Technical Bulletin TB04-05 November 2004

Agricultural
Experiment Station

College of
Agricultural Sciences

Department of
Soil and Crop Sciences

Department of
Bioagricultural Sciences
and Pest Management

Great Plains Systems
Research Unit – USDA

Sustainable Dryland Agroecosystem Management

D.G. Westfall
G.A. Peterson
F.B. Peairs
L. Sherrod
D.Poss
T. Shaver
K. Larson
D.L. Thompson
L.R. Ahuja
M.D. Koch
C.B. Walker

2004

SUSTAINABLE DRYLAND AGROECOSYSTEM MANAGEMENT[1]

D.G. Westfall[2], G.A. Peterson[2], F. B. Peairs[3], L.Sherrod[4], D. Poss[5], T. Shaver[5]
K. Larson[6], D.L. Thompson[5], L.R. Ahuja[7], M.D. Koch[5], and C. B. Walker[5]

A Cooperative Project
of the

Colorado Agricultural Experiment Station
Department of Soil and Crop Sciences
Department of Bioagricultural Sciences and Pest Management
Colorado State University
Fort Collins, Colorado

and the

USDA - Agriculture Research Service
Natural Resources Research Center
Great Plains Systems Research Unit
Fort Collins, Colorado

[1] Funding is provided by the Colorado Agricultural Experiment Station and USDA-ARS. The High Plains Regional Climate Center in Lincoln, NE provides weather data retrieval.

[2] Professors, Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO 80523

[3] Professor, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO 80523

[4] USDA-ARS Technician - Great Plains Systems Research Unit

[5] Research Associates, Colorado State University

[6] Research Scientist - Plainsman Research Center at Walsh, Colorado

[7] USDA-ARS Research Leader - Great Plains Systems Research Unit

Contents

Section B

Dryland Cropping Systems Production Results for 2002

List of Tables

RESEARCH APPLICATION SUMMARY

We established the Dryland Agroecosystem Project in the fall of 1985, and 1986 was the first crop year. Grain yields, stover yields, crop residue amounts, soil water measurements, and crop nutrient content have been reported annually in previously published technical bulletins. This publication covers the 2001 and 2002 grain yields, stover yields, crop residue amounts and N content of the crops and soil nitrate levels. A common introduction and materials and methods for these two years are presented, however, the production parameters mentioned above are presented by year, in two sections identified as Section A (2001) and Section B (2002) of this publication.

The following summary updates our findings over the past 18 years of the project. The long-term research objective of this project are to provide producers as well as to learn more about soil quality and carbon sequestration parameters, which have been the subject of several graduate students thesis. The data from the latter subjects are published in scientific journals and journal references are found at the end of this publication.

Average Yields:

Annual yield fluctuations concern growers because they increase risk. Stable yields translate into stable income levels in a producer's operations. Figure 1 provides a summary of average yield history for wheat, corn, sorghum, and soybean at our three study locations for the first 15 yrs. Wheat has been grown every year at all sites, corn every year at Sterling, and sorghum every year at Walsh. Other crops have been grown for shorter periods of time. Complete data for each crop are available in previously published bulletins (see reference section). Yields in Figure 1 are averaged over 15 years when a given crop was grown, even those where yield losses occurred due to hail, drought, early and late freezes, insect pests, winter kill of wheat, and herbicid carryover.

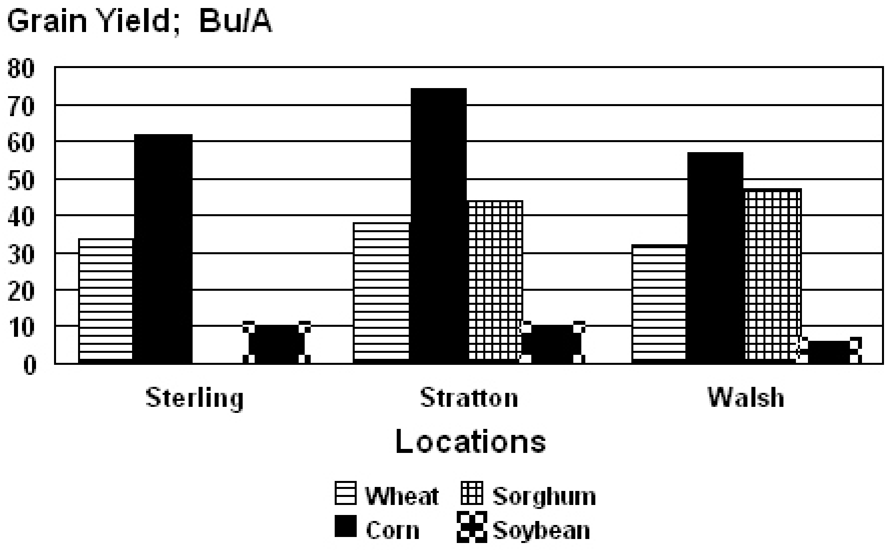


Figure 1. The first 15 yr grain yields averaged over soil positions for all years each crop has been grown at a given location (wheat yields after fallow).

Corn, Sorghum and Soybean Yields at Original Locations:

Fluctuations in corn and sorghum yields are of most interest because they represent the highest production input cost crops. Yields of all crops include hail and drought years over the last 18 yrs. The yields fluctuate markedly due to the climatic conditions that were outlined above. The last three years, drought has been of major concern resulting in "near" crop failures some years and some compete crop failures in 2002.

1) Corn yields at Sterling have averaged 58 bu/A (range = 0 to 107 bu/A).
2) Corn yields at Stratton have averaged 66 bu/A (range = 0 to 112 bu/A).
3) Corn yields at Walsh, using Bt varieties, averaged 57 bu/A from1997-2000 (range = 2 to 100 bu/A).
4) Grain sorghum yields at Stratton (5 years) averaged 44 bu/A (range = 3 to 71 bu/A).
5) Grain sorghum yields at Walsh averaged 42 bu/A (range = 3 to 71 bu/A).
6) Soybean yields have averaged 10 bu/A or less at all sites. We have concluded that the currently available soybeans varieties are not adapted to this environment.

Cropping Systems:

Over the long term of the project, the 3- and 4-year systems like wheat-corn(sorghum)-fallow and wheat-corn-millet-fallow or wheat-sorghum-sorghum-fallow increased annualized grain production by 74% compared to the 2-year wheat-fallow system during the first 12 years of our project (Figure 2). Yields are annualized to account for the nonproductive fallow year in rotation comparisons. Economic analyses show this to be a 25-40% increase in net annual income for the three-year rotation in northeastern Colorado. However, in southeastern Colorado the three year wheat-sorghum-fallow rotation, using stubble mulch tillage in the fallow prior to wheat planting, netted about the same amount of return as reduced till wheat-fallow. We need to continue to investigate systems using new herbicide programs that are less expensive.

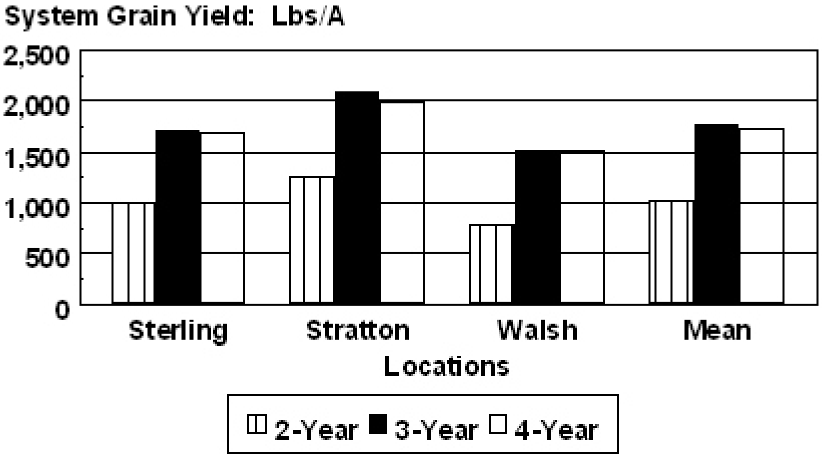


Figure 3. **Annualized grain yield by system for each location averaged over the first 12 years of research.**

Our data show that cropping intensification is feasible and profitable in the central Great Plains. More intensive rotations like wheat-corn(sorghum)-fallow and wheat-corn(sorghum)-millet-fallow have more than doubled grain water use efficiency. In years of limited rainfall, diversity is even more important by spreading the risk among different crops that may take advantage of rainfall in different times of the production year. Water storage in our limited rainfall environment as a result of no-till systems converts the limited moisture into increased grain production more effectively than a traditional stubble mulch tillage wheat-fallow system. However, the deletion of fallow also increases the risk of water deficit for the following crop. It is a management trade off between intensive cropping systems that result in increased return and production under the traditional tilled wheat-fallow system where risk due to moisture stress (drought) is less. However, government programs can affect management decisions greatly, particularly where producers have developed a good corn yield base.

Our opportunity cropping systems (essentially annual cropping systems with no fallow) have maximized production at all sites relative to all other rotations, but have not been the most profitable. The 3-year rotations have been most profitable. Based on our findings with the intensive systems from 1985 to 1997 (12 cropping seasons), we altered the systems in 1998 to determine how far we could go to minimizing fallow in our dryland cropping systems. More intensive cropping systems have been added and wheat-fallow has been omitted from the experiments. We now consider the 3-year (wheat-corn or sorghum-fallow) system as the standard of comparison. In the last few years of the "drought", some of these new more intensive cropping systems (continuous cropping) have not been successful. The main limitation has been lack of rain for germination of wheat in the fall and inadequate stored soil moisture due to the short time period available to store rain and snow water.

New Research Sites:

The dryland agroecosystem project established linkage with the Department of Bioagricultural Sciences and Pest Management in 1997. We are now evaluating the interactions of cropping systems with both pest and beneficial insects at three new experimental sites. The new sites at Briggsdale, Akron, and Lamar also allow us to test our most successful intensive cropping systems at three new combinations of precipitation and evaporative demand and enabling us to study insect dynamics as influenced by cropping system. We want to know if the presence of multiple crops in the system will alter populations of beneficial insects and provide new avenues of insect pest control. Results are included in this report regarding the data from these new sites in 2001 and 2002.

Adoption of Intensive Cropping Systems:

Producers in northeastern Colorado have been adopting the more intensive cropping systems at an increasing rate since 1990, until 2002. The drought that started in September-October of 2001 has had an dramatic effect on dryland crop production in Colorado, as well as the Western Great Plains in general. The maximum dryland corn acreage in Colorado reached in 2001 with 305,000 acres. The drought that started in September-October of 2001 had a devastating effect on dryland crop yields in 2002, particularly summer crops. Colorado

Agricultural Statistic reported that there were only 55,000 acres of dryland corn harvested in 2001. However, many thousands of additional acres were planted and not harvested due to the devastating effect of the drought on corn, and all summer crop, yields. In 2001, the state average dryland corn yield was 52 bu/A, while in 2002 it was 26 bu/A. Sunflower production followed the same trend, but not as dramatic as corn. In 2001 there were 182,000 acres of sunflower harvested with an average yield of 1,143 lb/A. In 2002, 130,000 were planted with 100,000 being harvested at an average yield of 630 lb/A. Corn is one of the principal crops grown in the more intensive systems; thus we use its acreage as an index of adoption rate by producers (see Table below). Since dryland corn is almost exclusively grown under no-till in a three or four year rotation, the actual acreage under intensive no-till dryland cropping systems is at least 3-4 times greater than the total dryland corn acreage. The average economic impact is an increased return to land, labor, capitol, and management of $14.85/acre (Kann et al., 2002), under an "average" rainfall environment.

Dryland Corn Acreage in Eight Northeastern Colorado Counties and state total from 1971 to 2002.

Year	Eight NE Counties*	Total for State
	Acres	
1971-1988	21,200	23,700
1989	27,000	28,000
1990	26,000	26,000
1991	32,500	33,000
1992	48,500	50,000
1993	79,000	90,000
1994	92,500	100,000
1995	95,500	100,000
1996	104,000	110,000
1997	138,500	150,000
1998	191,000	240,000
1999	220,000	290,000
2000	198,000	340,000
2001	233,000	305,000
2002	50,000	55,000

*Data from Colorado Agricultural Statistics (Adams, Kit Carson, Logan, Morgan, Phillips, Sedgewick, Washington, Yuma)

The drought has had a dramatic effect on producers' ability to operate under intensive no-till cropping systems management. Corn is a "high input" crop, compared to other dryland crops, therefore, inclusion of this crop into a cropping system under drought conditions increases the economic risk significantly. If farmers have a good proven yield goal they can still take the risk and plant corn and participate in the government programs to minimize economic risk. Consequently, the 55,000 acres harvested in 2002 do not accurately reflect the adoption of intensive cropping systems. However, the drought has definitely had an impact on adoption. As the drought cycle swings back to a "normal" rainfall climate, adoption will increase the favorable economics of intensive cropping systems management along with its associated minimization of soil erosion by wind, which is a major concern to the long-term sustainability of the dryland system.

OTHER CURRENT RESEARCH PROJECTS

Triticale-Corn-Forage Soybean Rotation at Sterling: {Established in fall 1993}

Objective:

Maximize time in crop, provide both a cash crop (corn) and forage crops for a mixed livestock-grain farm. Land preparation costs would also be minimized. From 1993 - 1998 this rotation was triticale-corn-hay millet. Forage soybean replaced hay millet in 1999 in attempt to grow a sandbur free, higher protein forage.

Procedure:

i) Winter triticale is planted in September into the millet residue . In the following years it will be planted into soybean residue.

ii) Harvest winter triticale for forage in June before heading, leaving a 8-10 inch stubble. Roundup and Atrazine, applied after harvest.

iii) Corn planted no-till into triticale stubble the following May.

iv) Corn is harvested in late September.

v) Forage soybean, was planted into corn stalks the following May and harvested in August.

Results:

i) Corn yields for the last 5 years in this rotation have averaged 22 bu/A. This has been caused by low precipitation. Prior to 2000 the average yield was 50 Bu/A including 1994, when no grain was produced due to dry weather, and including 1995, when the corn froze before maturity. In the last 6 years a Roundup Ready variety was grown to aid in sandbur control.

ii) Hay millet yields were non-harvestable in all years except 1997. The failures were primarily due to heavy sandbur infestations. We had to destroy the crop because sandbur populations were equal to the millet populations in most years. For this reason we chaged the summer forage crop to Round Up Ready soybean.

iii) Forage soybean hay yields in 2001 averaged 1.24 T/A over all soils. In 2002, no forage was harvested due to the drought.

iv) Triticale “Harvested” yields have averaged 1.73 T/A over the past 4 years (excluding 2002), even though we leave a 8-10" stubble remaining in the field for cover. In 2002, the stand was very poor due to lack of emergence due to the drought and the crop was killed with Roundup.

Summary:

Winter triticale seems to be a well adapted cool season forage crop. Although corn yields were greatly limited by lack of rainfall in 2001 and 2002. Corn following triticale should be equivalent to corn after wheat. The forage soybean has yielded relatively well in years where normal precipitation has been received, averaging 1.36 T/A until 2002, when no forage was harvested.

Triticale and corn grain yields by soil for 1998 -2002.

Year	Crop	Production	Soil Positions			
			Summit	Sideslope	Toeslope	Average
			---------------Tons/A or Bu/A-----------------			
1998	Triticale	Total	0.94	1.13	1.36	1.14
		Harvested[1]	0.77	1.00	1.05	0.94
	Corn	Grain	64	64	88	72
	Hay Millet	Total	0	0	0	0
1999	Triticale	Harvested[1]	1.64	1.17	1.92	1.58
	Corn	Grain	43	82	69	65
	Soybean	Forage @ 15% moisture	1.17	1.26	1.72	1.38
2000	Trticale	Harvested[1]	2.82	2.47	2.86	2.72
	Corn	Grain	18	18	24	20
	Soybean	Forage @ 15% moisture	1.60	1.39	1.35	1.45
2001	Triticale	Harvested[1]	1.38	1.28	2.48	1.71
	Corn	Grain	32.5	25.2	52.8	37
	Soybean	Forage @ 15% moisture	1.28	1.14	1.29	1.24
2002	Triticale	Harvested[1]	0	0	0	0
	Corn	Grain	0	0	0	0
	Soybean	Forage @ 15% moisture	0	0	0	0

[1] Harvested leaving 8" stubble;

Experiment Managers:

G.A. Peterson, G. Lindstrom, and D.G. Westfall

Soybean Variety and Plant Population Trials at Sterling and Stratton

Background:

Our interest in soybeans stems from our search for a crop we could harvest and immediately plant winter wheat, thus avoiding fallow. Soybean has the potential to be one of the crops that might fit the system. It has the following attributes:

1. Local market probable
2. Broadleaf plant for rotation
3. Roundup Ready (sandbur control)
4. Fits rotation (plant wheat after soybean harvest)
5. Use same planting and harvesting equipment as wheat
6. Economic potential good (Expected yields 20-25 bu/A and low fertilizer cost)

Objectives:

1) To determine the yield potential of dryland soybean varieties in eastern Colorado
2) To observe growth characteristics and potential harvest dates.
3) To determine appropriate plant populations for soybeans in NE Colorado

Procedure:

Planting Method:
    Row planted in 30" row spacing
Varieties:
    Asgrow 2202, 2602, 2703, and 3003
Populations:
    90,000, 135,000, and 180,000 seeds/A
Planting and Harvesting Dates:
    Sterling = 11 June and 11 October 2001
    Stratton = 6 June and 2 October 2001

Results:

Soybean grain yields averaged over varieties, plant populations and locations were a disappointingly low; 7 bu/A as shown in the following tables. At Sterling the longer season Asgrow 3303 had the highest yields at all plant populations, while at Stratton the shorter season Asgrow 2703 had the highest yields.

Plant population did not appear to affect yield of any variety at either location. Averaged over all varieties at both locations the yields were 7.3, 7.1, and 7.3 bu/A for the 90,000, 135,000 and 180,000 plant/A populations respectively.

Rainfall in August, the critical month for soybean was 1.33 and 0.82 inches for Sterling and Stratton respectively, which was well below the long-term average August precipitation of 1.9 and 2.6 inches for the two locations. Obviously grain yields were adversely affected by the below normal August precipitation. Because soybean grain yield is so dependent on August rainfall and because rainfall is highly variable in the West Central Great Plains, it does not appear that soybean is a good option for the area.

Soybean grain yields by variety and plant population at Sterling Colorado in 2001.

Variety	Population	Yield (13% moisture)
	Seeds/A	— Bu/A—
Asgrow 2202	90,000	5.4
	135,000	6.5
	180,000	7.1
Asgrow 2602	90,000	7.2
	135,000	6.9
	180,000	6.8
Asgrow 2703	90,000	7.0
	135,000	9.1
	180,000	6.4
Asgrow 3003	90,000	10.6
	135,000	12.3
	180,000	11.8

Soybean grain yields by variety and plant population at Stratton Colorado in 2001.

Variety	Population	Yield (13% moisture)
	Seeds/A	— Bu/A—
Asgrow 2202	90,000	5.0
	135,000	4.0
	180,000	5.4
Asgrow 2602	90,000	9.1
	135,000	6.5
	180,000	4.8
Asgrow 2703	90,000	9.5
	135,000	6.3
	180,000	11.1
Asgrow 3003	90,000	4.5
	135,000	5.1
	180,000	5.0

Soybean grain yields averaged by plant population and location in 2001.

Plant Population	**Yield (13% moisture)**
	— Bu/A---
90,000	7.3
135,000	7.1
180,000	7.3

Soybean grain yields averaged by variety and location in 2001.

Variety	**Yield (13% moisture)**
	— Bu/A---
Asgrow 2202	5.6
Asgrow 2602	6.9
Asgrow 2703	8.2
Asgrow 3003	9.2

Experiment Managers: D. Poss, G.A. Peterson, D.G. Westfall.

INTRODUCTION

Colorado agriculture is highly dependent on precipitation from both snow and rainfall. In the dryland environment each unit of precipitation is critical to production. At Akron each additional inch (25 mm) of water above the initial yield threshold translates into 4.5 bu/A of dryland winter wheat (12 kg/ha/mm), consequently profit is highly related to water conservation (Greb et al., 1974). These data point to the need for maximum precipitation use efficiency in this semi-arid cropping environment and the importance of this project to our producers.

Our research project was established in 1985 to identify systems that maximize efficient water use under dryland conditions in Eastern Colorado. A more comprehensive justification for its initiation can be found in Peterson, et al. (1988). A summary of our general understanding of the climate-soil-cropping systems interactions can be found in a recent publication by Peterson and Westfall (2004).

The general objective of the project is to identify no-till dryland crop and soil management systems that will maximize water use efficiency of the total annual precipitation and economic return.

Specific objectives are to:

1. Determine if cropping sequences with fewer and/or shorter summer fallow periods are feasible.
2. Quantify the relationships among climate (precipitation and evaporative demand), soil type and cropping sequences that involve fewer and/or shorter fallow periods.
3. Quantify the effects of long-term use of no-till management systems on soil structural stability, micro-organisms and faunal populations, and the organic C, N, and P content of the soil, all in conjunction with various crop sequences.
4. Identify cropping or management systems that will minimize soil erosion by crop residue maintenance.
5. Develop a data base across climatic zones that will allow economic assessment of entire management systems.

Peterson, et al. (1988) document details of the project in regard to the "start up" period and data from the 1986-87 crop year. Results from the 1988 - 1999 crop years were reported by Peterson, et al. (1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000 and 2001). As in previous bulletins, only annual results are presented with a few summary tables. We do not draw major conclusions based on one year crop responses because cropping systems are highly time and weather dependent. Other publications, such as Wood, et al. (1990), Croissant, et al. (1992), Peterson, et al. (1993a & 1993b), Nielsen, et al. (1996), Farahani, et al. (1998), Peterson and Westfall (2004), summarize and draw conclusions based on a combination of years.

Long-term (18 yr) averages of summer crops, corn and sorghum, are 58, 66 and 42 bu/A for Sterling(corn), Stratton(corn) and Walsh(sorghum), respectively. These average yields include years of near crop failure due to drought, hail, and early frost. Our research has shown that cropping intensification is certainly possible and profitable in the central Great Plains. More intensive rotations like wheat-corn(sorghum)-fallow have increased grain water use efficiency by 27%, compared to wheat-fallow, while the 4-year systems like wheat-corn-millet-fallow have increase water use efficiency by 37% (Peterson and Westfall, 2004). Water conserved in the no-till systems has been converted into increased grain production. Furthermore, our opportunity cropping systems have maximized production at all sites relative to all other rotations. Based on findings from1985 to 1997, we altered the systems in an attempt to determine the minimum amount of fallow that would be sustainable in this dryland environment. Wheat-fallow was omitted from the experiments, and we consider the 3-year (wheat-corn(sorghum)-fallow) system as the standard of comparison.

The dryland agroecosystem project established a linkage with the Department of Bioagricultural Sciences and Pest Management in 1998. We are evaluating the interactions of cropping systems with both pest and beneficial insects at three new experimental sites, Briggsdale, Akron, and Lamar, CO. This also allows us to test our most successful intensive cropping systems at three additional combinations of precipitation and evaporative demand. Compared with the original three experiments, these locations have much larger experimental units, enabling us to study insect dynamics as influenced by cropping system. We want to know if the presence of multiple crops in the system will alter populations of beneficial insects and provide new avenues of biological pest management of Russian Wheat Aphid in wheat and insect pests in other crops. Details of cropping system changes at the original sites and the treatments at the new sites are explained in the methods section of this report.

MATERIALS AND METHODS

From 1986 -1997 we studied interactions of climate, soils and cropping systems at three sites, located near Sterling, Stratton, and Walsh, in Eastern Colorado, that represent a gradient in potential evapotranspiration (PET) (Fig. 3). Elevation, precipitation and evaporative demand are shown in Table 1. All sites have long-term precipitation averages of approximately 16-18 inches (400-450 mm), but increase in PET from north to south. Open pan evaporation is used as an index of PET for the cropping season.

Table 1. Elevation, long-term average annual precipitation, and evaporation characteristics for each site.

Site	**Elevation**	**Annual Precipitation**[1]	**Growing Season Open Pan Evaporation**[2]	**Deficit (Precip. - Evap.)**
	--Ft. (m) --	---In. (mm) ---	---In. (mm) ---	---In. (mm) ---
Briggsdale	4850 (1478)	13.7 (350)	61 (1550)	- 48 (- 1220)
Sterling	4400 (1341)	17.4 (440)	63 (1600)	- 45 (- 1140)
Akron	4540 (1384)	16.0 (405)	63 (1600)	- 47 (- 1185)
Stratton	4380 (1335)	16.3 (415)	68 (1725)	- 52 (- 1290)
Lamar	3640 (1110)	14.7 (375)	76 (1925)	- 62 (- 1555)
Walsh	3720 (1134)	15.5 (395)	78 (1975)	- 61 (- 1555)

[1] Annual precipitation = 1961-1990 mean; [2] Growing season = March - October

Each of the original three sites (Sterling, Stratton, Walsh) was selected to represent a catenary sequence of soils common to the geographic area. Textural profiles for each soil at each location are shown in Figures 4a, 4b, and 4c. There are dramatic differences in soils across slope position at a given site and from site to site. We will contrast the summit soils at the three sites to illustrate how different the soils are. Each profile was described by NRCS personnel in summer 1991. Note first how the summit soils at the three sites differ in texture and horizonation. The surface horizons of these three soils (Ap) present a range of textures from loam at Sterling, to silt loam at Stratton, to sandy loam at Walsh. Obviously the water holding capacities and infiltration rates differ. An examination of the horizons below the surface reveals even more striking differences.

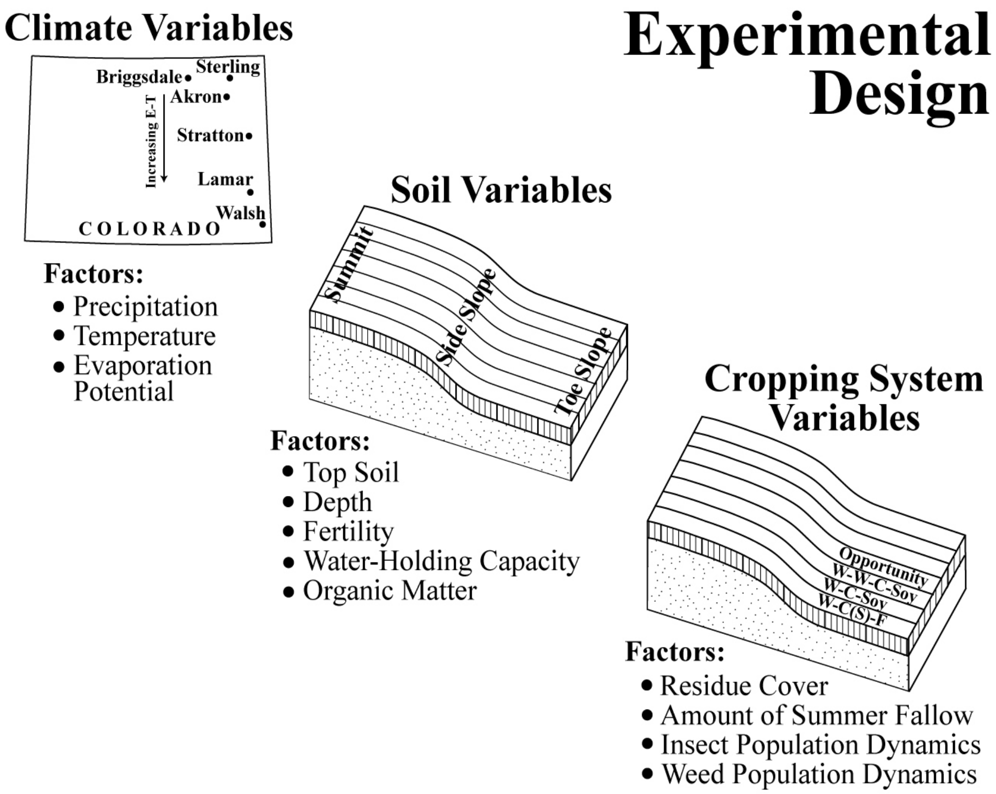
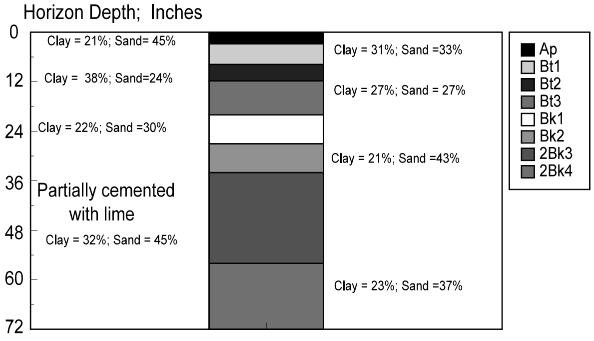


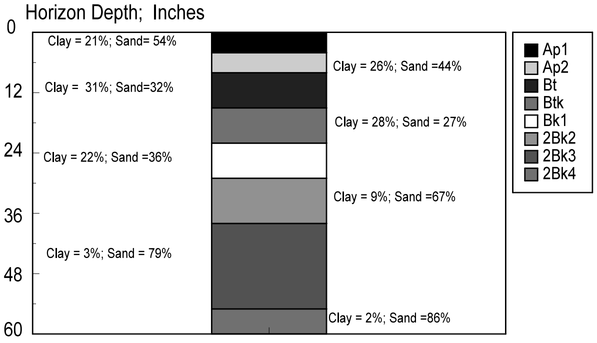
Figure 3. Experimental design with climate, soil, and cropping system variables.

The summit soil profile at Sterling (Figure 4a) changes from a clay content of 21% at the surface(Ap) to 31% in the 3-8" depth (Bt1) to a clay content of 38% in the layer between the 8-12" depth (Bt2). At the 12" depth the clay content drops abruptly to 27%. The water infiltration in this soil is greatly reduced by this fine textured layer (Bt2). At about the 36" depth (2Bk3) there is an abrupt change from 21% clay to 32% clay in addition to a marked increase in lime content. The mixture of 32% clay and 45% sand with lime creates a partially cemented zone that is slowly permeable to water, but relatively impermeable to roots. Profile plant available water holding capacity is 9" in the upper 36 inches of the profile.

