An Economic Evaluation of Alternative Crop Rotations Compared to Wheat-Fallow In Northeastern Colorado

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Interest has been high among Central Great Plains producers for alternative, intensive, dryland crop rotations to replace traditional conventional tillage wheat-fallow production. The idea behind these alternative crop rotations is to reduce (or eliminate) the frequency of a summer fallow period in the crop rotation and increase economic return. Advances in the drought tolerance and productivity of dryland crop varieties and changes in cultural practices have allowed this idea to become reality for many producers in eastern Colorado. The most common changes in cultural practices have come in the form of reduced tillage or no-till management practices and in increased herbicide usage to control weed growth in the cropping and fallow (i.e., non-cropped) periods. One of the widely recognized benefits of reduced tillage in dryland crop production is increased crop residue on the soil surface. Increased residue levels have been shown to moderate soil temperature and increase precipitation infiltration, resulting in increased moisture availability for crop production. Anderson et al., 1999, provide a description of these agronomic relationships.[2]

Economics are the driving factor in adoption of intensive no-till dryland cropping systems. Colorado State University researchers Gary Peterson and Dwayne Westfall established a research project in 1985 to address efficient water use under dryland conditions in eastern Colorado. The general objective of the project is to identify dryland crop and soil management systems that will maximize precipitation use efficiency and economic return. Peterson et al., 1988, detail the project in regard to the "start up" period and data from the 1986 and 1987 crop years.[3] Peterson et al., 1988-1999 detail annual production results after the startup period.[4] This report summarizes the economic analysis of the first 12 years of this project.

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Interactions of soil, climate, and cropping system are being studied in this research project. Two sites, Sterling in northeast Colorado and Stratton in east central Colorado, were chosen to represent a gradient in potential evapotranspiration (ET). These sites have long-term precipitation averages of approximately 16 inches. Potential ET for the March through October growing season (measured using an “open pan” method) ranges from 63 inches in Sterling to 68 inches in Stratton. These sites were selected and configured such that each plot is represented by summit, side-slope and toe-slope soil positions. All systems are managed with no-till techniques. A third site was also selected in southeastern Colorado (i.e., at Walsh), but data for that site has not been summarized, analyzed, or discussed in this report.

Table 1 describes the cropping systems tested, the time periods each was in existence, and the abbreviations utilized for each system throughout this paper. Although not evaluated in this paper, an opportunity cropping system has been tested annually and a perennial grass plot has been maintained in the research project. The last year for the wheat-fallow (W-F) system was 1997. It was discontinued in order to provide plot space for other more intensive rotations and because there are adequate data for W-F systems in the literature. The wheat-corn-fallow (W-C-F) cropping system became the standard for comparison at that point.

This paper evaluates net returns for the cropping systems described in Table 1. A statistical analysis of the W-F and W-C-F cropping systems will also be presented. These two cropping systems have the longest running history in this research project and provide the statistical requirements to make accurate observations. The wheat-corn-sunflower-fallow (W-C-S-F) cropping system faced several management situations that were not typical of farms in northeast and east central Colorado. As a result, yield data will be presented but no further economic analysis will be performed on this cropping system. The wheat-corn-millet (W-C-M) and wheat-wheat-corn-millet (W-W-C-M) cropping systems were only utilized in 1998. No economic analysis will be performed on these two continuous cropping systems as they represent only one year of observation.

INPUT DATA AND ENTERPRISE BUDGET ASSUMPTIONS

Crop Yield

Crop yield data for the cropping systems studies for the 1989 through 1999 time period are presented for the Sterling site in Table 2 and for the Stratton site in Table 3. Yields are presented for each crop in each cropping system. The data in Tables 2 and 3 averages the summit, side-slope, and toe-slope positions of the research plots.

Crop Prices

Price data for each crop were obtained from USDA Agricultural Marketing Service (AMS) in Greeley, CO. Prices are representative of northeastern Colorado. Daily price data were obtained for the time period corresponding to the crop production period, 1989-1999. These daily prices were averaged to calculate monthly prices, which were in turn averaged to come up with marketing year average prices. Table 4 presents the marketing year average price for the time period 1989-1999 for each crop analyzed. Also presented in Table 4 is a ten-year average price received for each crop. The marketing year average price received is calculated beginning in the month the crop is typically harvested. The ten-year average price is calculated on a calendar basis, meaning the average is calculated from January through December.

Enterprise Budgets

Enterprise analysis techniques have been utilized to generate cost of production estimates. Dryland crop enterprise cost estimates were developed from interviews with members of the Akron Maximum Economic Yield Club. These crop budget estimates are not averages, but rather represent cultural practices and input rates that follow best management practices for dryland crop production enterprises in this region of Colorado. As such, input rates, cultural practices, and machinery complements are considered ideal for best management practices production of each crop in each crop rotation analyzed.

The enterprise budgets utilized in this analysis represent a return to land and management. From net returns generated in each enterprise, a producer must allocate a return to land investment if land is owned, or to a lease payment if land is leased. A return to the producer’s unpaid labor and management in the operation should also be calculated in analyzing net returns over costs. If there is a positive net return at that point, there is said to be a positive return to the operator’s risk in the operation. An expense for crop insurance is included in each enterprise budget as part of the defined cultural practices. Harvest costs are calculated on a custom rate basis, which allows a more accurate accounting of harvest expenses. Gross receipts are based on crop production only.

This analysis does not include government payments or crop insurance indemnity payments in the calculation of gross receipts and enterprise net returns. Government payments are not included in these net returns estimates to avoid problems associated with farm-to-farm variations in cropland base acreages and fixed production flexibility contract payments. The planting flexibility and decoupled fixed payment provisions of the 1996 Freedom to Farm program eliminate the necessity of growing specific crops to earn government program payments, removing the need to show such payments for one crop as opposed to another in these enterprise budgets. While government payments are eliminated from this analysis, in the net returns calculations that follow crop producers are free to account for the decoupled government payments associated with their particular farm.

Costs are estimated for each cropping enterprise and for long or short fallow periods. Table 5 presents pre-harvest cost estimates and custom harvest rates for each crop enterprise in these cropping systems. Table 6 presents cost estimates and for each fallow enterprise. Fallow enterprises have been defined according to whether they follow a summer crop (a long fallow period) or a wheat crop (a short fallow period). Long fallow periods typically last from fall harvest of the summer crop until wheat is seeded the following fall. Short fallow periods typically last from summer harvest of the wheat crop until a summer crop is seeded the following spring. Expenses for the short fallow period, from wheat harvest to spring planting, are combined with summer crop costs in the summer crop enterprise budget. The short fallow period is defined as no-till in each case with a burn down herbicide required for weed control and moisture conservation prior to summer crop planting. The crop (Table 5) and fallow (Table

6) cost estimates are based on input from the Akron, Colorado Maximum Economic Yield Club and 1999 Colorado State University Extension budget estimates.

