Economics of Dryland Cropping Systems in the Great Plains: A Review

K. C. Dhuyvetter,* C. R. Thompson, C. A. Norwood, and A. D. Halvorson

Dryland wheat (*Triticum aestivum* L.) in the Great Plains generally is planted in a wheat- fallow (WF) rotation. Wheat grown in rotation with a summer row crop like corn (*Zea mays* L.), sorghum [*Sorghum bicolor* (L.) Moench], or sunflower [*Helianthus annuus* var. *macrocarpus* (DC.) Ck11.] increases cropping intensity, allowing a crop to be produced annually on 67 to 100% of tillable acres. A review of economic analyses of dryland cropping systems in the Great Plains was conducted to compare net returns, production costs, financial risk, and compatibility with the 1990 Farm Bill. Seven of eight studies reported that net returns were greater from a more intensive crop rotation than from WF when reduced-tillage (RT) or no-till (NT) were used following wheat harvest and prior to the summer crop planting. With government program payments, WF was more profitable with conventional tillage (CT) than with NT. Production costs increased as cropping intensity increased and tillage decreased. Economic risk analysis showed that wheat-sorghum-fallow (WSF) was less risky than WF in Kansas. Cropping systems using more intensive rotations with less tillage had higher production costs than WF, but also had increased net returns and reduced financial risk, while remaining in compliance with 1990 Farm Bill provisions.

THE MOST COMMON dryland cropping system in the Great Plains traditionally has been WF using mechanical tillage. The fallow period increases stored moisture and weed control. Between 1991 and 1993, harvested acres of dryland winter wheat in western Kansas, western Nebraska, and eastern Colorado ranged from approximately 6.2 to 7.2 million acres annually. During this same time, there were only 1.5 to 1.6 million acres harvested annually of dryland spring and summer crops such as corn, sorghum, sunflowers, barley (*Hordeum vulgare* L.), and oats (*Avena sativa* L.) (Byram, 1993 and 1994; Dobbs, 1994; Hudson and Fretwell, 1993 and 1994).

Researchers have found that dryland cropping systems using less tillage or crop rotations that are more intensive than WF are suitable for many areas of the Great Plains. These cropping systems can increase grain yield, improve fallow efficiency, improve water use efficiency, and reduce soil erosion compared with WF using CT (Black and Bauer, 1990; Fenster and McCalla, 1971; Halvorson, 1990; Halvorson and Reule, 1994; Jones et al., 1988; Nilson et al., 1985; Norwood, 1994; Norwood et al., 1990; Peterson et al., 1994; Wicks et al., 1988). Others have reported that decreasing the amount of tillage in WF did not increase yield (Dalrymple et al., 1993; Fenster and McCalla, 1970). Smika (1990) found that NT in WF allowed deeper water percolation than CT and RT and suggested following the wheat crop with a deep-rooted summer crop to take advantage of conserved moisture.

Even though the production benefits of alternative dryland cropping systems have been documented, producers have been slow to adopt these technologies. Possible reasons for nonadoption include concerns that returns will not adequately increase to cover added costs from increased machinery investment and increased herbicide and fertilizer use. Other concerns include the potentials for increased production and financial risk and the ability to comply with government programs. Additionally, because of the relatively low labor and management requirements of WF, producers may be hesitant to change to a more intensive cropping system.

The elimination of cross-compliance along with the flex acres provision of the 1990 Farm Bill increased producers' planting flexibility. However, the increased flexibility came with a reduction in acres eligible for government payments. Duncan (1991) stated that the added flexibility of the 1990 Farm Bill could offset adverse effects of reduced subsidies, if profitable cropping alternatives exist.

Objectives of this review were to determine if cropping alternatives more profitable than WF exist for dryland producers in the Great Plains and how alternative cropping systems affect net returns, production expenses, financial risk, and compliance with 1990 Farm Bill provisions.

ECONOMIC STUDIES OF ALTERNATIVE DRYLAND CROPPING SYSTEMS

Numerous studies have examined the production potential of alternative dryland cropping systems; however, few studies have shown the net returns and financial risk of these systems, while incorporating government program requirements. This review summarizes previous economic analyses relevant for producers in the dryland cropping areas of the Great Plains (Table 1). Grain yields used in the economic analyses for all studies evaluated were based on university and USDA-ARS research data.

