treatments on soil pH in the 0-2 cm soil layer of the wheat plots in 1982.

	Soil pH
Continuous Wheat	
Chemical	5.3
Chemical/Mechanical	5.3
Mechanical	5.4
Wheat-Soybeans	
Chemical	6.1
Chemical/Mechanical	5.6
Mechanical	5.6

LSD (.05) Between All Treatments = .3
LSD (.05) Within a Cropping Sequence = .2

Table 61. Effect of cropping sequence and seedbed preparation on soil pH in the 0-5 cm soil layer of the soybean plots in 1981.

	Soil pH
Cropping Sequence	
Continuous Soybeans	5.7
Soybeans-Sorghum	5.6
Soybeans-Wheat	5.8
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	5.7
Chemical/Mechanical	5.7
Mechanical	5.7
LSD (.05)	NS

Table 62. Effect of cropping sequence and seedbed preparation on soil pH in the 0-2 cm soil layer of the soybean plots in 1982.

	Soil pH
Cropping Sequence	
Continuous Soybeans	6.1
Soybeans-Sorghum	6.0
Soybeans-Wheat	6.1
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	6.2
Chemical/Mechanical	6.0
Mechanical	6.1
LSD (.05)	NS

Table 63. Effect of cropping sequence and seedbed preparation on soil pH in the 0-5 cm soil layer of the grain sorghum plots in 1981.

	Soil pH
Cropping Sequence	
Continuous Grain Sorghum	5.9
Grain Sorghum-Soybeans	5.8
LSD (.05)	NS
Method of Seedbed Preparation	
Chemical	5.7
Chemical/Mechanical	5.9
Mechanical	5.9
LSD (.05)	.1

Table 64. Effect of cropping sequence and seedbed preparation on soil pH in the 0-2 cm soil layer of the grain sorghum plots in 1982.

	Soil pH
Cropping Sequence	
Continuous Grain Sorghum	5.8
Grain Sorghum-Soybeans	5.5
LSD (.05)	.1
Method of Seedbed Preparation	
Chemical	5.5
Chemical/Mechanical	5.6
Mechanical	5.7
LSD (.05)	.2

SUMMARY

Field experiments indicate that conservation tillage is feasible and possibly advantageous in terms of crop yields, provided the proper cultural practices are utilized.

Little variation in wheat yields in the wheat-soybean rotation resulted from the method of seedbed preparation. However, in the continuous wheat system, yields were significantly lower in reduced tillage systems because of severe downy brome competition. The downy brome populations could not be controlled without tillage or crop rotation. Wheat yields were generally better in the wheat-soybean rotation than when wheat was grown continuously, provided that rainfall was adequate.

Soybean yields were equal to or better in chemically prepared seedbeds than in mechanically prepared seedbeds in each of the cropping sequences. Yields were also higher when soybeans were grown in rotation than when grown continuously. No planting problems or abnormal weed problems developed in any soybean plots.

Grain sorghum yields were higher from chemically prepared seedbeds than from mechanically prepared seedbeds in the grain sorghum-soybean rotation, possibly due to better water conservation. In the continuous grain sorghum plots little variation in yields resulted from method of seedbed preparation, even with pressure from fall panicum and large crabgrass in the chemically prepared seedbeds. Grain sorghum yields were higher from the grain sorghum-soybean rotation than from the continuous grain sorghum when the chemically prepared seedbeds were compared.

However, when tillage was included in the seedbed preparation, grain sorghum yields were higher when grain sorghum was grown continuously than when grown in the grain sorghum-soybean rotation.

No-till crop production requires a high level of management and continuous observation. Crop rotations are also beneficial in no-till crop production.

Phosphorus, potassium, and organic matter levels were higher near the soil surface in the chemically prepared seedbeds than in tilled plots. In some cases, the pH was slightly lower at the soil surface in the chemically prepared seedbeds than in the tilled seedbeds, but not to the extent that was expected.