One of the initial arguments in favor of intensive cropping rotations has been the ability to spread fixed costs of production over more producing acres. This analysis takes this into consideration in calculating annualized net returns. Cost of production estimates in Tables 5 and 6 assume $10.00 per acre overhead expenses in a W-F cropping system. In the calculation of annualized net returns, preharvest expenses are adjusted as follows: 1) in the two-crop in three-year rotations, overheads expenses will be $7.50 per acre; 2) in the three-crop in four-year rotations, overhead expenses will be $6.67 per acre; 3) in the continuous cropping rotations, overhead expenses will be $5.00 per acre. These overhead expense adjustments are made by reallocating the same amount of government payments over successively more intense amounts of cropped (non-fallow) acres.

METHODOLOGY

Calculation of Annualized Average Net Return for Cropping Systems

Net returns for each crop enterprise in each cropping system have been calculated based on the yield, price received and cost of production assumptions described above (Table 1). Net returns for each crop and fallow enterprise are then annualized for each cropping system. Annualized net income is estimated by averaging net returns across each of the individual crop and/or fallow enterprises of a particular crop rotation. The weight given to any particular crop or fallow enterprise in this annual averaging process equals the proportion of acreage it represents in the overall rotation. In this field research, all crop and/or fallow enterprises of each rotation are represented every year for each crop rotation. This allows for the annualized net returns of any particular cropping system to be calculated for each year of the study.

For comparison purposes, *rotation breakeven yields* are calculated based on the price received for each crop described in Table 4. This is referred to as a *rotation breakeven yield* because fallow enterprise expenses are shared between the producing enterprises according to the rotation intensity.

Table 7 presents results for the W-F cropping systems at the Sterling and Stratton sites. Average annualized net returns total $9 per acre at the Sterling site and $20 per acre at the Stratton Site. Table 8 presents results for the W-C-F cropping systems at the Sterling and Stratton sites. Average annualized net returns total $21 per acre at the Sterling and $37 per acre at the Stratton.

Wheat-Corn-Fallow Rotation Profitability Assuming Average Grain Prices

An ordinary least squares multiple regression statistical analysis of the Sterling and Stratton field test plot data was performed to determine what factors affected yields and profitability for the W-C-F cropping system. The factors used to explain yield and net returns variation in these statistical models include the field test plot site (Sterling versus Stratton, Colorado), the field slope of the plots within the plot sites (summit versus side-slope and toe-slope locations), and the specific crop years during the 1989 through 1999 period (Table 9). Wheat prices were assumed to be constant during the 1989-99 period at $3.25 per bushel, while corn prices were assumed to be constant at $2.53 per bushel. The assumption of constant grain prices places emphasis on annual yield variation to the exclusion of annual price variation. No government payments are included in crop revenue estimates, and no land or management costs are included in production cost calculations. The use of multiple regression statistical analysis with dummy variables to measure factor effects mandates the selection of one treatment for baseline comparisons. The arbitrarily selected base line of comparison in this analysis is the Sterling location, summit soil position and production year 1990. All values in the analysis are relative to the returns of the baseline treatment. This discussion primarily focuses on statistically significant multiple regression analysis results.

Wheat yields in a W-C-F cropping system were 5 bushels per acre higher for the Stratton as opposed to the Sterling field tests, and were 10 bushels per acre higher on toe-slope locations as opposed to a summit slope locations (Table 9). Wheat yields on side-slopes were 5 bushel per acre less than on summit slope locations in W-C-F cropping systems. Net returns for the wheat enterprise within a W-C-F cropping system were positively and negatively affected by the same factors as wheat yields. Wheat enterprise returns in the Stratton field test were $16 per acre more than in the Sterling field test, while wheat enterprise returns on toe-slope locations were $30 per acre higher than on summit slope locations. Wheat enterprise returns on side-slope locations were $15 per acre less than on summit slope locations in W-C-F cropping systems. Wheat yields and wheat enterprise net returns were both significantly lower during the 1991, 1992, 1994, 1997, and 1998 crop years as compared to 1990.

Corn yields in a W-C-F cropping system were 16 bushels per acre higher for the Stratton as opposed to the Sterling field tests, and were 29 bushels per acre higher on toe-slope locations as opposed to a summit slope locations (Table 9). Just as for the wheat enterprise, corn enterprise net returns in a W-C-F cropping system were positively and negatively affected by the same factors as yields. Corn enterprise returns in the Stratton field test were $35 per acre more than in the Sterling field test, and were $66 per acre higher on toe-slope locations than on summit slope locations. Wheat enterprise returns on side-slope locations were $15 per acre less than on summit slope locations in W-C-F cropping systems. Corn yields and corn enterprise net returns were both significantly lower during the 1994 and 1995 crop years as compared to 1990.

The overall profitability of the W-C-F cropping system was $17 per acre higher for the Stratton field test than on the Sterling field test site. The profitability of W-C-F systems on toe-slope locations were $32 per acre higher than on summit slope locations (Table 9). Whereas wheat enterprise profitability was negatively affected by location on a side-slope, overall W-C-F cropping system profitability was not. Wheat-corn-fallow (W-C-F) cropping system profitability was significantly lower in 1994 and 1995 (–$41 and –$47 per acre, respectively), and significantly higher in 1996 (+$20 per acre) in comparison to 1990.

There is some evidence of risk reduction through diversification of crop enterprises with a W-C-F cropping system in these results. The standard deviation for the overall W-C-F net returns model is $18 per acre. This is less than the standard deviation for wheat enterprise returns ($30 /acre) and corn enterprise returns ($45 /acre) in the W-C-F net returns model. In these statistical models a smaller standard deviation is an indication of less income variability. The combination of the wheat and corn enterprises together in a W-C-F rotation had less income variability than for either of the two enterprises alone as evidenced by a smaller standard deviation.

Wheat-Corn-Fallow Rotation Profitability Assuming Annual Grain Price Variation

Annual grain selling prices were allowed to vary in a second multiple regression statistical analysis of the Sterling and Stratton field test plot. Annual marketing year average cash prices for wheat in northeast Colorado and for corn in eastern Colorado during the 1989-99 time period were used in place of the longer-term constant average prices in the previous analysis. Using annual marketing year average prices rather than constant long term prices allows for an evaluation of the impact of price variability on W-C-F profitability, both by enterprise and for the total crop rotation. Again, government payments are not included in the enterprise budgets and in this statistical analysis.

Wheat enterprise net returns in a W-C-F cropping system were $15 per acre higher in the Stratton as opposed to the Sterling field tests (Table 10). Toe-slope locations produced $29 per acre more than did summit slope locations. Location on a side-slope had a negative but not statistically significant impact on wheat net returns (–$15 /acre) in a W-C-F cropping system. These results were similar to those from the previous analysis that did not allow for price variation. With annual price variation allowed, wheat enterprise net returns were significantly higher during the 1989, 1993, 1995, and 1996 crop years in comparison to 1990. These annual impacts differed sharply from those in the above analysis, where different years had primarily negative significant net returns impacts.