Sterling Summit Soil Profile



Sterling Sidelope Soil Profile



Sterling Toeslope Soil Profile

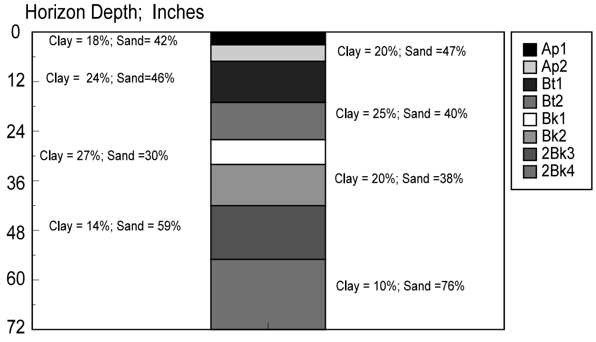
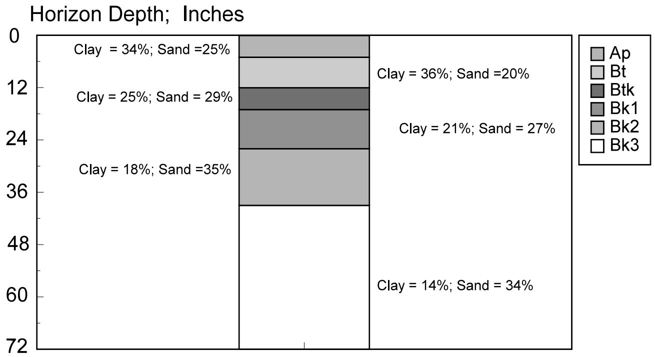
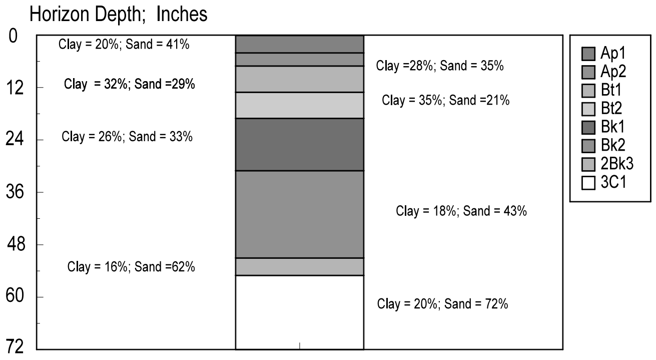


Figure 4a. Soil profile textural characteristics for soils at the Sterling site.

Stratton Summit Soil Profile



Stratton Sideslope Soil Profile



Stratton Toeslope Soil Profile

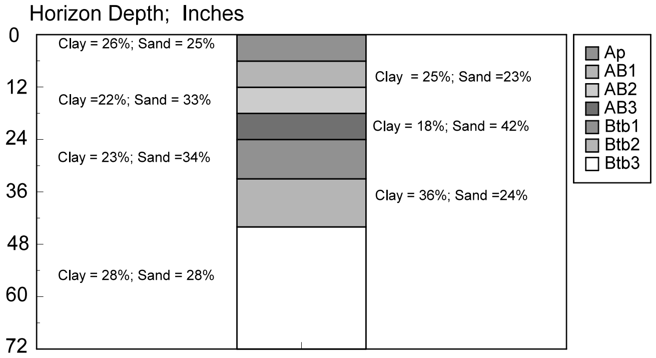
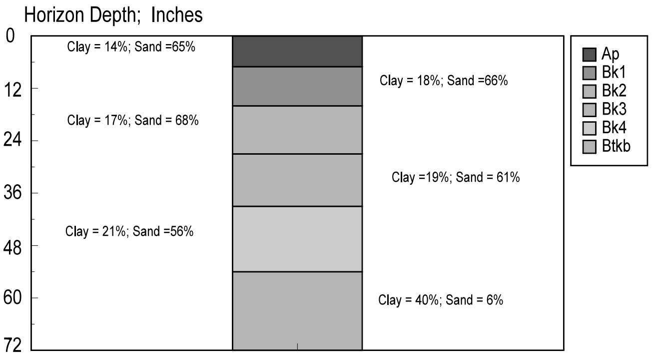
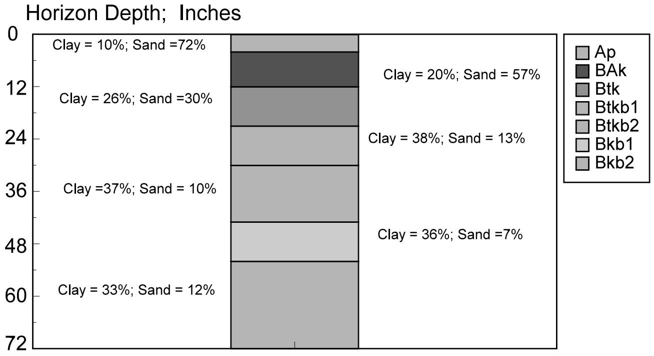


Figure 4b. Soil profile textural characteristics for soils at the Stratton site.

Walsh Summit Soil Profile



Walsh Sideslope Soil Profile



Walsh Toeslope Soil Profile

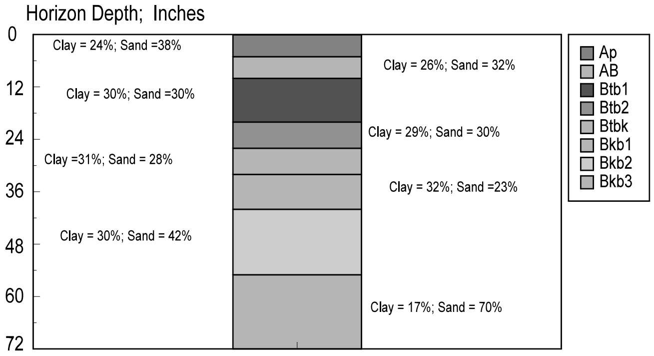


Figure 4c. Soil profile textural characteristics for soils at the Walsh site.

At Stratton the summit soil profile (Figure 4b) is highest in clay at the surface, 34% in the Ap horizon, and then decreases steadily to 14% clay (Bk3) below the 40" depth. There are few restrictions to water infiltration at the surface nor to roots anywhere in the profile compared to the summit soil at Sterling. Profile plant available water holding capacity is 12" in the upper 72 inches of soil.

The summit soil at Walsh (Figure 4c) has very sandy textures above 54" compared to either summit soil at the other sites. No restrictions to water infiltration nor root penetration occur in the profile. In this soil the abrupt increase in clay content at 54", 40% in the Btkb horizon represents a type of "plug" in the soil profile. Water can infiltrate rapidly in the coarse-textured surface horizons, but does not drain rapidly beyond the root zone due to the high clay content of the deepest horizon at 54". This makes this soil more productive than a similar soil with no clay "plug". The profile plant available water holding capacity is 11". About 2" of the total is in the 5-6' depth, leaving only a 9" storage capacity in the upper 5' of soil.

Many other soil contrasts can be observed by the reader, both within and across sites. All of these soils had been cultivated for more than 50 years, and all exhibit the effects of both wind and water erosion damage. The toeslopes are the recipients of soil materials from the summit and sideslope positions because of their landscape location relative to the others. Hence they also have the highest organic matter content in their surface horizons.

Soil profile characteristics for the three new locations are only available on a general basis. The soil type at Briggsdale and Akron is a Platner loam and at Lamar it is a Wiley silt loam.

The cropping system during the previous 50 years had been primarily dryland wheat-fallow with some inclusion of grain sorghum at Walsh and corn at Sterling. At the original sites we placed cropping system treatments over the soil sequence (Fig.3) to study the interaction of systems and soils. At the three new sites we have only one soil type at each. Cropping systems that were in place in 2001 and 2002 at the initial three sites established in 1985 are shown in Table 2a and 2b. Cropping systems for the three new sites (Briggsdale, Akron, and Lamar) initiated in 1997 that were in place in 2001 and 2002 are shown in Table 2c. Soybeans were replaced by millet in the systems at Sterling and Stratton in 2002 because of the poor performance of soybeans in this environment. The crops grown in the opportunity systems for each site are shown at the bottom of Table 2b. Both forage and grain crops have been grown over the years in this cropping system. All sites are managed with no-till techniques, and herbicide programs are reported in Appendix Tables A1-12. Complete details on measurements being made and reasons for treatment choices are given by Peterson, et al. (1988). Crop variety, planting rate, and planting date for each crop at each site are given in Tables 3a and 3b for 2001 and 2002, respectively.

Nitrogen fertilizer is applied annually in accordance with the NO_3-N of the soil profile (0-6 ft or 0-180 cm), soil organic matter content before planting, and expected yield on each soil position at each site. Therefore, N rate changes by year, crop grown, and soil position and the N rates at Sterling, Stratton and Walsh are given in Table 4 for 2001 and Table 37 for 2002. Nitrogen fertilizer for wheat, corn, and sunflower was dribbled on the soil surface over the row at planting time at Sterling and Stratton. Zinc (1 lb/A) was applied to the corn with the P fertilizer. Nitrogen on wheat at Walsh was topdressed in the spring, and N was sidedressed on corn and sorghum. We made all N applications as a 32-0-0 solution of urea-ammonium nitrate. The same procedures was used for fertilization at Briggsdale. However, at Lamar commercial applicators or large plot equipment is used to apply the fertilizer at these locations.

Phosphorus management is one of the experimental variables at Sterling, Stratton and Walsh. Consequently, we band applied P (10-34-0) at planting near the seed. Phosphorus is applied on one-half of each corn and soybean plot over all soils, but applied to the entire wheat plot when a particular rotation is in wheat. The rate of P is determined by the lowest soil test on the catena, which is usually found on the sideslope position. This rate has been 20 lbs P_2O_5/A (9.5 kg/ha of P) at each site each year thus far. We changed the P fertilization treatment for wheat in fall 1992, so that the half plot that had never received P fertilizer in previous years is now treated when planted to wheat. This was required because low P availability was resulting in poor wheat stands. Other crops in the rotation only receive P on the half plot designated as NP. Zinc (0.9 lbs/A or 1 kg/ha) is banded near the seed at corn planting at Sterling, Stratton, and Briggsdale to correct a soil Zn deficiency.

Table 2a. Cropping systems for each of the original sites established in 1985 that were in place in 2001.

Site	Rotations
Sterling	1) Wheat-Corn-Fallow (WCF)
	2) Wheat-Corn-Soybean (WCSb)
	3) Wheat-Wheat-Corn-Soybean (WWCSb)
	4) Opportunity Cropping*
	5) Perennial Grass
Stratton	1) Wheat-Corn-Fallow (WCF)
	2) Wheat-Corn-Soybean (WCSb)
	3) Wheat-Wheat-Corn-Soybean (WWCSb)
	4) Opportunity Cropping*
	5) Perennial Grass
Walsh	1) Wheat-Sorghum-Fallow (WSF)
	2) Wheat-Corn-Soybean (WCSb)
	3) Wheat-Wheat-Sorghum-Soybean (WWSSb)
	4) Continuous Row Crop (Alternate corn & sorghum)
	5) Opportunity Cropping*
	6) Perennial Grass

*Opportunity cropping is designed to be continuous cropping without fallow, but not monoculture.

We measure soil water with the neutron-scatter technique. Aluminum access tubes were installed, two per soil position, in each treatment at each original site in 1988. These tubes are not removed for any field operation and remain in the exact positions year to year. Precautions are taken to prevent soil compaction around each tube. By not moving the tubes over years we get the best possible estimates of soil water use in each rotation. Soil water measurements are made on all soils and rotations at planting and harvest of each crop, which also represents the beginning and end of non-crop or fallow periods. At the new sites soil samples are taken for gravimetric water measurements at crop planting. We do not present the soil water data in this report for 2001 and 2002.

Table 2b. Cropping systems for each of the original sites established in 1985 that were in place in 2002.

Site	Rotations
Sterling	1) Wheat-Corn-Fallow (WCF)
	2) Wheat-Corn-Millet (WCM)
	3) Wheat-Wheat-Corn-Millet (WWCM)
	4) Opportunity Cropping*
	5) Perennial Grass
Stratton	1) Wheat-Corn-Fallow (WCF)
	2) Wheat-Corn-Millet (WCM)
	3) Wheat-Wheat-Corn-Millet (WWCM)
	4) Opportunity Cropping*
	5) Perennial Grass
Walsh	1) Wheat-Sorghum-Fallow (WSF)
	2) Wheat-Corn-Mung Bean (WCB)
	3) Wheat-Wheat-Sorghum-Mung Bean (WWMB)
	4) Continuous Row Crop (Alternate corn & sorghum)
	5) Opportunity Cropping*
	6) Perennial Grass

---

*Opportunity cropping is designed to be continuous cropping without fallow, but not monoculture.

*Opportunity Cropping History

Year	Site		
	Sterling	Stratton	Walsh
1985	Wheat	Fallow	Sorghum
1986	Wheat	Wheat	Sorghum
1987	Corn	Sorghum	Millet
1988	Corn	Sorghum	Sudex
1989	Attempted Hay Millet	Attempted Hay Millet	Sorghum
1990	Wheat	Wheat	Attempted Sunflower
1991	Corn	Corn	Wheat
1992	Hay Millet	Hay Millet	Corn
1993	Corn	Corn	Fallow
1994	Sunflower	Sunflower	Wheat
1995	Wheat	Wheat	Wheat
1996	Corn	Corn	Fallow
1997	Hay Millet	Hay Millet	Corn
1998	Wheat	Wheat	Sorghum
1999	Corn	Corn	Corn
2000	Austrian Winter Pea	Austrian Winter Pea	Soybean
2001	Wheat	Wheat	Sorghum
2002	Corn	Corn	Sorghum

Table 2c. Cropping systems for the three new sites initiated in 1997 that were in place in 2001 and 2002.

Site	Rotations
Briggsdale	1) Wheat-Fallow (WF)
	2) Wheat-Hay Millet-Fallow (WHF)
	3) Wheat-Wheat-Corn-Soybean-Sunflower-Pea (WWCSbSfP)
	4) Opportunity*
Akron	1) Wheat-Fallow (WF)
	2) Wheat-Corn-Fallow (WCF)
	3) Wheat-Corn-Millet (Proso)-Fallow (WCMF)
	4) Wheat-Corn-Millet (Proso) (WCM)
Lamar	1) Wheat-Fallow (WF)
	2) Wheat-Sorghum-Fallow (WSF)

*Opportunity cropping is designed to be continuous cropping without fallow, but not monoculture.

Table 3a. Crop variety, seeding rate, and planting date for each site in 2000-2001 season.

Site	Crop	Variety	Seeding Rate	Planting Date	Harvest Date
Briggsdale	Wheat (fallow & other)	Lamar & Prowers99	60 lbs/A & 60 lbs/A	9/28/00	7/16/01
	Corn	NK4242	15,000 seeds/A	5/1/01	10/22/01
	Hay Millet	Golden German	10 lbs/A	6/15/01	8/20/01
	Sunflower	Triumph 765C	21,000 seeds/A	6/1/01	10/22/01
	Soybean	Asgrow 3901	90,000 seeds/A	5/24/01	9/13/01
	Forage Pea	Austrian winter	90 lbs/A	11/9/00	6/26/01
Sterling	Wheat	Prairie Red	60 lbs/A & 90 lbs/A	10/3/00	7/13/01
	Corn		18,000 seeds/A	5/14/01	10/18/01
	Soybean		90,000 seeds/A	6/11/01	10/11/01
Akron	Wheat	P.R. & Tam 107	60 lbs/A	10/13/00	7/17/01
	Corn	Dekalb DK5333RR	16,600 seeds/A	5/19/01	10/22/01
	Proso	Sunup	15 lbs/A	6/15/01	9/24/01
	Sunflower	Triumph 765	16,600	5/19/01	10/30/01
Stratton	Wheat	Prairie Red	60 lbs/A & 90 lbs/A	10/2/00	7/15/01
	Corn		18,000 seeds/A	5/15/01	10/29/01
	Soybean		90,000 seeds/A	6/4/01	10/2/01
Lamar	Wheat	Tam 107 & Prairie Red	60 lbs/A	11/1/00	7/9/01
	Sorghum	Cargill 627	45,000 seeds/A	6/13/01	11/2/01
Walsh	Wheat	Prairie Red	50 lbs/A	9/30/00	7/12/01
	Sorghum	Cargill 627	40,000 seeds/A	6/1/01	10/26/01
	Corn	Dekalb DK 520Y6RR	19,000 seeds/A	6/1/01	10/9/01
	Soybean	Asgrow AG 3903 RR	110,000 seeds/A	6/1/01	10/10/01

Table 3b. Crop variety, seeding rate, and planting date for each site in 2001-2002 season.

Site	Crop	Variety	Seeding Rate	Planting Date	Harvest Date
Briggsdale	Wheat (fallow & other)	Yuma & Yumar	60 lbs/A & 60 lbs/A	9/19/01	7/18/02
	Corn	Pioneer 3893 Dekalb 39-47	15,000 seeds/A	6/6/02	No harvest
	Hay Millet	Golden German	10 lbs/A	6/15/02	8/10/02
	Sunflower	Cargill 187	14,000 seeds/A	6/7/02	No harvest
	Grain Sorghum	Dekalb 48E	35,000	6/7/02	No harvest
Sterling	Wheat	Prairie Red	60 lbs/A & 90 lbs/A	9/24/01	7/10/02
	Corn	Dekalb DK4628 RR	18,000 seeds/A	5/15/02	none
	Proso millet	Huntsman	12 lbs/A	6/1/02	none
Akron	Wheat	P. R. & Tam 107	60 lbs/A	10/29/01	7/3/02
	Corn	DK 520 RR	17,200 seeds/A	5/20/02	no harvest
	Proso	Sunup	12 lbs/A	6/13/02	no harvest
	Sunflower	Triumph 765	17,200	6/10/02	9/27/02
Stratton	Wheat	Prairie Red	60 lbs/A & 90 lbs/A	9/25/01	7/9/02
	Corn	Dekalb DK4628 RR	18,000 seeds/A	5/21/02	None
	Proso millet	Huntsman	12 lbs/A	6/2/02	None
Lamar	Wheat	Tam 107 & Prairie Red	40 lbs/A	9/16/01	No Crop
	Sorghum	Not planted			
Walsh	Wheat	Prairie Red	50 lbs/A	10/2/01	None
	Sorghum	Mycogen 627	40,000 seeds/A	6/20/02	11/18/02
	Corn	DK 520 Y1 Bt	19,000 seeds/A	6/20/02	None
	Mung bean	Not Planed		None	None

SECTION A

DRYLAND CROPPING SYSTEMS PRODUCTION RESULTS FOR 2001

RESULTS AND DISCUSSION

Climatic Data

Precipitation at Sterling, Stratton and Walsh was near normal for the period July 2000 through June 2001. The last six months of 2000 is the time that precipitation is critical for the following year's wheat crop. It is also a period to begin storing soil water for the summer crops that will be planted in the spring of 2001 such as corn, soybean, sunflower, and millet. Sterling, Stratton, and Walsh received 8.24, 7.10, and 8.95 inches during this period, respectively (Table 5a). The first six months of 2001 was slightly below normal at Sterling and Stratton and above normal at Walsh. Precipitation amounts the last six months of 2001 were near normal at Sterling and Stratton and only 38% of normal at Walsh.

Precipitation amounts at the three new sites for the last six months of 2000 was 31%, 119%, and 50% of normal at Briggsdale, Akron, and Lamar, respectively (Tables 5b). All sites were near or above normal the first six months of 2001. However, the last six months of 2001 Briggsdale and Lamar were below normal at 71% and 58% of normal while Akron was 112% of normal. As a result of Akron receiving more precipitation during this time, the crop yields at Akron were much better than the crop yields at Briggsdale or Lamar.

July and August rainfall are critical for production of corn, sorghum, and soybean. At Sterling, Walsh, Briggsdale, and Lamar (July + August) rainfall was below normal while it was near normal at Stratton and Akron. (Table 5a & 5b). Therefore, summer crops were moisture stressed at four of the six sites.

____Precipitation data for the growing season for corn and wheat at all six sites are shown in Tables 5c-h, starting with the year each site was initiated. These data are divided into the vegetative and reproductive growth stages. Considerable deviations from the average precipitation occurred, however no general trend for above normal or below normal precipitation occurred when all sites are considered in 2001.

Wheat

Wheat yields in the year 2001 for each site, soil and cropping system combination are shown in (Tables 6 and 10). A more meaningful long-term comparisons of cropping systems since initiation of the new cropping systems at Sterling, Stratton and Walsh are summarized in Tables 7-9. These data are a summary of yields from the plots in the rotation that recived N and P fertilizer every year. Wheat yield after fallow in the WCF system at Sterling was near the average for 1998-2001, averaging 33 bu/A (Table 7), while at Stratton the yields were higher than the average, 40 and 46 bu/A on the summit and side slope positions (Table 8). The wheat on the toe slope lodged due to a flood event that swept through this area, but yields would have been excellent if they could have been harvested. At Walsh (Table 9) in the WSF system, the 2001 yields were above average, ranging from 28 on the summit to 48 bu/A on the toe slope position. Walsh received 11.9 inches of rain from January to June, 2001 (Table 5a), as compared to a long term average of 7.5 inches, thus accounting for the above average yields. The rainfall for this same period at Sterling and Stratton was 1 and 1.6 inches below normal, respectively. Precipitation during fallow before wheat seeding was near normal at all locations except July at Sterling. Only 1 inch of precipitation was received during July 2000, as compared to a normal of 3.32 inches.

At Sterling, Stratton and Walsh, wheat yields in the more intensive systems that do not have a fallow, WCSb and first year wheat in (W)WCSb, ranged from 20 to 34 bu/A (Tables 7-9). The 2001 yields were much better than the 2000 yields, due to more favorable precipitation. Average wheat yields (averaged over soils) in these more intensive WCSb and (W)WC(S)Sb that do not include fallow were 28, 26 and 25 bu/A for Sterling, Stratton, and Walsh, respectively (not including the lodged plots at Stratton). However, wheat yields in the WCF (rotation includes a fallow before wheat) were 33, 35, and 38 bu/A at the corresponding sites. In 2000 we observed an average 38% yield reduction in plots that did not include a fallow before wheat (WC(S)Sb and (W)WC(S)Sb) as compared to wheat after fallow (WCF), in 2001 this reduction in wheat yields averaged 25%. There is a yield sacrifice in these more intense systems. Yields of second year wheat in the W(W)C(S)Sb system averaged more than the yields of first year wheat and Walsh and less at Stratton. No logical relationships between moisture and yield differences are obvious (Tables 5a and 7-9).

Wheat yields were good at Briggsdale due to the favorable spring precipitation. Grain yields averaged 37 bu/ac over all rotations and varieties (Table 10). Lamar and Powers99 yielded essentially the same. Lamar and Prowers99 are genetically similar except for the Russian Wheat Aphid (RWA) resistant gene. Rotations that had fallow before wheat had the highest yields (Table 10), which is expected. Some anomalies in yields of the (W)WCSbSfSb, W(W)CSbSfSb, and Opportunity cropping were observed in relation to W(W)CSbSfSb rotation. [The (W) indicates the wheat crop we are referring to in the rotation, i.e., (W)WCSb indicates we are referring to the first crop after soybean in this system, etc.] The rotations of (W)WCSbSfSb, W(W)CSbSfSb, and Opportunity yielding 30.5, 26.9, and 36.6 bu/ac, respectively. The second year wheat in the W(W)CSbSfSb rotation had the longest fallow period prior to planting, however had the poorest wheat yield. Conversely, the wheat in the opportunity rotation, which followed soybeans had the shortest fallow period, had the highest yield.

Wheat yields at Akron were below normal. The overall yield averaged was 30.7 bu/ac with TAM 107 and Prairie Red yielding 30.3 and 31.2 bu/ac, respectively (Table 10).

Wheat yields at Lamar were low due to the crop not germinating until spring (Table 10). Despite the late germination and the limited moisture during the growing season, wheat yields were not as disappointing as expected. The yields in the WF rotation were higher than the WSF yielding 20 bu/ac and 17 bu/ac, respectively. Despite the presence of RWA late in the growing season, the TAM 107 yielded higher than the RWA-resistant Prairie Red in both rotations.

We have concluded that the current soybean varieties are not adapted to this semi-arid environment and in 2002 soybean was replaced by millet. However, the yield relationships in intensive systems with no fallow would be expected to be similar.

Corn and Sorghum

Corn yields following wheat were low across all sites in 2001, due to the difference in amount and distribution of July plus August and winter and spring precipitation. At Sterling, the July+August precipitation was 1.5 inches below normal (Table 5a) and the average corn yield was 50 bu/A (Table 11). Yields from 1998-2002 are presented in Tables 12-14 for the plots in each rotation that received both N and P fertilizer each year. This year's corn production was better than 2000, but lower than 1998 and 1999 (Table 12). These yield variations are always related to summer precipitation. The 2002 data will be discussed in Section B of this report.

At Stratton, the July+August precipitation was near normal for the two months but 4.4 inches fell in July and only 0.8 inches in August, resulting in the corn going into severe moisture stress during the first part of the reproductive stage of growth (pollination). This resulted in an average yield of 36 bu/A (Table 13). Yields on the summit and side slopes ranged from 4-18 bu/A, which would be classified as a crop failure. The overall average was brought up by the high yield in the toe slope which was driven by drainage water that inundated this position as the result of an intense rainfall event in July. Not considering the toe slope position, the yields averaged about 10 bu/A. Farmers would not harvest a field with this yield average because the return would not pay for the harvest cost.

At Walsh the precipitation during this period was 2.5 inches below normal and the average corn yields were 62 and 63 bu/A in the WCSb and Opportunity cropping system (Table 11). The continuous corn system averaged 54 bu/A. These yields are very good for dryland corn in this region. In general, 2001 was an "average" corn production year at Walsh.

Sorghum yields at Walsh, in 2001, averaged 63 and 60 bu/A in the two rotations that included sorghum, WSF and WWSSb, respectively (Table 14). The yield of sorghum after fallow was not substantially different than in the rotation that did not include fallow. This has been the trend since 1998, when we initiated these new more intense rotations. The 2001 and long-term average yield of continuous sorghum is about 10 bu/A less than yields of sorghum grown in a rotation.

Corn yields at Briggsdale were very low due to several reasons (Table 15). First, in 2001, precipitation in July and August was below normal (Table 5b). Second, plant populations were too high. The population we aimed for was 15,000 plants per acre. However, due to planter problems the population was in excess of 20,000 plants per acre. This high population used the stored soil water early in the season and the plants went into a moisture stress during the reproductive stage of growth. Many plants were barren.

Corn yields were also below average at Akron (Table 15). Even though soil moisture was good from planting until harvest, many ears were three to four inches in length. Test weights were low with an average if 53.7 lb/bu.

Despite good soil moisture at planting and good crop germination, sorghum yields were disappointing. Sorghum yields in 2001 were impacted by heavy grass pressure, high temperatures, and low August rainfall (Table 15).

Millet, Proso and Hay

Proso millet was not grown in any of the rotations at Sterling, Stratton or Walsh in 2001. However, due to the continued failure of soybeans to perform adequately, proso millet will be introduced back into the long-term rotations at Sterling and Stratton in 2002. Proso millet yields at Akron averaged 49 bu/A (Table 16), which is excellent for his area. Rainfall received in July and August was the major contributor to the high yields. Hail near harvest time decreased yields significantly.

Hay millet yields at Briggsdale were very good (Table 16). The yield was 1.8 t/A. This is a fast growing crop which was able to make good use of the above normal June precipitation. Even though the precipitation received in July was below normal it was still enough to produce favorable hay millet yields after the favorable precipitation levels in June.

Sunflower

The dry July and August also affected the sunflower yields at Briggsdale (Table 16). At less than 600 lb/A, these yields were below what we would expect for a long term average. The dry weather was the primary cause for the low sunflower yields.

The sunflowers at Akron averaged 1,140 lb/A. This was higher than expected given stand and pest problems.

Soybean

Soybeans for grain production at Sterling, Stratton and Walsh were low in 2001, ranging from 6-13 bu/A on the summit and side slopes at all sites and from 13-31 bu/A on the toe (Table 17). Soybeans were planted but not harvested for yield at Briggsdale. With the cultivars that are available, much of the seed that was produced shattered. The pods that were produced were so close to the ground it was impossible to harvest them with a combine. It is becoming apparent that soybeans are not a viable crop in this semi-arid environment. New cultivars need to be developed to withstand this environment. Until new cultivars are developed we will not include soybeans for seed production in our rotations. Soybeans will be eliminated from the Systems starting in 2002. Obviously they are not economical, especially when one considers the opportunity costs associated with this crop as compared to a more adapted crop. On the positive side, Round Up Ready soybean allowed us to have excellent weed control, especially for sandbur which has been an increasing problem at Sterling and Walsh. This is the main reason we were looking for a summer crop that was Round Up Ready to include in the rotations. Sandbur can become a real problem unless its growth cycle is broken with a crop that is Round Up Ready. Round Up Ready corn has solved some of this problem.

Forage Soybeans

Forage soybeans were grown for the first time at Briggsdale in 2001. The public variety, Donegal, was chosen. This variety has been genetically bred as a forage variety. It is a much higher maturity group than the grain varieties used in Colorado. It grows taller and produces more forage. There is potential for this to be an excellent livestock feed source with its higher protein content compared to hay crops traditionally grown on dryland. However, its yield was much less than the hay millet (Table 16). These soybeans were grown in the sequence of the rotation that is difficult for any crop, following sunflowers. The forage soybeans may be suitable following a crop other than sunflowers. This crop will be eliminated from the rotation in the future and will be replaced by a summer fallow period.

Opportunity Cropping

Opportunity cropping is an attempt to crop continuously without resorting to monoculture. It has no planned summer fallow periods, and is cropped as intensively as possible. In 2001 wheat was grown in the opportunity systems at Sterling and Stratton. The other locations do not have this rotation. Wheat yields in this system were much lower that yields in other cropping systems at Sterling and about equal to wheat in all rotations at Stratton (Table 6).

From the initiation of our project in fall 1985 we have grown 14, 14, and 12 crops in 16 years at Sterling, Stratton and Walsh, respectively in the opportunity system (Tables 18-20). Productivity in opportunity cropping has been excellent at Sterling and Stratton, but more marginal at the Walsh site. In 16 years at the two northern sites, the system has produced a total of 137 to 206 bushels of wheat per acre, 368 to 427 bushels of corn or sorghum, and 4.7 to 4.7 tons of forage per acre at Sterling and Stratton, respectively. Crop productivity at Walsh over 16 years has been 93 bushels of wheat, 322 bushels of corn or sorghum, 2 bushels of soybean, and 0.5 tons of forage. Two fallow years were included at Walsh and crops failed in two years, 1987 and 1990.