Phosphorus levels were lower in the soil surface layers in the grain sorghum plots than in the wheat or soybean plots. Potassium levels were lower where soybeans were produced than where wheat or grain sorghum was grown. Organic matter was highest in grain sorghum plots and lowest in soybean plots, reflecting the relative amounts of residue produced by each crop. Soil pH did not appear to be affected by cropping sequence.

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APPENDIX

Table 65. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1981.

	Available Phosphorus (μ gm/Gm of Soil)				
	Soil Layer (cm)				
Treatment	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Wheat	106	72	53	35	30
Wheat-Soybeans	107	78	60	45	37
LSD (.05)	NS	NS	NS	NS	NS
Method of Seedbed Preparation					
Chemical	112	76	59	44	36
Chemical/Mechanical	109	80	56	39	30
Mechanical	97	70	54	38	33
LSD (.05)	NS	NS	NS	NS	NS

Table 66. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Treatment	Available Phosphorus (μgm/Gm of Soil) Soil Layer (cm)				
	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Soybeans	69	36	23	14	11
Soybeans-Wheat	110	68	51	27	17
Soybeans-Sorghum	71	44	31	22	18
LSD (.05)	23	22	21	NS	NS
Method of Seedbed Preparation					
Chemical	81	52	40	25	18
Chemical/Mechanical	86	47	32	19	15
Mechanical	83	49	32	18	13
LSD (.05)	NS	NS	NS	NS	NS

Table 67. Effect of cropping sequence and seedbed preparation on available phosphorus concentration in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

	Available Phosphorus (μ gm/Gm of Soil)				
	Soil Layer (cm)				
Treatment	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Grain Sorghum	63	36	23	13	9
Grain Sorghum-Soybeans	76	44	33	15	10
LSD (.05)	NS	NS	NS	NS	NS
Method of Seedbed Preparation					
Chemical	69	40	27	13	9
Chemical/Mechanical	70	39	27	15	10
Mechanical	69	40	29	13	10
LSD (.05)	NS	NS	NS	NS	NS

Table 68. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1982.

	Exchangeable Potassium (μgm/Gm of Soil)				
	Soil Layer (cm)				
Treatment	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Wheat	431	318	287	288	280
Wheat-Soybeans	362	312	290	285	278
LSD (.05)	NS	NS	NS	NS	NS
Method of Seedbed Preparation					
Chemical	393	318	289	291	226
Chemical/Mechanical	402	315	282	276	271
Mechanical	379	313	294	293	290
LSD (.05)	NS	NS	NS	NS	NS

Table 69. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Treatment	Exchangeable Potassium (μgm/Gm of Soil) Soil Layer (cm)				
	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Soybeans	256	210	220	229	226
Soybeans-Wheat	373	318	314	316	302
Soybeans-Sorghum	318	240	221	213	205
LSD (.05)	NS	98	73	51	43
Method of Seedbed Preparation					
Chemical	320	259	250	257	253
Chemical/Mechanical	319	255	250	252	245
Mechanical	307	252	254	249	231
LSD (.05)	NS	NS	NS	NS	NS

Table 70. Effect of cropping sequence and seedbed preparation on exchangeable potassium concentration in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

	Exchangeable Potassium (μgm/Gm of Soil)				
	Soil Layer (cm)				
Treatment	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Grain Sorghum	287	232	213	232	231
Grain Sorghum-Soybeans	305	255	246	261	254
LSD (.05)	NS	NS	NS	16	7
Method of Seedbed Preparation					
Chemical	317	251	226	247	242
Chemical/Mechanical	292	239	226	242	241
Mechanical	280	240	237	251	245
LSD (.05)	23	NS	NS	NS	NS

Table 71. Effect of cropping sequence and seedbed preparation on organic matter in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1981.

Treatment	Organic Matter (%) Soil Layer (cm) 5-10	10-15	15-20	20-25
Cropping Sequence				
Continuous Wheat	2.2	2.0	1.9	1.7
Wheat-Soybeans	2.2	2.0	1.9	1.7
LSD (.05)	NS	NS	NS	NS
Method of Seedbed Preparation				
Chemical	2.2	2.0	2.0	1.7
Chemical/Mechanical	2.2	2.0	1.9	1.7
Mechanical	2.1	2.0	1.9	1.7
LSD (.05)	NS	NS	NS	NS

Table 72. Effect of treatments on organic matter in the 25-30 cm soil layer of the wheat plots at Manhattan, Kansas in 1981.