NET RETURNS

Net return measures the relative profitability of cropping systems. While net returns and profitability are not neces-

K.C. Dhuyvetter, Kansas State Univ. Northeast Area Ext. Office, 1515 College Ave., Manhattan, KS 66502; C.R. Thompson, and C.A. Norwood, Kansas State Univ. Southwest Res.-Ext. Cent., 1501 Fulton Terrace, Garden City, KS 67846; A.D. Halvorson, USDA-ARS, PO Box 459, Mandan, ND 58554. Kansas Agric. Exp. Stn. Contribution no. 95-300-J. Received 25 Apr. 1995. *Corresponding author (kdhuyvet@oznet.ksu.edu).

Published in J. Prod. Agric. 9:216–222 (1996).

Abbreviations: CT, conventional tillage; NRCS, Natural Resource Conservation Service; NT, no-till; RT, reduced tillage; SF, sorghum-fallow; SS, continuous sorghum; WCF, wheat-corn-fallow; WCMF, wheat-corn-millet-fallow; WF, wheat-fallow; WSF, wheat-sorghum-fallow; WSHF, wheat-sorghum-hay-fallow; WW, continuous winter wheat; WWSf, spring wheat-winter wheat-sunflower.

Table 1. Authors, locations, and years of production data for economic papers reviewed.

Author	Location(s) of data	Years	Annual precipitation, in.†
Aakre, 1991 ‡	Mandan, ND	1985–1990	14.3
Dhuyvetter and Norwood, 1994	Garden City, KS	1987–1993	19.5
Halvorson et al., 1994	Akron, CO	1987–1992	16.9
Jones and Johnson, 1993	Bushland, TX	1984–1992	20.5
Norwood and Dhuyvetter, 1993	Garden City, KS	1987–1991	18.2
Peterson et al., 1993	Sterling/Stratton, CO	1988–1992	16.8
Peterson et al., 1993	Walsh, CO	1988–1992	16.9
Williams et al., 1990	Hays, KS	1976–1986	21.1
Williams, 1988	Tribune, KS	1973–1985	15.8

† Annual precipitation during years of the study.
‡ Aakre (Six years of economics on the cropping system that works, 1991 North Central ASA Summer Meeting, unpublished, North Dakota State University, Fargo).

sarily the same, depending on how net returns are defined, both give an indication of the relative economic success of cropping systems. Therefore, the words are used interchangeably throughout this paper. In addition to economic returns, it is important that producers consider erosion and production aspects of different cropping systems. All studies reviewed examined the profitability of alternative cropping systems, but analytical methods varied across studies. Therefore, economic returns can be compared within a study, but not across studies (Table 2).

Aakre (Six years of economics on the cropping system that works, 1991 North Central ASA Summer Meeting, unpublished, North Dakota State University, Fargo) concluded that spring wheat-winter wheat-sunflower (WWSf) was more profitable than spring-WF in south central North Dakota. Returns over variable operating costs were compared under CT, RT, and NT. Returns for WF were highest with CT and lowest with NT. Returns for WWSf were lowest with CT and highest with RT. WWSf returns with RT were 38% greater than WF returns with CT. Johnson et al. (1986) found similar results for wheat and barley rotations in northeast Montana based on agricultural statistics average yield data. They analyzed cropping systems planted to a mix of spring wheat and barley on 50%, 60%, and 100% of tillable acres annually using CT, RT, and NT. Returns were highest for the continuous cropping system with NT. In the rotations including fallow acres, returns were greatest with CT and lowest with NT.

Dhuyvetter and Norwood (1994) concluded that more intensive cropping systems increased profit potential compared with WF in southwest Kansas. Land was assumed to be owned or cash rented; thus, returns were calculated as 100% of the income minus operating and machinery ownership costs. Returns were compared for WF, WSF, and continuous sorghum (SS). WF and WSF also were evaluated with CT, RT, and NT. WF returns were highest with RT, but were only slightly greater than returns with CT. Additionally, returns with NT were the lowest; thus, little economic incentive existed to decrease the amount of tillage in WF. Returns from WSF were maximized with RT. However, the authors stated that the most profitable tillage

Table 2. Economic returns per tillable acre for dryland cropping systems in the Great Plains.