Corn enterprise net returns in a W-C-F cropping system were $36 per acre higher in the Stratton as opposed to the Sterling field test sites (Table 10). Toe-slope locations had $66 per acre higher corn returns than did summit slope locations, while corn enterprise returns on side-slopes the W-C-F system did not significantly differ from summit slope locations. These results were similar to those from the previous analysis that did not allow for price variation. In addition, with annual price variation allowed, corn enterprise net returns were significantly lower during the 1994 and 1995 crop years, and significantly higher in 1996 as compared to 1990. These annual impacts were similar in direction but differed in magnitude from those in the model with constant prices assumed. In particular, the negative impact of 1995 upon corn enterprise net returns was reduced by $45 per acre.

Allowing for annual price variability, the overall profitability of the W-C-F cropping system was $17 per acre higher in the Stratton as opposed to the Sterling field sites, and $32 per acre higher on toe-slope locations than on summit slope locations (Table 10). These results were essentially unchanged from those with constant average prices. W-C-F cropping system profitability was $23 per acre lower in 1994, and $23 and $53 per acre higher in 1989 and 1996, respectively, in comparison to 1990. The results for 1989 and 1995 differed markedly from those in the previous model with constant average grain prices.

Even though the statistical results varied between the W-C-F model with constant prices (Table 9) and the W-C-F model with variable grain prices (Table 10), the standard deviations or the variability of the net return results for the two W-C-F models were nearly equal statistically. Both the W-C-F net returns model utilizing constant grain prices and the W-C-F net returns model utilizing varying marketing year average prices had standard deviations of $18 per acre.

Wheat-Fallow Rotation Profitability Assuming Average Grain Prices

In addition to the previous analyses of W-C-F yields and net returns, a statistical analysis of the Sterling and Stratton data was carried out to determine what factors affected yields and profitability for the W-F cropping system. The factors used to explain yield and net returns variation in these explanatory models include location (Sterling versus Stratton, CO), the field slope of the plots within the plot sites (summit versus side-slope and toe-slope locations), and the specific crop years during the 1989 through 1997 period (Table 11). Wheat prices were assumed to be constant during the 1989-97 period at $3.25 per bushel. Only statistically significant model results are discussed.

Wheat yields in a W-F cropping system were 8 bushels per acre higher at the Stratton test site than at the Sterling site, and 10 bushels per acre higher at on toe-slope locations than on summit slope locations (Table 11). Wheat enterprise net returns in a W-C-F cropping system were positively affected by the same factors as yields. Wheat returns at the Stratton site were $12 per acre higher than at the Sterling test site. Wheat returns on toe-slope locations were $14 per acre higher than on summit locations. Both wheat yields and wheat enterprise net returns were significantly lower during the 1989, 1992, 1994, 1995, and 1997 crop years.

Profitability Differences between Wheat-Corn-Fallow and Wheat-Fallow Rotations

The profitability of the W-F and W-C-F cropping systems were compared over the 1989-1997 period using both constant average and marketing year average prices (Table 11). For models with both constant and variable selling prices, W-C-F net returns on toe-slope locations were $24 per acre higher than W-F net returns on summit slope locations. Wheat-corn-fallow (W-C-F) rotation net returns in 1994 were $20 and $24 per acre lower than for W-F rotations using constant and varying marketing year average prices, respectively. Conversely, W-C-F net returns in 1996 were $22 and $16 per acre higher than for W-F for the constant and variable price regimes, respectively. Also, in 1997 W-C-F returns were $33 and $24 per acre higher than those in W-F for the constant and variable price regimes, respectively.

Illustrating Crop Yields and Net Returns by Crop Rotation

Figures 1 through 12 show the distributions of crop yields and net returns for the W-C-F and W-F rotations examined in this study. Figure 1 shows the combined average wheat yields by year in the W-C-F cropping system at the Sterling and Stratton sites. The average wheat yield in W-C-F for each year during the 1989-99 period was 38 bushels per acre. Only in 1992 and 1997 did wheat yields in W-C-F drop below 30 bushels per acre. Figure 2 shows the probability distribution of wheat yields in W-C-F for this period, again averaged over all soils and locations. Wheat in W-C-F yielded at least 30 bushels per acre 71 percent of the time, and at least 40 bushels per acre 41 percent of the time. Net returns to land for the wheat enterprise in W-C-F were $0 or greater 93 percent of the time for all the study plot replications (Figure 3). Net returns to land refer to the amount of crop income (excluding government payments) left over after all expenses have been paid except land and management costs. Wheat in W-C-F net returns in Figure 3 were calculated using a set average price of $3.25 per bushel over the entire 1989-99 period.

Figure 4 shows average corn yields by year in the W-C-F cropping system. The average corn yield in W-C-F for each year during the 1989-99 period was 69 bushels per acre. Only in 1994 and 1995 did corn yields in W-C-F drop below 60 bushels. Figure 5 shows the probability distribution of corn yields in W-C-F for this period using all of the experimental plot replications. Corn in W-C-F yielded at least 60 bushels per acre 60 percent of the time, and at least 80 bushels per acre 41 percent of the time on all the W-C-F replicated plots in this study. Pre-government payment net returns to land and management for the corn enterprise in W-C-F were $0 or greater 69 percent of the time when averaged over soils and locations (Figure 6). Corn in W-C-F net returns in Figure 6 were calculated using a set average price of $2.53 per bushel over the entire 1989-99 period.

Figure 7 shows yearly average net returns from a W-C-F cropping system in this study. The average W-C-F net return for each year during the 1989-99 period was $29 per acre. This assumes constant prices for wheat of $3.25 per bushel, and for corn of $2.53 per bushel, with no government payments and no costs for land and management included. Only in 1994 and 1995 did W-C-F net returns drop below $25 per acre. In those two years, W-C-F net returns to land and management were negative. Using these same price assumptions over all W-C-F plot replications in the study, net returns for the entire W-C-F rotation were $0 or greater 81 percent of the time, and $25 or more 56 percent of the time (Figure 8).

Figure 9 shows the impact of annual wheat and corn price variation upon net returns for the W-C-F cropping system. Net returns for W-C-F were compared for marketing year average wheat and corn prices and for constant average prices during the 1989-99 period. Average W-C-F net returns for constant average prices were slightly higher ($29 per acre) during the 1989-99 period than were returns with varying annual prices ($27 per acre). The most notable net return differences occurred in 1995, 1996, 1998, and 1999. In 1995-96, the effect of higher prices was indicated as variable price W-C-F net returns were markedly higher than constant price W-C-F net returns. Conversely, in 1998 and 1999, the impact of low prices was seen as variable price W-C-F net returns were markedly lower than were constant price W-C-F net returns.