Treatment	25-30 cm Layer
Continuous Wheat	
Chemical	1.6
Chemical/Mechanical	1.7
Mechanical	1.7
Wheat-Soybeans	
Chemical	1.7
Chemical/Mechanical	1.5
Mechanical	1.6

LSD (.05) Within a Cropping Sequence = .2

LSD (.05) Between All Treatments = .2

Table 73. Effect of cropping sequence and seedbed preparation on organic matter in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Treatment	Organic Matter (%) Soil Layer (cm)				
	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Soybeans	2.1	2.1	2.0	1.9	1.8
Soybeans-Wheat	2.2	2.0	2.0	1.9	1.8
Soybeans-Sorghum	2.5	2.4	2.3	2.0	1.8
LSD (.05)	.3	.2	.3	NS	NS
Method of Seedbed Preparation					
Chemical	2.3	2.2	2.1	2.0	1.8
Chemical/Mechanical	2.4	2.2	2.1	1.9	1.7
Mechanical	2.2	2.1	2.1	1.9	1.8
LSD (.05)	NS	NS	NS	NS	NS

Table 74. Effect of cropping sequence and seedbed preparation on organic matter in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

	Organic Matter (%) Soil Layer (cm)				
Treatment	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Grain Sorghum	2.4	2.2	2.1	2.0	1.8
Grain Sorghum-Soybeans	2.4	2.2	2.1	2.0	1.8
LSD (.05)	NS	NS	NS	NS	NS
Method of Seedbed Preparation					
Chemical	2.3	2.2	2.1	2.0	1.9
Chemical/Mechanical	2.4	2.2	2.0	2.0	1.8
Mechanical	2.4	2.3	2.2	2.0	1.8
LSD (.05)	NS	NS	.1	NS	NS

Table 75. Effect of cropping sequence and seedbed preparation on soil pH in the subsurface soil layers of the wheat plots at Manhattan, Kansas in 1981.

Treatment	Soil pH				
	Soil Layer (cm)				
	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Wheat	5.4	5.6	5.8	6.0	6.2
Wheat-Soybeans	5.6	5.7	5.8	6.1	6.2
LSD (.05)	.1	.1	NS	NS	NS
Method of Seedbed Preparation					
Chemical	5.5	5.6	5.8	6.0	6.2
Chemical/Mechanical	5.4	5.6	5.8	6.1	6.2
Mechanical	5.5	5.6	5.8	6.1	6.3
LSD (.05)	.1	NS	NS	NS	.1

Table 76. Effect of cropping sequence and seedbed preparation on soil pH in the subsurface soil layers of the soybean plots at Manhattan, Kansas in 1981.

Treatment	Soil pH				
	Soil Layer (cm)				
	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Soybeans	5.8	5.8	5.8	6.1	6.1
Soybeans-Wheat	5.6	5.6	5.7	5.9	6.0
Soybeans-Grain Sorghum	5.7	5.5	5.7	5.9	6.1
LSD (.05)	NS	.2	.1	NS	NS
Method of Seedbed Preparation					
Chemical	5.7	5.6	5.7	5.9	6.0
Chemical/Mechanical	5.7	5.6	5.7	5.9	6.1
Mechanical	5.7	5.7	5.8	6.0	6.1
LSD (.05)	NS	.1	.1	.1	NS

Table 77. Effect of cropping sequence and seedbed preparation on soil pH in the subsurface soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

	Soil pH				
	Soil Layer (cm)				
Treatment	5-10	10-15	15-20	20-25	25-30
Cropping Sequence					
Continuous Grain Sorghum	5.9	5.9	5.9	6.2	6.3
Grain Sorghum-Soybeans	5.9	5.9	6.0	6.1	6.2
LSD (.05)	NS	NS	NS	NS	NS
Method of Seedbed Preparation					
Chemical	5.8	5.9	5.9	6.1	6.2
Chemical/Mechanical	5.9	5.9	5.9	6.1	6.2
Mechanical	5.9	5.9	6.0	6.2	6.3
LSD (.05)	NS	NS	NS	NS	NS

Table 78. Analysis of Variance of the effect of year, cropping sequence, and seedbed preparation on wheat yields at Manhattan, Kansas.