Author	Tillage‡	Crop rotation † WW	WF§	WWSf	WSF	WSHF	SF	SS	WCF	WCMF
		$/acre								
Aakre, 1991 ¶	CT		31.65	34.92						
	RT		30.88	43.63						
	NT		29.15	42.96						
Dhuyvetter and Norwood, 1994	CT		30.29		35.83					
	RT		31.84		43.31					
	NT		27.42		37.07			30.92		
Halvorson et al., 1994 (farmer owned machinery cost)	CT		35.41							
	RT		37.79							
	NT		33.88							
Halvorson et al., 1994 (custom hire machinery cost)	CT		27.56							
	RT		33.97							
	NT		30.32							
Jones and Johnson, 1993	CT	9.34	16.90		41.46			75.12		
	NT	7.44	17.90		47.29			52.92		
Norwood and Dhuyvetter, 1993	CT		10.05		10.92					
	RT		12.01		16.19					
	NT		4.43		15.40					
Peterson et al., 1993, Northeast Colorado#	CT		34.81						48.91	44.07
	RT		32.11						47.23	41.85
	NT		25.02						43.56	39.40
Peterson et al., 1993, Southeast Colorado#	CT		22.13		17.14	14.05				
	RT		19.43		15.46	12.88				
	NT		12.34		11.79	11.85				
Williams et al., 1990 ††	CT	−4.37	0.68		11.35		1.70	−12.72		
	NT	−2.17	1.79		10.74		−3.59	−10.25		
Williams, 1988 ††	CT	−21.80	−2.06		−0.54			−2.71		
	RT		4.81		10.74		6.48			

† WW = continuous winter wheat, WF = wheat-fallow, WWSf = spring wheat-winter wheat- sunflower, WSF = wheat-sorghum-fallow, WSHF = wheat-sorghum-forage hay-fallow, SF = sorghum-fallow, SS = continuous sorghum, WCF = wheat-corn-fallow, WCMF = wheat-corn-millet-fallow.
‡ CT = conventional tillage, RT = reduced tillage, NT = no-till.
§ WF = spring wheat-fallow for Aakre, 1991 and winter wheat-fallow for all other studies.
¶ Aakre (Six years of economics on the cropping system that works, 1991 North Central ASA Summer Meeting, unpublished, North Dakota State University, Fargo).
\# Tillage included for wheat production of rotation only, all systems used no-till prior to the planting of the summer crop(s).
†† Government payments are not included in returns, all other studies include payments.

system would be a combination of RT prior to the wheat crop and NT prior to the sorghum crop. Similar to WF, WSF wheat returns were highest with RT and lowest with NT. However, the returns from sorghum continued to increase as tillage decreased. Without government program payments, returns of SS were greater than those of WF, but less than those of WSF.

Norwood and Dhuyvetter (1993) compared the returns for WF and WSF with CT, RT, and NT. A mixture of owned and crop share rented land was assumed. Returns were calculated as the producer's share of income minus operating, machinery ownership, and land costs. Their findings were similar to those of Dhuyvetter and Norwood (1994), indicating that land tenure did not affect the relative profitability of the cropping systems evaluated.

Halvorson et al. (1994) concluded that RT or NT can be adopted by farmers in WF in northeast Colorado without economic loss. Returns were compared for WF with CT, RT, and NT. Returns to land, labor, and management were calculated using both estimated farmer costs (production and machinery ownership costs) and custom rates charged for the various tillage and spraying operations. With the estimated farmer costs, RT was most profitable and NT was least profitable. When costs were based on custom rates, RT was still the most profitable system; however, CT was least profitable. Returns with CT were the lowest because custom tillage was more expensive than custom spraying.

Jones and Johnson (1993) concluded that cropping systems with sorghum had greater returns than systems with wheat only in the panhandle of Texas. Returns over variable operating costs were compared for continuous winter wheat (WW), WF, WSF, and SS with CT and NT. Returns were greatest for SS with CT and lowest for WW with NT. Returns were considerably higher for SS and WSF than for WW and WF, regardless of tillage. WF and WSF returns were greater with NT than with CT.