Yearly wheat yields in a W-C-F cropping system as opposed to a W-F cropping system for the 1989-97 period are presented in Figure 10. Annual average yields for both cropping systems are presented within Figure 10. Wheat yields in W-C-F averaged 38 bushel per acre, while wheat yields in W-F averaged 36 bushel per acre during the 1987-97 period. Net returns for W-C-F and W-F for the 1989-97 period assuming constant average prices are presented in Figure 11, with annual net returns for the two cropping systems shown within the figure. The W-C-F average net returns equal $28 per acre for the 1989-97 period in comparison to a $14 net return average for W-F. In a number of years W-C-F net returns were markedly higher than for W-F, including 1989, 1991, 1992, 1996 and 1997. Conversely, W-C-F net returns were notably lower than for W-F in 1994 and 1995. When marketing year average prices were used for 1989-97 (Figure 12), W-C-F net returns averaged $30 per acre compared to W-F net returns of $18 per acre. Each year's net returns for the W-F and W-C-F cropping systems are identified in Figure 12. The most notable difference between the results in Figure 11 (constant grain prices) and Figure 12 (grain price variation) is in found in the year 1995, where high wheat and corn prices had a strong influence on net returns.

Summary

An economic analysis of cropping system net returns indicated that an intensive two-crop in three year rotation was more profitable than a conventional wheat-fallow (one-crop in two years) rotation. Study results were affected by field site location, location or field slope within the field site, and by crop conditions within any one year.

The base crop rotation used for comparison in this study during the 1989-1999 period was the W-C-F cropping system. A comparison between the W-F and the W-C-F systems for the 1989-1997 period showed that net returns from the wheat-fallow system were markedly lower than for wheat-corn-fallow. The W-F rotation was discontinued in this field research after 1997.

The crop production costs used in this study were developed by Colorado State University Cooperative Extension from interviews with Northeast Colorado crop producers in the Akron Maximum Economic Yield Club. As such, these cost estimates represent best management practices as identified by this group of progressive crop producers. The direct income-increasing impact of fixed government farm payments upon crop enterprise returns was not included in this analysis. In other words, fixed production flexibility contract payments as defined in the 1996 U.S. farm program are not included in these net returns calculations. Marketing loan gains or loan deficiency payments are also excluded from this analysis. However, marketing average cash prices only declined to or below marketing loan rate levels in one year for both wheat (1991) and corn (1999) during the time period of this analysis. The net returns increasing impact of crop insurance coverage also was also not accounted for in this study. To the degree that low yields and/or low net income may have triggered either multiple peril or crop revenue coverage insurance payments to farmers, these net returns estimates may be understated.

Table 1. Cropping System Descriptions and Abbreviations for Sterling and Stratton.

Cropping System	Years Tested	Abbreviation
Wheat-Fallow	1989-1997	W-F
Wheat-Corn-Fallow	1989-1999	W-C-F
Wheat-Corn-Millet-Fallow	1989-1993	W-C-M-F
Wheat-Corn-Sunflower-Fallow	1994-1997	W-C-S-F
Wheat-Corn-Millet	1998	W-C-M
Wheat-Wheat-Corn-Millet	1998	W-W-C-M

Table 2. 1989-1999 Crop Yield Data, Sterling Site, Dryland Agroecosystem Project, Colorado State University.

Crop	Crop Rotation	Units /acre	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Wheat	W-F	Bu.	36.0	40.0	32.3	25.3	42.3	29.0	15.0	48.7	21.0		
Wheat	W-C-F	Bu.	42.7	34.7	19.7	21.0	53.7	28.7	28.7	63.0	29.3	27.3	41.7
Corn	W-C-F	Bu.	71.3	82.7	71.3	90.7	48.7	16.3	11.7	69.7	109.0	46.0	62.0
Wheat	W-C-M-F	Bu.	42.3	43.7	35.7	24.0	45.3						
Corn	W-C-M-F	Bu.	76.3	80.3	80.3	102.7	55.3						
Millet	W-C-M-F	Cwt.	45.3	30.0	54.0	37.7	13.7						
Wheat	W-C-S-F	Bu.						33.0	26.7	61.0	30.3		
Corn	W-C-S-F	Bu.						13.7	18.0	74.3	104.7		
Sunflower	W-C-S-F	Lbs.						0.0	0.0	989.7	1483.7		
Wheat	W-C-M	Bu.										31.0	
Corn	W-C-M	Bu.										74.3	
Millet	W-C-M	Cwt.										0.0	
Wheat 1	W-W-C-M	Bu.										0.0	
Wheat 2	W-W-C-M	Bu.										39.7	
Corn	W-W-C-M	Bu.										61.3	
Millet	W-W-C-M	Cwt.										0.0	

Table 3. 1989-1999 Crop Yield Data, Stratton Site, Dryland Agroecosystem Project, Colorado State University.

Crop	Crop Rotation	Units /acre	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Wheat	W-F	Bu.	44.0	57.3	49.0	28.3	40.0	39.7	36.7	46.0	18.0		
Wheat	W-C-F	Bu.		53.0	44.0	27.7	38.3	37.0	45.3	41.0	26.3	39.7	49.0
Corn	W-C-F	Bu.		66.0	98.3	89.7	74.3	53.0	32.3	109.7	52.7	106.3	90.0
Wheat	W-C-M-F	Bu.		61.0	51.3	33.0	43.3						
Corn	W-C-M-F	Bu.		67.7	93.0	88.0	80.3						
Millet	W-C-M-F	Cwt.		30.3	24.3	40.0	24.7						
Wheat	W-C-S-F	Bu.						46.0	40.3	47.0	25.0		
Corn	W-C-S-F	Bu.						46.0	36.7	105.7	43.7		
Sunflower	W-C-S-F	Lbs.						0.0	0.0	665.3	251.7		
Wheat	W-C-M	Bu.										39.3	
Corn	W-C-M	Bu.										118.7	
Millet	W-C-M	Cwt.										47.0	
Wheat 1	W-W-C-M	Bu.										34.3	
Wheat 2	W-W-C-M	Bu.										42.3	
Corn	W-W-C-M	Bu.										107.0	
Millet	W-W-C-M	Cwt.										17.7	

Table 4. Marketing Year Average Price Received for Crops in Diversified Cropping Systems [1]

Marketing Year	Wheat ($ per Bu.)	Corn ($ per Bu.)	Millet ($ per Cwt.)
1989	$3.74	$2.45	
1990	3.57	2.42	5.96
1991	2.45	2.36	3.89
1992	3.33	2.39	3.33
1993	3.09	2.21	6.51
1994	3.07	2.65	14.61
1995	3.50	2.58	5.94
1996	4.98	4.00	6.31
1997	4.11	2.61	4.38
1998	3.09	2.33	4.02
1999	2.47	1.88	4.04

[1] Marketing year average cash prices are for northeast Colorado.

Table 5. Crop Enterprise Cost of Production Estimates.