Source	d.f.	Mean Square
Year	7	23505058
Error (a)	24	272276
Cropping Sequence	1	9301558
Year x Cropping Sequence	7	1524360
Error (b)	24	120116
Seedbed Preparation	2	3189176
Cropping Sequence x Seedbed Preparation	2	2729661
Year x Seedbed Preparation	14	793772
Year x Cropping Sequence x Seedbed Preparation	14	682109
Error (c)	96	58619

Table 79. Analysis of Variance of the effect of year, cropping sequence, and seedbed preparation on soybean yields in Manhattan, Kansas.

Source	d.f.	Mean Square
Year	7	41144214
Error (a)	24	266711
Cropping Sequence	2	13448243
Year x Cropping Sequence	14	433832
Error (b)	48	134909
Seedbed Preparation	2	1073054
Cropping Sequence x Seedbed Preparation	4	347772
Year x Seedbed Preparation	14	389425
Year x Cropping Sequence x Seedbed Preparation	28	87231
Error (c)	144	46537

Table 80. Analysis of Variance of the effect of year, cropping sequence, and seedbed preparation on grain sorghum yields at Manhattan, Kansas.

Source	d.f.	Mean Square
Year	7	97482837
Error (a)	24	2276900
Cropping Sequence	1	7114406
Year x Cropping Sequence	7	8073784
Error (b)	24	280718
Seedbed Preparation	2	2039597
Cropping Sequence x Seedbed Preparation	2	10852079
Year x Seedbed Preparation	14	713678
Year x Cropping Sequence x Seedbed Preparation	14	784442
Error (c)	96	347375

Table 81. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture and test weight of winter wheat at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square: Grain Moisture (%)	Mean Square: Test Weight (Kg/Hl)
Replication	3	.143	22.344
Cropping Sequence	1	.042	.010
Error (a)	3	.009	3.733
Seedbed Preparation	2	.222	12.885
Cropping Sequence x Seedbed Preparation	2	.012	5.510
Error (b)	12	.109	2.476

Table 82. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture and test weight of winter wheat at Manhattan, Kansas in 1982.

Source	d.f.	Mean Square: Grain Moisture (%)	Mean Square: Test Weight (Kg/Hl)
Replication	3	.018	17.978
Cropping Sequence	1	.010	5.869
Error (a)	3	.030	3.297
Seedbed Preparation	2	.033	7.678
Cropping Sequence x Seedbed Preparation	2	.058	3.508
Error (b)	12	.054	3.516

Table 83. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height, and seed weight of the soybeans at Manhattan, Kansas in 1981.

		Mean Square		
Source	d.f.	Grain Moisture (%)	Plant Height (cm)	Seed (gms) Weight (100 seeds)
Replication	3	.040	37.657	.551
Cropping Sequence	2	1.019	429.194	31.125
Error (a)	6	.076	81.269	.348
Seedbed Preparation	2	.048	140.528	2.109
Cropping Sequence x Seedbed Preparation	4	.078	17.194	.648
Error (b)	18	.015	23.009	.513

Table 84. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height, and seed weight of the soybeans at Manhattan, Kansas in 1982.

		Mean Square		
Source	d.f.	Grain Moisture (%)	Plant Height (cm)	Weight (100 seeds)
Replication	3	.178	174.324	4.887
Cropping Sequence	2	.299	460.083	6.701
Error (a)	6	.151	48.157	2.638
Seedbed Preparation	2	.022	188.583	10.958
Cropping Sequence x Seedbed Preparation	4	.071	40.042	3.252
Error (b)	18	.185	32.185	1.551

Table 85. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height and test weight of the grain sorghum at Manhattan, Kansas in 1981.