Peterson et al. (1993) concluded that more intensive cropping systems increased profit potential compared with WF in northeast Colorado, but WF was more profitable than WSF in southeast Colorado. Returns to land, labor, capital, management, and risk were compared for WF, wheat-corn-fallow (WCF), and wheat-corn-millet-fallow (WCMF) in northeast Colorado and WF, WSF, and wheat-sorghum-hay-fallow (WSHF) in southeast Colorado. Tillage systems evaluated prior to the wheat crop were CT, RT, and NT. NT was used prior to the summer crop(s). WF returns were highest for CT and lowest for NT in both northeast and southeast Colorado. However, the authors cautioned that CT may not comply with Natural Resource Conservation Service (NRCS) residue requirements on highly erodible land. Returns increased 40% for WCF and 27% for WCMF compared with WF in northeast Colorado. In southeast Colorado, returns decreased 23% for WSF and 37% for WSHF compared with WF. Production of grain per unit of rainfall with WSF increased compared with WF in southeast Colorado, but because of a weed control problem, increased herbicide costs were greater than the returns from the improved productivity. Wiese et al. (1994) also found that the cost of herbicides for NT in WSF was prohibitive compared with sweep plowing when certain weed species were present.

Williams et al. (1990) found that returns for dryland crop rotations in north central Kansas were highest with WSF. Returns to land and management were compared for WF, WW, sorghum-fallow (SF), SS, and WSF with CT and NT. The returns were greater from NT than from CT for all rotations except SF and WSF. However, returns differed little between CT and NT in most rotations. Returns were highest from WSF and second highest from WF. SS and WW were the most intensive rotations producing a crop every year, but they had the lowest returns.

Williams (1988) concluded that returns for dryland cropping in extreme western Kansas were higher with reduced tillage practices than with conventional tillage. The returns to management were compared for WF, WW, SF, SS, and WSF. WF and WSF were evaluated with CT and RT. SF was evaluated with RT only, while WW and SS were evaluated with CT only. When CT and RT were compared, returns were always greater with RT, indicating that increased yield in conjunction with reduced fuel, labor, and repair costs more than offset the increased herbicide costs. Returns were greatest from WSF and next best from SF and WF. WW was the least profitable rotation evaluated.

PRODUCTION COSTS

Dryland farming is inherently risky in the Great Plains because of variable precipitation, temperature fluctuations, hail, and other unpredictable conditions. Because of this production risk, many producers attempt to minimize out-of-pocket production costs as a means of reducing financial risk. However, minimizing costs may not be a good risk management strategy. The increased production costs of alternative cropping systems probably have contributed to the slow rate of adoption of these systems. Production costs used in the analyses of the studies reviewed were not consistent. Therefore, production costs per tillable acre can be compared within each study, but not across studies (Table 3).

In all studies with multiple crop rotations, production costs per tillable acre increased as cropping intensity increased because of more planted acres. Therefore, producers have to recognize that, even though crop rotations more intensive than WF may increase total grain yield and profitability, capital requirements also increase substantially.

The effect of tillage system on production costs varied across studies. Several studies indicated that labor, repair, and fuel and oil costs declined as the number of tillage operations decreased, but total production costs increased because herbicide expense increased more than tillage costs decreased (Dhuyvetter and Norwood, 1994; Norwood and Dhuyvetter, 1993; Peterson et al., 1993; and Williams, 1988). Dhuyvetter and Norwood (1994) pointed out that the cost difference between CT and NT was greater for WF than WSF, indicating the relatively high cost of NT in WF. They concluded that NT in WF was cost prohibitive because of the high herbicide expense.

Aakre (1991, unpublished data) showed very little difference in production costs among tillage systems. Halvorson et al. (1994) estimated that farmer production and machinery ownership costs of WF were lowest for RT. However, costs of NT were only slightly higher than those of RT.

Table 3. Production costs per tillable acre for dryland cropping systems in the Great Plains.