Above average annual precipitation has been a major factor contributing to the productivity; annual precipitation, until 2001, has been 2 to 3 inches above the long-term averages for all sites during the 16 year study period. Therefore, growers should use extreme caution in extrapolating these results to their own operations. In a time period of “drought”, these relationships will not hold true.

Our goal has been to produce wheat and corn or sorghum, the highest value crops, as frequently as possible in our systems. We have used forages to transition from row crops back to fall-planted wheat. We harvest the forage and plant winter wheat that fall. Another good possibility is planting proso millet the year after corn or sorghum, harvesting it as early as possible, and then planting wheat immediately into the proso stubble. However, if adequate fall precipitation is not received, wheat germination will be a yield-limiting factor.

Opportunity cropping has had some advantages over the 3-year systems, such as excellent residue cover and ease of weed control. The combination of crop competition and no fallow has reduced weed pressures compared to other systems. One major difference in weed pressure has been in regard to the invasion of the perennials, Tumblegrass (*Schedonnardis paniculata*) and Red Threeawn (*Aristada longiseta*), in our no-till systems. All systems with fallows, especially WF and WC(S)F, have had devastating invasions of these grassy weeds and have required shallow sweep tillage to control these grasses. The opportunity system has remained free of these weeds. These particular perennial grasses are shallow rooted and do not become established in these systems. We conclude that it is due to the low surface soil water content and competition for the light. Fallow, where we are saving water and keeping the surface weed free, provides an excellent environment for their establishment. In contrast, opportunity cropping has no long fallows. Crop plants keep the soil surface dry much of the time and the two grassy invaders have not established.

Crop Residue Base

Maintenance of crop residue cover during non-crop periods and during seedling growth stages is vital to maximizing water storage in the soil. Crop residues provide protection from raindrop impact, slow runoff, and decrease water evaporation rates from the soil. Cover also greatly reduces erosion, both by wind and water.

Residue amount is being monitored by soil and crop within each system (Tables 21-24). Residues present at planting are needed to protect the soil during the early plant growth stages when there is little canopy present. Residue levels are subject to annual variations in climate, both in terms of production and decomposition rates. Obviously, drier years decrease production but also may decrease decomposition rates. The net effect is difficult to assess because the particular portion of the year that is extra dry or wet will change the direction of the impact. Residue quantities always are largest on toeslopes at each site, which is a function of productivity level. Walsh and Briggsdale, the most stressed sites, usually have the lowest residue amounts.

Cropping systems that involve a fallow period, like WCF or WSF, have minimum residue levels just prior to wheat planting because this time marks the end of the summer fallow period where decomposition has been occurring with no new additions of crop biomass. Therefore, cover is at its minimum, and soil erosion potential is at its maximum point. One of the advantages of our new continuous cropping systems is the avoidance of a year with no crop residue input.

Residues present at wheat planting are given in Table 21 and 24. Residue amounts were moderate to high at wheat planting in all cropping systems in 2001 except in the WF and WMF system at Briggsdale (Table 24), which had 0 and 160 lb/A residue present. However at Sterling, Stratton, and Walsh, the general trend was for the residue levels in the systems that contain fallow to be higher than the continuous cropped systems (Tables 21). The small residue input from the low-yielding soybean crops has result in a degradation of the residue base in all rotations containing soybean at all sites (Tables 21-25). In addition to very low yields from soybean, inadequate residue production to maintain the residue base over the long-term would be expected to be an additional problem associated with this crop.

At corn planting (Table 22), systems with fallow were no worse than the continuously cropped systems and tend to have greater amounts of residue at the Sterling and Stratton sites. Residue amounts at soybean planting (Table 23) are about the same for both continuous cropping systems.

Over the long-term, one would expect the continuously cropped systems to have the most residue present on the soil surface. However, type of residue will influence accumulation because of differences in surface area for decomposition and C:N ratio of the material. For example, corn because of its large stalk diameter has a smaller surface area available for decomposition relative to wheat. Soybean residue has a C:N ratio that is much smaller than that of either corn or wheat, and therefore will decompose more quickly under similar environmental conditions. Therefore, systems with more corn and wheat are likely to have more residue accumulation, especially since our soybean yields of grain and stover are very low relative to corn and wheat. Additionally, one of the main driving factors is total biomass production by the crop. If more intensive cropping results in a reduction in yields (biomass), less residue is returned to the soil and the residue levels will decrease over time.

Nitrogen Content of Grain and Stover

Nitrogen content was determined for both grain and stover for each crop at each site (Tables 25-27). The reader can calculate crude protein content for each grain type by multiplying wheat grain N content by 5.7; corn, sorghum or soybean grain or straw content by 6.3. All nutrient concentrations are on a dry weight basis, consequently crude protein levels will appear high compared to market levels. To obtain market levels, a grain moisture correction must be applied.

On a dry matter basis, wheat proteins averaged 12.6% at Sterling, 16.1% at Stratton, 15.8 % at Walsh (Tables 25a and 29a). The relatively high protein contents at Stratton and Walsh are the result of dry weather and low grain yield, which concentrates protein. To correct these values for grain moisture content, multiply by 0.88, which results in a protein average of 11.1% at Sterling,14.2% at Stratton, 13.9% at Walsh. Goos, et al. (1984) established that if grain protein levels were above 11.1%, yield was not likely to be limited by N deficiency. A comparison of 2001 wheat protein to this standard indicates that N fertilization was adequate for the wheat crop at all sites.

Wheat straw N concentrations ranged from 0.24 to 1.34% across sites, averaging 0.64% (Table 25b). On the average, each ton of straw contained about 13 lb of N. There was no obvious relationship of straw N concentration and crop rotation at any site.

Nitrogen levels in corn and sorghum grain averaged 1.73%, 1.58%, and 1.94% at Sterling, Stratton, and Walsh, respectively (Table 26a), or 9.25%, 8.46%, and 11.22% protein based upon a 15% moisture content. Corn stover N contents at Sterling varied from 0.41 to 1.43% and averaged 0.68% (Table 26b), data are not available for Stratton Each ton of corn stalks thus contained an average of 15 lb of N. The grain sorghum stover varied from 0.47to 1.25% N (Table 27b) and averaged 0.47% N. Each ton of grain sorghum residue contains about 15 lb of N.

Nitrogen levels in soybean grain (Table 27a) ranged from 4.93 to 6.45%, which is equivalent to 31 to 41% crude protein at market moisture content of the grain. The soybean stover was higher in N content than either wheat or corn, ranging from 0.45 to 1.93% N, averaging 0.81% N (Table 27b). Each ton of soybean residue would contain about 16 lb of N.

Soil Nitrate-Nitrogen

Residual soil NO_3-N analyses are routinely conducted on soil profile samples (0-6 ft or 0-180 cm) taken prior to planting for each crop, except for soybean, on each soil at each site (Table 28). These analyses are used to make fertilizer N applications for a particular crop on each soil at each site. Accumulation of residual nitrate allows reduction in the fertilizer rate. By using residual soil nitrate analyses of the root zone we also can determine if nitrate is leaching beneath the root zone. With improved precipitation-use efficiency in the more intensive crop rotations, the amount of nitrate escaping the root zone should be minimized. In the first 12 years of experimentation we found that the wheat-fallow system generally had higher residual nitrates than the 3- or 4-year rotations at the end of fallow prior to wheat planting.

At fall wheat planting in 2000 the amount of residual soil nitrate-nitrogen present varied from site to site, but wheat planted after fallow (WCF and WSF) tended to have more nitrate-nitrogen present than other systems. The nitrate-nitrogen in the more intense cropping systems was generally low. However, the opportunity system at Sterling and Stratton tended to have the highest, or among the highest, levels of residual soil nitrate. The nitrate levels in the toe slopes at Stratton are high, due to the high rate of mineralization that occurs in this high organic matter soil that is wetter than other soils in this landscape, thus promoting mineralization.

Residual NO_3-N does not appear to be accumulating in the soil profile of any cropping system, which indicates that no system is over-fertilized. If fertilizer N is not used by wheat, for example, it is used by the subsequent corn or sorghum crop. The carry-over N is accounted for in the soil test used and reduces the amount of fertilizer N applied to the crop.

Interaction of cropping systems with pest and beneficial insects

Introduction

Intensifying a cropping system has potentially many positive impacts. One of the facets of these cropping systems is the increased crop diversification may allow for better pest control including weeds, insects, and pathogens. This experiment focuses on the impacts a more diverse cropping system has on the affects of pest insect and predator populations and relationships.

In 1986 the Russian wheat aphid (RWA) entered Colorado and has become a major pest in small grains. There are nearly three million acres of dryland winter wheat in Colorado that the RWA can potentially impact. RWA management tactics include chemical, cultural, host plant resistance, and biological control methods. Chemical control is costly and often requires repeat applications. Cultural control, using rotations, is not effective since the aphid is able to move great distances. Genetically altering the host plant for resistance has been successful. RWA may become resistant to these varieties if that is the only method of control utilized.

Biological control through the release of predators has been ineffective. Donohue (1996) reported lack of recovery of released predators in two consecutive years. However, in 1995 there was a higher predator to aphid ratio in the more diverse cropping system, suggesting that diverse cropping systems may support higher populations of predators.

There are reasons for the ineffectiveness of biological control. First, the predators have a relatively short life span of two to three weeks without prey. Second, the conventional cropping system in northeastern Colorado has been wheat/fallow. This system has a fourteen-month period with no crop and few or no pests or prey for predators. The solution to RWA and other pest control may be using Integrated Pest Management (IPM) tactics (Holtzer, et al., 1996). Having more diverse cropping systems promotes a more diverse insect population throughout the year. With a more diverse insect population there is not only more prey for predators but also a wider variety of predators. Releasing predators into cropping systems that include crops that provide other aphid species for the predators to feed on may improve establishment and maintenance of the predator populations (Holtzer, et al., 1996).

Specific objectives are to:

1. Determine if cropping systems with fewer and/or shorter fallow periods are feasible.
2. Identify nontraditional crops that can be profitably grown in eastern Colorado.
3. Determine the effectiveness of more diverse cropping systems at achieving an integrated approach to IPM.
4. Monitor pests and predators in all crops and rotations throughout the growing season.
5. Identify predators present in each cropping system.

Materials & Methods

The Briggsdale plots are 3 miles south of Briggsdale on County Road 84 between County Roads 77 (Hwy. 392) and 79. Wheat/fallow was the system used before WMF. The Akron plots are located at the Central Great Plains Research station east of Akron. The Lamar site is located southwest of Lamar, one half mile south of Prowers county Roads AA & 2.

The rotation at these sites represent typical rotations for the area (Table 1). The exception to this is the 6 year rotation at Briggsdale which was established to experiment with nontraditional crops for the Briggsdale area. Variety planted, seeding rate, N rate, and planting date are presented in table 3a.

Results & Discussion - Entomological Data

Wheat

Insects are monitored throughout the growing season at critical growth stages three to five times for each crop.

Aphids:

The wheat was sampled three times throughout the growing season. Fifty random tillers were taken from each plot. The samples were put in Berlese funnels to extract the aphids from the plants. Not one aphid, RWA or other cereal aphids, was found out of a total of 120 samples, or 6,000 tillers at Briggsdale (Table 29). Winter 2000-2001 was cold and had a significant amount of wet snow in April and May. One or both of these environmental conditions could have had an adverse affect on the aphids.

Sampling at Akron and Lamar was similar to Briggsdale. Russian wheat aphids were detected at these sites, however, their numbers were very low (Table 29).

Brown Wheat Mite:

Brown wheat mites were sampled using a Vortis suction sampler which 'sucks' them off the plant and soil surface. Brown wheat mite populations were also very low (Table 29). The sample with the most mites at Briggsdale had 16 mites compared to an average of nearly 300 per sample at the earliest sampling date in 2000. The wet snow in April and May probably had an adverse affect on the Brown Wheat Mite.

The Akron site the traps caught fewer mites than Briggsdale and no mites were captured at Lamar. Brown wheat mite problems in 2001 were few and far between throughout eastern Colorado.

Other pests:

Army and pale western cutworms were other pest that were monitored. These populations were low in 2001 (Table 29). No pale western cutworms were found at Briggsdale and a few army cutworms were found at Briggsdale. A few army cutworms and pale western cutworms were found at Lamar, but the levels were very low. No cutworms were observed at Lamar.

Predators:

Predators are monitored at the sampling stages in which aphids are monitored. Four, thirty second observations in each plot were made identifying as many predators as possible during that time period.

During these counts no predator insects were found at Briggsdale or Akron and only a few were observed at Lamar (Table30). A few coccinellids and lacewings were found while collecting other samples. There was a low number of predators because there was very little prey for them. It is difficult this early in the experiment to assess what is an average predator population. There isn't any background information in this geographic area with this information.

Pheromone traps:

Pheromone trap catches in the fall can be a predictor to problems insects in the wheat the following spring. Catches were high in fall 2001 at Briggsdale and Akron (Table 31). 159 Pale

Western cutworm adults were caught in the fall, which is a strong indication of higher population in spring 2002. At Akron, Army cutworm catches were very high catching 76 adults last fall.

Corn & Sorghum

Corn insect pressure was also very low in 2001 at Briggsdale and Akron. There were a few western corn rootworm adults on the ears during the 14 August sampling time at Briggsdale (Table 32). The corn plant health was poor this year due to a combination of high population and dry weather conditions. This resulted in an unfavorable environment for the insects. At Akron only a few aphids were found throughout the growing season. A few greenbugs and corn earworm larvae were observed in the grain sorghum at Lamar.

Only a few coccinellids were found while sampling the corn at Briggsdale and Akron (Table 30). Again this is due to the low levels of prey. Akron and Lamar had a few spiders which are also beneficial arthropods.

Millet

The millet was sampled for aphids at the boot stage. Fifty random tillers were taken and the aphids were extracted using Berlese funnels. No aphids were found and no predatory insects were found at Briggsdale. Aphids were the only pest insect found in the millet at Akron. A few coccinellids and spiders were found as beneficial insects.

Sunflower

The sunflowers were sampled on three dates. The pest levels were low in this crop like the others due to the dry conditions (Table 35). Very few pests were found during the growing season and a few stem weevils and seed weevils were found in the stalk/head at maturity. At Akron there were more pests found throughout the growing season due to more sunflowers being grown in the area and better growing conditions.

A few predatory insects were found in low numbers including lacewings, pirate bugs, and syrphids.

SECTION B

DRYLAND CROPPING SYSTEMS PRODUCTION RESULTS FOR 2002

RESULTS AND DISCUSSION

Climate Data

Precipitation is the most limiting variable in dryland agriculture in Eastern Colorado. Precipitation amounts for the last six months of 2001 were near normal, 7.5 in. (190 mm) and 7.8 in (198 mm) at Sterling and Stratton, respectively (Table 38a). The precipitation at Walsh was only 38% of normal. For the first six months of 2002 all sites were significantly less than normal at 23%, 42%, and 38% of normal at Sterling, Stratton, and Walsh, respectively (Table 38c-e). During this period nearly all months at all sites were significantly below normal . For the last six months of 2002, Sterling was near normal with 7.1 in (180 mm), Stratton was well below normal with 5.5 in (138 mm), and Walsh was well above normal at 10.8 (274 mm). Four inches of the 10.8 inches at Walsh was received in a two day period, August 28 and 29.

The three newest sites, Briggsdale, Akron, and Lamar experienced similar climates as the three original sites. For the last six months of 2001 Briggsdale and Akron were slightly above normal at 5.0 in (127 mm) and 8.1 in (206 mm), respectively (Table 38b). Lamar was 58% of normal for the same period. The precipitation for the first six months of 2002 was less than 50% of normal at all three sites. The period January through April was especially dry averaging 36%, 26%, and 35% of normal at Briggsdale, Akron, and Lamar, respectively (Tables 38f-h). The last six months of 2002 was better than the first six months, however remained well below normal. A two-day period in August brought a significant amount of rain in short time periods resulting in significant run-off.

Wheat

Due to the drought, as explained above, crop failure of wheat was very widespread in Colorado, as well at our research locations in 2002. Only the WCF rotation produced a crop large enough to merit harvest, and that occurred only at Sterling and Stratton. On the summit and side slope positions at Sterling grain yields ranged from 7-9 bu/A, while at the toe slope position, the yields were 15-16 bu/A (Tables 39a & 39b). At Stratton, the summit and side slope yields ranged from 13-15 bu/A, while the toe slope ranged from 29-31 bu/A. None of the more intense rotations produced enough yield to merit harvest. No wheat was harvested from any rotations at Walsh in 2002. The lack of a fallow preceding wheat in the more intense cropping systems did not result in enough stored soil moisture to allow stand establishment at planting and the extremely dry growing season resulted in poor production from any wheat that did emerge.

Wheat yields at Briggsdale were also low due to the drought. However, considering the severity of the drought, the yields were favorable averaging 14.1 bu/A over all systems and varieties. There were no differences in yield with respect to variety (Tables 40a &40b). There were significant differences with respect to system. The first year wheat in the WWCCSfF system died in April due to lack of moisture (The fallow sequence in this system were leguminous crops prior to 2002) . These plots were planted to forage soybeans in 2001. The forage soybean yields were low, however the soil water was depleted. Due to the lack of moisture the wheat never tillered resulting in thin stands in the fall and early spring. The second year wheat did not have a fallow before planting, it followed wheat. There were two additional months of soil water storage from precipitation compared to the first year wheat. This treatment also had significantly more residue present at planting resulting in less evaporation. July and August precipitation totaled 3.08 inches giving this crop an advantage over the first year wheat. However, there wasn't much soil water for the crop to grow on so the yields were low at less than 5 bu/ac (Tables 40a & 40b). The yields in the two systems where wheat follows fallow were considerably higher averaging nearly 19 bu/ac.

Wheat yields at Akron were well below average at 10.4 bu/ac (Table 40a & 40b). There was no significant difference between varieties. The precipitation during the December 2001 through June 2002 was 33% of average. With precipitation levels 67% below the long-term average, producing a profitable crop is very difficult. A hail storm on 1 July reduced yields by approximately 20%. The wheat yield in the WCM system was significantly less than that of the WF and the WCSfF systems due to there not being a fallow period between millet harvest and wheat planting. The wheat yields in the WCF system was also low, for which there is no explanation.

The wheat was not harvested in 2002 at Lamar as germination was poor and the field was patchy. Wheat was terminated with herbicides on 21 May, at which time biomass samples were taken. The results are presented in Table 40a. The WF system produced almost twice the biomass compared to the WSF system. The resistant variety, Prairie Red, produced more biomass than TAM 107 in both systems.

Corn and Sorghum

The drought of the summer of 2002 resulted in a corn crop failure at Sterling and Stratton. Only1.7 and 1.9 inches of precipitation was received from May 1 to July 31 at Sterling and Stratton, respectively. This compares with a long-term average of 9.3 and 8.7 inches, respectively. Some rain did occur in August, but the corn was so drought stressed that no benefit was received from this late rain. Sorghum yields at Walsh were also severely limited by the drought. A total of 2.2 inches of precipitation occurred from May 1 to July 31, compared to a long-term average of 7.8 inches. In August 5.4 inches was received but again, the sorghum was so severely drought stressed that little benefit was realized from the August precipitation. Sorghum grain yields ranged from 1 to 22 bu/A (Tables 41a & 41b). The highest yielding cropping systesm were the WSF and WWSSb. The benefit of the fallow period before wheat planting was very evident during this period of drought. The soybean crop was essentially a failure in 2002, therefore, some soil moisture shortage occurred prior to wheat planting. Yields in these two cropping systems ranged from 10-22 bu/A.

Corn was not harvested in 2002 at Briggsdale due to crop failure caused by the drought. Biomass samples were taken (Tables 40a & 40b). The biomass yields where corn followed corn were considerably higher than where the corn followed wheat. One would expect the corn after wheat to yield more due to having more residue and more time for soil water storage. The explanation for this lies in the stored soil water at planting. The second-year corn had significantly more soil water at planting than the first-year corn. The reason for this is unknown. The differences between the two treatments include hybrid, crop residue type and amount, and previous crop. The differences between the two treatments was also obviously visually apparent throughout the growing season.

Corn was also not harvested at Akron. The plants grew to only thirty inches tall. Biomass samples were taken. Total biomass yields were very low, averaging 154 lb/A (Table 42). Biomass yields for the WCM were approximately half the WCF and the WCSF systems. This could be due to there not being fallow period prior to the wheat in the WCM system. The wheat production levels were much lower in this system where there is much less residue left following wheat harvest. This can result in higher evaporation levels prior to corn emergence and early during the corn growing season.

Grain sorghum was not planted at the Lamar site during 2002 due to drought conditions. Precipitation during the growing season was 44% of the long term average.

Soybean

Soybeans were planted at Sterling, Stratton and Walsh in 2002. Marginal yields had been achieved in previous years but in 2002 the drought affected the crop so severely that no harvestable yield was produced.

Millet

Foxtail millet did surprisingly well considering the severity of the drought at Briggsdale. The millet appeared dead prior to receiving the rain at the end of August. The crop grew incredibly fast from that point on and final yields were over 0.75 ton per acre.

Proso millet was not harvested at Akron in 2002. Precipitation received during the growing season was very low. In addition to the drought a hail storm on 1 July also had an impact on yields. Biomass yield of the proso millet was 213 lb/A.

Sunflowers

Sunflowers were not harvested at Briggsdale. Stands were very poor due to a herbicide application error. A low rate of 2,4-D was applied to all of the plots including the sunflower plots one week prior to planting. Many of the sunflower plants emerged and began to show symptoms of growth regulator herbicide damage almost immediately.

Sunflower yields at Akron were very low averaging 20 lb/A. The stover averaged 184 lb/A. The extremely dry summer was the cause of the low yields.

Residues

Crop residue measurements were not taken in 2002 at Sterling, Stratton, and Walsh. However, measurements of crop residue amounts in the spring prior to planting corn, sunflowers, millet and grain sorghum were taken at Briggsdale, Akron and Lamar. The average residue level for the sunflower at Briggsdale and Akron ranged from 1,828 to 2,621 lb/A compared to a range of 4,471 to 4,614 lb/A for millet (Table 43). The sunflower crop followed soybeans this year. Soybeans leave little crop residue left and the plant material is very fragile and decomposes quite rapidly.

Crop residue levels in the fall prior to planting wheat at Briggsdale were quite variable. The WF system had the highest level of crop residue due to the excellent wheat crop in 2001 (Table 43). The first year wheat in the WWCCSfF system had 1,520 lb/A of residue, primarily sunflower stalks which were not evenly distributed across the plots. The residue level in the WMF system was low due to the fact that the majority of the crop biomass was removed as hay, leaving a four to five inch stubble. The millet stubble that remained decomposed rapidly compared to wheat, corn, and sunflower crop residue. In most years the second year wheat would have the most residue however in the fall 2002 it had the least. This was due to the wheat crop that preceded this wheat failed in spring 2002. It failed due to the reasons mentioned earlier in this report. This resulted in almost a bare soil this fall when the wheat was planted.

At Akron, residue levels have steadily increased in all plots with reduced or no tillage until this past year. The plots had no tillage in the past season except the conventionally tilled WF system. Since 1996, there has only been tillage to incorporate herbicides in the treatment that contains sunflower outside of the conventionally tilled plots. The WCM system has showed the most dramatic increase with residues over 2,000 lbs/A at corn planting.

Residue levels at Lamar were lower in the WF system than the WSF system (Table 43). However, the percent area covered by residue in the WF system was higher than in the WSF system. This difference in residue distribution may affect the infestation patterns of dispersing late RWA.

Residues were not collected prior to planting sorghum at Lamar since no crop was planted due to drought conditions.

Nitrogen Content of Grain and Stover

Total N content of the wheat grain is presented in Table 44a for the WCF systems at Sterling and Stratton, the only wheat systems that were harvested. Wheat straw N levels are presented in Table 44b and the sorghum stover N levels are presented in Table 44c.

The year 2002 can be classified as one of the worst crop production year in recent history in the West Central Great Plains. The low precipitation in the 2001-2002 cropping year resulted in the failure of most crops in this already limited rainfall environment.

Results & Discussion - Entomological Data

Insect monitoring occurred in 2002, despite the drought. A summary of the results are presented below.

Wheat

Insects are monitored throughout the growing season at critical growth stages three to five times for each crop.

Aphids:

At Briggsdale the wheat was sampled on 11 April for aphids, cutworms, and predators. No aphids were found, either RWA or other aphids (Table 45). Also, no symptomatic tillers were noticed. There were a few RWA found at Akron during the jointing stage. No other aphids were found. The wheat was sampled for aphids at spring regrowth and at the boot stage. No aphids were found.

Brown Wheat Mite:

Brown wheat mites were also sampled on 11 April at Briggsdale (Table 45). Brown wheat mites were present, but in small numbers. The average over all plots was 11.5 BWM per 1.75 ft^2.

There was no apparent trend with respect to wheat variety or system. Brown wheat mite populations were also very low at Akron. Populations were highest at the jointing growth stage, but only a fraction of the requirement for economic threshold. Although Brown wheat mites were found in a few locations east of the Lamar site, none were found in the sparse wheat crop at this site during spring 2002.

Other pests:

Both army cutworms and pale western cutworms were present in small numbers at Briggsdale (Table 45). Neither pest was near an economic threshold. The average number larvae per foot was 0.04 and 0.01 cutworms per square foot for Army Cutworm and Pale Western Cutworm, respectively. Pale western cutworms were present at Akron at slightly higher levels than the past few years. The average over all treatments was 0.55/ft.^{2} with the highest being 5/ft.^{2}.

Millet

The foxtail millet was not sampled for insects in 2002 at Briggsdale. The crop was very near dessication until late August when in rained enough to get the crop growing again. Greenbugs and Bird-cherry oat aphids were the only notable pests insects in the proso millet this year at Akron.

Corn/Sorghum

At Briggsdale cutworms and Western corn rootworm larvae were sampled in late June in corn. No corn plants were found to be damaged (cut off) as a result of cutworms. Western corn rootworm larvae were found in the second year corn. This is the treatment where you would expect to find Western corn rootworm larvae. However, in this treatment, which was corn in 2001, very few larvae were found (Table 46). No Western corn rootworm were found in the first year corn. Corn insect counts at Akron were also very low. Pale western and Army cutworms were found. Aphid species present included Greenbugs, Bird-cherry oat aphid, and corn leaf aphid. A few corn rootworm beetles were found on the ears. No insect observations were made in the sorghum crop as no crop was planted at Lamar.

Sunflower

The sunflowers were not sampled since there was a very poor stand. A few pest insects were found in the sunflowers at Akron, all at very low numbers. The following pests were found: cutworms, spotted sunflower stem weevil, sunflower head moth, banded sunflower head moth, red seed weevil, and grey seed weevil (Table 47).

REFERENCES

Croissant, R.L., G.A. Peterson, and D.G. Westfall. 1992. Dryland cropping systems in eastern Colorado. Service in Action No. 516. Cooperative Extension. Colo. State Univ. Fort Collins, CO.

Farahani, H.J., G.A. Peterson, and D.G. Westfall. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Advaces in Agron. 64:197-223.

Goos, R.J., D.G. Westfall, and A.E. Ludwick. 1984. Grain protein content as an indicator of nitrogen fertilizer needs in winter wheat. Colorado State University Service in Action No. 555.

Greb, B.W., D.E. Smika, N.P. Woodruff and C.J. Whitfield. 1974. Summer fallow in the Central Great Plains. In: Summer Fallow in the Western United States. ARS-USDA. Conservation Research Report No. 17.

Iremonger, C.J., D.G. Westfall, G.A. Peterson, and R.L. Kolberg. 1997. Nitrogen fertilization induced pH drift in a no-till dryland cropping system. Agron. Abstracts p.225. Amer. Soc. of Agron., Madison, WI.

Nielsen, D., G.A. Peterson, R. Anderson, V. Ferreira, W. Shawcroft, and K. Remington. 1996. Estimating corn yields from precipitation records. Cons. Tillage Fact Sheet 2-96. USDA/ARS and USDA/NRCS. Akron, CO.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R.L. Anderson. 1993a. Sustainable dryland cropping systems: economic analysis. Tech. Bul. TB93-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, W. Wood, and S. Ross. 1988. Crop and soil management in dryland agroecosystems. Tech. Bul. LTB88-6. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, W. Wood, L. Sherrod, and E. McGee. 1989. Crop and soil management in dryland agroecosystems. Tech. Bul. TB89-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, C.W. Wood, and E. McGee. 1990. Crop and soil management in dryland agroecosystems. Tech. Bul.TB90-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, C.W. Wood, and E. McGee. 1991. Crop and soil management in dryland agroecosystems. Tech. Bul.TB91-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, E. McGee, and R. Kolberg. 1992. Crop and soil management in dryland agroecosystems. Tech. Bul.TB92-2. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1993b. Sustainable dryland agroecosystem management. Tech. Bul. TB93-4. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1994. Sustainable dryland agroecosystem management. Tech. Bul. TB94-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and D. Poss. 1995. Sustainable dryland agroecosystem management. Tech. Bul. TB95-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and D. Poss. 1996. Sustainable dryland agroecosystem management. Tech. Bul. TB96-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, D. Poss, K. Larson, and D.L. Thompson. 1997. Sustainable dryland agroecosystem management. Tech. Bul. TB97-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, D. Poss, K. Larson, D.L. Thompson, and L.R. Ahuja. 1998. Sustainable dryland agroecosystem management. Tech. Bul. TB98-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, F.B. Peairs, L. Sherrod, D. Poss, W. Gangloff, K. Larson, D.L. Thompson, L.R. Ahuja, M.D. Koch, and C.B. Walker. 1999. Sustainable dryland agroecosystem management. Tech. Bul. TB99-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, F.B. Peairs, L. Sherrod, D. Poss, W. Gangloff, K. Larson, D.L. Thompson, L.R. Ahuja, M.D. Koch, and C.B. Walker. 2000. Sustainable dryland agroecosystem management. Tech. Bul. TB00-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, F.B. Peairs, L. Sherrod, D. Poss, W. Gangloff, K. Larson, D.L. Thompson, L.R. Ahuja, M.D. Koch, and C.B. Walker. 2001. Sustainable dryland agroecosystem management. Tech. Bul. TB01-2. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Wood, C. W., D. G. Westfall, G. A. Peterson and I. C. Burke. 1990. Impacts of cropping intensity on carbon and nitrogen mineralization under no-till agroecosystems. Agron. J. 82: 1115-1120.