		Mean Square		
Source	d.f.	Grain Moisture (%)	Plant Height (cm)	Test Weight (Kg/Hl)
Replication	3	.529	65.111	2.099
Cropping Sequence	1	5.320	.167	2.802
Error (a)	3	.299	28.611	.402
Seedbed Preparation	2	3.362	15.542	5.460
Cropping Sequence x Seedbed Preparation	2	.552	26.792	.222
Error (b)	12	.741	22.944	.485

Table 86. Analysis of Variance of the effect of cropping sequence and seedbed preparation on grain moisture, plant height and test weight of the grain sorghum at Manhattan, Kansas in 1982.

		Mean Square		
Source	d. f.	Grain Moisture (%)	Plant Height (cm)	Test Weight (Kg/Hl)
Replication	3	.441	12.153	.295
Cropping Sequence	1	10.140	22.042	9.170
Error (a)	3	.054	13.042	1.034
Seedbed Preparation	2	3.733	72.042	9.690
Cropping Sequence x Seedbed Preparation	2	.421	38.792	.745
Error (b)	12	.140	8.139	.942

Table 87. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K) content of the grain harvested from the wheat plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square N(%)	P(%)	K(%)
Replication	3	.138	.01491	.01909
Cropping Sequence	1	.457	.03139	.01927
Error (a)	3	.093	.00176	.00099
Seedbed Preparation	2	.145	.00459	.01140
Cropping Sequence x Seedbed Preparation	2	.179	.00966	.00612
Error (b)	12	.025	.00326	.00288

Table 88. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K) content of the grain harvested from the wheat plots at Manhattan, Kansas in 1982.

Source	d.f.	Mean Square N(%)	P(%)	K(%)
Replication	3	.034	.00106	.00040
Cropping Sequence	1	.012	.00001	.00094
Error (a)	3	.017	.00032	.00057
Seedbed Preparation	2	.008	.00026	.00113
Cropping Sequence x Seedbed Preparation	2	.009	.00058	.00011
Error (b)	12	.011	.00044	.00050

Table 89. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K), content of the grain harvested from the soybean plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square		
		N(%)	P(%)	K(%)
Replication	3	.051	.00053	.01003
Cropping Sequence	2	.411	.00035	.00880
Error (a)	6	.016	.00012	.00245
Seedbed Preparation	2	.061	.00011	.00047
Cropping Sequence x Seedbed Preparation	4	.022	.00013	.00101
Error (b)	18	.008	.00012	.00177

Table 90. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P) and potassium (K), content of the grain harvested from the soybean plots at Manhattan, Kansas in 1982.

Source	d.f.	Mean Square		
		N(%)	P(%)	K(%)
Replication	3	.146	.00050	.00937
Cropping Sequence	2	.385	.00105	.02141
Error (a)	6	.159	.00546	.02028
Seedbed Preparation	2	.008	.00173	.01441
Cropping Sequence x Seedbed Preparation	4	.136	.00278	.01009
Error (b)	18	.152	.00235	.01252

Table 91. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P), and potassium (K) content of the grain harvested from the grain sorghum plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square		
		N(%)	P(%)	K(%)
Replication	3	.019	.00027	.00349
Cropping Sequence	1	.427	.00001	.00807
Error (a)	3	.010	.00025	.00014
Seedbed Preparation	2	.010	.00195	.00402
Cropping Sequence x Seedbed Preparation	2	.021	.00094	.00072
Error (b)	12	.010	.00038	.00098

Table 92. Analysis of Variance of the effect of cropping sequence and seedbed preparation on nitrogen (N), phosphorus (P), and potassium (K) content of the grain harvested from the grain sorghum plots at Manhattan, Kansas in 1982.