	Winter Wheat	Corn	Proso Millet	Proso Millet	Oil Sunflower	Oil Sunflower
Tillage System	---	NT[1]	NT	NT	NT	NT
Previous Crop	---	Wheat	Wheat	Corn	Corn	Wheat
Preharvest Operating Costs						
Seed	$5.05	$15.03	$2.57	$2.57	$13.80	$13.80
Fertilizer	19.20	21.30	9.00	9.00	15.00	15.00
Herbicide	2.50	19.00	9.50	2.00	10.00	10.00
Crop Insurance	5.76	9.95	---	---	6.97	6.97
Insecticide	---	---	---	---	7.00	7.00
Custom Aerial Appln.: Insecticide	---	---	---	---	3.75	3.75
Machinery Fuel & Lube	1.30	3.14	3.04	1.76	3.41	3.41
Machinery Repairs	1.48	4.44	2.83	1.78	4.71	4.71
Interest on Operating Capital	1.54	4.22	1.31	0.97	3.43	3.43
Property & Ownership Costs						
Machinery Replacement	3.69	16.30	7.99	5.32	14.90	14.90
Machinery Taxes & Insurance	0.70	3.38	1.70	1.03	2.72	2.72
General Farm Overhead	10.00	10.00	10.00	10.00	10.00	10.00
Custom Swathing (proso millet)	---	---	7.00	7.00	---	---
Interest on Custom Swathing	---	---	0.21	0.21	---	---
Total Operating Costs (nonharvest)	$51.23	$106.76	$55.15	$41.63	$95.68	$95.68
Custom Harvest Costs						
Per acre flat rate charge	$13.00	$13.00	$13.00	$13.00	$13.00	$13.00
Per bu. (or cwt.) charge over 20 bu. (or cwt.) per acre	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13
Hauling charge per bu. (or cwt.)	$0.13	$0.13	$0.13	$0.13	$0.13	$0.13

[1] "NT" refers to no till production practices

Table 6. Fallow Enterprise Cost of Production Estimates.

	Fallow	Fallow	Fallow	Fallow	Fallow
Tillage System	NT[1]	RT[1]	CT[1]	NT	RT
Previous Crop	Summer Crop	Summer Crop	Wheat	Wheat	Wheat
Fallow Period Operating Costs					
Herbicide	$8.50	$0.00	$5.00	$12.50	$7.50
Custom Herbicide Application	---	---	3.75	---	---
Machinery Fuel & Lube	0.68	2.28	4.70	1.02	2.96
Machinery Repairs	0.50	1.99	3.17	0.75	2.49
Interest on Operating Capital	0.60	0.19	0.72	0.78	0.50
Property & Ownership Costs					
Machinery Replacement	1.26	4.16	7.47	1.90	5.42
Machinery Taxes & Insurance	0.31	0.77	1.33	0.47	1.08
General Farm Overhead	10.00	10.00	10.00	10.00	10.00
Total Fallow Operating Costs	$21.86	$19.39	$36.13	$27.41	$16.50

[1] "NT" refers to no till production practices, "RT" to reduced tillage, and "CT" to conventional tillage.

Table 7. Average Annualized Net Returns for W-F Cropping Systems at Sterling and Stratton (1989-1997)

	Yield	Gross Revenue	Total Production Expense	Net Return	Annualized Net Return	Rotation Breakeven Yield
	(Bu./ac.)	($/acre)	($/acre)	($/acre)	($/acre)	(Bu./ac.)
Sterling						
Wheat in W-F (NT)[1]	32.2	$104.60	$70.00	$34.60		26.9
Fallow in W-F (NT)			17.41	-17.41		
					8.60	
Stratton						
Wheat in W-F (NT)	39.9	$129.64	$72.00	$34.60		27.5
Fallow in W-F (NT)			17.41	-17.41		
					20.11	

[1] (NT) refers to no till production practices.

Table 8. Average Annualized Net Returns for W-C-F Cropping Systems at Sterling and Stratton (1989-1999)

	Yield	Gross Revenue	Total Production Expense	Net Return	Annualized Net Return	Rotation Breakeven Yield
	(Bu./ac.)	($/acre)	($/acre)	($/acre)	($/acre)	(Bu./ac.)
Sterling						
Wheat in W-C-F	35.5	$115.33	$68.36	$46.97		22.5
Corn in W-C-F (NT)[1]	61.8	156.25	130.72	25.53		53.5
Fallow in W-C-F (NT)			9.39	-9.39		
					21.04	
Stratton						
Wheat in W-C-F	40.1	$130.43	$69.56	$60.87		22.9
Corn in W-C-F (NT)	77.2	195.40	134.74	60.66		55.1
Fallow in W-C-F (NT)			9.39	-9.39		
					37.38	

[1] (NT) refers to no till production practices.

Table 9. Wheat-Corn-Fallow Rotation Net Return and Yield Models [1, 2]
Analysis of 1989-1999 Data Assuming Constant Grain Prices

	Wheat Yields (Bu /ac)	Wheat Net Returns ($ /ac)	Corn Yields (Bu /ac)	Corn Net Returns ($ /ac)	W-C-F Net Returns ($ /ac)
Constant (1990) Base Plot: Sterling Base Location: Summit Base Year: 1990	*39.5	*$59	*56.4	$14	*$21
Stratton Plot (Difference from Sterling Plot)	*+5.4	*+16	*+16.4	*+35	*+17
Side-slope Location (Diff. from Summit Location)	*–5.1	*–16	+0.5	+1	–5
Toe-slope Location (Diff. from Summit Loc)	*+10.0	*+30	*+28.7	*+66	*+32
1989 Effect [3]	+1.5	+5	+5.2	+12	+6
1991 Effect	*–12.0	*–36	+10.5	+24	–4
1992 Effect	*–19.5	*–59	+15.8	+36	–7
1993 Effect	+2.2	+6	–12.8	–29	–8
1994 Effect	*–11.0	*–33	*–39.7	*–91	*–41
1995 Effect	–6.8	–20	*–52.3	*–120	*–47
1996 Effect	+8.2	+24	+15.3	+35	*+20
1997 Effect	*–16.0	*–48	+6.5	+15	–11
1998 Effect	*–10.3	*–31	+1.8	+4	–9
1999 Effect	+1.5	+4	+1.7	+4	+3
Number of Observations	63	63	63	63	63
Degrees of Freedom	49	49	49	49	49
R-Squared	0.61	0.61	0.70	0.70	0.72
Adjusted R-Squared	0.50	0.50	0.62	0.62	0.65
Model Standard Deviation	9.8	$30	19.8	$45	$18
Model F Test					
F (n1,n2)	13, 49	13, 49	13, 49	13, 49	13, 49
F Critical Value	*5.83	*5.81	*8.76	*8.71	*9.70

[1] "*" indicates that the effect of a particular factor upon a model is statistically significant at the 10% level or greater.
[2] This analysis assumed average selling prices over the 1989-1999 period of $3.25 /bu for wheat and $2.53 /bu for corn.
[3] These year-by-year dummy variables measure the effect of a specific crop year upon either crop yields or net returns at both the Sterling and Stratton locations.