Table 4. Nitrogen fertilizer application by soil and crop for 2001.

					ROTATION		
SITE	SOIL	CROP	WCF	WCSb	WWCSb	OPP[1]	
			---------------------	-------Lbs/A-------	---------------------		
Sterling	Summit	Wheat	64	64	64	64	
	Sideslope	"	64	64	64	64	
	Toeslope	"	64	64	64	64	
	Summit	Corn	101	101	101		
	Sideslope	"	101	101	101		
	Toeslope	"	101	101	101		
	Summit	Soybean	-	6	6		
	Sideslope	"	-	6	6		
	Toeslope	"	-	6	6		
			WCF	WCSb	WWCSb	OPP[1]	
Stratton	Summit	Wheat	64	64	64	64	
	Sideslope	"	64	64	64	64	
	Toeslope	"	64	64	64	64	
	Summit	Corn	101	101	101		
	Sideslope	"	101	101	101		
	Toeslope	"	101	101	101		
	Summit	Soybean	-	6	6		
	Sideslope	"	-	6	6		
	Toeslope	"	-	6	6		
			WSF	WCSb	WWSSb	OPP	CONT. CROP
Walsh	Summit	Wheat	65	50	50	-	-
	Sideslope	"	65	50	50	-	-
	Toeslope	"	65	50	50	-	-
	Summit	Sorghum	51	-	51	-	51
	Sideslope	"	51	-	51	-	51
	Toeslope	"	51	-	51	-	51
	Summit	Corn	-	106	-		101
	Sideslope	"	-	106	-		101
	Toeslope	"	-	106	-		101
	Summit	Soybean	-	6	6	6	-
	Sideslope	“	-	6	6	6	-
	Toeslope	“	-	6	6	6	-

Table 5a. Monthly precipitation for the original sites for the 2000-2001 growing season.

MONTH	LOCATION					
	STERLING		STRATTON		WALSH	
	--Inches---------------------------------------					
2000	2000	Normals[1]	2000	Normals[1]	2000	Normals[1]
JULY	0.99	3.23	2.43	2.80	3.17	2.62
AUGUST	2.51	1.90	2.00	2.60	0.78	1.96
SEPTEMBER	1.55	1.04	0.69	1.45	0.10	1.74
OCTOBER	1.98	0.76	1.29	0.85	3.94	0.89
NOVEMBER	0.91	0.50	0.56	0.62	0.15	0.53
DECEMBER	0.30	0.40	0.13	0.28	0.81	0.31
SUBTOTAL	8.24	7.83	7.10	8.60	8.95	8.05
2001	2001	Normals	2001	Normals	2001	Normals
JANUARY	0.55	0.33	0.81	0.28	1.89	0.27
FEBRUARY	0.60	0.33	0.38	0.30	0.96	0.28
MARCH	0.94	1.07	0.59	0.76	1.17	0.81
APRIL	1.13	1.60	0.72	1.23	0.42	1.15
MAY	4.46	3.27	2.95	2.70	5.46	2.69
JUNE	1.50	3.00	0.66	2.45	1.96	2.29
SUBTOTAL	8.59	9.60	6.11	7.72	11.86	7.49
2001	2001	Normals	2001	Normals	2001	Normals
JULY	2.28	3.23	4.39	2.80	0.71	2.62
AUGUST	1.33	1.90	0.82	2.60	1.36	1.96
SEPTEMBER	2.33	1.04	1.39	1.45	0.03	1.74
OCTOBER	0.74	0.76	0.38	0.85	0.10	0.89
NOVEMBER	0.80	0.50	0.58	0.62	0.53	0.53
DECEMBER	0.00	0.40	0.23	0.28	0.33	0.31
SUBTOTAL	7.48	7.83	7.79	8.60	3.06	8.05
YEAR TOTAL	16.07	17.43	13.90	16.32	14.92	15.54
18 MONTH TOTAL	26.01	25.26	21.23	24.92	23.87	23.59

[1] Normal = 1961-1990 data base

Table 5b. Monthly precipitation for the three new sites for the 2000-2001 growing season.

MONTH	LOCATION					
	BRIGGSDALE		AKRON		LAMAR	
	--------------------------------------Inches------------------------------------					
2000	2000	Normals[1]	2000	Normals[1]	2000	Normals[1]
JULY	0.51	2.63	2.65	2.73	1.55	2.23
AUGUST	0.32	1.77	2.12	2.04	0.39	1.85
SEPTEMBER	0.91	1.29	1.62	0.98	0.30	1.33
OCTOBER	0.19	0.70	1.94	0.60	1.19	0.71
NOVEMBER	0.10	0.36	0.15	0.56	0.06	0.56
DECEMBER	0.27	0.27	0.11	0.32	0.05	0.40
SUBTOTAL	2.30	7.02	8.59	7.23	3.53	7.08
2001	2001	Normals	2001	Normals	2001	Normals
JANUARY	0.27	0.26	0.86	0.33	1.29	0.42
FEBRUARY	0.29	0.18	0.43	0.30	0.43	0.42
MARCH	0.41	0.75	0.54	0.91	0.27	0.90
APRIL	1.85	1.27	0.93	1.32	0.14	1.15
MAY	3.85	2.08	3.96	3.25	4.43	2.50
JUNE	2.30	2.10	1.34	2.62	2.38	2.19
SUBTOTAL	9.00	6.64	8.06	8.73	8.94	7.58
2001	2001	Normals	2001	Normals	2001	Normals
JULY	2.04	2.63	2.63	2.73	2.45	2.23
AUGUST	0.54	1.77	2.25	2.04	0.62	1.85
SEPTEMBER	1.01	1.29	1.70	0.98	0.27	1.33
OCTOBER	0.66	0.70	0.70	0.60	0.07	0.71
NOVEMBER	0.72	0.36	0.82	0.56	0.22	0.56
DECEMBER	0.00	0.27	0.00	0.32	0.51	0.40
SUBTOTAL	4.97	7.02	8.10	7.23	4.14	7.08
YEAR TOTAL	13.94	13.66	16.16	15.96	13.08	14.66
18 MONTH TOTAL	16.24	20.68	24.19	23.19	16.68	21.74

[1] Normal = 1961-1990 data base

Table 5c. Precipitation by growing season segments for Sterling from 1987-2001.

	Growing Season Segments			
	Wheat		Corn	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	Inches			
1987-88	5.2	9.9	11.1	15.8
1988-89	3.1	6.5	10.5	14.3
1989-90	5.1	4.7	11.8	13.0
1990-91	3.8	7.2	12.3	11.7
1991-92	4.5	4.8	9.1	14.8
1992-93	4.5	6.2	15.5	10.6
1993-94	6.4	3.0	10.2	6.1
1994-95	7.3	14.4	9.6	17.2
1995-96	4.2	9.2	7.5	18.0
1996-97	4.7	7.0	10.6	21.4
1997-98	5.5	4.9	16.7	13.8
1998-99	5.8	7.7	13.5	12.8
1999-00	5.7	3.0	12.6	8.6
2000-01	6.8	8.2	11.5	13.8
Long Term Average	4.4	7.9	11.2	13.2

Table 5d. Precipitation by growing season segment for Stratton from 1987-2001.

	Growing Season Segments			
	Wheat		Corn	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	Inches			
1987-88	4.3	7.2	8.8	12.6
1988-89	3.0	9.4	5.3	15.5
1989-90	5.3	6.1	11.0	13.4
1990-91	4.4	4.1	10.7	14.7
1991-92	3.3	6.1	14.2	13.6
1992-93	3.3	3.8	11.8	14.7
1993-94	4.3	7.8	16.7	13.5
1994-95	7.0	10.0	14.8	13.7
1995-96	3.5	6.0	8.1	14.5
1996-97	2.9	6.2	12.2	23.2
1997-98	8.0	5.9	22.6	13.9
1998-99	4.4	8.5	15.6	12.3
1999-00	6.2	3.9	14.2	8.8
2000-01	4.7	4.3	9.8	10.6
Long Term Average	4.5	6.4	11.2	12.9

Table 5e. Precipitation by growing season segment for Walsh from 1987-2001.

	Growing Season Segments			
	Wheat		Sorghum & Corn	
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Oct
Year	Inches			
1987-88	4.3	7.6	7.4	11.1
1988-89	4.1	11.5	8.1	20.2
1989-90	5.7	7.4	14.1	12.5
1990-91	5.0	7.7	11.7	12.2
1991-92	2.7	5.8	7.1	13.2
1992-93	6.1	9.2	13.8	14.5
1993-94	3.2	5.3	8.7	16.3
1994-95	4.6	7.2	16.6	7.2
1995-96	1.7	3.5	1.9	17.1
1996-97	5.8	5.3	17.2	11.3
1997-98	6.9	2.3	12.3	13.3
1998-99	8.2	7.4	19.4	14.5
1999-00	7.9	3.2	15.8	10.0
2000-01	9.0	7.9	13.4	9.6
Long Term Average	4.8	6.1	10.6	12.2

Table 5f. Precipitation by growing season segment for Briggsdale from 1997-2001.

	Growing Season Segments			
	Wheat		Sorghum	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	Inches			
1997-98	3.9	3.9	11.6	11.9
1998-99	4.6	8.4	15.3	12.4
1999-00	4.7	3.7	11.4	4.9
2000-01	2.9	8.0	5.6	10.4
Long Term Average	3.8	5.5	9.5	10.6

Table 5g. Precipitation by growing season segment for Akron from 1997-2001.

	Growing Season Segments			
	Wheat		Corn	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	Inches			
1997-98	5.6	2.1	11.1	6.5
1998-99	2.8	7.9	11.4	17.1
1999-00	6.0	2.7	16.3	9.9
2000-01	6.4	6.3	12.1	12.7
Long Term Average	4.0	7.2	10.1	12.2

Table 5h. Precipitation by growing season segment for Lamar from 1997-2001.

	Growing Season Segments			
	Wheat		Sorghum	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	Inches			
1997-98	10.5	2.6	19.4	15.9
1998-99	7.5	9.2	22.5	11.0
1999-00	4.5	2.4	9.9	4.4
2000-01	3.6	7.0	5.7	10.2
Long Term Average	4.7	5.8	10.0	10.8

Table 6a. Grain and stover yields for WHEAT in English units in 2001.

	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
SITE &	*GRAIN*		*STOVER*		*GRAIN*		*STOVER*		*GRAIN*		*STOVER*	
ROTATION	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	32.8	33.5	2660	2720	13.8	31.4	2245	2550	39.1	34.2	3370	2950
WCSb	24.8	27.4	2015	2220	21.7	24.1	1760	1955	25.9	26.7	2235	2305
(W)WCSb	28.4	29.5	2305	2390	25.6	26.8	2080	2175	32.6	32.0	2810	2755
W(W)CSb	37.7	36.2	3060	2935	33.7	32.1	2730	2600	44.0	42.7	3790	3680
OPP	18.9	24.0	1535	1945	23.1	20.5	1880	1660	14.5	14.5	1250	1250
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STRATTON:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	38.5	39.5	2815	3080	42.6	46	2920	3260				
WCSb	24.6	24	1985	1800	20	23.8	1885	2535		Wheat	lodged	
(W)WCSb	30.3	39.8	2165	2965	34.1	34	2500	2405				
W(W)CSb	19.7	20.5	1620	1545	21.9	20.7	1655	1560				
OPP	39.2	41.5	3600	2610	42.3	41.2	2930	3160				
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
WALSH:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WSF	29.0	27.5	2940	2790	34.2	33.7	3120	3080	53.3	43.8	5130	4225
WCSb	18.0	19.5	1830	1980	19.9	24.4	1815	2230	33.0	24.8	3175	2390
(W)WSSa	26.0	27.5	2635	2785	24.2	23.3	2210	2125	32.9	23.6	3170	2275
W(W)SSa	30.3	23.2	3075	2350	34.0	26.8	3640	2440	32.8	27.7	3155	2670

1. Wheat grain yield expressed at 12% moisture.

* Only receives phosphorus in wheat phase of each rotation.

Table 6b. Grain, stover and total biomass yields for WHEAT in metric units in 2001.

	SLOPE POSITION																	
	SUMMIT						SIDE						TOE					
SITE & ROTATION	*GRAIN*		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*	
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	----------------kg/ha------------------						--------------------kg/ha------------------						------------------kg/ha------------------					
WCF	1861	1902	2977	3043	4838	4945	786	1784	1258	2856	2044	4640	2218	1942	3774	3301	5992	5243
WCSb	1411	1556	2257	2487	3668	4043	1230	1371	1970	2189	3200	3560	1472	1515	2501	2580	3973	4095
(W)WC	1613	1673	2579	2676	4192	4349	1455	1519	2328	2434	3783	3953	1848	1818	3144	3087	4992	4905
W(W)C	2144	2053	3429	3286	5573	5339	1912	1821	3059	2912	4971	4733	2496	2423	4245	4119	6741	6542
OPP	1075	1361	1719	2177	2794	3538	1314	1163	2103	1861	3417	3024	823	823	1400	1399	2223	2222
STRATTON:	----------------kg/ha------------------						--------------------kg/ha------------------						------------------kg/ha------------------					
WCF	2275	2315	3152	3447	5427	5762	2517	2725	3273	3650	5790	6375	-	-	-	-	-	-
WCSb	1458	1418	2225	2014	3683	3432	1179	1408	2108	2837	3287	4245	-	-	-	-	-	-
(W)WC	1794	2355	2425	3322	4219	5677	2013	2013	2796	2695	4809	4708	-	-	-	-	-	-
W(W)C	1166	1213	1810	1730	2976	2943	1294	1223	1854	1749	3148	2972	-	-	-	-	-	-
OPP	2634	2144	403150	2925	6665	5069	2372	2570	3281	3541	5653	6111	-	-	-	-	-	-
WALSH:	----------------kg/ha------------------						--------------------kg/ha------------------						------------------kg/ha------------------					
WSF	1646	1562	3291	3124	4937	4686	1942	1915	3496	3447	5438	5362	3027	2490	5747	4729	8774	7219
WCSb	1028	1109	1025	1109	2053	2218	1129	1384	1016	1249	2145	2633	1875	1404	1779	1337	3654	2741
(W)WS	1475	1559	2950	3119	4425	4678	1374	1320	2477	2381	3851	3701	1868	1341	3548	2546	5416	3887
W(W)S	1720	1317	3445	2634	5165	3951	1932	1519	3478	2734	5410	4253	1861	1572	3535	2987	5396	4559

* Only receives phosphorus in wheat phase of each rotation.

Table 7. **Wheat yields by rotation at optimum fertility by year and year and soil position at STERLING from 1998-2001.**

		SLOPE POSITION			
	ROTATION	SUMMIT	SIDE	TOE	MEAN
		-----------------Bu/A-------------------------			
1998	WCF	28	16	40	28
	WCP	32	33	30	32
	(W)WCP	----------------No yield-------------			
	W(W)CP	32	36	46	38
1999	WCF	36	40	46	41
	WCSb	33	24	31	29
	(W)WCSb	29	28	29	29
	W(W)CSb		----------------No yield-------------		
2000	WCF	34	30	42	35
	WCSb	14	18	16	16
	(W)WCSb	16	19	9	15
	W(W)CSb	28	26	21	25
2001	WCF	34	31	34	33
	WCSb	27	24	27	26
	(W)WCSb	30	27	32	30
	W(W)CSb	36	32	43	37
AVERAGE	WCF	33	29	40	34
	WCSb	26	25	26	26
	(W)WCSb	19	18	17	18
	W(W)CSb	24	23	28	25

Table 8. **Wheat yields by rotation at optimum fertility by year and year and soil position at STRATTON from 1998-2001.**

		SLOPE POSITION			
	ROTATION	SUMMIT	SIDE	TOE	MEAN
		------------------------------Bu/A------------------------------			
1998	WCF	37	29	51	39
	WCP	34	34	48	39
	(W)WCP	35	31	40	35
	W(W)CP	37	39	51	42
1999	WCF	55	38	50	48
	WCSb	36	27	34	32
	(W)WCSb	34	30	44	36
	W(W)CSb		---------------No yield-------------		
2000	WCF	22	10	24	19
	WCSb	12	8	32	17
	(W)WCSb	6	6	34	15
	W(W)CSb	9	3	13	8
2001	WCF	40	46	Lodged	35
	WCSb	24	24	Lodged	29
	(W)WCSb	40	34	Lodged	29
	W(W)CSb	20	21	Lodged	25
AVERAGE	WCF	38	31	31	34
	WCSb	26	25	28	26
	(W)WCSb	29	25	30	28
	W(W)CSb	16	16	16	16

Table 9. **Wheat yields by rotation at optimum fertility by year and year and soil position at WALSH from 1998-2001.**

		SLOPE POSITION			
	ROTATION	SUMMIT	SIDE	TOE	MEAN
		--------------------------------Bu/A---------------------------			
1998	WSF	31	31	38	33
	WCSf	25	31	40	32
	(W)WSSf	8	12	20	13
	W(W)SSf	27	29	32	29
1999	WSF	52	52	54	53
	WCSb	40	46	52	46
	(W)WSSb	37	36	37	37
	W(W)SSb	54	50	52	52
2000	WSF	24	29	32	28
	WCSb	14	14	14	14
	(W)WSSb	14	11	13	13
	W(W)SSb	16	14	24	18
2001	WSF	28	34	48	38
	WCSb	20	24	25	30
	(W)WSSb	28	23	24	21
	W(W)SSb	23	27	28	33
AVERAGE	WSF	34	36	43	38
	WCSb	25	29	33	30
	(W)WSSb	22	20	23	22
	W(W)SSb	30	30	34	32

Table 10. Wheat grain & straw yields by variety and rotation at Briggsdale, Akron, & Lamar in 2001.

Site &	Grain Yield[1] by Variety			Stover Yield by Variety		
Rotation	Lamar	Prowers99	Mean	Lamar	Prowers99	Mean
	----------- bu/acre -----------			----------- lb/acre -----------		
Briggsdale						
WF	46.6	43.7	45.2	4700	4720	4710
WMF	44.4	43.8	44.1	4350	4200	4270
W'WCSbSfSb[2]	31.4	29.5	30.5	3200	2830	3020
WW'CSbSfSb[2]	26.9	26.9	26.9	2640	2360	2480
Opportunity	37.5	36.7	36.6	3790	3520	3650
Akron	TAM 107	Prairie Red	Mean	TAM 107	Prairie Red	Mean
WF	31.2	32.3	31.8	3350	3940	3650
WCF	31.7	29.8	30.8	3350	3150	3250
WCSfF	26.2	27.0	26.6	2580	2570	2580
WCM	32.0	35.5	33.8	3290	4050	3670
Lamar	TAM 107	Prairie Red	Mean	TAM 107	Prairie Red	Mean
WF	20.0	19.2	19.6	1860	1570	1715
WSF	19.0	15.1	17.1	2060	1160	1610

[1] Grain adjusted to 12.5% moisture

[2] Wheat/Wheat/Corn/Soybean/Sunflower/Forage Soybean

Table 11a. Grain and stover yields for CORN AND SORGHUM in English units in 2001.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	GRAIN		*STOVER*		*GRAIN*		*STOVER*		*GRAIN*		*STOVER*	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	---- Bu./A. ----		---- lbs./A. ----		---- Bu./A. ----		---- lbs./A. ---		---- Bu./A. ----		---- lbs./A. ----	
WCF	34	34	1700	1715	36	38	1820	1895	82	70	4070	3525
WCSb	22	27	1530	1335	44	50	2525	2160	62	64	3510	2965
WWCSb	37	38	1795	2160	49	64	1510	2400	68	73	3530	3655
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	---- Bu./A. ----		---- lbs./A.----		---- Bu./A. ----		---- lbs./A. ---		---- Bu./A. ----		---- lbs./A. ---	
WCF	4	10	225	250	21	18	1070	910	82	105	4155	5315
WCSb	5	4	260	230	19	14	980	700	77	72	3920	5330
WWCSb	6	5	650	505	11	7	405	400	81	99	3800	4175
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	----- Bu./A. ----		--- lbs./A. ----		---- Bu./A. ----		--- lbs./A. ----		---- Bu./A. ---		---- lbs./A. ---	
WSF	63	66	2370	2190	67	77	2215	2545	33	45	1090	1495
WCSb	37	55	1815	2585	40	70	1895	3270	28	61	1750	2835
WWSSb	64	65	2100	2155	68	60	2245	1980	53	56	1765	1860
OPP	64	67	2110	2210	60	60	1970	1965	41	52	1365	1730
CS (Corn)	45	60	1495	2805	42	52	1955	2790	48	49	2260	2150
CS (Sorghum)	63	57	1075	1015	57	54	1110	1060	33	36	525	555

1. Corn grain yield expressed at 15.5% moisture.
2. Sorghum grain yield expressed at 14% moisture.

Table 11b. Grain, stover and total biomass yields for CORN and SORGHUM in 2001.

SITE & ROTATION	SLOPE POSITION																	
	SUMMIT						SIDE						TOE					
	GRAIN		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	-------------------kg/ha-------------------						-------------------kg/ha-------------------						---------------------kg/ha----------------------					
WCF	1814	1829	1778	1793	3592	3622	1939	2020	190019	1979	3839	3999	4344	3759	4257	3684	8600	7444
WCSb	1151	1465	1597	1395	2748	2860	2361	2640	2639	2257	5000	4898	3324	3404	3667	3099	6991	6503
WWCSb	1959	2028	1874	2256	3833	4284	2602	3378	1580	2506	4182	5884	3605	3900	3692	3820	7297	7720
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	-------------------kg/ha---------------------						---------------------kg/ha-------------------						----------------------kg/ha---------------------					
WCF	236	261	236	261	472	522	1121	953	1121	953	2242	1905	4343	5554	4343	5554	8686	11108
WCSb	272	243	272	243	545	486	1023	734	1023	734	2046	1468	4095	5570	4095	5570	8190	11139
WWCSb	351	276	678	529	1029	805	597	390	423	417	1020	807	4283	5256	3970	4362	8253	9618
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	-------------------kg/ha----------------------						-----------------kg/ha-----------------						-------------------Kg/ha----------------------					
WSF	3326	3519	2162	2288	5489	5807	3561	4092	2315	2660	5875	6752	1748	2401	1136	1560	2884	3961
WCSb	2209	2925	2650	3510	4859	6435	2193	375006	2632	4500	4825	8250	2020	3105	3030	3727	5050	6832
WWSSb	3374	3465	2193	2252	5568	5718	3607	3182	2345	2068	5952	5250	2837	2992	1844	1945	4681	4938
CC (Sorghum)	3347	3017					3030	2847					1763	1893				
CC (Corn)	2211	3131	2653	3757	4864	6888	2204	3570	2645	4284	4849	7854	2598	2002	3118	2402	5716	4404
OPP	3391	3549	2204	2307	5594	5855	3169	3159	2060	2053	5229	5212	2194	2778	1426	1806	3620	4583

Table 12. **Corn yields by rotation at optimum fertility by year and soil position at STERLING from 1999-2001.**

YEAR		SLOPE POSITION			
	ROTATION	SUMMIT	SIDE	TOE	MEAN
		---------------------------------Bu/A------------------------------------			
1998	WCF	50	44	54	49
	WCSb	56	71	96	74
	WWCSb	44	55	84	61
1999	WCF	56	62	81	66
	WCSb	50	56	70	59
	WWCSb	39	67	66	57
2000	WCF	10	23	28	20
	WCSb	18	21	24	21
	WWCSb	7	20	25	17
2001	WCF	34	38	70	47
	WCSb	27	50	64	47
	WWCSb	38	64	73	56
2002	WCF	0	0	0	0
	WCSb	0	0	0	0
	WWCSb	0	0	0	0
Mean	WCF	38	42	58	46
Excluding 2002	WCSb	38	50	64	59
	WWCSb	32	52	62	48

Table 13. **Corn yields by rotation at optimum fertility by year and soil position at STRATTON from 1999-2001.**

YEAR		SLOPE POSITION			
	ROTATION	SUMMIT	SIDE	TOE	MEAN
		---Bu/A---			
1998	WCF	122	94	117	111
	WCSb	110	94	124	109
	WWCSb	122	100	117	113
1999	WCF	88	80	100	89
	WCSb	73	70	96	80
	WWCSb	82	86	108	92
2000	WCF	38	20	53	37
	WCSb	47	45	52	48
	WWCSb	44	40	48	44
2001	WCF	10	18	105	44
	WCSb	4	14	72	30
	WWCSb	5	7	99	37
2002	WCF	0	0	0	0
	WCSb	0	0	0	0
	WWCSb	0	0	0	0
Mean	WCF	64	53	94	70
Excluding 2002	WCSb	58	56	86	67
	WWCSb	63	58	93	72

Table 14. Sorghum and corn yields by rotation at optimum fertility by year and soil position at WALSH from 1999-2001.

YEAR		SLOPE POSITION			
	ROTATION	SUMMIT	SIDE	TOE	MEAN
		----------------------------	Bu/A	----------------------------	
1998	WSF	60	76	76	71
	WCSb	38	56	100	65
	WWSSb	61	74	80	72
	Cont. Row C	54	62	80	65
	Cont. Row S	60	64	60	61
1999	WSF	64	68	60	64
	WCSb	46	65	54	55
	WWSSb	59	70	54	61
	Cont. Row C	45	58	50	51
	Cont. Row S	52	58	45	52
2000	WSF	22	26	18	22
	WCSb	20	11	2	11
	WWSSb	27	24	18	23
	Cont. Row C	6	6	1	4
	Cont. Row S	24	22	4	17
2001	WSF	66	77	54	63
	WCSb	55	70	61	62
	WWSSb	65	60	56	60
	OPP	67	60	52	60
	Cont. Row C	60	52	49	54
	Cont. Row S	57	54	36	49
2002	WSF	17	22	16	18
	WCSb	14	11	9	11
	WWSSb	17	15	10	14
	Cont. Row C	7	2	2	4
	Cont. Row S	3	2	5	3
Mean Excluding 2002	WSF	53	62	50	55
	WCSb	40	50	54	48
	WWSSb	53	57	52	54
	Cont. Row C	41	44	45	43
	Cont. Row S	48	50	36	45

Table 15. Grain & Stover Yields for Corn at Briggsdale & Akron and Grain Sorghum yields at Lamar in 2001.

Site & Rotation	Grain[1] bu/ac	Stover lb/ac
Briggsdale		
WWCSbSfSb	5.7	2010
Akron		
WCF	51.0	2890
WCSfF	52.9	3370
WCM	58.3	3170
Lamar		
WSF	30.9	6140

[1] Grain yields were corrected to 15.5% moisture

Table 16. Grain and stover yields for summer crops (other than corn) at Briggsdale and Akron in 2001.

Site & Rotation	Crop	Grain	Stover	Corrected Moisture[1]
		— bu/ac —	— bu/ac ---	%
Briggsdale				
WMF	Hay Millet		3500 lb/ac (1.8 t)	15.0%
WWCSbSfSb	Gr. Soybean	0 bu/ac	0 lb/ac	13.0%
WWCSbSfSb	Sunflowers	560 lb/ac	1150 lb/ac	10.0%
WWCSbSfSb	Forage Soybean		1220 lb/ac(0.6t)	15.0%
Akron				
WCM	Proso Millet	49.1 bu/ac	2200 lb/ac	
WCSfF	Sunflowers	1140 lb/ac	2420 lb/ac	

[1] Percent moisture grain was corrected to.

Table 17a. Grain and stover yields for Soybean at Sterling, Stratton and Walsh in English units in 2001.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	GRAIN		*STOVER*		*GRAIN*		*STOVER*		*GRAIN*		*STOVER*	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCSb	6.5	10.5	10.2	16.4	7.1	8.2	11.0	12.9	12.6	14.6	19.8	22.9
WWCSb	5.9	5.7	9.2	9.0	12.8	13.3	20.	20.8	17.7	17.4	27.8	27.2
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCSb	9.3	12.7	9.7	9.1	10.7	11.9	2.3	2.4	16.2	30.9	42.1	40
WWSb	10	9.8	14.1	10.9	10.2	12.0	2.1	6.8	23.2	25	44.2	17.5
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	--------Bu/A------		--------lb./A------		--------Bu/A------		------ lbs./A. ------		--------Bu/A------		------ lbs./A. ------	
WCSb	7.5	9.2	11.8	14.4	7.9	10.6	12.3	16.5	17.5	17.2	27.3	26.9
WWSSb OPP	8.5	8.2	13.3	12.9	8.2	9.6	12.9	15.1	14.1	14.0	22.1	21.8

1. Soybean yield expressed at 13.0% moisture.

Table 17b. Grain and stover yields for Soybean at Sterling, Stratton and Walsh in metric units in 2001.

SITE & ROTATION	SLOPE POSITION																	
	SUMMIT						SIDESLOPE						TOESLOPE					
	GRAIN		STOVER		TOTAL		*GRAIN*		STOVER		*TOTAL*		*GRAIN*		*STOVER*		TOTAL	
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STERLING:	kg/ha						kg/ha						kg/ha					
WCSb	355	571	11	17	366	588	385	449	12	13	397	462	690	798	21	24	711	822
WWCSb	322	312	10	9	332	321	698	726	21	22	719	748	967	948	29	28	996	976
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
STRATTON:	kg/ha						kg/ha						kg/ha					
WCSb	506	694	10	9	516	703	586	647	2	2	588	649	-	-	-	-	-	-
WWSb	548	533	15	11	563	544	557	654	44	7	601	661	1267	1473	46	18	1313	1491
	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP	N	NP
WALSH:	kg/ha						kg/ha						kg/ha					
WCSb	411	502	12	15	423	517	430	577	13	17	443	594	953	938	29	28	982	966
WWSSb	463	450	14	14	477	464	449	526	13	16	462	542	770	761	23	23	793	784

1. Soybean yield expressed at 13.0% moisture.

Table 18. Grain and forage yields in the opportunity cropping system at STERLING.