Source	d.f.	Mean Saure		
		N(%)	P(%)	K(%)
Replication	3	.013	.00058	.00043
Cropping Sequence	1	1.179	.00694	-0-
Error (a)	3	.009	.00153	.00130
Seedbed Preparation	2	.013	.00169	.00271
Cropping Sequence x Seedbed Preparation	2	.037	.00164	.00071
Error (b)	12	.008	.00045	.00055

Table 93. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the available phosphorus concentration in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	28547	14348	16329	17665	21145	20545
Cropping Sequence	1	17604	26	888	1001	2481	1442
Error (a)	3	1124	2354	2313	1147	1699	1637
Seedbed Preparation	2	3116	2004	843	245	349	270
Cropping Sequence x Seedbed Preparation	2	1207	3154	858	722	1580	1708
Error (a)	12	2511	2783	1515	1204	1081	878

Table 94. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the available phosphorus concentration in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	5043	8881	8366	6367	4878	2925
Cropping Sequence	2	21411	25870	12556	9740	2153	818
Error (a)	6	2159	2153	1916	1689	1172	891
Seedbed Preparation	2	6057	305	350	1040	644	207
Cropping Sequence x Seedbed Preparation	4	1934	486	629	344	258	64
Error (a)	18	1671	832	699	436	257	143

Table 95. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the available phosphorus concentration in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	2826	3858	4914	3243	791	81
Cropping Sequence	1	1908	4030	1504	2380	345	74
Error (a)	3	33	1734	686	272	95	19
Seedbed Preparation	2	29621	17	22	30	32	26
Cropping Sequence x Seedbed Preparation	2	611	54	35	100	126	7
Error (b)	12	2290	1630	789	381	130	26

Table 96. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the exchangeable potassium concentration in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	223929	155155	148523	118310	87480	69848
Cropping Sequence	1	319704	84135	1067	234	182	43
Error (a)	3	30761	16111	12829	8192	10628	8577
Seedbed Preparation	2	7911	4517	259	1134	2641	3094
Cropping Sequence x Seedbed Preparation	2	3320	4839	4608	6829	4414	5359
Error (b)	12	18722	24821	13762	8510	7298	7559

Table 97. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the exchangeable potassium content in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	16474	36339	35434	18005	18445	11566
Cropping Sequence	2	194877	165955	149000	139383	144903	126665
Error (a)	6	20604	57430	38379	21254	10530	7446
Seedbed Preparation	2	6281	2295	661	281	629	3318
Cropping Sequence x Seedbed Preparation	4	22712	2710	2012	1971	2473	2401
Error (b)	18	10166	3096	2939	2197	1960	2102

Table 98. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the exchangeable potassium concentration in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	66593	65059	50435	42207	35893	36207
Cropping Sequence	1	13443	7884	13020	24704	20475	12195
Error (a)	3	3827	4999	3499	2970	613	113
Seedbed Preparation	2	2829	11406	1539	1329	665	139
Cropping Sequence x Seedbed Preparation	2	3233	3811	721	127	67	265
Error (b)	12	10832	2628	2726	1898	1195	1402

Table 99. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	.0478	.2360	.1538	.0833	.0300	.0104
Cropping Sequence	1	.0150	.0038	.0004	.0417	.0417	.0338
Error (a)	3	.0206	.0482	.0038	.0072	.0317	.0126
Seedbed Preparation	2	.3054	.0538	.0029	.0150	.0013	.0279
Cropping Sequence x Seedbed Preparation	2	.0113	.0463	.0079	.0267	.0329	.0538
Error (b)	12	.0333	.0600	.0321	.0286	.0838	.0119

Table 100. Analysis of Variance of the effects of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	.0419	.0418	.0067	.0667	.0936	.1185
Cropping Sequence	2	.9211	.3611	.3286	.2636	.0308	.0036
Error (a)	6	.0663	.1059	.0453	.0725	.0242	.0355
Seedbed Preparation	2	.2853	.0678	.0553	.0019	.0258	.0286
Cropping Sequence x Seedbed Preparation	4	.0728	.0228	.0074	.0336	.0379	.0082
Error (b)	18	.0162	.0304	.0207	.0453	.0298	.0409