Author	Tillage‡	Crop rotation †								
		WW	WF§	WWSf	WSF	WSHF	SF	SS	WCF	WCMF
		$/acre								
Aakre, 1991 ¶ (operating costs)	CT		27.21	49.93						
	RT		26.33	49.58						
	NT		27.73	49.93						
Dhuyvetter and Norwood, 1994 (operating and machinery ownership costs)	CT		31.48		44.53					
	RT		34.68		47.76					
	NT		40.04		51.45			61.26		
Halvorson et al., 1994 (operating and farmer owned machinery cost)	CT		42.67							
	RT		40.29							
	NT		44.20							
Halvorson et al., 1994 (operating and custom hire machinery cost)	CT		50.51							
	RT		44.11							
	NT		47.75							
Jones and Johnson, 1993 (operating costs)	CT	56.98	37.04		46.34			68.80		
	NT	68.78	36.37		44.13			79.24		
Norwood and Dhuyvetter, 1993 (operating, machinery ownership, and land costs)	CT		51.52		67.27					
	RT		54.85		72.66					
	NT		62.92		73.91					
Peterson et al., 1993, Northeast Colorado # (operating and machinery ownership costs)	CT		38.34						61.76	62.54
	RT		41.04						63.44	63.71
	NT		48.12						67.11	66.16
Peterson et al., 1993, Southeast Colorado # (operating and machinery ownership costs)	CT		37.91		60.12	59.19				
	RT		40.60		61.80	60.37				
	NT		47.69		65.47	61.39				
Williams 1988 (operating, machinery ownership, and land costs)	CT	77.63	57.95		68.91			92.78		
	RT		61.31		73.73		70.71			

† WW = continuous winter wheat, WF = wheat-fallow, WWSf = spring wheat-winter wheat- sunflower, WSF = wheat-sorghum-fallow, WSHF = wheat-sorghum-forage hay-fallow, SF = sorghum-fallow, SS = continuous sorghum, WCF = wheat-corn-fallow, WCMF = wheat-corn-millet-fallow.
‡ CT = conventional tillage, RT = reduced tillage, NT = no-till.
§ WF = spring wheat-fallow for Aakre, 1991 and winter wheat-fallow for all other studies.
¶ Aakre (Six years of economics on the cropping system that works, 1991 North Central ASA Summer Meeting, unpublished, North Dakota State University, Fargo).
# Tillage included for wheat production of rotation only, all systems used no-till prior to the planting of the summer crop(s).

Costs with custom rates were lowest for RT and higher for CT than NT. Jones and Johnson (1993) estimated variable operating costs using custom farming rates for machinery expense. Fertilizer costs were included only in WW and SS. Operating costs increased as tillage decreased in WW and SS, but decreased slightly for WF and WSF.

Norwood and Dhuyvetter (1993) showed that machinery investment across tillage systems (CT, RT, and NT) was similar and did not affect relative profitability. However, machinery investment was considerably higher for WSF than for WF because of the addition of row-crop equipment. Peterson et al. (1993) assumed that machinery ownership costs were the same for CT and RT and only slightly less with NT. Williams (1988) assumed that machinery investment was the same for both CT and RT. All studies reviewed assumed that acreage remained constant across cropping system. However, decreasing tillage and changing crop mix may allow more acres to be farmed with the same machinery complement, thus decreasing cost per tillable acre.

FINANCIAL RISK

Financial risk, or income variability, is the result of annual fluctuations in grain yields and prices. The practice of a fallow period prior to dryland wheat was initiated for several reasons. Fallowing conserves moisture and decreases yield variability, so it is considered a risk management practice. More intensive crop rotations decrease the fallow period; however, current technologies for conserving moisture decrease the need for fallowing. In addition to tillage and agronomic practices, crop insurance is a risk management tool. Price risk is managed by marketing method, government program participation, and crop(s) produced.

Aakre (1991, unpublished data) concluded that returns were more variable from WWSf than from spring-WF based on average returns of the cropping systems between 1985 and 1990 in North Dakota. Increased variability in returns was attributed to yield variability as opposed to cost or price variability. Aakre also pointed out that, although WF was less risky, profit potential also was less.

Dhuyvetter and Norwood (1994) and Norwood and Dhuyvetter (1993) found that more intensive cropping systems were less risky than WF in southwest Kansas. Using coefficient of variation as a measure of expected dollar of risk per dollar of return, risk was minimized with WSF using RT prior to wheat and NT prior to sorghum. This cropping system also produced the highest mean return of all systems evaluated. Risk in WF was similar for CT and RT and much lower than that for NT. With sorghum production in WSF, risk decreased as tillage decreased and was lowest for NT.

Halvorson et al. (1994) and Peterson et al. (1993) did not include a formal analysis of risk; however, they indicated that risk management should be considered when choosing a cropping system. Peterson et al. (1993) indicated that more intensive crop rotations increased residue retention, improved weed control with crop rotation, and increased marketing advantages. They also pointed out that CT in WF would have the risk of noncompliance with NRCS residue requirements.