YEAR	CROP	SLOPE POSITION			
		SUMMIT	SIDE	TOE	MEAN
		---------------------Bu/A or T/A---------------------			
1986	Wheat	27	25	28	27
1987	Corn	46	59	70	58
1988	Corn	52	60	63	58
1989	Attempted Hay Millet	0	0	0	0
1990	Wheat	29	40	42	37
1991	Corn	57	69	105	77
1992	Hay Millet	2.35	2.45	3.17	2.66
1993	Corn	30	37	44	37
1994	Sunflower	0	0	0	0
1995	Wheat	25	31	32	29
1996	Corn	68	72	84	75
1997	Hay Millet	2.22	1.97	1.98	2
1998	Wheat	24	24	26	25
1999	Corn	55	67	66	63
2000	Austrian winter pea	0.72	0.70	0.00	0.47
2001	Wheat	24	20	14	19
2002	Corn	0	0	0	0
Total	Wheat (5)	129	140	142	137
Production	Corn (6) (Not 2002)	308	364	432	368
	Forage (3)	4.57	4.42	5.15	4.71
	Sunflower (1)	0	0	0	0
	Austrian winter pea(1)	0.72	0.70	0.00	0.47

Table 19. **Grain and forage yields in the opportunity cropping system at STRATTON.**

YEAR	CROP	SLOPE POSITION			
		SUMMIT	SIDE	TOE	MEAN
		----------------------Bu/A or T/A----------------------			
1986	Wheat	32	29	23	28
1987	Sorghum	31	34	51	39
1988	Sorghum	30	28	52	37
1989	Attempted Hay Millet	0	0	0	0
1990	Wheat	45	32	78	52
1991	Corn	89	75	114	93
1992	Hay Millet	2.75	2.52	2.55	2.61
1993	Corn	47	54	44	48
1994	Sunflower	0	0	0	0
1995	Wheat	55	47	50	51
1996	Corn	110	118	124	117
1997	Hay Millet	2.37	2.34	1.55	2.09
1998	Wheat	30	32	40	34
1999	Corn	93	80	106	93
2000	Austrian winter pea	2.07	1.56	2.80	2.14
2001	Wheat	42	41	Lodged	42
2002	Corn	0	0	0	0
Total	Wheat (5)	2004	181	191	206
Production	Corn & Sorghum (6) (not 2002)	400	389	491	427
	Forage (3)	5.12	4.86	4.10	4.69
	Sunflower (1)	0	0	0	0
	Austrian winter pea(1)	2.07	1.56	2.80	2.14

Table 20. Grain and forage yields in the opportunity cropping system at WALSH.

YEAR	CROP	SLOPE POSITION			
		SUMMIT	SIDE	TOE	MEAN
		---Bu/A or T/A---			
1986	Sorghum	34	25	42	34
1987	Millet	0	0	0	0
1988	Forage	0.39	0.32	0.71	0.47
1989	Sorghum	18	38	82	46
1990	Sunflower	0	0	0	0
1991	Wheat	40	38	44	41
1992	Corn	45	46	56	49
1993	Fallow	0	0	0	0
1994	Wheat	32	37	46	38
1995	Wheat	13	12	18	14
1996	Fallow	0	0	0	0
1997	Corn	54	63	83	67
1998	Sorghum	72	80	84	79
1999	Corn	49	54	40	48
2000	Soybean	2	2	2	2
2001	Wheat	24	21	14	19
Total Production	Wheat (4)	109	108	122	112
	Sorghum & Com (6)	272	306	387	322
	Forage (1)	0.39	0.32	0.71	0.47
	Sunflower (1)	0	0	0	0
	Millet (1)	0	0	0	0
	Soybean (1)	2	2	2	2

Table 21. Crop residue weights on all plots in WHEAT during the 2000-2001 crop year.

	SLOPE POSITION					
SITE & ROTATION	**SUMMIT**		**SIDESLOPE**		**TOESLOPE**	
	Pre-Plant		***Pre-Plant***		***Pre-Plant***	
	NP*	NP	NP*	NP	NP*	NP
STERLING:	---------Kg/ha----------		---------Kg/ha----------		---------Kg/ha----------	
WCF	5295	5550	3315	4245	4585	6230
WCSb						
(W)WCSb						
W(W)CSb	3980	3095	4875	3600	4345	4310
CC	3550	7015	4460	6520	3235	4085
	NP*	NP	NP*	NP	NP*	NP
STRATTON:	---------Kg/ha----------		---------Kg/ha--------		---------Kg/ha--------	
WCF	5080	5870	5040	5755	4750	5990
WCSb						
(W)WCSb						
W(W)CSb	3605	4985	5780	3550	5515	5230
CC	5555	4090	3350	2410	3960	3850
	NP*	NP	NP*	NP	NP*	NP
WALSH:	---------Kg/ha--------		---------Kg/ha--------		---------Kg/ha--------	
WSF	4000	2925	3120	3840	4445	2225
WCSb	935	1465		995	1555	1095
(W)WSSb	2900	4045	2285	2110	1965	1740
W(W)SSb		3345	1360	5670	4135	2035

1. For conversion to lbs/Acre multiply Kg/ha by 0.893.

* Only receives phosphorus in wheat phase of each rotation.

Table 22. Crop residue weights on all plots in Corn/Sorghum during the 2001 crop year.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE &	*Pre-Plant*		*Pre-Plant*		*Pre-Plant*	
ROTATION	NP*	NP	NP*	NP	NP*	NP
STERLING:	-------kg ha^{-1}--------		-------kg ha^{-1}--------		-------kg ha^{-1}--------	
WCF	5390	4540	4810	4455	8395	9620
WCSb	2560	4455	2580	1875	5620	2295
WWCSb	7685	7255	4110	6530	5180	3655
	NP*	NP	NP*	NP	NP*	NP
STRATTON:	------kg ha^{-1}--------		-------kg ha^{-1}--------		-------kg ha^{-1}--------	
WCF	5335	6800	3415	6550	8035	7735
WCSb	3365	3245	3940	3970	6580	8500
WWCSb	4820	4150	4610	3560	8390	7235
	NP*	NP	NP*	NP	NP*	NP
WALSH:	-------kg ha^{-1}--------		-------kg ha^{-1}--------		-------kg ha^{-1}--------	
WSF	2700	2210	2765	3100	1925	1930
WCSb	2415	2725	1500	1845	1760	2310
WWSSb	2730	2880	2580	2740	3390	3260
Cont. Crop (S)	2485	2360	2930	2115	3135	2900
Cont. Crop (C)	2590	2180	3500	2675	4430	3235

1. For conversion to lbs/Acre multiply Kg/ha by 0.893. * Only receives phosphorus in wheat phase of each rotation.

Table 23. Crop residue weights on all plots in Soybean during the 2001 crop year.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE & ROTATION	***Pre-Plant***		***Pre-Plant***		***Pre-Plant***	
	NP*	NP	NP*	NP	NP*	NP
STERLING:	-------kg ha^{-1}--------		-------kg ha^{-1}--------		-------kg ha^{-1}--------	
WCSb	3420	2935	3990	2230	3670	2580
WWCSb	2460	2210	2400	2750	3740	2640
	NP*	NP	NP*	NP	NP*	NP
STRATTON:	------kg ha^{-1}--------		-------kg ha^{-1}--------		-------kg ha^{-1}--------	
WCSb	3150	3140	3460	3390	6220	4340
WWCSb	3715	4500	2575	2615	7420	4700

1. For conversion to lbs/Acre multiply Kg/ha by 0.893.

* Only receives phosphorus in wheat phase of each rotation.

Table 24. Crop residues prior to planting at Briggsdale, Akron, and Lamar in 2001.

	Spring Planted Crops			Fall Planted Crops		
Site	2001 Crop	Rotation	Residue	2001 Crop	Rotation	Residue
			lb/ac			lb/ac
Briggsdale	Corn	WWCSbSfSb	1600	Wheat	WF	1690
	Soybean	WWCSbSfSb	650	Wheat	WMF	0
	F. Soybean	WWCSbSfSb	900	Wheat	W'WCSbSfSb	310
	Sunflower	WWCSbSfSb	1000	Wheat	WW'CSbSfSb	1600
	Millet	WMF	2000			
Akron	Corn	WCF	1700	Wheat	WF	160
	Corn	WCM	2420	Wheat	WCF	1120
	Corn	WCSfF	860	Wheat	WCM	3320
	Sunflower	WCSfF	1430	Wheat	WCSfF	930
	Millet	WCM	4610			
Lamar	Sorghum	WSF	1790	Wheat	WF	2460
				Wheat	WSF	2340

Table 25a. Total Nitrogen content of WHEAT GRAIN in the 2000-2001 crop.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE & ROTATION	*N Side**	*NP Side*	*N Side**	*NP Side*	*N Side**	*NP Side*
	N	N	N	N	N	N
STERLING:	------------ % -----------		------------ % -----------		------------ % -----------	
WCF	2.13	2.25	2.18	2.26	1.96	1.94
WCSb	2.25	2.10	2.31	1.89	2.16	2.20
(W)WCSb	2.26	2.35	1.84	2.49	2.37	2.31
W(W)CSb	2.39	2.33	1.87	1.89	2.34	2.28
OPP (W)	2.26	2.56	2.26	2.22	2.27	2.16
	N	N	N	N	N	N
STRATTON:	------------ % -----------		----------- % -----------		------------ % -----------	
WCF	2.87	2.55	2.57	2.41		
WCSb	2.81	2.99	3.26	3.24	2.48	2.89
(W)WCSb	3.25	3.15	3.57	3.33		
W(W)CSb	2.64	2.61	2.82	2.87		
OPP (W)	2.81	2.57	2.88	2.89		
	N	N	N	N	N	N
WALSH:	------------ % -----------		------------ % ---------		------------ % -----------	
WSF	2.74	2.79	2.69	2.82	2.72	2.83
WCSb	2.53	2.56	2.97	2.97	2.77	2.73
(W)SSb						
W(W)SSb	2.67	2.61	2.64	2.82	3.03	2.78
(W) WSSb	2.60	2.68	2.66	2.86	2.95	3.16

* Only receives phosphorus in wheat phase of each rotation.

Table 25a. Total Nitrogen content of WHEAT STRAW in the 2000-2001 crop.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE W(W)SSB	*N Side**	*NP Side*	*N Side**	*NP Side*	*N Side**	*NP Side*
ROTATION	**N**	**N**	**N**	**N**	**N**	**N**
STERLING:	------------ % -----------		------------ % -----------		------------ % -----------	
WCF	0.61	0.56	0.68	0.53	0.35	0.54
WCSb	0.56	0.77	0.55	0.76	0.57	0.58
(W)WCSb	0.57	0.43	0.53	0.63	0.35	0.48
W(W)CSb	0.40	0.45	0.39	0.24	0.41	0.49
OPP (W)	0.97	0.71	0.67	0.66	0.57	0.50
	N	**N**	**N**	**N**	**N**	**N**
STRATTON:	------------ % -----------		----------- % -----------		------------ % -----------	
WCF	0.63	0.65	0.45	0.59	1.10	1.32
WCSb	0.79	0.98	0.51	0.61	1.01	0.82
(W)WCSb	0.73	0.85	0.61	0.71	1.34	1.08
W(W)CSb	0.86	0.81	0.78	0.56	0.98	0.75
OPP (W)	0.74	0.74	0.59	0.59	1.09	1.12
	N	**N**	**N**	**N**	**N**	**N**
WALSH:	------------ % -----------		------------ % ---------		------------ % -----------	
WSF	0.97	0.60	0.55	0.46	0.32	0.45
WCSb	0.42	0.40	0.45	0.47	0.69	0.49
(W)SSb	0.27	0.49	0.47	0.51	0.79	0.67
W(W)SSb	0.53	0.56	0.59	0.50	0.70	0.66

* Only receives phosphorus in wheat phase of each rotation.

Table 26a. Total Nitrogen content of CORN GRAIN or SORGHUM GRAIN in the 2001 crop.

	SLOPE POSITION					
	SUMMIT		**SIDESLOPE**		**TOESLOPE**	
SITE & ROTATION	***N Side****	***NP Side***	***N Side****	***NP Side***	***N Side****	***NP Side***
	N	**NP**	**N**	**NP**	**N**	**NP**
STERLING:	------------ % -----------		------------ % -----------		------------ % -----------	
WCF	1.75	1.75	1.65	1.75	1.47	1.59
WCSb	1.80	1.80	1.83	1.80	1.77	1.74
WWCSb	1.79	1.67	1.72	1.80	1.69	1.72
	N	**NP**	**N**	**NP**	**N**	**NP**
STRATTON:	------------ % -----------		------------ % -----------		----------- % ------------	
WCF	1.80	1.73	1.70	1.42	1.42	1.33
WCSb	1.70	1.76	1.49	1.67	1.44	1.37
WWCSb	1.73	1.68	1.65	1.66	1.43	1.45
	N	**NP**	**N**	**NP**	**N**	**NP**
WALSH:	------------ % -----------		------------ % ---------		------------ % -----------	
WSF	1.38	1.41	1.54	1.43	1.82	1.81
WCSb	1.56	1.55	1.63	1.46	1.73	1.68
WWSSb	1.48	1.47	1.51	1.57	1.83	1.84
Cont. Crop (C)	1.67	1.53	1.70	1.61	1.78	1.77
Cont. Crop (S)	1.48	1.48	1.63	1.66	1.92	1.83

* Only receives phosphorus in wheat phase of each rotation.

Table 26b. Total Nitrogen content of CORN STOVER or SORGHUM STOVER in the 2001 crop.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE & ROTATION	***N Side****	***NP Side***	***N Side****	***NP Side***	***N Side****	***NP Side***
	N	**NP**	**N**	**NP**	**N**	**NP**
STERLING:	------------ % -----------		------------ % -----------		------------ % -----------	
WCF	0.87	0.58	0.46	0.45	0.41	0.45
WCSb	0.79	1.43	0.73	0.76	0.63	0.58
WWCSb	0.82	0.60	0.73	0.48	0.57	0.90
	N	**NP**	**N**	**NP**	**N**	**NP**
STRATTON:	------------ % -----------		------------ % -----------		----------- % ------------	
WCF						
WCSb						
WWCSb						
	N	**NP**	**N**	**NP**	**N**	**NP**
WALSH:	------------ % -----------		------------ % ---------		------------ % -----------	
WSF	0.52	0.47	0.61	0.65	0.75	0.68
WCSb	1.06	0.72	0.69	0.66	1.25	0.92
WWSSb	0.87	0.77	0.58	0.59	0.69	0.68
Cont. Crop (C)	0.55	0.67	0.96	0.59	0.66	0.79
Cont. Crop (S)	0.53	0.85	0.78	0.64	0.86	1.09

* Only receives phosphorus in wheat phase of each rotation.

Table 27a. Total Nitrogen content of SOYBEAN GRAIN in the 2001 crop.

	SLOPE POSITION					
	SUMMIT		**SIDESLOPE**		**TOESLOPE**	
SITE & ROTATION	***N Side****	***NP Side***	***N Side****	***NP Side***	***N Side****	***NP Side***
	N	**N**	**N**	**N**	**N**	**N**
STERLING:	------------ % -----------		------------ % -----------		------------ % -----------	
WCSb	6.33	6.40	6.45	6.43	6.18	5.63
WWCSb	6.01	6.34	6.10	5.96	4.93	5.69
	N	**N**	**N**	**N**	**N**	**N**
STRATTON:	------------ % -----------		------------ % -----------		------------ % -----------	
WCSb	5.82	5.83	6.05	5.94	5.69	5.62
WWCSb	6.34	6.32	6.24	6.04	5.61	5.66
	N	**N**	**N**	**N**	**N**	**N**
WALSH:	------------ % -----------		------------ % ---------		------------ % -----------	
WSSb	5.41	5.27	5.44	5.50	5.77	5.51
WWSSb	5.09	5.12	5.13	5.16	5.59	5.53

* Only receives phosphorus in wheat phase of each rotation.

Table 27b. Total Nitrogen content of SOYBEAN STOVER in the 2001 crop.

	SLOPE POSITION					
	SUMMIT		**SIDESLOPE**		**TOESLOPE**	
SITE & ROTATION	***N Side****	***NP Side***	***N Side****	***NP Side***	***N Side****	***NP Side***
	N	**N**	**N**	**N**	**N**	**N**
STERLING:	----------- % -----------		----------- % -----------		----------- % -----------	
WCSb	1.05	1.08	1.45	1.24	0.76	0.87
WWCSb	1.10	0.98	1.03	1.07	0.75	0.75
	N	**N**	**N**	**N**	**N**	**N**
STRATTON:	----------- % -----------		----------- % -----------		----------- % -----------	
WCSb	0.96	0.55	0.65	0.86	0.65	0.62
WWCSb	0.80	0.98	1.93	1.10	0.80	0.71
	N	**N**	**N**	**N**	**N**	**N**
WALSH:	----------- % -----------		----------- % ---------		----------- % -----------	
WSSb	0.51	0.49	0.47	0.59	0.64	0.50
WWSSb	0.45	0.49	0.50	0.47	0.56	0.78

* Only receives phosphorus in wheat phase of each rotation.

Table 28. Nitrate-N content of the soil profile at Planting for each crop during 2000-2001 crop year.

Site & Rotation	SLOPE POSITION								
	SUMMIT			SIDESLOPE			TOESLOPE		
	Crop and Time			Crop and Time			Crop and Time		
	Wheat Fall 00	Corn S 01	Sorghum S 01	Wheat Fall 00	Corn S 01	Sorghum S 01	Wheat S 00	Corn S 01	Sorghum S 01
	-----------kg NO3-N ha $^{-1}$-----------			---------kg NO3-N ha $^{-1}$-----------			------------kg NO3-N ha $^{-1}$----------		
STERLING									
WCF	68	35		34	13		43	27	
WCSb		40			22			32	
(W)WCSb									
W(W)CSb	28	36		23	20		54	32	
OPP(W)	79			42			78		
STRATTON:									
WCF	108			73			160		
WCSb									
(W)WCSb									
W(W)CSb	25			74			52		
OPP(W)	106			57			150		
WALSH									
WSF	53	25		64	35		96	45	
WCSb		29			52			82	
(W)WSSb									
W(W)SSb		37			37			42	
CC (C)		28			60			46	
CC (S)		42			61			68	
OPP(W)									

Table 29. Pest insects in wheat at Briggsdale, Akron, & Lamar by day in 2001.

	Wheat Growth Stage		
	Tillering	Jointing	Boot
Briggsdale			
Army cutworm (#/ft.^{2})	0.00	0.07	--
Pale western cutworm (#/ft.^{2})	0.00	0.00	--
Russian wheat aphid (#/50 tillers)	0.00	0.00	0.00
Other cereal aphids (#/50 tillers)	0.00	0.00	0.00
Brown wheat mite (#/1.75 ft.^{2})	3	1	0
Banks grass mite (#/50 tillers)	0.00	--	0.00
Akron			
Army cutworm (#/ft.^{2})	0.05	0.15	--
Pale western cutworm (#/ft.^{2})	0.05	0.20	--
Russian wheat aphid (#/50 tillers)	0.10	0.00	0.63
Other cereal aphids (#/50 tillers)	0.00	0.00	0.00
Brown wheat mite (#/1.75 ft.^{2})	0.25	1.75	3.50
Banks grass mite (#/50 tillers)	0.00	0.00	0.00
Lamar			
Army cutworm (#/ft.^{2})		0.00	0.00
Pale western cutworm (#/ft.^{2})		0.00	0.00
Russian wheat aphid (#/50 tillers)		0.00	1.00
Other cereal aphids (#/50 tillers)		0.00	0.00
Brown wheat mite (#/1.75 ft.^{2})		0.00	0.00
Banks grass mite (#/50 tillers)		0.00	0.00

Table 30. Predator insects in wheat at Briggsdale, Akron, & Lamar by day in 2001.

		Wheat Growth Stage		
Site		Tillering	Jointing	Boot
Briggsdale	There were no predator insects found in the wheat at Briggsgale in 2001 season .			
Akron	There were no predator insects found in the wheat at Akron in 2001 season .			
Lamar	Coccinellids (#/4-30 sec. counts)		0.00	1.50
	Spiders (#/4-30 sec. counts)		0.00	0.20
	No other predator insects were found in the wheat at Lamar in 2001			

Table 31. Pheromone trap catches for wheat insects at Briggsdale, Akron and Lamar in Fall 2001.

Briggsdale	Total Captured /trap	Peak Date(s)
Army Cutworm	12.5	12 September
Pale Western Cutworm	159	12 September
Akron	Total Captured /trap	Peak Date(s)
Army Cutworm	75.5	10 September
Pale Western Cutworm	2.5	3 September
Lamar	Total Captured /trap	Peak Date(s)
Army Cutworm		
Pale Western Cutworm		

Table 32. Pest insects in corn at Briggsdale & Akron and sorghum at Lamar in 2001.

	Growth Stage		
	V5	V7	Blister
Briggsdale			
Cutworms (% cut plants)	0	--	--
Western corn rootworm adults (#/ear zone)	--	0	0.6
Banks grass mite #/highest damaged leaf)	--	0	0
Aphids (#/plant)	--	0	0
Western bean cutworm (#/ear)	--	0	0
Corn earworm (#/ear)	--	0	0
Akron	V3	V7	Blister
Cutworms (% cut plants)	0	--	--
Western corn rootworm adults (#/ear zone)	--	0	0
Banks grass mite #/highest damaged leaf)	--	0	0
Aphids (#/plant)	--	0.04	0.01
Western bean cutworm (#/ear)	--	0	0
Corn earworm (#/ear)	--	0	0
Lamar	V3	Boot	Heading
Cutworms (% cut plants)	0	--	--
Greenbug (#/plant)	0.5	0	0
Other cereal aphids (#/plant)	0	0	0
Corn earworm larvae (#/head)	--	--	0.1

Table 33. Natural enemies of corn at Briggsdale & Akron and sorghum at Lamar in 2001.

	Growth Stage		
	V5	V7	Blister
Briggsdale	---- #/ 4 - 30 sec. counts -----		
Coccinellids (ie. lady beetles)	0	0	0.05
Akron	V3	V7	Blister
Spiders	0	0.02	0
Lamar	V3	Boot	Heading
Coccinellids (ie. lady beetles)	1.3	0	0
Spiders	0.25	0	0

Table 34. Pheromone trap catches for corn insects at Briggsdale and Akron and sorghum insects at Lamar in 2001.

Briggsdale	Total Captured /trap	Peak Date(s)
Corn earworm	25.5	2 August
Western bean cutworm	26.5	18 July
European corn borer	6.0	28 June 7 August
Akron	Total Captured /trap	Peak Date(s)
Corn earworm	61	6 August
Western bean cutworm	19	20 July
European corn borer	0	--
Lamar	Total Captured /trap	Peak Date(s)

Table 35. Pest insects in sunflowers at Briggsdale & Akron in 2001.

	Growth Stage		
Briggsdale	V3	late flowering	maturity
Cutworms (% cut plants)	0	--	--
Stem weevil (#/stalk)	--	--	4.25
Seed weevil (#/head)	--	0.09	2.50
Sunflower moth larvae (#/head)	--	--	0
Banded SF moth larvae (#/head	--	--	0
Aphids (#/plant)	0	0	--
Akron	V3	flowering complete	maturity
Cutworms (% cut plants)	0	--	--
Stem weevil (#/stalk)	--	0	4.5
Seed weevil (#/head)	--	4 adults	18.0 larvae
Sunflower moth larvae (#/head)	--	5.0	12.5
Banded SF moth larvae (#/head	--	2.0	4.5
Aphids (#/plant)	6.0	11.5	--

Table 36. Pheromone trap catches for sunflower insects at Briggsdale and Akron in 2001.

Briggsdale	Total Captured /trap	Peak Date(s)
Sunflower head moth	38.0	21 August
Banded SF head moth	13.0	21 August
Akron	Total Captured /trap	Peak Date(s)
Sunflower head moth	24	2 August
Banded SF head moth	29	30 July

Table 37. **Nitrogen fertilizer application by soil and crop for 2002.**

			ROTATION				
SITE	SOIL	CROP	WCF	WCM	WWCM	OPP[1]	
			----------Lbs/A----------				
Sterling	Summit	Wheat	64	64	64	64	
	Sideslope	"	64	64	64	64	
	Toeslope	"	64	64	64	64	
	Summit	Corn	101	101	101		
	Sideslope	"	101	101	101		
	Toeslope	"	101	101	101		
	Summit	Millet		38	38		
	Sideslope	"	-	38	38		
	Toeslope	"	-	38	38		
			WCF	WCM	WWCM	OPP[1]	
Stratton	Summit	Wheat	64	64	64	64	
	Sideslope	"	64	64	64	64	
	Toeslope	"	64	64	64	64	
	Summit	Corn	101	101	101		
	Sideslope	"	101	101	101		
	Toeslope	"	101	101	101		
	Summit	Millet	-	38	38		
	Sideslope	"	-	38	38		
	Toeslope	"	-	38	38		
							CONT.
			WSF	WCM	WWSM	OPP	CROP
Walsh	Summit	Wheat	65	50	50	-	-
	Sideslope	"	65	50	50	-	-
	Toeslope	"	65	50	50	-	-
	Summit	Sorghum	51	-	51	-	51
	Sideslope	"	51	-	51	-	51
	Toeslope	"	51	-	51	-	51
	Summit	Corn	-	106	-		101
	Sideslope	"	-	106	-		101
	Toeslope	"	-	106	-		101
	Summit	Mung beans	-	6	6	6	-
	Sideslope	A	-	6	6	6	-
	Toeslope	A	-	6	6	6	-

Table 38a. Monthly precipitation for the original sites for the 2001-2002 growing seasons.

MONTH	SITE					
	STERLING		STRATTON		WALSH	
	Inches					
2001	2001	Normals[1]	2001	Normals[1]	2001	Normals[1]
JULY	2.28	3.33	4.39	3.25	0.71	2.73
AUGUST	1.33	2.04	0.82	2.59	1.36	2.57
SEPTEMBER	2.33	1.20	1.39	0.94	0.03	1.54
OCTOBER	0.74	0.86	0.38	0.99	0.10	0.98
NOVEMBER	0.80	0.57	0.58	0.71	0.53	0.56
DECEMBER	0.00	0.36	0.23	0.33	0.33	0.37
SUBTOTAL	7.48	8.36	7.79	8.81	3.06	8.75
2002	2002	Normals	2002	Normals	2002	Normals
JANUARY	0.06	0.34	0.38	0.36	0.57	0.31
FEBRUARY	0.05	0.35	0.13	0.47	0.00	0.32
MARCH	0.22	1.03	0.52	0.94	0.04	1.00
APRIL	0.42	1.56	0.55	1.71	0.21	1.35
MAY	0.60	3.09	0.34	3.07	0.67	2.84
JUNE	0.89	2.92	1.31	2.35	1.36	2.18
SUBTOTAL	2.24	9.29	3.23	8.90	2.85	8.00
2002	2002	Normals	2002	Normals	2002	Normals
JULY	0.24	3.33	0.25	3.25	0.88	2.73
AUGUST	4.29	2.04	3.02	2.59	5.45	2.57
SEPTEMBER	1.09	1.20	0.82	0.94	1.85	1.54
OCTOBER	0.96	0.86	1.14	0.99	1.56	0.98
NOVEMBER	0.43	0.57	0.23	0.71	0.20	0.56
DECEMBER	0.07	0.36	0.03	0.33	0.84	0.37
SUBTOTAL	7.08	8.36	5.49	8.81	10.78	8.75
YEAR TOTAL	9.32	17.65	8.72	17.71	13.63	16.75
18 MONTH TOTAL	16.80	26.01	16.51	26.52	16.69	25.50

[1] Normal = 1961-1990 data base

Table 38b. Monthly precipitation for the three new sites for the 2001-2002 growing seasons.

MONTH	LOCATION					
	BRIGGSDALE		AKRON		LAMAR	
	------Inches------					
2001	2001	Normals[1]	2001	Normals[1]	2001	Normals[1]
JULY	2.04	2.51	2.63	2.95	2.45	2.26
AUGUST	0.54	1.81	2.25	2.26	0.62	2.34
SEPTEMBER	1.01	1.28	1.70	0.98	0.27	1.29
OCTOBER	0.66	0.66	0.70	0.85	0.07	0.84
NOVEMBER	0.72	0.45	0.82	0.70	0.22	0.72
DECEMBER	0.00	0.26	0.00	0.36	0.51	0.36
SUBTOTAL	4.97	6.97	8.10	8.10	4.14	7.81
2002	2002	Normals	2002	Normals	2002	Normals
JANUARY	0.07	0.30	0.09	0.36	0.55	0.43
FEBRUARY	0.19	0.19	0.07	0.37	0.01	0.45
MARCH	0.56	0.78	0.08	1.06	0.01	1.03
APRIL	0.06	1.28	0.50	1.42	0.44	1.39
MAY	0.56	1.94	0.46	3.00	0.20	2.42
JUNE	1.62	2.07	1.71	2.28	0.94	2.29
SUBTOTAL	3.06	6.56	2.91	8.49	2.15	8.01
2002	2002	Normals	2002	Normals	2002	Normals
JULY	0.05	2.51	0.10	2.95	0.03	2.26
AUGUST	3.65	1.81	3.44	2.26	1.63	2.34
SEPTEMBER	0.21	1.28	1.50	0.98	0.87	1.29
OCTOBER	0.63	0.66	1.04	0.85	1.15	0.84
NOVEMBER	0.40	0.45	0.39	0.70	0.24	0.72
DECEMBER	0.00	0.26	0.03	0.36	0.56	0.36
SUBTOTAL	4.94	6.97	6.50	8.10	4.48	7.81
YEAR TOTAL	8.00	13.53	9.41	16.59	6.63	15.82
18 MONTH TOTAL	12.97	20.50	17.51	24.69	10.77	23.63

[1] Normal = 1971-2000 data base

Table 38c. Precipitation by growing season segments for Sterling from 1987-2002.

	GROWING SEASON SEGMENTS			
	Wheat		Corn	
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Oct
Year	------------------------------Inches--------------------------------			
1987-88	5.2	9.9	11.1	15.8
1988-89	3.1	6.5	10.5	14.3
1989-90	5.1	4.7	11.8	13.0
1990-91	3.8	7.2	12.3	11.7
1991-92	4.5	4.8	9.1	14.8
1992-93	4.5	6.2	15.5	10.6
1993-94	6.4	3.0	10.2	6.1
1994-95	7.3	14.4	9.6	17.2
1995-96	4.2	9.2	7.5	18.0
1996-97	4.7	7.0	10.6	21.4
1997-98	5.5	4.9	16.7	13.8
1998-99	5.8	7.7	13.5	12.8
1999-00	5.7	3.0	12.6	8.6
2000-01	6.8	8.2	11.5	13.8
2001-02	4.2	1.9	8.2	8.1
Long Term Average	4.4	7.9	11.2	13.2

Table 38d. Precipitation by growing season segment for Stratton from 1987 -2002.