Table 101. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square					
		Soil Layer					
		0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	.5428	.6215	.5294	.3456	.5326	.2233
Cropping Sequence	1	.0817	.0204	.0067	.0067	.0104	.0150
Error (a)	3	.0294	.0049	.0056	.0033	.0215	.0406
Seedbed Preparation	2	.7617	.0117	.0217	.0454	.0088	.0304
Cropping Sequence x Seedbed Preparation	2	.0617	.0217	.0017	.0004	.0029	.0088
Error (b)	12	.0778	.0211	.0300	.0124	.0175	.0340

Table 102. Analysis of Variance of the effect of cropping sequence and seedbed preparation on the organic matter content in the different soil layers of the wheat plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square					
		Soil Layer					
		0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	.0371	.0383	.0933	.0660	.0949	.0971
Cropping Sequence	1	.1838	.2017	.0817	.0038	.0104	.0038
Error (a)	3	.0126	.0072	.0050	.0071	.0137	.0049
Seedbed Preparation	2	.0204	.0154	.0054	.0079	.0088	.0054
Cropping Sequence x Seedbed Preparation	2	.0013	.0204	.0004	.0238	.0054	.0038
Error (b)	12	.0136	.0057	.0090	.0103	.0060	.0018

Table 103. Analysis of Variance of the effect of cropping sequence and seedbed preparation on soil pH in the different soil layers of the soybean plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	.0911	.0763	.0677	.0985	.0884	.0566
Cropping Sequence	2	.1358	.0578	.2058	.1075	.1353	.0478
Error (a)	6	.0825	.0407	.0232	.0182	.0779	.0596
Seedbed Preparation	2	.0008	.0119	.0175	.0258	.0419	.0103
Cropping Sequence x Seedbed Preparation	4	.0092	.0040	.0083	.0021	.0132	.0036
Error (b)	18	.0190	.0293	.0036	.0056	.0094	.0047

Table 104. Analysis of Variance of the effect of cropping sequence and seedbed preparation on soil pH in the different soil layers of the grain sorghum plots at Manhattan, Kansas in 1981.

Source	d.f.	Mean Square Soil Layer 0-5 cm	5-10 cm	10-15 cm	15-20 cm	20-25 cm	25-30 cm
Replication	3	.0626	.0633	.1206	.1215	.1467	.2626
Cropping Sequence	1	.0204	.0017	-0-	.0038	.0067	.0104
Error (a)	3	.0215	.0117	.0011	.0038	.0067	.0060
Seedbed Preparation	2	.0704	.0104	.0079	.0129	.0104	.0200
Cropping Sequence x Seedbed Preparation	2	.0104	.0179	.0038	.0013	.0029	.0017
Error (b)	12	.0071	.0058	.0042	.0060	.0050	.0081

Table 105. Analysis of Variance of the effect of cropping sequence and seedbed preparation on available phosphorus, exchangeable potassium,organic matter, and soil pH of the 0-2 cm layer of the soil in the wheat plots at Manhattan, Kansas in 1982.

Source	d.f.	Mean Square			
		Phosphorus	Potassium	Organic Matter	pH
Replication	3	737	150627	.1722	.0526
Cropping Sequence	1	15759	489918	3.0817	1.0838
Error (a)	3	137	38279	.2006	.0515
Seedbed Preparation	2	13794	1756295	6.6150	.1400
Cropping Sequence x Seedbed Preparation	2	1047	1868	2.1014	.1850
Error (b)	12	618	68740	.0772	.0175

Table 106. Analysis of Variance of the effect of cropping sequence and seedbed preparation on available phosphorus, exchangeable potassium, organic matter and soil pH of the 0-2 cm layer of the soil in the soybean plots at Manhattan, Kansas in 1982.