Table 10. Wheat-Corn-Fallow Rotation Net Return Models With Varying Grain Prices [1,2]
Analysis of 1989-1999 Data Using Season Marketing Year Average Grain Prices

	Wheat Net Returns ($ /ac)	Corn Net Returns ($ /ac)	W-C-F Net Returns ($ /ac)
Constant (1990) Base Plot: Sterling Base Location: Summit Base Year: 1990	*$27	*$1	$6
Stratton Plot (Difference from Sterling Plot)	*+15	*+36	*+17
Side-slope Location (Diff. from Summit Location)	–16	+2	–5
Toe-slope Location (Diff. from Summit Loc)	*+29	*+66	*+32
1989 Effect [3]	*+51	+17	*+23
1991 Effect	–0	+25	+8
1992 Effect	–29	+20	–3
1993 Effect	*+32	–9	+7
1994 Effect	+9	*–77	*–23
1995 Effect	*+80	*–75	+1
1996 Effect	*+102	*+55	*+53
1997 Effect	–19	+11	–3
1998 Effect	–23	–19	–14
1999 Effect	+3	–19	–5
Number of Observations	63	63	63
Degrees of Freedom	49	49	49
R-Squared	0.73	0.66	0.72
Adjusted R-Squared	0.65	0.57	0.65
Model Standard Deviation	$32	$43	$18
Model F Test			
F(n1,n2)	13, 49	13, 49	13, 49
F Critical Value	*10.00	*7.30	*9.77

[1] "*" indicates that the Effect of a particular factor upon a model is statistically significant at the 10% level or greater.
[2] Marketing year average grain prices are assumed for these models rather than constant average prices over the period of the analysis.
[3] These year-by-year dummy variables measure the effect of a specific crop year upon either crop yields or net returns at both the Sterling and Stratton locations.

Table 11. Wheat-Fallow Rotation Net Return and Yield Models, and Net Return Differences Between Wheat-Corn-Fallow and Wheat-Fallow Rotations [1, 2]
Analysis of 1989-1997 Data Assuming Constant Grain Prices

	Wheat Yields (Bu /ac)	W-F Net Returns ($ /ac)	Net Returns Difference: W-C-F vs. W-F Constant $ ($ /ac)	Net Returns Difference: W-C-F vs. W-F Varying $ ($ /ac)
Constant (1990) Base Plot: Sterling Base Location: Summit Base Year: 1990	*42.6	*$24	–$2	–$1
Stratton Plot (Difference from Sterling Plot)	*+7.7	*+12	–1	–0
Side-slope Location (Diff. from Summit Location)	–2.8	–4	–0	–1
Toe-slope Location (Diff. from Summit Loc)	*+9.6	*+14	*+24	*+24
1989 Effect [3]	*–8.7	*–13	+16	+9
1991 Effect	–8.0	–12	+8	+0
1992 Effect	*–21.8	*–33	+25	+13
1993 Effect	–7.5	–11	+4	+4
1994 Effect	*–14.3	*–21	*–20	*–24
1995 Effect	*–22.8	*–34	–13	–6
1996 Effect	–1.3	–2	*+22	*+16
1997 Effect	*–29.2	*–44	*+33	*+24
Number of Observations	54	54	51	51
Degrees of Freedom	42	42	39	39
R-Squared	0.69	0.69	0.68	0.64
Adjusted R-Squared	0.61	0.61	0.60	0.54
Model Standard Deviation	8.8	$13	$16	$15
Model F Test				
F(n1,n2)	11, 42	11, 42	11, 39	11, 39
F Critical Value	*8.52	*8.51	*7.69	*6.28

[1] "*" indicates that the Effect of a particular factor upon a model is statistically significant at the 10% level or greater.
[2] Except for the last column of this table, these analyses assume average selling prices over the 1989-1997 period of $3.25 /bu for wheat and $2.53 /bu for corn. Marketing year average grain prices are assumed for the model with varying grain prices in the last column on the right.
[3] These year-by-year dummy variables measure the effect of a specific crop year upon either crop yields or net returns at both the Sterling and Stratton locations.

Figure 1. W-C-F Wheat Yields

Data for All Soils at Sterling and Stratton for 1989-99

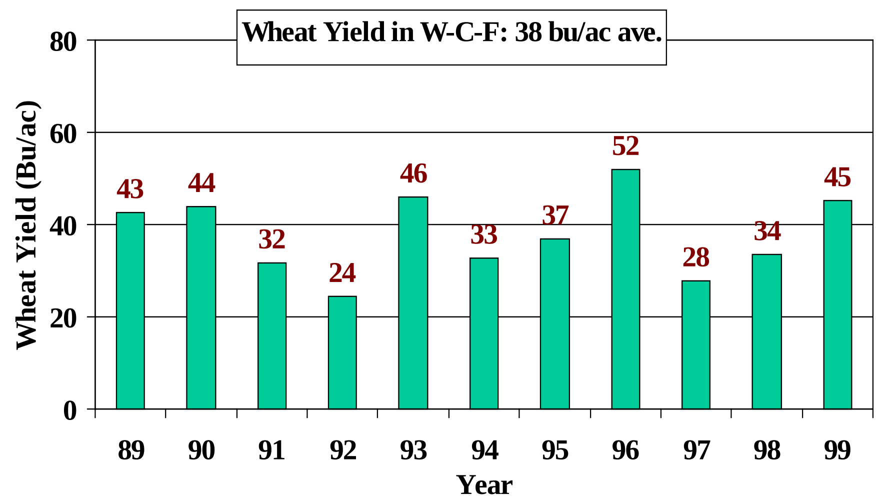

Figure 2. Distribution of W-C-F Wheat Yield

Data for All Soils at Sterling and Stratton for 1989-99

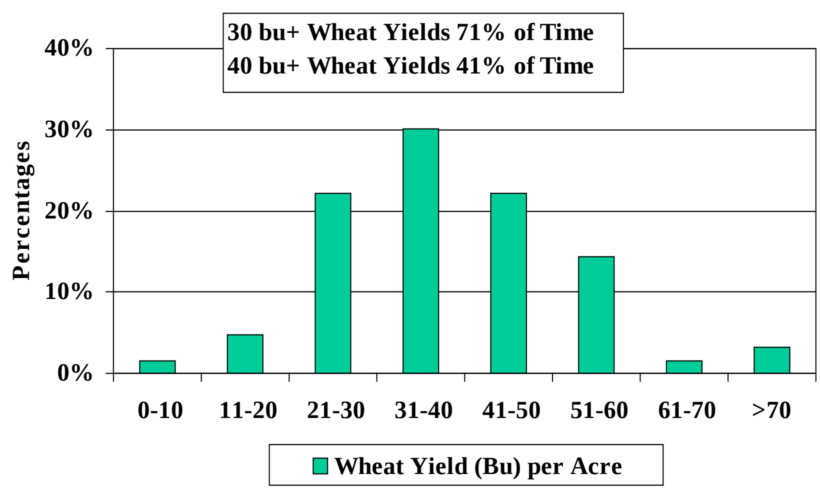

Figure 3. Distribution of W-C-F Wheat Net Return

Data for All Soils at Sterling and Stratton for 1989-99,
$3.25/bu Price Received for Wheat