Using data from north central Kansas, Williams et al. (1990) found that WSF produced the highest net returns and the fewest losses and would be preferred by risk-averse managers. The returns from WSF had higher standard deviations than those from WF, indicating higher potential risk. However, when returns were analyzed using stochastic dominance techniques, WSF with CT was preferred at all risk intervals indicating it would be the cropping system preferred by both risk-averse and risk-seeking managers. The authors found that small changes in yield or production costs would make WSF with NT and CT equivalent. Therefore, they concluded that the preferred system was highly sensitive to factors affecting returns.

Using stochastic dominance techniques with data from extreme western Kansas, Williams (1988) found that risk-averse managers would prefer RT for wheat and grain sorghum over CT. WSF with RT net returns had the highest average and the lowest coefficient of variation, but not the lowest standard deviation. WF with RT had the lowest standard deviation, but also had a considerably lower mean. At low levels of risk aversion, WSF and WF with RT were preferred. At high levels of risk aversion, WF with RT was preferred. The authors concluded that risk seekers would prefer SS, because it had the highest standard deviation and the largest possible net return.

EFFECTS OF GOVERNMENT PROGRAM

Crops produced in the Great Plains primarily are government program crops (Duncan, 1991). Prior to the 1990 Farm Bill, planting restrictions provided little economic incentive to consider alternative cropping systems. Helms et al. (1987) concluded that government payments play a significant role in decisions regarding tillage and other production practices. Including government programs in an economic analysis is difficult because crop bases, program payment yields, and government payments vary considerably among producers. However, it is critical that the effects of government programs are included in any analysis, because most producers participate in them. Dryland wheat enterprise data from western Kansas indicate that government payments as a percentage of returns over variable cost decreased from about 65% in 1990 to approximately 40% in 1993 (Langemeier and DeLano, 1989–1993) (Fig. 1).

Aakre (1991, unpublished data) assumed farm program participation for both spring WF and WWSf based on provisions of the 1990 Farm Bill. Spring WF with 50% wheat base could not be switched to WWSf (67% wheat) without overplanting the wheat base and foregoing deficiency payments. However, a producer with a 50% wheat base could

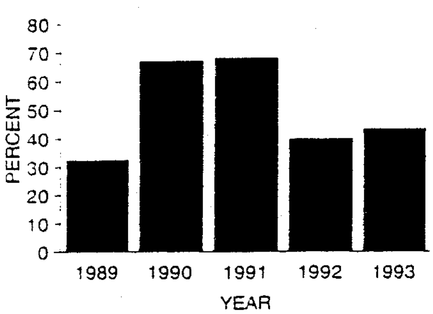

Fig. 1. Government payments as a percentage of returns over variable cost for dryland wheat enterprise.

substitute an alternative crop in place of spring wheat into the rotation and still remain in compliance with program provisions of the 1990 Farm Bill.

Dhuyvetter and Norwood (1994) included provisions of the 1990 Farm Bill in their analysis. Based on the historical prevalence of WF, they assumed an initial wheat base of approximately 50% of tillable acres and no feed-grain base. WSF was more profitable than WF when government payments were included for wheat only. SS (nonprogram crop) was not as profitable as WF when government payments were included for the wheat. Results indicated that a combination of 50% SS and 50% WF (75% of tillable acres cropped annually) would be in compliance with the 1990 Farm Bill and was more profitable than WF alone. The more intensive crop rotations received slightly less in government payments than WF, but the income from the increased production more than offset this reduction. Norwood and Dhuyvetter (1993) included provisions of the 1990 Farm Bill and found that WSF was more profitable than WF both with and without government payments. They concluded that the elimination of the cross-compliance provision of the 1990 Farm Bill was an important incentive for farmers to switch to alternative cropping systems and that the Acreage Conservation Reserve level did not affect the relative profitability of the systems evaluated.

Halvorson et al. (1994) included provisions of the 1990 Farm Bill in their economic analysis but only for WF. Thus, government program payments were constant across all tillage systems. The authors pointed out, that if CT was not in compliance with NRCS residue requirements, NT returns with government payments would be greater than CT returns without government payments.

Jones and Johnson (1993) included government program payments for both wheat and sorghum. Under provisions of the 1990 Farm Bill, producers would not be able to make major changes in crop mix without reducing government payments. For example, a producer would not be able to switch from WF or WW to SS, or vice versa, and maintain government payments. Therefore, the assumption that government payments would be received for both wheat and sorghum may not apply to many producers.