Source	d.f.	Mean Square			
		Phosphorus	Potassium	Organic Matter	pH
Replication	3	178	65742	.0748	.0166
Cropping Sequence	2	10195	490078	1.2100	.0325
Error (a)	6	629	112496	.0259	.0621
Seedbed Preparation	2	29554	64119	2.3308	.1200
Cropping Sequence x Seedbed Preparation	4	5602	16094	.3008	.1225
Error (b)	18	345	19372	.1086	.0683

Table 107. Analysis of Variance of the effect of cropping sequence and seedbed preparation on available phosphorus exchangeable potassium, organic matter and soil pH of the 0-2 cm layer of the soil in the grain sorghum plots at Manhattan, Kansas in 1982.

Source	d.f.	Mean Square			
		Phosphorus	Potassium	Organic Matter	pH
Replication	3	2198	30038	.1682	.1071
Cropping Sequence	1	12331	69876	.0038	.5104
Error (a)	3	1596	187505	.2371	.0104
Seedbed Preparation	2	24038	27541	2.1929	.1314
Cropping Sequence x Seedbed Preparation	2	2948	2163	.0463	.0314
Error (b)	12	588	17200	.0335	.0333

CROP PRODUCTION AS AFFECTED BY CROPPING SEQUENCE AND METHOD OF SEEDBED PREPARATION IN CONSERVATION TILLAGE

by

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Field experiments were conducted from 1975 to 1982 at Manhattan, Kansas, to determine the effects of several conservation tillage systems on crop yields and soil fertility patterns under Kansas conditions. Grain sorghum (Sorghum bicolor (L.) Moench), soybeans (Glycine max (L.) Merrill), and wheat (Triticum aestivum L.) were grown continuously and in a soybean-wheat and a soybean-grain sorghum rotation. Within each treatment were three methods of seedbed preparation: mechanical, chemical/mechanical, and chemical. The mechanically prepared seedbeds were tilled as needed for weed control; the chemically/mechanically prepared seedbeds were tilled sparingly with an emphasis on chemical weed control; and the chemically prepared seedbeds were not tilled, relying totally on herbicides for weed control.

No planting problems occurred with soybeans, but there were planting problems with wheat and grain sorghum in the chemically prepared seedbeds. Because of heavy residues and compacted soils in the chemically prepared wheat seedbeds, acceptable plant stands could not be established in dry years with the wheat drill used. Low soil temperatures in the chemically prepared grain sorghum plots resulted in slower germination and seedling growth, making these plants more susceptible to chinch bug injury.

Weed control was excellent in all soybean plots regardless of cropping sequence or seedbed preparation. Weed control was adequate in grain sorghum plots except the chemically prepared seedbed in a continuous cropping system. Under these conditions an annual grass problem of large crabgrass (Digitaria sanguinalis (L.) Scop.), and fall panicum (Panicum dichotomiflorum Michx.) developed, but in 1981 and 1982 better control of the annual grasses was achieved with the use of an acetanilide herbicide and safened seed. As with grain sorghum, an annual grass problem developed in the chemically prepared seedbeds of continuous wheat. Downy brome (*Bromus tectorum* L.) infestations became very heavy and apparently can not be controlled without tillage or crop rotation.

Crop yields in the chemically prepared seedbeds were equivalent to or greater than in tilled plots, except in the continuous wheat, where downy brome competed. Yields were generally better when crops were grown in rotation than when grown continuously, except where grain sorghum was grown with the use of pre-plant tillage.

Soil fertility patterns were also affected by cropping sequence and seedbed preparation. Phosphorus, potassium, and organic matter levels were higher near the surface of the soil in the chemically prepared seedbeds than in tilled areas. The pH at the soil surface was lower in the chemically prepared seedbeds than in the tillage seedbeds in some cases, but not to the extent that was expected.

Phosphorus levels were lower in the soil surface layers in the grain sorghum plots than in wheat or soybean plots, possibly due to the high grain sorghum yields and corresponding phosphorus uptake in 1981 and 1982. Potassium levels were lower where soybeans were cropped than where wheat or grain sorghum was grown. Organic matter was highest in the grain sorghum plots and lowest in the soybean plots, reflecting the relative amounts of residue produced by each crop. The soil pH did not appear to be affected by cropping sequence.