	GROWING SEASON SEGMENTS			
	Wheat		Corn	
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Oct
Year	----------------------------Inches--------------------------------			
1987-88	4.3	7.2	8.8	12.6
1988-89	3.0	9.4	5.3	15.5
1989-90	5.3	6.1	11.0	13.4
1990-91	4.4	4.1	10.7	14.7
1991-92	3.3	6.1	14.2	13.6
1992-93	3.3	3.8	11.8	14.7
1993-94	4.3	7.8	16.7	13.5
1994-95	7.0	10.0	14.8	13.7
1995-96	3.5	6.0	8.1	14.5
1996-97	2.9	6.2	12.2	23.2
1997-98	8.0	5.9	22.6	13.9
1998-99	4.4	8.5	15.6	12.3
1999-00	6.2	3.9	14.2	8.8
2000-01	4.7	4.3	9.8	10.6
2001-02	3.8	2.2	9.5	6.9
Long Term Average	4.5	6.4	11.2	12.9

Table 38e. Precipitation by growing season segment for Walsh from 1987-2002.

	GROWING SEASON SEGMENTS			
	Wheat		Corn	
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Oct
Year	------------------------------Inches------------------------------			
1987-88	4.3	7.6	7.4	11.1
1988-89	4.1	11.5	8.1	20.2
1989-90	5.7	7.4	14.1	12.5
1990-91	5.0	7.7	11.7	12.2
1991-92	2.7	5.8	7.1	13.2
1992-93	6.1	9.2	13.8	14.5
1993-94	3.2	5.3	8.7	16.3
1994-95	4.6	7.2	16.6	7.2
1995-96	1.7	3.5	1.9	17.1
1996-97	5.8	5.3	17.2	11.3
1997-98	6.9	2.3	12.3	13.3
1998-99	8.2	7.4	19.4	14.5
1999-00	7.9	3.2	15.8	10.0
2000-01	9.0	7.9	13.4	9.6
2001-02	1.7	2.2	2.9	11.8
Long Term Average	4.8	6.1	10.6	12.2

Table 38f. Precipitation by growing season segment for Briggsdale from 1997-2002.

	GROWING SEASON SEGMENTS			
	Wheat		Corn	
	Vegetat. Sep - Mar	Reprod. Apr - Jun	Preplant Jul - Apr	Growing Season May - Oct
Year	------------------------------Inches------------------------------			
1997-98	3.9	3.9	11.6	11.9
1998-99	4.6	8.4	15.3	12.4
1999-00	4.7	3.7	11.4	4.9
2000-01	2.9	8.0	5.6	10.4
2001-02	3.2	2.2	5.9	6.7
Long Term Average	3.8	5.5	9.5	10.6

Table 38g. Precipitation by growing season segment for Akron from 1997-2002.

	GROWING SEASON SEGMENTS			
	Wheat		Corn	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	-----------------------------	Inches	--------------------------------	
1997-98	5.6	2.1	11.1	6.5
1998-99	2.8	7.9	11.4	17.1
1999-00	6.0	2.7	16.3	9.9
2000-01	6.4	6.3	12.1	12.7
2001-02	3.5	2.7	8.8	8.3
Long Term Average	4.0	7.2	10.1	12.2

Table 38h. Precipitation by growing season segment for Lamar from 1997-2002.

	GROWING SEASON SEGMENTS			
	Wheat		Corn	
	Vegetat.	Reprod.	Preplant	Growing Season
	Sep - Mar	Apr - Jun	Jul - Apr	May - Oct
Year	-----------------------------	Inches	--------------------------------	
1997-98	10.5	2.6	19.4	15.9
1998-99	7.5	9.2	22.5	11.0
1999-00	4.5	2.4	9.9	4.4
2000-01	3.6	7.0	5.7	10.2
2001-02	1.6	1.6	5.1	4.8
Long Term Average	4.7	5.8	10.0	10.8

Table 39a. Grain and stover yields for WHEAT in English units in 2002.

	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
SITE & ROTATION	*GRAIN*		*STOVER*		*GRAIN*		*STOVER*		*GRAIN*		*STOVER*	
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	8	7	-	-	8	9	-	-	15	16	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-
(W)WCSb	-	-	-	-	-	-	-	-	-	-	-	-
W(W)CSb	-	-	-	-	-	-	-	-	-	-	-	-
OPP	-	-	-	-	-	-	-	-	-	-	-	-
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STRATTON:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	13	17	-	-	16	15	-	-	29	31	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-
(W)WCSb	-	-	-	-	-	-	-	-	-	-	-	-
W(W)CSb	-	-	-	-	-	-	-	-	-	-	-	-
OPP	-	-	-	-	-	-	-	-	-	-	-	-
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
WALSH:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WSF	-	-	-	-	-	-	-	-	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-
(W)WSSa	-	-	-	-	-	-	-	-	-	-	-	-
W(W)SSa	-	-	-	-	-	-	-	-	-	-	-	-

1. Wheat grain yield expressed at 12% moisture. * Only receives phosphorus in wheat phase of each rotation.

Table 39b. Grain, stover and total biomass yields in metric units for WHEAT in 2002.

	SLOPE POSITION																	
	SUMMIT						SIDE						TOE					
SITE &	*GRAIN*		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*	
ROTATION	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	-----------------kg/ha--------------------						---------------------kg/ha--------------------						-------------------kg/ha--------------------					
WCF	435	360	-	-	-	-	430	485	-	-	-	-	800	885	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(W)WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W(W)CSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STRATTON:	-----------------kg/ha--------------------						---------------------kg/ha--------------------						-------------------kg/ha-------------------					
WCF	715	900	-	-	-	-	855	810	-	-	-	-	1565	1670	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(W)WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W(W)CSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
OPP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WALSH:	-----------------kg/ha--------------------						---------------------kg/ha--------------------						-------------------kg/ha-------------------					
WSF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
(W)WSSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
W(W)SSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

* Only receives phosphorus in wheat phase of each rotation.

Table 40a. Grain[1] and stover yields for all crops in English units in 2002.

SITE & ROTATION	Wheat				Corn/Sorghum		Millet		Sunflower	
	GRAIN		*STOVER*		*GRAIN*	*STOVER*	*GRAIN*	*STOVER*	*GRAIN*	*STOVER*
	Susceptible Variety	Resistant Variety	Susceptible Variety	Resistant Variety						
BRIGGSDALE:	------ bu/A ------		------ lbs/A ------		bu/A	lbs/A	lb/A	lbs/A	lb/A	lbs/A
WF	18.7	20.0	1260	1220						
WM(Hay)F	18.2	18.1	910	930			0			
(W)W(C)CSfF	0	0	0	0	0	930			0	0
W(W)C(C)SfF	4.6	5.2	370	490	0	2600				
Opportunity					0	820				
AKRON:	------ bu/A ------		------ lbs/A ------		bu/A	lbs/A	bu/A	lbs/A	lb/A	lbs/A
WF	12.6	13.9	1360	1540						
WCF	7.4	8.0	959	927	0	200				
WCM (Proso)	6.0	5.9	2580	2570	0	96	0	213		
WCSfF	15.2	14.2	1700	1570	0	166				
LAMAR:	------ bu/A ------		------ lbs/A ------		bu/A	lbs/A				
WF	0	0	734	902						
WSF	0	0	347	507	0	0				

1. Grain or hay yield expressed at the following moistures: Wheat - 12%; Corn - 15.5%; Hay millet @ Briggsdale - 15%; Proso millet @ Akron - 10%; Sunflowers - 10%.

Table 40b. Grain[1] and stover yields for all crops in Metric units in 2002.

	Wheat				Corn/Sorghum		Millet		Sunflower	
SITE	*GRAIN*		*STOVER*		*GRAIN*	*STOVER*	*GRAIN*	*STOVER*	*GRAIN*	*STOVER*
& ROTATION	Susceptible Variety	Resistant Variety	Susceptible Variety	Resistant Variety						
BRIGGSDALE:	------ kg/ha ------		------ kg/ha ------		------ kg/ha ------		kg/ha	kg/ha	------ kg/ha ------	
WF	1260	1340	1410	1370						
WM(hay)F	1220	1220	1020	1040	0	1040	0			
(W)W(C)CSfF	0	0	0	0	0	2910			0	0
W(W)C(C)SfF	309	349	1560	549	0	918				
Opportunity										
AKRON:	------ kg/ha ------		------ kg/ha ------		------ kg/ha ------		------ kg/ha ------		------ kg/ha ------	
WF	847	931	1530	1720						
WCF	497	538	644	1040	0	224				
WCM (proso)	403	396	289	2880	0	108				
WCSfF	1020	954	1900	1760	0	186	0	239		
LAMAR:	------ kg/ha ------		------ kg/ha ------		------ kg/ha ------					
WF	0	0	822	1010						
WSF	0	0	389	568	20	184				

1. Grain yield expressed at the following moistures: Wheat - 12%; Corn - 15.5%; Hay millet @ Briggsdale - 15%; Proso millet @ Akron - 10%; Sunflowers - 10%.

Table 41a. Grain and stover yields for CORN and SORGHUM in English units in 2002.

SITE & ROTATION	SLOPE POSITION											
	SUMMIT				SIDESLOPE				TOESLOPE			
	GRAIN		*STOVER*		*GRAIN*		*STOVER*		*GRAIN*		*STOVER*	
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WCF	-	-	-	-	-	-	-	-	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-	-	-	-	-	-	-
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STRATTON:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. -----	
WCF	-	-	-	-	-	-	-	-	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-	-	-	-	-	-	-
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
WALSH:	------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------		------ Bu./A. ------		------ lbs./A. ------	
WSF	22	17	-	-	18	22	-	-	16	16	-	-
WCSb	13	14	-	-	11	11	-	-	9	9	-	-
WWSSb	21	17	-	-	21	15	-	-	13	10	-	-
CC(Sorg)	3	3	-	-	1	2	-	-	2	5	-	-
CC(Corn)	5	7	-	-	2	2	-	-	2	2	-	-

1. Wheat grain yield expressed at 12% moisture.

*** Only receives phosphorus in wheat phase of each rotation**

Table 41b. Grain, stover and total biomass yields in metric units for CORN and SORGHUM in 2002.

SITE & ROTATION	SLOPE POSITION																	
	SUMMIT						SIDE						TOE					
	GRAIN		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*		*GRAIN*		*STOVER*		*TOTAL*	
	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP	NP*	NP
STERLING:	-----------------kg/ha--------------------						---------------------kg/ha--------------------						-------------------kg/ha--------------------					
WCF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
STRATTON:	-----------------kg/ha--------------------						---------------------kg/ha--------------------						-------------------kg/ha-------------------					
WCF	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WALSH:	-----------------kg/ha--------------------						---------------------kg/ha--------------------						-------------------kg/ha-------------------					
WSF	1175	880	-	-	-	-	930	1160	-	-	-	-	835	850	-	-	-	-
WCSb	855	595	-	-	-	-	500	630	-	-	-	-	500	475	-	-	-	-
WWSSb	1105	900	-	-	-	-	1100	785	-	-	-	-	680	515	-	-	-	-
CC(Sorg)	140	165	-	-	-	-	70	80	-	-	-	-	95	245	-	-	-	-
CC(Corn)	240	360	-	-	-	-	95	105	-	-	-	-	105	105	-	-	-	-

* Only receives phosphorus in wheat phase of each rotation.

Table 43. Crop residue weights from all crops during the 2001 - 2002 crop year.

SITE & ROTATION	Crop			
	Wheat	Corn/Sorghum	Millet	Sunflower
BRIGGSDALE:	------------------------------ kg/ha[1] ------------------------------			
WF	2778			
WMF	515		4614	
(W)W(C)CSfF	1691	5186		2621
W(W)C(C)SfF	314	5466		
Opportunity		3987		
AKRON:	------------------------------ kg/ha[1] ------------------------------			
WF	436			
WCF	1593	1954		
WCM	4336	2434	4471	
WCSfF	968	1127		1828
LAMAR:	------------------------------ kg/ha[1] ------------------------------			
WF	2188			
WSF	2452	0		

1. For Conversion to lbs/Acre multiply kg/ha by 0.893.

Table 44a. Total Nitrogen content of WHEAT GRAIN in 2002 crop.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE & ROTATION	*N Side**	*NP Side*	*N Side**	*NP Side*	*N Side**	*NP Side*
	N	N	N	N	N	N
STERLING:	%		%		%	
WCF	2.71	2.63	2.76	2.72	2.79	2.73
WCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
	N	N	N	N	N	N
STRATTON:	%		%		%	
WCF	2.73	2.75	2.76	2.73	2.67	2.67
WCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
	N	N	N	N	N	N
WALSH:	%		%		%	
WSF	-	-	-	-	-	-
WCSb	-	-	-	-	-	-
WSSb	-	-	-	-	-	-
WWSSb	-	-	-	-	-	-

* Only receives phosphorus in wheat phase of each rotation.

Table 44b. Total Nitrogen content of WHEAT STRAW in 2002 crop.

	SLOPE POSITION					
	SUMMIT		SIDESLOPE		TOESLOPE	
SITE & ROTATION	*N Side**	*NP Side*	*N Side**	*NP Side*	*N Side**	*NP Side*
	N	N	N	N	N	N
STERLING:	%		%		%	
WCF	0.92	1.15	1.13	1.11	1.33	1.48
WCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
	N	N	N	N	N	N
STRATTON:	%		%		%	
WCF	0.71	0.65	0.61	0.79	0.62	0.66
WCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
WWCSb	-	-	-	-	-	-
	N	N	N	N	N	N
WALSH:						
	%		%		%	
WSF	-	-	-	-	-	-
WCSb	-	-	-	-	-	-
WSSb	-	-	-	-	-	-
WWSSb	-	-	-	-	-	-

* Only receives phosphorus in wheat phase of each rotation.

Table 45. Pest insects in wheat by day in 2002.

Site & Insect	Date (growth stage)		
		11 April (Jointing)	
BRIGGSDALE:			
Army Cutworm (#/5 ft.^{2})		**0.04**	
Pale Western Cutworm (#/5 ft.^{2})		**0.01**	
Russian Wheat Aphid (#/50 tillers)		**0**	
Other Cerial Aphids (#/50 Tillers)		**0**	
Brown Wheat Mite (#/ 1.75 ft.^{2})		**12**	
Banks Grass Mite (#/50 tillers)		**0**	
	18 March (Tillering)	**17 April (Jointing)**	**13 May (Boot)**
AKRON:			
Army Cutworm (#/5 ft.^{2})	0	2.75	--
Russian Wheat Aphid (#/50 tillers)	0	0.25	0.75
Brown Wheat Mite (#/ 1.75 ft.^{2})	1.1	1.8	4.7
LAMAR:			
	No observations due to crop failure		

Table 46. Pest insects in corn or sorghum (Lamar) by day in 2002.

Site & Insect	Date	
	26 June	
BRIGGSDALE:		
Cutworms (% cut plants)	0	
Western corn rootworm larvae (#/plant)	0.03	
Western corn rootworm adults (#/ear zone)	--	
Banks grass mite (#/highest damaged leaf)	--	
Aphids (#/plant)	--	
Western bean cutworm (#/ear)	--	
Corn earworm (#/ear)	--	
	24 June	29 July
AKRON:		
Cutworms (% cut plants)	**0**	**0**
Western corn rootworm adults (#/ear zone)	**0**	**0.15**
Banks grass mite (#/highest damaged leaf)	**14**	**--**
Aphids (#/plant)	**0**	**0**
Western bean cutworm (#/ear)	**--**	**--**
Corn earworm (#/ear)	**--**	**--**
LAMAR:		
No observations since crop was not planted.		

Table 47. Pest insects in SUNFLOWERS by day in 2002.

Site & Insect	Date		
BRIGGSDALE:			
No Observations due to poor stands.			
	20 June	**5 Sept.**	**31 Oct.**
AKRON:			
Cutworms (% cut plants)	0	0	0
Stem weevil (#/stalk)	--	0	2.1
Seed weevil (#/head)	--	1	3.3
Sunflower moth larvae (#/head)	--	0	1.5
Banded sunflower moth larvae (#/head)	--	0	0.5
Aphids (#/plant)	0	0	--

APPENDIX I
ANNUAL HERBICIDE PROGRAMS FOR EACH SITE

Table A1. Weed control methods including herbicide rate, cost and date applied at STERLING in 2001.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Corn-Fallow					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	27 April 2001
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	27 April 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	30 July 2001
	Clarity	8 oz/ac	0.58 l/ha	$5.70/ac	30 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	28 Aug. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	26 Sept. 2001
Corn (RR):	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	14 May 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	14 May 2001
	Round-up Ultra	24 oz/ac	1.75 l/ha	$7.26/ac	11 June 2001
Fallow:	Landmaster BW	40 oz/ac	2.92 l/ha	$5.48/ac	27 April 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	11 June 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	11 June 2001
	Gramoxone Extra	32 oz/ac	2.33 l/ha	$7.06/ac	6 July 2001
	Crop Oil Conc.	1 gal./100	9.33 l/ha	$5.40/100	6 July 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	30 July 2001
	Clarity	8 oz/ac	0.58 l/ha	$5.70/ac	30 July 2001
	Round-up Original	48 oz/ac	3.50 l/ha	$9.39/ac	12 Sept. 2001
Rotation: Wheat-Corn-Soybean					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	27 April 2001
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	27 April 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	30 July 2001
	Clarity	8 oz/ac	0.58 l/ha	$5.70/ac	30 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	28 Aug. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	26 Sept. 2001
Corn (RR):	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	14 May 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	14 May 2001
	Round-up Ultra	24 oz/ac	1.75 l/ha	$7.26/ac	11 June 2001
Soybean:	Landmaster BW	40 oz/ac	2.92 l/ha	$5.48/ac	27 April 2001
	Authority	2.67 oz/ac	187 g/ha	$7.70/ha	9 May 2001
	Assure II	8 oz/ac	0.58 l/ha	$8.85/ac	6 July 2001
	Round-up Original	24 oz/ac	1.75 l/ha	$4.70/ac	30 July 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	12 Sept. 2001
	2,4-D amine	16 oz/ac	1.17 l/ha	$1.44/ac	12 Sept. 2001
Rotation:Wheat-Wheat-Corn-Soybean					
Wheat1:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	27 April 2001
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	27 April 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	30 July 2001
	Clarity	8 oz/ac	0.58 l/ha	$5.70/ac	30 July 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	12 Sept. 2001
	2,4-D amine	16 oz/ac	1.17 l/ha	$1.44/ac	12 Sept. 2001
Wheat2:	Raptor (IMI Wheat)	5 oz/ac	0.36 l/ha	$20.51/ac	20 April 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	30 July 2001
	Clarity	8 oz/ac	0.58 l/ha	$5.70/ac	30 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	28 Aug. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	26 Sept. 2001
Corn (RR):	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	14 May 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	14 May 2001
	Round-up Ultra	24 oz/ac	1.75 l/ha	$7.26/ac	11 June 2001
Soybean:	Landmaster BW	40 oz/ac	2.92 l/ha	$5.48/ac	27 April 2001
	Authority	2.67 oz/ac	187 g/ha	$7.70/ac	9 May 2001
	Assure II	8 oz/ac	0.58 l/ha	$8.85/ac	6 July 2001
	Round-up Original	24 oz/ac	1.75 l/ha	$4.70/ac	30 July 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	12 Sept. 2001
	2,4-D amine	16 oz/ac	1.17 l/ha	$1.44/ac	12 Sept. 2001
Rotation: Opportunity					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	27 April 2001
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	27 April 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	30 July 2001
	Clarity	8 oz/ac	0.58 l/ha	$5.70/ac	30 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	28 Aug. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	26 Sept. 2001

Note: Atrazine is applied at 75 % of the rate on summit and sideslope soils.

TableA 2. Weed control methods including herbicide rate, cost and date applied at STRATTON in 2001.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Corn-Fallow					
Wheat:	Banvel	2.0 oz/ac	0.15 l/ha	$1.43/ac	18 April 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	18 April 2001
	Round-up Original	20 oz/ac	1.46 l/ha	$3.91/ac	31 July 2001
	2,4-D amine	24 oz/ac	1.75 l/ha	$2.16/ac	31 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	25 Sept. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	25 Sept. 2001
Corn (RR):	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	15 May 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	15 May 2001
	Steadfast	0.75 oz/ac	52.6 g/ha	$15.30/ac	15 June 2001
	Round-up Orginal	24 oz/ac	1.75 l/ha	$4.70/ac	21 June 2001
Fallow:	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	10 May 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	10 May 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	15 June 2001
	2,4-D Amine	12 oz/ac	0.87 l/ha	$1.08/ac	15 June 2001
Rotation: Wheat-Corn-Soybean					
Wheat:	Banvel	2.0 oz/ac	0.15 l/ha	$1.43/ac	18 April 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	18 April 2001
	Round-up Original	20 oz/ac	1.46 l/ha	$3.91/ac	31 July 2001
	2,4-D amine	24 oz/ac	1.75 l/ha	$2.16/ac	31 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	25 Sept. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	25 Sept. 2001
Corn (RR):	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	15 May 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	15 May 2001
	Round-up Original	24 oz/ac	1.75 l/ha	$4.70/ac	21 June 2001
Soybean:	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	10 May 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	10 May 2001
	Authority	2.67 oz/ac	187 g/ha	$7.70/ac	10 May 2001
	Round-up Ultra	32 oz/ac	2.33 l/ha	$8.13/ac	15 June 2001
	Assure II	8 oz/ac	0.58 l/ha	$8.85/ac	15 June 2001
	Round-up Original	24 oz/ac	1.75 l/ha	$4.70/ac	21 June 2001
	Round-up Original	32 oz/ac	2.33 l/ha	$6.26/ac	31 July 2001
Rotation:Wheat-Wheat-Corn-Soybean					
Wheat1:	Banvel	2.0 oz/ac	0.15 l/ha	$1.43/ac	18 April 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	18 April 2001
	Round-up Original	20 oz/ac	1.46 l/ha	$3.91/ac	31 July 2001
	2,4-D amine	24 oz/ac	1.75 l/ha	$2.16/ac	31 July 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	25 Sept. 2001
Wheat2:	Raptor (IMI Wheat)	5 oz/ac	0.36 l/ha	$20.51/ac	18 April 2001
	Round-up Original	20 oz/ac	1.46 l/ha	$3.94/ac	31 July 2001
	2,4-D amine	24 oz/ac	1.75 l/ha	$2.16/ac	31 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	25 Sept. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	25 Sept. 2001
Corn (RR):	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	15 May 2001
	Clarity	6 oz/ac	0.44 l/ha	$4.28/ac	15 May 2001
	Round-up Original	24 oz/ac	1.75 l/ha	$4.70/ac	21 June 2001
Soybean:	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	10 May 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	10 May 2001
	Authority	2.67 oz/ac	187 g/ha	$7.70/ac	10 May 2001
	Round-up Ultra	32 oz/ac	2.33 l/ha	$8.13/ac	15 June 2001
	Assure II	8 oz/ac	0.58 l/ha	$8.85/ac	15 June 2001
	Round-up Original	24 oz/ac	1.75 l/ha	$4.70/ac	21 June 2001
	Round-up Original	32 oz/ac	2.33 l/ha	$6.26/ac	31 July 2001
Rotation: Opportunity					
Wheat:	Banvel	2.0 oz/ac	0.15 l/ha	$1.43/ac	18 April 2001
	2,4-D ester 6#	10 oz/ac	0.73 l/ha	$1.46/ac	18 April 2001
	Round-up Original	20 oz/ac	1.46 l/ha	$3.91/ac	31 July 2001
	2,4-D amine	24 oz/ac	1.75 l/ha	$2.16/ac	31 July 2001
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	25 Sept. 2001
	Round-up Original	16 oz/ac	1.17 l/ha	$3.13/ac	25 Sept. 2001

Note: Atrazine is applied at 125 % of the rate on toeslope soils.

Table A3. Weed control methods including herbicide rate, cost and date applied at WALSH in 2001.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Sorghum-Fallow					
Wheat:	Clarity	3 oz/ac	0.22 l/ha	$2.14/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	30 Aug. 2001
Sorghum:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Clarity	4 oz/ac	0.29 l/ha	$2.85/ac	23 June 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	23 June 2001
Fallow:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	30 Aug. 2001
Rotation: Wheat-Corn-Soybean					
Wheat:	Clarity	3 oz/ac	0.22 l/ha	$2.14/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	30 Aug. 2001
Corn:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 June 2001
Soybean:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
Rotation: Wheat-Wheat-Sorghum-Soybean					
Wheat:	Clarity	3 oz/ac	0.22 l/ha	$2.14/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	30 Aug. 2001
Wheat:	Clarity	3 oz/ac	0.22 l/ha	$2.14/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	30 Aug. 2001
Sorghum:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Clarity	4 oz/ac	0.29 l/ha	$2.85/ac	23 June 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	23 June 2001
Soybean:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 July 2001
Opportunity					
Sorghum:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Clarity	4 oz/ac	0.29 l/ha	$2.85/ac	23 June 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	23 June 2001

Continuous Cropping:					
Corn:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	23 June 2001
Sorghum:	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	13 April 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	13 April 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	15 May 2001
	Round-up Ultra	16 oz/ac	1.17 l/ha	$4.06/ac	2 June 2001
	Clarity	4 oz/ac	0.29 l/ha	$2.85/ac	23 June 2001
	Salvo	8 oz/ac	0.58 l/ha	$1.78/ac	23 June 2001

Table A4. Weed control methods including herbicide rate, cost and date applied at Briggsdale in 2001 season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Fallow					
Wheat:	Ally	0.1 oz/A	7.0 g/ha	$2.30/A	14 April 2001
	2,4-D ester 4#	8 oz/A	0.58 l/ha	$0.82/A	14 April 2001
(Stubble)	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	27 July 2001
	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	4 October 2001
Fallow:	Round-up*	20 oz/A	1.46 l/ha	$6.02/A	9 May 2001
	Clarity	6 oz/A	0.44 l/ha	$4.21/A	9 May 2001
	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	13 June 2001
	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	27 July 2001
(Wheat Planting)	Round-up	20 oz/A	1.46 l/ha	$6.02/A	7 September 2001
Rotation: Wheat-Millet-Fallow					
Wheat:	Ally	0.1 oz/A	7.0 g/ha	$2.30/A	14 April 2001
	2,4-D ester 4#	8 oz/A	0.58 l/ha	$0.82/A	14 April 2001
(Stubble)	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	27July 2001
	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	4 October 2001
Millet:	Round-up *	20 oz/A	1.46 l/ha	$6.02/A	9 May 2001
	Clarity	6 oz/A	0.44 l/ha	$4.21/A	9 May 2001
	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	13 June 2001
Fallow:	Round-up*	20 oz/A	1.46 l/ha	$6.02/A	9 May 2001
	Clarity	6 oz/A	0.44 l/ha	$4.21/A	9 May 2001
	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	13 June 2001
	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	27 July 2001
(Wheat Planting)	Round-up*	20 oz/A	1.46 l/ha	$6.02/A	7 September 2001
Rotation:Wheat-Wheat-Corn-Soybean-Sunflower-Pea:					
Wheat:	Ally	0.1 oz/A	7.0 g/ha	$2.30/A	14 April 2001
	2,4-D ester 4#	8 oz/A	0.58 l/ha	$0.82/A	14 April 2001
(Stubble)	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	27July 2001
	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	4 October 2001
Wheat:	Ally	0.1 oz/A	7.0 g/ha	$2.30/A	14 April 2001
	2,4-D ester 4#	8 oz/A	0.58 l/ha	$0.82/A	14 April 2001
(Stubble)	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	27July 2001
(Wheat Planting)	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	4 October 2001
Corn:	Fallowmaster*	32 oz/A	2.33l/ha	$5.31/A	7 May 2001
	Prowl 3.3 EC	32 oz/A	2.33l/ha	$5.11/A	7 May 2001
	Atrazine 4L	32 oz/A	2.33l/ha	$2.80/A	7 May 2001
Soybeans:	Round-up*	16 oz/A	1.17 l/ha	$4.82/A	24 April 2001
	2,4-D Ester 4	8 oz/A	0.58 l/ha	$0.58/A	24 April 2001
	Authority	2.67 oz/A	187 g/ha	$9.91/A	9 May 2001
	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	13 June 2001
Sunflowers:	Round-up*	16 oz/A	1.17 l/ha	$4.82/A	24 April 2001
	2,4-D Ester 4	8 oz/A	0.58 l/ha	$0.58/A	24 April 2001
	Spartan	2.67 oz/A	187 g/ha	$9.91/A	9 May 2001
Forage	Round-up*	16 oz/A	1.17 l/ha	$4.82/A	24 April 2001
Soybeans:	2,4-D Ester 4	8 oz/A	0.58 l/ha	$0.58/A	24 April 2001
	Authority	2.67 oz/A	187 g/ha	$9.91/A	9 May 2001
Rotation: Opportunity					
Wheat:	Ally	0.1 oz/A	7.0 g/ha	$2.30/A	14 April 2001
	2,4-D ester 4#	8 oz/A	0.58 l/ha	$0.82/A	14 April 2001
(Stubble)	FallowMaster*	44 oz/A	3.2 l/ha	$6.49/A	8 July 2001
	Round-up*	24 oz/A	1.75 l/ha	$7.23/A	4 October 2001

*Applied 17 lbs. Ammonium Sulfate/100 gallons water with Round-up products.