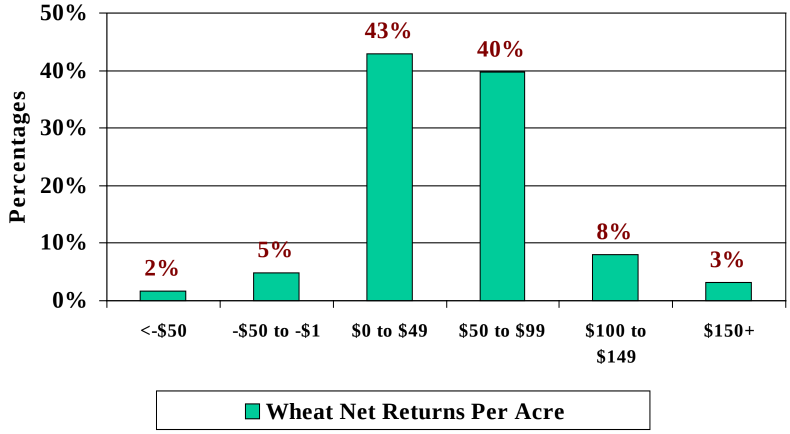

Figure 4. W-C-F Corn Yields

Data for All Soils at Sterling and Stratton for 1989-99

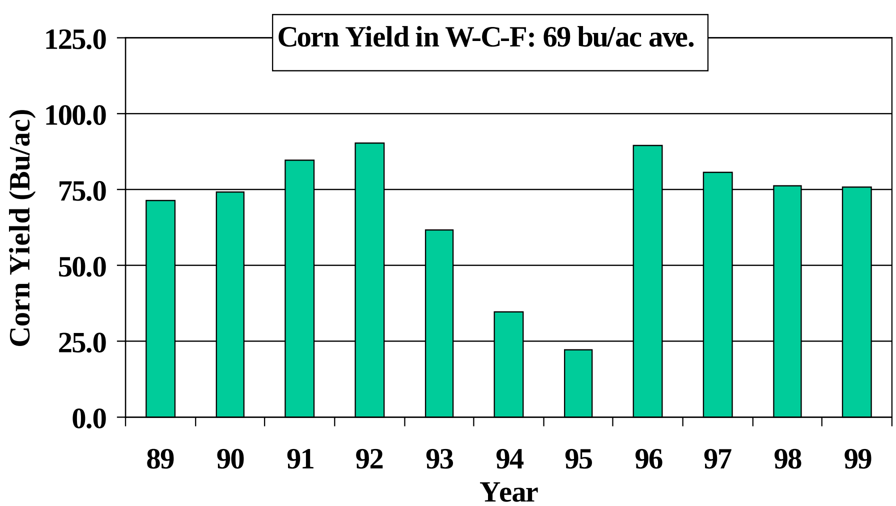

Figure 5. Distribution of W-C-F Corn Yield

Data for All Soils at Sterling and Stratton for 1989-99

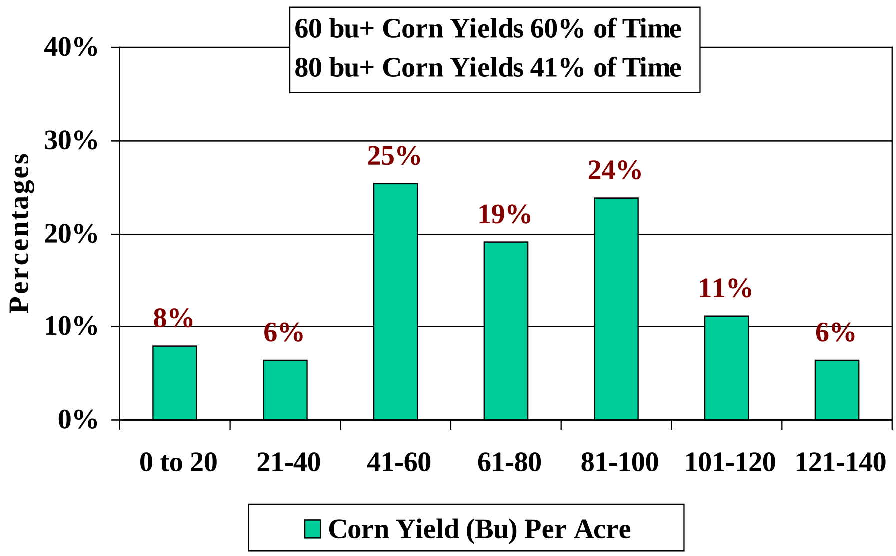

Figure 6. Distribution of W-C-F Corn Net Return

Data for All Soils at Sterling and Stratton for 1989-99,
$2.53/bu Price Received for Corn

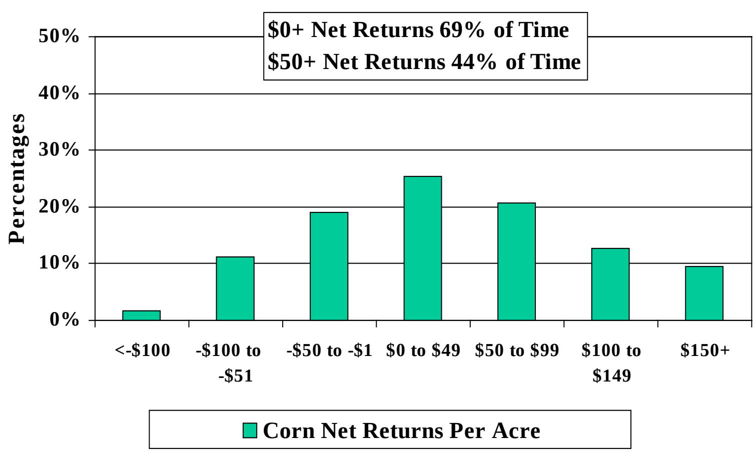

Figure 7. W-C-F Net Returns

Data for All Soils at Sterling and Stratton for 1989-99,
$3.25/bu for Wheat, $2.53/bu for Corn

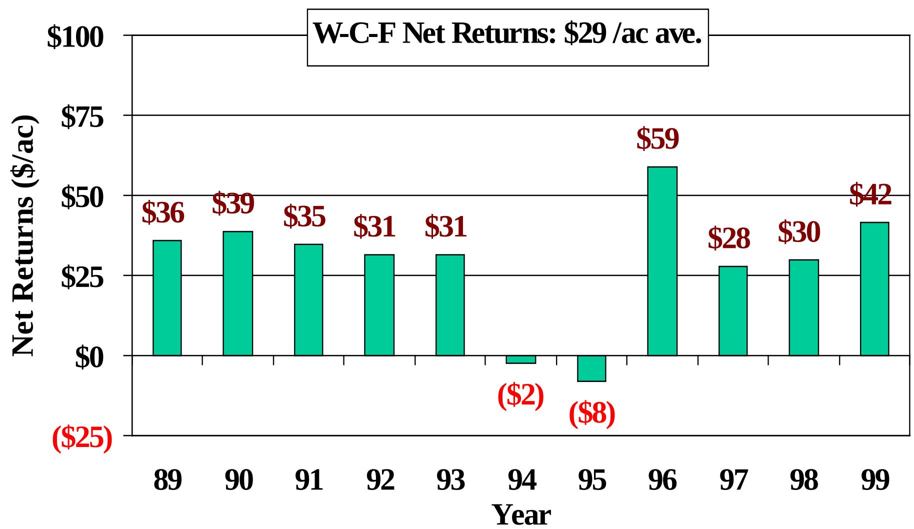

Figure 8. Distribution of W-C-F Net Return

Data for All Soils at Sterling and Stratton for 1989-99,
$3.25 for Wheat, $2.53 for Corn