Peterson et al. (1993) included provisions of the 1990 Farm Bill and assumed only a wheat base. In northeast Colorado, WCF was more profitable than WF when government payments were made only on wheat. In southeast Colorado, WF was more profitable than WSF when government payments were made only on wheat. If payments were made on both wheat and sorghum (wheat and feed-grain base), returns were slightly higher from WSF than from WF. At both locations, CT prior to wheat was the most profitable. However, the authors indicated that RT would be the most profitable if CT was out of compliance, based on NRCS residue requirements.

Williams et al. (1990) included provisions of the 1985 Farm Bill in their analysis. When government payments were included, WF was more profitable than WSF with a wheat base only, but this was due to the cross-compliance provision of the 1985 Farm Bill. The authors examined the effect of a one-time base change approved to comply with soil conservation requirements (switch portion of wheat base to feed-grain base), and found WSF was more profitable than WF. They concluded that the 1985 Farm Bill did not encourage the use of NT for wheat and sorghum in north central Kansas. This was attributed to the high Acreage Conservation Reserve level (27.5%) used for wheat in the analysis (J.R. Williams, 1994, personal communication, Kansas State University, July).

SUMMARY

The papers reviewed represented production research from North Dakota to Texas. Eight studies evaluated the economics of various tillage systems and multiple crop rotations. One study analyzed the economics of tillage systems for a given crop rotation.

Economic returns of rotations with a crop grown on 67 to 75% of tillable acres annually in the central Great Plains were greater than the returns of WF at all locations evaluated, with the exception of southeast Colorado. In Texas, rotations with sorghum were more profitable than rotations with wheat only. In North Dakota, returns were greater from WWSf than from spring-WF.

All studies included in the review evaluated various tillage systems. NT was never more profitable than RT in WF. Results were mixed as to whether RT or CT was most profitable in WF. Short-term profitability of a tillage system reflects the cost of the tillage system and the ability of the crop(s) to effectively use stored moisture. Long-term profitability of a tillage system also includes the cost of soil erosion and the impact on land productivity. Havlin et al. (1994) found that the impact of a 1-in. loss in topsoil equalled about $3/acre per yr for dryland wheat in western Kansas. Tanaka and Williams (1994) concluded that the economic likelihood of a producer changing to conservation tillage for spring WF would be small because there was little impact on short-term profitability.

Most studies comparing more intensive cropping rotations showed that RT and NT were more profitable than CT. Several authors indicated that a combination tillage system using CT or RT prior to wheat and NT prior to the summer crop would be the most profitable.

Costs of production included in the economic analyses varied across the studies. Most studies found that cost of production increased as tillage intensity decreased because the increase in herbicide costs was greater than the reduction in tillage costs. The more intensive crop rotations had higher production costs than WF at all locations due to more planted acres.

The majority of the papers reviewed did not include a formal analysis of financial risk; however, most authors mentioned risk as an important consideration in determining an optimal dryland cropping system. Aakre (1991, unpublished data) suggested that rotations offering higher returns are riskier, indicating a risk/return tradeoff. However, the studies that formally analyzed risk, using either mean-variance or stochastic dominance, found that more intensive cropping systems were either equivalent to or less risky than WF, indicating the possibility of increasing returns and decreasing financial risk at the same time (Dhuyvetter and Norwood, 1994; Norwood and Dhuyvetter, 1993; Williams et al., 1990; Williams, 1988).

Even though government payments are declining, payments are still important to producers. Therefore, producers will tend to consider alternative cropping systems only if the practices comply with provisions of the government program. Studies that included government program provisions in the analyses found that intensive crop rotations were more profitable than the traditional WF, even when government payments were included for wheat only. However, a producer's initial base levels (wheat and feed grains) can affect the optimal crop rotation on a whole-farm basis. Although base levels can restrict some producers from incorporating more intensive crop rotations for a whole-farm, these rotations still could be incorporated on a smaller scale under provisions of the 1990 Farm Bill. The flex acres provision of the 1990 Farm Bill increased producers' planting flexibility compared with previous farm bills, but the elimination of the cross-compliance provision was critical to making alternative cropping systems more profitable than WF.