Table A5. Weed control methods including herbicide rate or tillage, cost and date applied at Akron in 2001 season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Fallow					
Wheat:	**Clarity**	**3 oz/A**	**0.21 l/ha**	**$1.75/A**	**01 May 2001**
	2,4-D	**6 oz/A**	**0.42l/ha**	**$0.69/A**	**01 May 2001**
	Roundup	**32 oz./A**	**2.33 l/ha**	**$9.64/A**	**27 June 2001**
Fallow:	**tandem disc**			**$7.00/A**	**12 Sept 2000**
	sweep tillage			**$5.50/A**	**01 May 2001**
	sweep tillage			**$5.50/A**	**24 May 2001**
	sweep tillage			**$5.50/A**	**14 Aug 2001**
	sweep tillage			**$5.50/A**	**24 Sept 2001**
Rotation: Wheat-Corn-Fallow					
Wheat:	**Clarity**	**3 oz/A**	**0.21 l/ha**	**$1.75/A**	**01 May 2001**
	2,4-D	**6 oz/A**	**0.42l/ha**	**$0.69/A**	**01 May 2001**
Corn:	**Roundup**	**32 oz/A**	**2.33 l/ha**	**$9.64/A**	**18 May 2001**
	Glyphomax	**26 oz/A**	**1.89 l/ha**	**$5.60/A**	**19 July 2001**
Fallow:	**Roundup**	**32 oz/A**	**2.33 l/ha**	**$9.64/A**	**17 May 2001**
	Roundup	**32 oz/A**	**2.33 l/ha**	**$9.64/A**	**27 June 2001**
	Roundup	**32 oz/A**	**2.33 l/ha**	**$9.64/A**	**24 Sept 2001**
Rotation:Wheat-Corn-Millet					
Wheat:	**Clarity**	**3 oz/A**	**0.21 l/ha**	**$1.75/A**	**01 May 2001**
	2,4-D	**6 oz/A**	**0.42l/ha**	**$0.69/A**	**01 May 2001**
Corn:	**Roundup**	**32 oz/A**	**2.33 l/ha**	**$9.64/A**	**18 May 2001**
	Glyphomax	**26 oz/A**	**1.89 l/ha**	**$5.60/A**	**19 July 2001**
Millet:	**Roundup**	**32 oz/A**	**2.33 l/ha 2.33 l/ha**	**$9.64/A**	**17 May 2001**
	Roundup	**32 oz/A**		**$9.64/A**	**09 June 2001**

Table A6. Weed control methods including herbicide rate, cost and date applied at Lamar during the 2001-2002 growing season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Weed Pressure	Cost	Date Applied
Rotation: Wheat-Fallow						
Wheat:	Fallowmaster Landmaster	32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha	I I		1 Jul 2001
Wheat:	RT Master 2,4-D	32 oz/A 12 oz/A	2.33 l/ha 0.87 l/ha	III III		21 May 2002
Fallow:	Fallowmaster*	44 oz/A	3.20l/ha	I		25 Jul 2001
Rotation: Wheat-Sorghum-Fallow						
Wheat:	Fallowmaster Landmaster	32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha	I I		1 Jul 2001
Wheat:	RT Master 2,4-D	32 oz/A 12 oz/A	2.33 l/ha 0.87 l/ha	III III		21 May 2002
Fallow:	Fallowmaster*	44 oz/A	3.20l/ha	I		25 Jul 2001

*Applied 17 lbs. Ammonium Sulfate/100 gallons water with Round-up products.

Weed Preesure Ratings: I =Farmer would need to spray. II = Farmer would delay application. III =Farmer would not plan a spray application.

Table A7. Weed control methods including herbicide rate, cost and date applied at STERLING in 2002.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Corn-Fallow					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	3 May 2002
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	3 May 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	12 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	12 Aug. 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	4 Sept. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
Corn (RR):	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac/	22 June 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
Fallow:	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	6 May 2002
	RT Master	20 oz/ac	1.46 l/ha	$3.74/ac	12 June 2002
	Gramoxone Max	32 oz/ac	2.33 l/ha	$8.83/ac	3 July 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	12 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	12 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	27 Sept. 2002
Rotation: Wheat-Corn-Millet					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	3 May 2002
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	3 May 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	12 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	12 Aug. 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	4 Sept. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
Corn (RR):	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac/	22 June 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
Proso Millet:	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	6 May 2002
	RT Master	20 oz/ac	1.46 l/ha	$3.74/ac	12 June 2002
	2,4-D ester 6#	12 oz/ac	0.87 l/ha	$1.75/ac	3 July 2002
	Clarity	4 oz/ac	0.29 l/ha	$2.85/ac	3 July 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	12 Aug. 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	27 Sept. 2002
Rotation:Wheat-Wheat-Corn-Millet					
Wheat1:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	3 May 2002
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	3 May 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	12 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	12 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
Wheat2:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	3 May 2002
	2,4-D ester 6#	8 oz/ac	0.58 l/ha	$1.17/ac	3 May 2002
	Raptor (IMI Wheat)	5 oz/ac	0.36 l/ha	$20.51/ac	3 May 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	12 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	12 Aug. 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.53/ac	4 Sept. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002
Corn (RR):	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac/	22 June 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	4 Sept. 2002
	2,4-D ester 6	16 oz/ac	1.17 l/ha	$2.34/ac	4 Sept. 2002

Proso Millet:	**RT Master**	**24 oz/ac**	**1.75 l/ha**	**$4.49/ac**	**6 May 2002**
	RT Master	**20 oz/ac**	**1.46 l/ha**	**$3.74/ac**	**12 June 2002**
	2,4-D ester 6#	**12 oz/ac**	**0.87 l/ha**	**$1.75/ac**	**3 July 2002**
	Clarity	**4 oz/ac**	**0.29 l/ha**	**$2.85/ac**	**3 July 2002**
	RT Master	**24 oz/ac**	**1.75 l/ha**	**$4.49/ac**	**12 Aug. 2002**
	RT Master	**16 oz/ac**	**1.17 l/ha**	**$2.99/ac**	**27 Sept. 2002**
Rotation: Opportunity					
Corn:	**Round-up UltraMax**	**20 oz/ac**	**1.46 l/ha**	**$7.56/ac/**	**22 June 2002**
	RT Master	**24 oz/ac**	**1.75 l/ha**	**$4.49/ac**	**4 Sept. 2002**
	2,4-D ester 6	**16 oz/ac**	**1.17 l/ha**	**$2.34/ac**	**4 Sept. 2002**
Note: Atrazine is applied at 75 % of the rate on summit and sideslope soils.					

Table A8. Weed control methods including herbicide rate, cost and date applied at STRATTON in 2002.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Corn-Fallow					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha/	$2.33/ac	7 May 2002
	Starane + Salvo	16 oz/ac	1.17 l/ha	$6.37/ac	7 May 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	30 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Corn (RR):	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac	13 June 2002
Fallow:	RT Master	32 oz/ac	2.33 l/ha	$5.98/ac	7 May 2002
	RT Master	20 oz/ac	1.46 l/ha	$3.74/ac	13 June 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	13 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Rotation: Wheat-Corn-Millet					
Wheat:	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	7 May 2002
	Starane + Salvo	16 oz/ac	1.17 l/ha	$6.37/ac	7 May 2002
	RT Master	32 oz/ac	2.33 l/ha	$5.98/ac	3 June 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	30 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Corn (RR):	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac	13 June 2002
Proso Millet:	RT Master	32 oz/ac	2.33 l/ha	$5.98/ac	7 May 2002
	RT Master	20 oz/ac	1.46 l/ha	$3.74/ac	13 June 2002
(to kill proso)	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	13 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Rotation:Wheat-Wheat-Corn-Millet					
Wheat1:	Ally	1/10 oz/ac	7.0 g/ha/	$2.33/ac	7 May 2002
	Starane + Salvo	16 oz/ac	1.17 l/ha	$6.37/ac	7 May 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Wheat2:	Raptor (IMI Wheat)	5 oz/ac	0.36 l/ha	$20.51/ac	30 April 2002
	Ally	1/10 oz/ac	7.0 g/ha	$2.33/ac	7 May 2002
	Starane + Salvo	16 oz/ac	1.17 l/ha	$6.37/ac	7 May 2002
	RT Master	32 oz/ac	2.33 l/ha	$5.98/ac	3 June 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54/ac	30 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Corn (RR):	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac	13 June 2002
Proso Millet:	RT Master	32 oz/ac	2.33 l/ha	$5.98/ac	7 May 2002
	RT Master	20 oz/ac	1.46 l/ha	$3.74/ac	13 June 2002
	RT Master	16 oz/ac	1.17 l/ha	$2.99/ac	13 Aug. 2002
	RT Master	24 oz/ac	1.75 l/ha	$4.49/ac	30 Aug. 2002
	2,4-D ester 6#	16 oz/ac	1.17 l/ha	$2.34/ac	30 Aug. 2002
Rotation: Opportunity					
Corn:	Round-up UltraMax	20 oz/ac	1.46 l/ha	$7.56/ac	13 June 2002

Note: Atrazine is applied at 125 % of the rate on toeslope soils.

Table A9. Weed control methods including herbicide rate, cost and date applied at WALSH in 2002.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Sorghum-Fallow					
Wheat:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Landmaster	54 oz/ac	3.94 l/ha	$7.40/ac	16 Sept. 2002
Sorghum:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Fallow:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Landmaster	54 oz/ac	3.94 l/ha	$7.40/ac	16 Sept. 2002
Rotation: Wheat-Corn-Soybean					
Wheat:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Landmaster	54 oz/ac	3.94 l/ha	$7.40/ac	16 Sept. 2002
Corn: (Sorghum in 2002)	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Soybean: (Sorghum in 2002)	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Rotation: Wheat-Wheat-Sorghum-Soybean					
Wheat:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Landmaster	54 oz/ac	3.94 l/ha	$7.40/ac	16 Sept. 2002
Wheat:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Landmaster	54 oz/ac	3.94 l/ha	$7.40/ac	16 Sept. 2002
Sorghum: (Sorghum in 2002)	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Soybean: (Sorghum in 2002)	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Opportunity					
Sorghum:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Continuous Cropping:					
Corn: (Sorghum in 2002)	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002
Sorghum:	Round-up Ultra	18 oz/ac	1.31 l/ha	$4.57/ac	23 June 2002
	Atrazine	3/4 lb ai/ac	52.6 g/ha	$1.90/ac	18 July 2002
	Clarity	5 oz/ac	0.36 l/ha	$3.58/ac	18 July 2002
	Crop Oil	32 oz/ac	2.33 l/ha	$1.34/ac	18 July 2002

Table A10. Weed control methods including tillage, herbicide rate, cost and date applied at Briggsdale in 2002 season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Fallow					
Wheat:					
(Stubble)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Fallow:	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
	Round-up Ultra*	16 oz/ac	1.17 l/ha	$4.06	10 July 2002
	2,4-D Lo Vol	8 oz/ac	0.58 l/ha	$1.17	10 July 2002
(Wheat Planting)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Rotation: Wheat-Millet-Fallow					
Wheat:					
(Stubble)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Millet:	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
Fallow:	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
	Round-up Ultra*	16 oz/ac	1.17 l/ha	$4.06	10 July 2002
	2,4-D Lo Vol	8 oz/ac	0.58 l/ha	$1.17	10 July 2002
(Wheat Planting)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Rotation:Wheat-Wheat-Corn-Corn-Sunflower-Fallow:					
Wheat:	Round-up Ultra*	16 oz/ac	1.17 l/ha	$4.06	10 July 2002
	2,4-D Lo Vol	8 oz/ac	0.58 l/ha	$1.17	10 July 2002
(Wheat Planting)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Wheat:					
(Stubble)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Corn1:	Prowl	32 oz/ac	2.33 l/ha	$5.16	6 June 2002
	Atrazine 4L	32 oz/ac	2.33 l/ha	$2.54	6 June 2002
	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
Corn2:	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
	Round-up UltraMAX*	20 oz/ac	1.46 l/ha	$7.56	5 July 2002
Sunflowers:	Spartan	2.0 oz/Ac	140 g/ha	$5.67	23 May 2002
	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
Fallow:	RT Master*	32 oz/ac	2.33 l/ha	$5.98	15 June 2002
	Round-up Ultra*	16 oz/ac	1.17 l/ha	$4.06	10 July 2002
	2,4-D Lo Vol	8 oz/ac	0.58 l/ha	$1.17	10 July 2002
(Wheat planting)	RT Master*	16 oz/ac	1.17 l/ha	$2.99	20 Sept. 2002
Rotation: Opportunity					
Grain Sorghum:	RT Master*	32 oz/ac	2.33 l/ha	$5.98	5 July 2002
	Marksman	32 oz/Ac	2.33 l/ha	$7.13	4 June 2002

*Applied 1 qt/100 gal. of Choice ($0.25/ac) to all Round-up products and 2 qt/100 gal. of Activator 90 ($0.54/ac) with RT Master.

Table A11. Weed control methods including tillage, herbicide rate or tillage, cost and date applied at Akron in 2002 season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Fallow					
Wheat:	no application	-----	-----	-----	-----
Fallow:	tandem disc sweep tillage sweep tillage sweep tillage			\$7.00/A \$5.50/A \$5.50/A \$5.50/A	23 May 2002 23 July 2002 14 Aug 2002 27 Sept 2002
Rotation: Wheat-Corn-Fallow					
Wheat:	no application	-----	-----	-----	-----
Corn:	Roundup Ultra* Roundup Ultra Max*	32 oz/A 26 oz/A	2.33 l/ha 1.89 l/ha	\$8.12/A \$9.30/A	27 May 2002 24 June 2002
Fallow:	Roundup Ultra* Roundup Ultra* Roundup Ultra*	32 oz/A 32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha 2.33 l/ha	\$8.12/A \$8.12/A \$8.12/A	27 May 2002 27 June 2002 16 Sept 2002
Rotation:Wheat-Corn-Millet					
Wheat:	no application	-----	-----	-----	-----
Corn:	Roundup Ultra* Roundup Ultra Max	32 oz/A 26 oz/A	2.33 l/ha 1.89 l/ha	\$8.12/A \$9.30/A	27 May 2002 24 June 2002
Millet:	Roundup Ultra*	32 oz/A	2.33 l/ha	\$8.12/A	27 May 2002
Rotation: Wheat-Corn-Sunflower-Fallow:					
Wheat:	no application	-----	-----	-----	-----
Corn:	Roundup Ultra* Roundup Max*	32 oz/A 26 oz/A	2.33 l/ha 1.89 l/ha	\$8.12/A \$9.30/A	27 May 2002 24 June 2002
Sunflower	Sonalan 10G	10 lb/A	11200g/ha	\$10.50/A	07 June 2002
Fallow:	Roundup Ultra* Roundup Ultra* Roundup Ultra*	32 oz/A 32 oz/A 32 oz/A	2.33 l/ha 2.33 l/ha 2.33 l/ha	\$8.12/A \$8.12/A \$8.12/A	27 May 2002 27 June 2002 16 Sept 2002

*Applied 1 qt/100 gal. of Choice (\$0.25/ac) to all Round-up products.

Table A12. Weed control methods including tillage, herbicide rate, cost and date applied at Lamar during the 2001-2002 growing season.

Crop	Herbicide/Tillage	Rate (English)	Rate (Metric)	Cost	Date Applied
Rotation: Wheat-Fallow					
Wheat:	RT Master* 2,4-D	32 oz/A 12 oz/A	2.33 l/ha 0.87 l/ha	$5.98/A $1.08/A	21 May 2002
Fallow:					
Rotation: Wheat-Sorghum-Fallow					
Wheat:	RT Master* 2,4-D	32 oz/A 12 oz/A	2.33 l/ha 0.87 l/ha	$5.98/A $1.08/A	21 May 2002
Sorghum:	Shallow tillage				
Fallow:					

*Applied 17 lbs. Ammonium Sulfate/100 gallons water with glyphosate products.

APPENDIX II
PROJECT PUBLICATIONS

Papers in Scientific Journals:

Kitchen, N. R., L. A. Sherrod, C. W. Wood, G. A. Peterson and D. G. Westfall. 1990. Nitrogen contamination of soils from sampling bags. Agron. J. 82:354-356.

Kitchen, N. R., J. L. Havlin and D. G. Westfall. 1990. Soil sampling under no-till banded phosphorus. Soil Sci. Soc. Am. J. 54:1661-1665.

Wood, C. W., D. G. Westfall, G. A. Peterson and I. C. Burke. 1990. Impacts of cropping intensity on carbon and nitrogen mineralization under no-till agroecosystems. Agron. J. 82: 1115-1120.

Wood, C. W., D. G. Westfall and G. A. Peterson. 1991. Soil carbon and nitrogen changes upon initiation of no-till cropping systems in the West Central Great Plains. Soil Sci. Soc. Am. J. 55:470-476.

Wood, C. W., G. A. Peterson, D. G. Westfall, C. V. Cole and W. F. Willis. 1991. Nitrogen balance and biomass production of newly established no-till dryland agroecosystems. Agron. J. 83:519-526.

Moore, I.D., P.E. Gessler, G.A. Nielsen, and G.A. Peterson. 1993. Soil attribute prediction using terrain analysis. Soil Sci. Soc. Am. J. 57:443-452.

Peterson, G.A., D.G. Westfall, and C.V. Cole. 1993. Agroecosystem approach to soil and crop management research. Soil Sci. Soc. Am. J. 57:1354-1360.

Evans, S.D., G.A. Peterson, D.G. Westfall and E. McGee. 1994. Nitrate leaching in dryland agroecosystems as influenced by soil and climate gradients. J. Environ. Qual. 23:999-1005.

Peterson, G.A., A.J. Schlegel, D.L. Tanaka, and O.R. Jones. 1996. Precipitation use efficiency as affected by cropping and tillage systems. J. of Prod. Agric. 9:180-186.

Westfall, D.G., J.L. Havlin, G.W. Hergert, and W.R. Raun. 1996. Nitrogen management in dryland cropping systems. J. of Prod. Agric. 9:192-199.

Paustian, K.A., E.T. Elliott, G.A. Peterson, and K. Kendrick. 1996. Modeling climate, CO_2 and management impacts on soil carbon in semi-arid agroecosystems. Plant and Soil 187:351-365.

Kolberg, R.L., N.R. Kitchen, D.G. Westfall, and G.A. Peterson. 1996. Cropping intensity and nitrogen management impact on dryland no-till rotations in the semi-arid western Great Plains. J. Prod. Agric. 9:517-522.

Follett, R.F., E.A. Paul, S.W. Leavitt, A.D. Halvorson, D. Lyon, and G.A. Peterson. 1997. Carbon isotope ratios of Great Plains soils in wheat-fallow systems. Soil Sci. Soc. Am. J. 61:1068-1077.

Paul, E.A., R.F. Follett, S.W. Leavitt, A.D. Halvorson, G.A. Peterson, and D. Lyon. 1997. Carbon isotope ratios of Great Plains soils in wheat-fallow systems. Soil Sci. Soc. Am. J. 61:1058-1067.

Kolberg R.L., B. Roupett, D.G. Westfall, and G.A. Peterson. 1997. Evaluation of an *in situ* net nitrogen mineralization method in dryland agroecosystems. Soil Sci. Soc. Am. J. 61:504-508.

McGee, E.A., G.A. Peterson, and D.G. Westfall. 1997. Water storage efficiency in no-till dryland cropping systems. J. Soil and Water Cons. 52:131-136.

Peterson, G.A., A.D Halvorson, J.L. Havlin, O.R. Jones, D.J. Lyon, and D.L. Tanaka. 1998. Reduced tillage and increasing cropping intensity in the Great Plains conserves soil carbon. Soil and Tillage Res. 47:207-218.

Farahani, H.J., G.A. Peterson, D.G. Westfall, and L.R. Ahuja. 1998. Soil water storage in dryland cropping systems: The significance of cropping intensification. Soil Sci. Soc. Am. J. 62:984-991.

Power, J.F. and G.A. Peterson. 1998. Nitrogen transformations, utilization, and conservation as affected by fallow tillage method. Soil and Tillage Res. 49:37-47.

Farahani, H.J., G.W. Buchleiter, L.R. Ahuja, G.A. Peterson, and L. Sherrod. 1999. Season evaluation of the root zone water quality model in Colorado. Agron. J. 91:212-219.

Ma, L., G.A. Peterson, L.R. Ahuja, L. Sherrod, M.J. Shafer, and K.W. Rojas. 1999. Decomposition of surface crop residues in long-term studies of dryland agroecosystems. Agron. J. 91:401-409.

Frey, S.D., E.T. Elliott, K. Paustian, and G.A. Peterson. 2000. Fungal translocation as a mechanism for soil nitrogen inputs to surface residue decomposition in a no-tillage agroecosystem. Soil Biol. and Biochem. 32:689-698.

Del Grosso, S., Parton, W.J. Mosier, A.R., Hartman, M.D., Keough, C.A., Peterson, G.A., Ojima, D.S., and Schimel, D.S. 2001. Simulated effects of land use, soil texture, and precipitation on N gas emissions using DAYCENT. p. 413-431. In: Follett, R.F. and Hatfield, J.L. (eds.) Nitrogen in the Environment: Sources, Problems, and Management. Elsevier, Amsterdam.

Del Grosso, S., Ojima, D.S., Parton, W.J. Mosier, and Peterson, G.A. 2002. Regional assessment of net greenhouse gas fluxes from agricultural soils in the USA Great Plains under current and improved management. p. 469-474. In:Van Ham and Williams-Jacobse (eds.) Non-CO2 Greenhouse Gases. Millpress, Rotterdam.

Del Grosso, S., Ojima, D.S. Parton, W.J. Mosier, A.R., Peterson, G.A., and Schimel, D.S. 2002. Simulated effects of dryland cropping intensification on soil organic matter and greenhouse gas exchanges using the DAYCENT ecosystem model. Environmental Pollution 116:S75-S83.

Grant, C.A., Peterson, G.A., and Campbell, C.A. 2002. Nutrient considerations for diversified cropping systems in the Northern Great Plains. Agron. J. 94:186-198.

Sherrod, L.A., Dunn, G., Peterson, G.A., and Kolberg, R.L. 2002. Inorganic carbon analysis by modified pressure-calcimeter method. Soil Sci. Soc. Am. J. 66:299-305.

Shaver, T.M., Peterson, G.A., Ahuja, L.R., Westfall, D.G., Sherrod, L.A., and Dunn, G. 2002. Surface soil physical properties after twelve years of dryland no-till management. Soil Sci. Soc. Am. J. 66:1296-1303.

Ortega, R.A., Peterson, G.A., and Westfall, D.G. 2002. Residue accumulation and changes in soil organic matter as affected by cropping intensity in no-till dryland agroecosystems. Agron. J. 94:944-954.

Halvorson, A.D., Peterson, G.A., and Reule, C.A. 2002. Tillage system and crop rotation effects on dryland crop yields and soil carbon in the Central Great Plains. Agron. J. 94:1429-1436.

Del Grosso, S., Parton, W.J. Mosier, A.R., Hartman, M.D., Keough, C.A., Peterson, G.A., Ojima, D.S., and Schimel, D.S. 2001. Simulated effects of land use, soil texture, and precipitation on N gas emissions using DAYCENT. p. 413-431. In: Follett, R.F. and Hatfield, J.L. (eds.) Nitrogen in the Environment: Sources, Problems, and Management. Elsevier, Amsterdam.

Del Grosso, S., Ojima, D.S., Parton, W.J. Mosier, and Peterson, G.A. 2002. Regional assessment of net greenhouse gas fluxes from agricultural soils in the USA Great Plains under current and improved management. p. 469-474. In:Van Ham and Williams-Jacobse (eds.) Non-CO2 Greenhouse Gases. Millpress, Rotterdam.

Del Grosso, S., Ojima, D.S. Parton, W.J. Mosier, A.R., Peterson, G.A., and Schimel, D.S. 2002. Simulated effects of dryland cropping intensification on soil organic matter and greenhouse gas exchanges using the DAYCENT ecosystem model. Environmental Pollution 116:S75-S83.

Grant, C.A., Peterson, G.A., and Campbell, C.A. 2002. Nutrient considerations for diversified cropping systems in the Northern Great Plains. Agron. J. 94:186-198.

Sherrod, L.A., Dunn, G., Peterson, G.A., and Kolberg, R.L. 2002. Inorganic carbon analysis by modified pressure-calcimeter method. Soil Sci. Soc. Am. J. 66:299-305.

Shaver, T.M., Peterson, G.A., Ahuja, L.R., Westfall, D.G., Sherrod, L.A., and Dunn, G. 2002. Surface soil physical properties after twelve years of dryland no-till management. Soil Sci. Soc. Am. J. 66:1296-1303.

Ortega, R.A., Peterson, G.A., and Westfall, D.G. 2002. Residue accumulation and changes in soil organic matter as affected by cropping intensity in no-till dryland agroecosystems. Agron. J. 94:944-954.

Halvorson, A.D., Peterson, G.A., and Reule, C.A. 2002. Tillage system and crop rotation effects on dryland crop yields and soil carbon in the Central Great Plains. Agron. J. 94:1429-1436.

Shaver, T.M., Peterson, G.A., and Sherrod, L.A. 2003. Cropping intensification in dryland systems improves soil physical properties: regression relationships. Geoderma 116:149-164.

Sherrod, L.A., Peterson, G.A., Westfall, D.G., and Ahuja, L.R. 2003. Cropping intensity enhances soil organic carbon and nitrogen in a no-till agroecosystem. Soil Sci. Soc. Am. J. 67:1533-1543.

Johnson, C.K., Eskridge K.M., Wienhold, B.J., Doran, J.W., Peterson, G.A., and Buchleiter, G.W. 2003. Using electrical conductivity classification and within-field variability to design field-scale research. Agron. J. 95:602-613.

Andales, A.A., Ahuja, L.R., and Peterson, G.A. 2003. Evaluation of GPFARM for dryland cropping systems in eastern Colorado. Agron. J. 95:1510-1524.

Peterson, G. A., and D. G. Westfall. 2004. Managing precipitation use in sustainable dryland agroecosystems. Ann. Appl. Biol. 144:127-138.

Chapters in Books or Monographs:

Peterson, G.A. 1994. Interactions of surface residues with soil and climate. p. 9-12. IN: W.C. Moldenhauer and A.L. Black (eds.) Crop residue management to reduce erosion and improve soil quality: Northern Great Plains. USDA/ARS Cons. Res. Report No. 38. Washington, D.C.

Westfall, D.G., W.R. Raun, J.L. Havlin, G.V. Johnson, J.E. Matocha, and F.M. Hons. 1994. Fertilizer management. p. 33-36. IN: B.A. Stewart and W.C. Moldenhauer (eds.) Crop residue management to reduce erosion and improve soil quality: Southern Great Plains. USDA/ARS Cons. Res. Report No. 37. Washington, D.C.

Metherell, A.K., C.A. Cambardella, W.J. Parton, G.A. Peterson, L.A. Harding, and C.V. Cole. 1995. Simulation of soil organic matter dynamics in dryland winter wheat-fallow cropping systems. p.259-270. *IN:* Soil management and greenhouse effect. R. Lal, J. Kimble, E. Levine, and B.A. Stewart. (eds.) Lewis Publishers, Boca Raton, FL.

Peterson, G.A. and D.G. Westfall. 1997. Management of dryland agroecosystems in the Central Great Plains of Colorado. p.371-380. *IN:* Soil organic matter in temperate agroecosystems. Paul, E.A., K.A. Paustian, E.T. Elliot, and C.V. Cole. (eds.) Lewis Publishers, Boca Raton, FL.

Halvorson, A.D., M.F. Vigil, G.A. Peterson, and E.T. Elliott. 1997. Long-term tillage and crop residue management study at Akron, Colorado. p.361-370. *IN:* Soil organic matter in temperate agroecosystems. Paul, E.A., K.A. Paustian, E.T. Elliot, and C.V. Cole. (eds.) Lewis Publishers, Boca Raton, FL.

Farahani, H.J., G.A. Peterson, and D.G. Westfall. 1998. Dryland cropping intensification: A fundamental solution to efficient use of precipitation. Advances in Agron. 64:197-223.

Bradford, J.M. and G.A. Peterson. 1999. Conservation Tillage. p. G247-G270 *IN:* M.E. Sumner (ed.) Handbook of Soil Science. CRC Press, Boca Raton, FL.

Publications in Proceedings:

Peterson, G. A. and D. G. Westfall. 1987. Integrated research in soil and crop management. p. 3-5. IN: Proc. Western Phosphate Conf. March 1987. Corvallis, OR.

Kitchen, N. R. , D. G. Westfall and G. A. Peterson. 1988. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 172-179. IN: 1988 Symposium Proc. Fluid Fertilizer Research as a Basis for Efficient Crop Production. March 15-17, 1988.

Wood, C. W., D. G. Westfall and J. M. Ward. 1988. Phosphorus placement in dryland winter wheat. IN: Proc. Great Plains Soil Fert. Workshop 2:79-83.

Peterson, G. A., D. G. Westfall and W. O. Willis. 1988. Systems research: a necessity for the future of agronomic research. p. 739-740. IN: Proc. Int. Conf. Dryland Farming, Aug. 15-19, 1988. Amarillo, TX.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1988. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 223-229. IN: Proc. Fluid Fert. Found. Symp., March, 1988, Scottsdale, AZ.

Westfall, D. G. and G. A. Peterson. 1989. Long-term dryland cropping systems research for the Central Great Plains. p. 1. IN: Proc. Western Soc. Soil Sci. Bozeman, MT, June 20-22, 1989.

Peterson, G. A. and D. G. Westfall. 1990. Long-term soil-crop management research for the 21st century. p. 132-136. IN: Proc. Great Plains Soil Fert. Conf., Denver, CO, March 6-7, 1990.

Kitchen, N. R., D. G. Westfall, G. A. Peterson and J. L. Havlin. 1990. Soil sampling under no-till banded phosphorus fertilizer. p. 159-164. IN: Proc. Great Plains Soil Fert. Conf., Denver, CO, March 6-7, 1990.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1990. Fertilizer use efficiency in dryland no-till crop rotations. p. 218-227. IN: Proc. Fluid Fert. Found., Scottsdale, AZ, March 13-15, 1990.

Peterson, G. A. and D. G. Westfall. 1990. Dryland cropping systems to enhance water quality. p. 93-104. IN: Proc. Non-point Water Quality Symp., Colorado Springs, CO, March 22-23, 1990.

Westfall, D. G. and G. A. Peterson. 1990. Nitrogen efficiency in dryland agroecosystems. p. 155-163. IN: Proc. Great Plains Conserv. Tillage Symp. Great Plains Agricultural Council Bulletin No. 131. Bismarck, ND, August 21-23, 1990.

Peterson, G. A. and D. G. Westfall. 1990. Sustainable dryland agroecosystems. p. 23-29. IN: Proc. Great Plains Conserv. Tillage Symp. Great Plains Agricultural Council Bulletin No. 131. Bismarck, ND, Aug. 21-23, 1990.

Peterson, G.A.. 1991. Soil and crop management as a driving variable. p. 255. IN: J.D. Hanson, M.J. Shaffer, D.A. Ball and C.V. Cole (eds.), Sustainable Agriculture for the Great Plains, Symposium Proceedings. USDA-ARS, ARS-89.

Westfall, D.G. and G.A. Peterson. 1991. Optimum production and nitrogen fertilizer use in dryland no-till crop rotations. p.48. IN: Proc. Pacific Div. AAAS, June 23-27, 1991, Logan, UT.

Westfall, D.G., R.L. Kolberg, N.R. Kitchen, and G.A. Peterson. 1991. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 260-270. IN: Proc. Fluid Fert. Found. Symp., March 1991, Scottsdale, AZ.