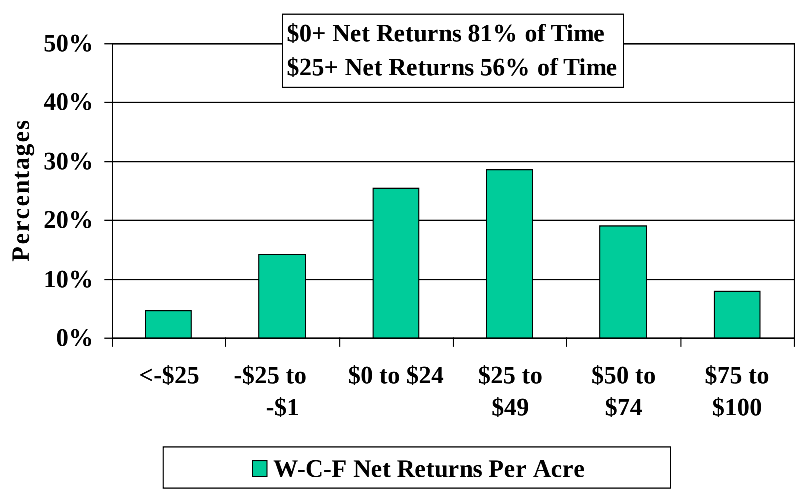

Figure 9. W-C-F Net Returns With Different Price Schemes

Annual Average Price Received versus Marketing Year Average Price Received, 1989-99

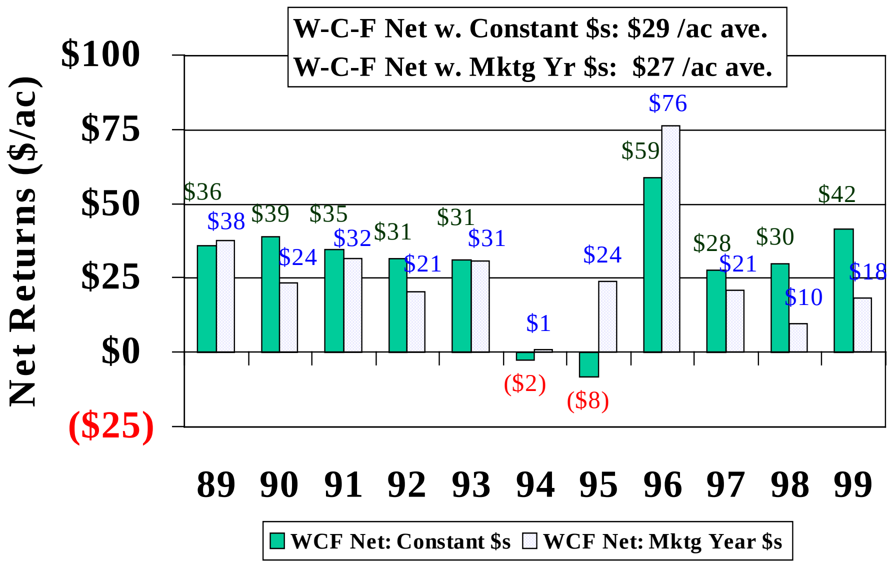

Figure 10. Wheat Yields in W-C-F vs W-F

Data for All Soils at Sterling and Stratton for 1989-97

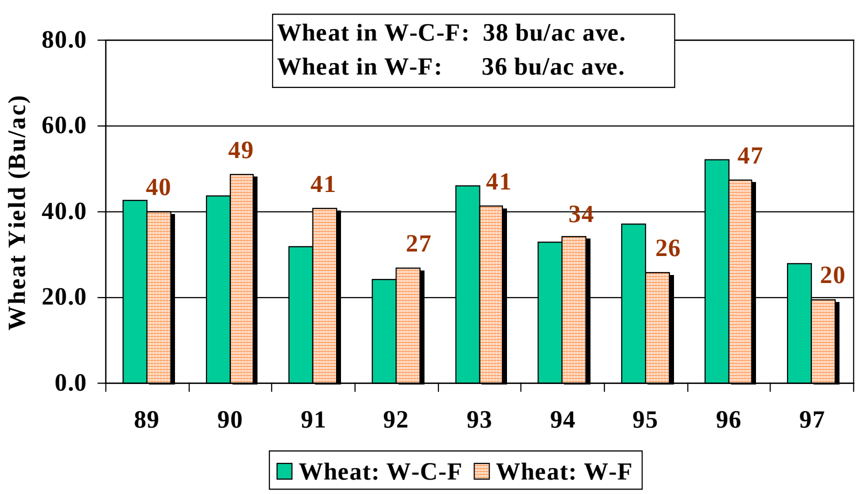

Figure 11. Net Returns in W-C-F vs W-F

Data for All Soils at Sterling and Stratton for 1989-97

$3.25/Bu for Wheat, $2.53/Bu for Corn

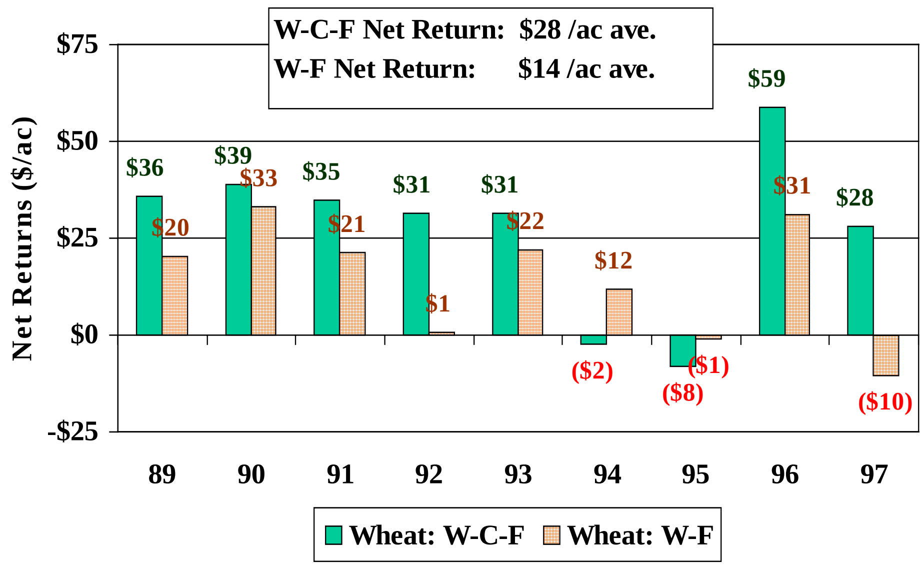

Figure 12. Net Returns in W-C-F vs W-F

Data for All Soils at Sterling and Stratton for 1989-97

Marketing Year Average Price Received for Wheat and Corn