Peterson, G.A., D.G. Westfall, and A.D. Halvorson. 1992. Economics of dryland crop rotations for efficient water and nitrogen use. p. 47-53. IN: Proc. Great Plains Soil Fert. Conf., Denver, CO, March 3-4, 1992.

Westfall, D.G., R.L. Kolberg, and G.A. Peterson. 1992. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 244-257. IN: Proc. Fluid Fert. Found. Symp., March 1992, Scottsdale, AZ.

Peterson, G.A., and C.V. Cole. 1993. Productivity of Great Plains soils: Past, present and future. IN: Proceedings of the Great Plains Ecosystems Symposium. Kansas City, MO. 7-9 April 1993.

Moore, I.D., P.E. Gessler, G.A. Nielsen, and G.A. Peterson. 1993. Soil attribute prediction using terrain analysis. p. 27-55. IN: Robert, P.C., et al. (eds.) Proc. of Workshop: Soil Specific Crop Management. Minneapolis, MN. 14-16 April 1992. Am. Soc. of Agron. Madison, WI.

Westfall, D.G., R.L. Kolberg, and G.A. Peterson. 1993. Nitrogen fertilizer use efficiency in dryland no-till crop rotations. p. 153-163. IN: Proc. Fluid Fert. Found. Symp. March 1993. Scottsdale, AZ.

Westfall, D.G., G.A. Peterson, and R.L. Kolberg. 1994. Fluid systems for dryland agriculture. p. 129-134. IN: Proc. Fluid Fert. Found. Symp. “Research for Tomorrow” February 1994. Scottsdale, AZ.

Westfall, D.G., R.L. Kolberg, and G.A. Peterson. 1994. Nitrogen management for intensified dryland agroecosystems. p. 12-17. IN: Proc. Great Plains Soil Fertility Conference. 7-9 March 1994. Denver, CO.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R. E. Anderson. 1994. Sustainable dryland cropping systems: Economic analysis. p. 30-35. IN: Proc. Great Plains Soil Fertility Conference. 7-9 March 1994. Denver, CO.

Rouppet, B., R.L. Kolberg, R.L. Waskom, D.G. Westfall, and G.A. Peterson. 1994. In-situ soil nitrogen mineralization methodology. p. 30-35. IN: Proc. Great Plains Soil Fertility Conference. 7-9 March 1994. Denver, CO.

Peterson, G.A. and D.G. Westfall. 1994. Intensified cropping systems: The key to environmental and economic sustainablity in the Great Plains. p. 73-84. IN: Proc. Intensive Wheat Management Conference. 10-11 March 1994. Denver, CO.

Peterson, G.A. and D.G. Westfall. 1994. Economic and environmental impact of intensive cropping systems - Semiarid region. p. 145-158. IN: Proc. Nutrient Management on Highly Productive Soils Conference. 16-18 May 1994. Atlanta, GA.

Westfall, D.G., G.A. Peterson, and R.L. Kolberg. 1994. Nitrogen and phosphorus management of dryland cropping systems. p. 35-41. IN: Proc. Great Plains Residue Management Conference. GPAC Bull. No. 150. 15-17 August 1994. Amarillo, TX.

Peterson, G.A., D.G. Westfall, and L. Ahuja. 1995. Sustainable dryland agroecosystems for the Great Plains. IN: Proc. Planning for a Sustainable Future: The case of the North American Great Plains Symposium. 8-10 May 1995. Lincoln, NE.

Peterson, G.A., D.G. Westfall, and R.L. Kolberg. 1995. Fertilidad en trigo y otros cultivos en areas secas. p. 119-130. IN: Fertilidad de Suelos, Fertilizacion y Siembra Directa. III Jornadas Regionales Symposium. September 1995. Sierra la Ventana, Argentina.

Westfall, D.G., G.A. Peterson, and R.L. Kolberg. 1995. Fluid systems for dryland agriculture. p. 127-140. IN: 1995 Fluid Forum Proc. Sponsored by Fluid Fertilizer Foundation. February 1995, Scottsdale, AZ.

Westfall, D.G., G.A. Peterson, and R.L. Kolberg. 1995. Sustainable dryland cropping systems. IN: Proc. Western Nutrient Management Conf. 1:101-105. 9-10 March 1995. Salt Lake City, UT.

Peterson, G.A. 1996. Nitrogen fertilizer management for Great Plains dryland cropping systems: A review. p.19-25. IN: Proc. Great Plains Soil Fertility Conference. 5-6 March 1996. Denver, CO.

Westfall, D.G., G.A. Peterson, and R.L. Kolberg. 1996. Fluid systems for dryland agriculture. p.102-112. IN: 1996 Fluid Forum Proc. Sponsored by Fluid Fertilizer Foundation. February 1996, Scottsdale, AZ.

Westfall, D.G. and G.A. Peterson. 1996. Post CRP nitrogen management in dryland cropping systems. p.6 IN CRP Conference Proceedings. CRP Conference. Amarillo, TX.

Ortega, R.A., D.G. Westfall, and G.A. Peterson. 1996. Crop residue distribution and activity in soils as affected by cropping intensity in no-till dryland agroecosystems. p.75-82. IN Proc. Great Plains Soil Fertility Conference. 5-6 March 1996. Denver, CO.

Westfall, D.G., R.L. Kolberg, and G.A. Peterson. 1996. Nitrogen fertilization of intensive cropping systems. p.48-57. IN: 1996 Proc. AgriFuture Farm Technology Expo and Convention Workshop. February 1996. Red Deer, Alberta.

Westfall, D.G. and G.A. Peterson. 1996. Managing the move to more intensive cropping. p.14-22. IN: 1996 Proc. AgriFuture Farm Technology Expo and Convention Workshop. February 1996. Red Deer, Alberta.

Peterson, G.A. and D.G. Westfall. 1997. Benefits of zero till and rotations in the North American Great Plains. p. 5-16. IN: Proc. of the 19th Annual Manitoba-North Dakota Zero Tillage Workshop. 27-29 Jan. 1997, Brandon, Manitoba, Canada.

Ortega, R. A., D.G. Westfall, and G.A. Peterson. 1997. Using natural soil variability to calibrate soil tests. p. 14-31. *IN*: 1997 Fluid Forum Proc. Sponsored by the Fluid Fertilizer foundation, February, 23-25, 1997, Scottsdale, AZ.

Ortega, R. A., D.G. Westfall, and G.A. Peterson. 1997. Spatial variability of soil P and its impact on dryland winter wheat yields. p. 150-159. *IN*: Proc. of the Western Nutrient Management Conf. March 6-7, 1997. Salt Lake City, UT.

Peterson, G. A. and D.G. Weatfall. 1997. Crop water extraction patterns across soil types. p. 41-48. *IN*: Proc. of the Ninth Ann. Conf. of the Colorado Cons. Tillage Assn. February 4-5, 1997. Sterling, CO.

Westfall, D.G., M. Amrani, and G.A. Peterson. 1998. Availability of zinc in fertilizers as influenced by water-solubility. p. 7-12. IN: Great Plains Soil Fertility Conference Proceedings. Schlegel, A.J. (Ed.) Great Plains Soil Fertility Conference. March 1998. Denver, CO.

Sherrod, A.L., G.A. Peterson, and D.G. Westfall. 1998. No-till rotational residue dynamics across an ET gradient. p. 61-66. IN: Great Plains Soil Fertility Conference Proceedings. Schlegel, A.J. (Ed.) Great Plains Soil Fertility Conference. March 1998. Denver, CO.

Ortega, R.A., D.G. Westfall, and G.A. Peterson. 1998. Using natural soil variability in landscapes: Site specific management of nitrogen on dryland corn. p. 98-113. *IN*: 1998 Fluid Forum Proc. Sponsored by the Fluid Fertilizer foundation, February, 22-25, 1998, Scottsdale, AZ.

Westfall, D.G., R.A. Ortega, and G.A. Peterson. 1998. Landscape variability and wheat managment. p. 1-8. *IN:* Proc. Intensive Wheat Mgt. Conf. Mar 4-5, 1998, Denver, CO. Sponsored by The Potash and Phosphate Institute.

Peterson, G.A. and D.G. Westfall. 1998. Efficient nutrient use in no-till intensively cropped dryland systems. p. 57-66. Proceedings of the 6th Congresso Nacional de AAPRESID. 19-21 August. Mar del Plata, Argentina.

Westfall, D.G., R.A. Ortega, and G.A. Peterson. 1998. Spatial variability of soil P and its impact on dryland winter wheat yields. V. 1, p. 301. *IN:* Proc 16th World Congress of Soil Science. August 20-26, 1998. Montpellier, France.

Ortega, R.A., D.G. Westfall, G.A. Peterson, and W.J. Gangloff . 1999. Using natural variability in landscapes to calibrate soil tests. p. 64-77. IN: Proc. Fluid Forum. 21-23 Feb. 1999. Scottsdale, AZ.

Peterson, G.A. and D.G. Westfall.1999. Adapt versus adopt: If it works in Saskatchewan why won't it work here?. Proceedings of the 11th Annual Conference of the Colorado Tillage Association. 2-3 February 1999. Sterling, Colorado.

Sherrod, A.L., G.A. Peterson, D.G. Westfall, and L.R. Ahuja. 2000. Carbon sequestration rates after 12 years under no-till dryland cropping systems rotations. p. 75-81. IN: Great Plains Soil Fertility Conference Proceedings. Schlegel, A.J. (Ed.) Great Plains Soil Fertility Conference. March 2000. Denver, CO.

Peterson, G.A., D.G. Westfall, L.A. Sherrod, and T.M. Shaver. 2000. Dryland agroecosystem management for the Central Great Plains. Proceedings of Farming and Ranching for Profit, Stewardship, and Community Conference. 7-9 March 2000. Portland, OR.

<u>Technical bulletins or other reports:</u>

Peterson, G. A., D. G. Westfall, W. Wood and S. Ross. 1988. Crop and soil management in dryland agroecosystems. Tech. Bull. LTB88-6. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D. G. Westfall, C. W. Wood, L. Sherrod and E. McGee. 1989. Crop and soil management in dryland agroecosystems. Tech. Bull. TB89-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D. G. Westfall, C. W. Wood, L. Sherrod and E. McGee. 1990. Crop and soil management in dryland agroecosystems. Tech. Bull. TB90-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G. A., D. G. Westfall, L. Sherrod, E. McGee and R. Kolberg. 1991. Crop and soil management in dryland agroecosystems. Tech. Bull. TB91-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, E. McGee and R. Kolberg. 1992. Crop and soil management in dryland agroecosystems. Tech. Bul.TB92-2. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Croissant, R.L., G.A. Peterson, and D.G. Westfall. 1992. Dryland cropping systems in eastern Colorado. Service in Action No. 516. Cooperative Extension. Colo. State Univ. Fort Collins, CO.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R.L. Anderson. 1993. Sustainable dryland cropping systems: Economic analysis. Tech. Bul. TB93-3. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1993. Sustainable dryland agroecosystem management. Tech. Bul. TB93-4. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Kolberg, R.L., D.G. Westfall, G.A. Peterson, N.R. Kitchen, and L. Sherrod. 1993. Nitrogen fertilization of dryland cropping systems. Tech. Bul. TB93-6. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1994. Sustainable dryland agroecosystem management. Tech. Bul. TB94-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and D. Poss. 1995. Sustainable dryland agroecosystem management. Tech. Bul. TB95-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and D. Poss. 1996. Sustainable dryland agroecosystem management. Tech. Bul. TB96-1. Colorado State University and Agricultural Experiment Station. Ft. Collins, CO.

Nielsen, D., G.A. Peterson, R. Anderson, V. Ferreira, W. Shawcroft, and K. Remington. 1996. Estimating corn yields from precipitation records. Cons. Tillage Fact Sheet 2-96. USDA/ARS and USDA/NRCS. Akron, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, D. Poss, K. Larson, D.Thompson, D. 1997. Sustainable dryland agroecosystem management. Tech. Bull. TB97-3. Colorado State University and Agricultural Experiment Station, Fort Collins, CO.

Peterson, G.A., D.G. Westfall, L. Sherrod, D. Poss, K. Larson, D. Thompson, and L.R. Ahuja. 1998. Sustainable dryland agroecosystem management. Tech. Bull. TB98-1. Agric. Exp. Stn., Colo. State Univ., Fort Collins, CO.

Peterson, G.A., D.G. Westfall, F.B. Peairs, L. Sherrod, D. Poss, W. Gangloff, K. Larson, D. Thompson, L.R. Ahuja, M.D. Koch, and C.B. Walker. 1999. Sustainable dryland agroecosystem management. Tech. Bull. TB99-1. Agric. Exp. Stn., Colo. State Univ., Fort Collins, CO.

Peterson, G.A., D.G. Westfall, F.B. Peairs, L. Sherrod, D. Poss, W. Gangloff, K. Larson, D. Thompson, L.R.. Ahuja, M.D. Koch, and C.B. Walker. 2000. Sustainable dryland agroecosystem management. Tech. Bull. TB00-3. Agric. Exp. Stn., Colo. State Univ., Fort Collins, CO.

Kaan, D.A., O'Brien, D.M., Burgener, P.A., Peterson, G.A., and Westfall, D.G. 2002. An economic evaluation of alternative crop rotations compared to wheat-fallow in Northeastern Colorado. Tech. Bull. TB02-1. Agric. Exp. Stn., Colo. State Univ., Fort Collins, CO.

Kaan, D.A., O'Brien, D.M., Burgener, P.A., Peterson, G.A., and Westfall, D.G. 2002. An economic evaluation of alternative crop rotations compared to wheat-fallow in Northeastern Colorado. Tech. Bull. TB02-1. Agric. Exp. Stn., Colo. State Univ., Fort Collins, CO.

Published Abstracts:

Peterson, G. A. and D. G. Westfall. 1987. Integrated research: a necessity for the future of soil and crop management. Agron. Abstracts p. 213. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., C. W. Wood and D. G. Westfall. 1988. Building a crop residue base in no-till cropping systems. Agron. Abstracts p. 246. Amer. Soc. of Agron., Madison, WI.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1989. Potential N and C mineralization in dryland no-till cropping soils as influenced by N fertilization management. Agron. Abstracts p. 244. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., D. G. Westfall. 1989. Long-term soil-crop management research for the 21st century. Agron. Abstracts p. 249. Amer. Soc. of Agron., Madison, WI.

Westfall, D. G., N. R. Kitchen and J. L. Havlin. 1989. Soil sampling procedures under no-till banded phosphorus fertility. Agron. Abstracts p. 256. Amer. Soc. of Agron., Madison, WI.

Wood, C. W., G. A. Peterson and D. G. Westfall. 1989. Potential C and N mineralization in dryland agroecosystems as affected by landscape position and crop rotation. Agron. Abstracts p. 256. Amer. Soc. of Agron., Madison, WI.

Follett, R. H., G. A. Peterson, C. W. Wood and D. G. Westfall. 1989. Developing a crop residue base to decrease erosion potential. Abstract of the Annual Meeting of the Soil and Water Conservation Society. 30 July 1989. Edmonton, Canada.

Kitchen, N. R., D. G. Westfall and G. A. Peterson. 1990. Nitrogen fertilization management in no-till dryland cropping systems. Agron. Abstracts p. 272. Amer. Soc. of Agron., Madison, WI.

Peterson, G. A., C. W. Wood and D. G. Westfall. 1990. Cumulative biomass production and N utilization in no-till dryland agroecosystems. Agron. Abstracts p. 322. Amer. Soc. of Agron., Madison, WI.

Wood, C. W., D. G. Westfall and G. A. Peterson. 1990. Impact of cropping intensity under no-till on soil C and N. Agron. Abstracts. p. 328. Amer. Soc. of Agron., Madison, WI.

Evans, S.D., G.A. Peterson, D.G. Westfall, and E.A. McGee. 1991. Nitrate leaching in dryland agroecosystems as influenced by soil and climate gradients. Agron. Abstracts. p.330. Amer. Soc. of Agron., Madison, WI.

McGee, E.A., G.A. Peterson, and D.G. Westfall. 1991. Water-use efficiency of dryland no-till cropping systems in the west central Great Plains. Agron. Abstracts. p.336. Amer. Soc. of Agron., Madison, WI.

McMaster, G.S., J.A. Morgan, and G.A. Peterson. 1991. Wheat yield components for different cropping systems, climates, and catenas. Agron. Abstracts. p.153. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., D.G. Westfall, and E.A. McGee. 1992. Increasing productivity and sustainability of dryland agroecosystems. Abstracts of the First International Crop Science Congress. 14-22 July, 1992. Ames, Iowa. Crop Science Society of America. Madison, WI.

Westfall, D.G., and G.A. Peterson. 1992. Sustainable dryland agroecosystems. Agron. Abstracts. p. 86. Amer. Soc. of Agron., Madison, WI.

McGee, E.A., G.A. Peterson, and D.G. Westfall. 1992. Water-use efficiency as affected by cropping intensity, slope, and evaporative gradient in no-till dryland agroecosystems. Agron. Abstracts. p. 331. Amer. Soc. of Agron., Madison, WI.

Iremonger, C.J., D.G. Westfall, and G.A. Peterson. 1992. Fertilizer phosphorus and cropping intensity effects on P availability. p. 86-92. IN: Proc. Western Phosphorus/Sulfur Workshop. Aug. 6-8, 1992. Anchorage, AK.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R.L. Anderson. 1993. Sustainable dryland cropping systems: Economic analysis. Agron. Abstracts p. 325. Amer. Soc. of Agron., Madison, WI.

Kolberg, R.L., B. Rouppet, D.G.Westfall, and G.A. Peterson. 1993. In situ soil nitrogen mineralization methodology. Agron. Abstracts p. 276. Amer. Soc. of Agron., Madison, WI.

Halvorson, A.D., G.A. Peterson, and S.E. Hinkle. 1993. Tillage and cropping system effects on dryland wheat and corn production. Agron. Abstracts p. 316. Amer. Soc. of Agron., Madison, WI.

Mrabet, R., A. Bouzza, and G.A. Peterson. 1993. Potential reduction in soil erosion in Morocco using no-till systems. Agron. Abstracts p. 323. Amer. Soc. of Agron., Madison, WI.

Rouppet, B., D.G. Westfall, and G.A. Peterson. 1994. In-situ nitrogen mineralization in no-till dryland agroecosystems. Agron. Abstracts p. 316. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., A.J. Schlegel, D.L. Tanaka, and O.R. Jones. 1994. Precipitation use efficiency as related to cropping systems and tillage. Agron. Abstracts p. 356. Amer. Soc. of Agron., Madison, WI.

Ortega, R.A., G.A. Peterson, and D.G. Westfall. 1994. Net nitrogen mineralization as affected by cropping systems and residue production. Agron. Abstracts p. 372. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., D.G. Westfall, N.E. Toman and R.L. Anderson. 1994. Sustainable dryland cropping systems on the Colorado High Plains: Economic analysis. AAAS-WSSA Meeting Abstract. 20-23 April 1994.

Sherrod, L., G.A. Peterson, D.G. Westfall, and R.L. Kolberg. 1995. Carbon and nitrogen dynamics as affected by rotation intensity in the Great Plains. Agron. Abstracts p. 25. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., A.L. Black, A.D. Halvorson, J.L. Havlin, O.R. Jones, and D.J. Lyon. 1995. North American agricultural soil organic matter network: The American Great Plains. Agron. Abstracts p. 25. Amer. Soc. of Agron., Madison, WI.

Ortega, R.A., G.A. Peterson, and D.G. Westfall. 1995. Phosphorus test calibration using spatial variability of a landscape in eastern Colorado. Agron. Abstracts p. 268. Amer. Soc. of Agron., Madison, WI.

Rodriguez, J.B., J.R. Self, G.A. Peterson, and D.G. Westfall. 1995. Sodium bicarbonate-DTPA test for macro and micro nutrients in soils. Agron. Abstracts p. 317. Amer. Soc. of Agron., Madison, WI.

Farahani, H.J., L.A. Ahuja, G.W. Buchleiter, and G.A. Peterson. 1995. Mathematical modeling of irrigated and dryland corn production in eastern Colorado. Abstract for Clean Water-Clean Environment-21st Century Symposium. March 1995. Kansas City, MO.

Farahani, H.J., L.A. Ahuja, G.A. Peterson, R. Mrabet, and L. Sherrod. 1995. Root zone water quality model evaluation of dryland/no-till crop production in eastern Colorado. Abstract of International Symposium on Water Quality Modeling. April 1995. Kissimmee, FL.

Peterson, G.A. and D.G. Westfall. 1995. Post-CRP land use-alternative systems. Abstract of Symposium on Converting CRP-Land to Cropland and Grazing: Conservation Technologies of the Transition. Sponsored by Soil and Water Cons. Soc. of Amer. 6-8 June 1995. Lincoln, NE.Sherrod, L., G.A.Peterson, and D.G. Westfall. 1996. No-till rotational residue dynamics across an ET gradient. Agron. Abstracts p. 282. Amer. Soc. of Agron., Madison, WI.

Poss, D.J, G.A. Peterson, and D.G. Westfall. 1996. Growing annual legumes in dryland agroecosystems in northeastern Colorado. Agron. Abstracts p. 283. Amer. Soc. of Agron., Madison, WI.

Halvorson, A.D., C.A. Reule, and G.A. Peterson. 1996. Long-term N fertilization effects on soil organic C and N. Agron. Abstracts p. 276. Amer. Soc. of Agron., Madison, WI.

Kolberg, R.L., D.G. Westfall, and G.A. Peterson. 1996. Influence of cropping intensity and nitrogen fertilizer rates on *In situ* nitrogen mineralization. Agron. Abstracts p. 247. Amer. Soc. of Agron., Madison, WI.

Farahani, H.J., G.A. Peterson, D.G. Westfall, L.A. Sherrod, and L.A. Ahuja. 1996. The inefficiency of summer fallow in dryland no-till cropping systems. Agron. Abstracts p. 295. Amer. Soc. of Agron., Madison, WI.

Iremonger, C.J., D.G. Westfall, G.A. Peterson, and R.L. Kolberg. 1997. Nitrogen fertilizer induced soil pH drift in a no-till dryland cropping system. Agron. Abs. p.225. Amer. Soc. of Agron., Madison, WI.

Ortega, R.A., D.G. Westfall, and G.A. Peterson, G.A. 1997. Spatial variability of soil P and its impact on dryland winter wheat yields. Agron. Abs. p.231. Amer. Soc. of Agron., Madison, WI..

Peterson, G.A., D.G. Westfall, H.J. Farahani, L.A. Sherrod, and L.R. Ahuja. 1997. Enhancing productivity of central Great Plains dryland agroecosystems. Agron. Abs. p.261. Amer. Soc. of Agron., Madison, WI..

Westfall, D. G., R.A. Ortega, and G.A. Peterson. 1997. Spatial variability of soil properties and wheat yields over landscapes. p. 11-12. *IN*: Abstracts of 1st European Conf. on Precision Agr. Sept. 7-10, 1997. Warwick University.

Ortega, R.A., W.J. Gangloff, D.g. Westfall, and G.A. Peterson. 1998. Multivariate approach to nitrogen recommendations for dryland corn in eastern Colorado. Agron. Abs. p.55. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., L.A. Sherrod, D.G. Westfall, and L.R. Ahuja. 1998. Intensive dryland cropping systems increase soil organic matter. Agron. Abs. p.276. Amer. Soc. of Agron., Madison, WI.

Guzman, J., G.A. Peterson, D.G. Westfall, and P.L. Chapman. 1998. Dryland corn yields as a function of weather and soil variables. Agron. Abs. p.277. Amer. Soc. of Agron., Madison, WI.

Lyon, D.J. and G.A. Peterson. 1999. Three crops in three years with no-till dryland systems in the semiarid Great Plains. Agron. Abs. p.100. Amer. Soc. of Agron., Madison, WI.

Grant, C.A., G.A. Peterson and C. A. Campbell. 1999. Nutrient considerations for diversified cropping systems in the Northern Great Plains. Agron. Abs. p.101. Amer. Soc. of Agron., Madison, WI.

Kruger, H.K. G.A. Peterson, and D.G. Westfall. 1999. Below ground dry matter production and nitrogen content of four legumes in dryland agroecosystems. Agron. Abs. p.245. Amer. Soc. of Agron., Madison, WI.

Poss, D.J., G.A. Peterson, and D.G. Westfall. 1999. Austrian winter pea in dryland systems in Northeastern Colorado. Agron. Abs. p.279. Amer. Soc. of Agron., Madison, WI.

Sherrod, L.A.,G.A. Peterson, D.G. Westfall, and L.R. Ahuja. 1999. Carbon sequestration rates after 12 years under no-till dryland cropping systems rotations. Agron. Abs. p.280. Amer. Soc. of Agron., Madison, WI.

Shaver, T.M., G.A. Peterson, D.G. Westfall, and L.R. Ahuja. 1999. Surface soil properties after 12 years of dryland no-till management. Agron. Abs. p.280. Amer. Soc. of Agron., Madison, WI.

Berrada, A. and G.A.Peterson. 2000. Development of a sustainable dryland cropping systems in SW Colorado and SE Utah. Agron. Abs. p.132. Amer. Soc. of Agron., Madison, WI.

Gangloff, W., D.G. Westfall, and G.A. Peterson. 2000. Availability of organic and inorganic zinc fertilizers. Agron. Abs. p.277. Amer. Soc. of Agron., Madison, WI..

Gangloff, W., R. Ortega, R.M. Reich, D.G. Westfall, and G.A.Peterson. 2000. Statistical analysis of the management zone concept. Agron. Abs. p.358. Amer. Soc. of Agron., Madison, WI..

McMaster, G.S., L.A. Deer-Ascough, J.C. Ascough, G.A. Peterson, G. Dunn, C. Palic, M. Shaffer, and M.A. Welz. 2000. Using the GPFARM DDS for evaluating dryland cropping system production and economics in the west central Great Plains. Agron. Abs. p.22. Amer. Soc. of Agron., Madison, WI.

Peterson, G.A., D.G. Westfall, L.R. Ahuja, L.A. Sherrod, and D.J. Poss. 2000. Advances in dryland agroecosystems: Results of 15 years of research. Agron. Abs. p.310 Amer. Soc. of Agron., Madison, WI..

Shaver, T.M., G.A. Peterson, D.G. Westfall, L.A, Sherrod, L.R. Ahuja, and G. Dunn. 2000. No-till cropping system effects on organic carbon content of surface soil aggregates, POM, and mineral fractions. Agron. Abs. p.311. Amer. Soc. of Agron., Madison, WI.

Sherrod, L.A., G. Dunn, G.A. Peterson, and R.L. Kolberg. 2000. Total inorganic carbon analysis by modified pressure calcimeter. Agron. Abs. p.365 Amer. Soc. of Agron., Madison, WI..

Sorge, G.M., G.A. Peterson, D.G. Westfall, and J.M. Krall. 2000. Incorporating legumes in semiarid, no-till agroecosystems: Soil quality effects. Agron. Abs. p.317 Amer. Soc. of Agron., Madison, WI..

Andales, A.A., Ahuja, L.R., and Peterson, G.A. 2002. A modeling approach to the evaluation of altenative cropping systems. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Indianapolis, IN 10-14 Nov. 2002.

Andales, A.A., Ahuja, L.R., and Peterson, G.A. 2002. A modeling approach to the evaluation of altenative cropping systems. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Indianapolis, IN 10-14 Nov. 2002.

Halvorson, A.D., Del Grosso, S.J., Mosier, A.R., Parton, W.J., Peterson, G.A., and Robertson, G.P. 2003. Measurement and modeling of soil atmosphere N2O and CO2 exchange for global warming potential in agroecosystems. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Denver, CO 2-6 Nov. 2003.

Sherrod, L.A., Peterson, G.A., Westfall, D.G. and Ahuja, L.R. 2003. Soil organic carbon pools after 12 years in a no-till agroecosystem as impacted by PET gradient, topography, and cropping system intensity. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Denver, CO 2-6 Nov. 2003.

Johnson, C.K., Eskridge K.M., Wienhold, B.J., Doran, J.W., Peterson, G.A., Buchleiter, G.W. and Corwin, D.L. 2003. Designing field scale experiments using apparent soil electrical conductivity. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Denver, CO 2-6 Nov. 2003.

Andales, A.A., Ahuja, L.R., Green, T.R., Erskine, R.H., and Peterson, G.A. 2003. Spatial and temporal correlations among dryland grain yield and soil water content in a sloping field. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Denver, CO 2-6 Nov. 2003.

Koch, M.D., Peairs, F.B., and Peterson, G.A. 2003. Integrating pest management with dryland cropping rotations. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Denver, CO 2-6 Nov. 2003.

Poss, D.J., Peterson, G.A., and Peairs, F.B. 2003. Dryland cropping systems in a low precipitation high evapotranspiration environment. Agron. Abs. Amer. Soc. of Agron., Madison, WI. Denver, CO 2-6 Nov. 2003.

Non-technical papers:

Westfall, D. G. and G. A. Peterson. 1990. Improving your dryland performance. Solutions 34(5):32-34 and 49.

Wood, C. W., G. A. Peterson and D. G. Westfall. 1990. Greater crop management intensity increases soil quality. Better Crops 74(3):20-22.

Westfall, D.G., G.A. Peterson, and J.L. Sanders. 1992. Phosphorus reduces stress in intensive dryland no-till crop rotations. Better Crops with Plant Food. Vol. 76. Fall 1992. pp. 20-21.

Westfall, D.G., G.A. Peterson, R.L. Kolberg, and L. Sherrod. 1994. Extra crop is payoff in dryland no-till intensified cropping system. Fluid Journal 2:18-20.

Peterson, G.A. 1996. Nitrogen: The vital nutrient in the Great Plains. Fluid Journal Vol.4, No.3, p.18-21.

Peterson, G.A. and D.G. Westfall. 1996. Maximum water conservation after wheat harvest. Cons. Tillage Digest Vol.3. No.5, p.9.

Ortega, R.A., D.G. Westfall, and G.A. Peterson. 1997. Variability of phosphorus over landscapes and dryland winter wheat yields. Better Crops: 81(2) 24-27.

Peterson, G.A. and D.G. Westfall. 1998. No-till practices in the Central Great Plains make summer fallow unnecessary. Conservation Tillage Digest 5:(No. 5)14-16.

Ortega, R.A., D.G. Westfall, G.A. Peterson, and W.J. Gangloff. 1998. Soil variability in landscapes affects nitrogen management. Fluid Journal. Vol. 6: (No. 3) 23-26.