Farm programs in the past were basically neutral to tillage and did not affect tillage method used. However, the conservation compliance provisions of the 1985 and 1990 Farm Blls encouraged less tillage. Several studies found that CT was more profitable than RT or NT in WF when government payments were the same. However, if CT in WF does not meet NRCS conservation compliance requirements, it will not be the most profitable tillage system since it will be ineligible for government payments. Producers with a wheat base only could increase cropping intensity and remain in compliance, but would not be able to go completely to SS.

Government program rigidity and producers' attitudes have most likely been major reasons for the slow adoption rate of alternative crop rotations. The results of the studies reviewed are very positive for dryland producers willing to consider alternative cropping systems in the Great Plains. By using more intensive crop rotations than the traditional WF and RT or NT practices for enhancing moisture conservation, producers can increase returns, decrease financial risk, and remain in compliance with 1990 Farm Bill requirements.

REFERENCES

Black, A.L., and A. Bauer. 1990. Sustainable cropping systems for the Northern Great Plains. p. 15–21. *In* Proc. Great Plains Conserv. Tillage Symp., Bismarck, ND. 21–23 Aug. Great Plains Agric. Council Bull. no. 131.

Byram, T.J. 1993. 1993 Kansas farm facts. Kansas Agric. Stat., Topeka.

Byram, T.J. 1994. 1994 Kansas farm facts. Kansas Agric. Stat., Topeka.

Dalrymple, A.W., S.D. Miller, and K.J. Fornstrom. 1993. Soil water conservation and winter wheat yield in three fallow systems. J. Soil Water Conserv. 48(1):53–57.

Dhuyvetter, K.C., and C.A. Norwood. 1994. Economic incentives for adopting alternative dryland cropping systems. p. 18–23. *In* J.L. Havlin (ed.) Proc. Great Plains Soil Fertility Conf., Vol. 5., Denver, CO. 7–9 Mar. Kansas State Univ., Manhattan.

Dobbs, B. 1994. 1993/94 Nebraska agricultural statistics. Nebraska Agric. Stat. Service, Lincoln.

Duncan, M. 1991. The 1990 Farm Bill: Provisions and implications. p. 78–97. *In* M.D. Skold (ed.) Proc. Great Plains Agric. Council, Wichita, KS. 4–6 June. Colorado State Univ., Ft. Collins.

Fenster, C.R., and T.M. McCalla. 1970. Tillage practices in western Nebraska with a wheat-fallow rotation. Univ. of Nebraska Agric. Exp. Stn. Bull. SB 507.

Fenster, C.R., and T.M. McCalla. 1971. Tillage practices in western Nebraska in a wheat-sorghum-fallow rotation. Univ. of Nebraska Agric. Exp. Stn. Bull. SB 515.

Halvorson, A.D. 1990. Cropping systems and nitrogen fertilization for efficient water use in the central Great Plains. p. 117–123. *In* Proc. Great Plains Conserv. Tillage Symp., Bismarck, ND. 21–23 Aug. Great Plains Agric. Council Bull. no. 131.

Halvorson, A.D., R.L. Anderson, N.E. Toman, and J.R. Welsh. 1994. Economic comparison of three winter wheat-fallow tillage systems. J. Prod. Agric. 7:381–385.

Halvorson, A.D., and C.A. Reule. 1994. Nitrogen fertilizer requirements in an annual dryland cropping system. Agron. J. 86:315–318.

Havlin, J.L., H. Kok, and A.P. Barkley. 1994. An economic evaluation of soil erosion and productivity. p. 59–65. *In* D. Lyon (ed.) Proc. Great Plains Residue Manage. Conf., Amarillo, TX. 15–17 Aug. Great Plains Agric. Council Bull. no. 150.

Helms, G.L., D. Bailey, and T.F. Glover. 1987. Government programs and adoption of conservation tillage practices on nonirrigated wheat farms. Am. J. Agric. Econ. 69:786–795.

Hudson, C.A., and L.A. Fretwell. 1993. Colorado agricultural statistics 1993. Colorado Agric. Stat. Serv., Lakewood.

Hudson, C.A., and L.A. Fretwell. 1994. Colorado agricultural statistics 1994. Colorado Agric. Stat. Serv., Lakewood.

Johnson, J.B., A. Baquet, A. Clarke, C. Miller, and M. Watts. 1986. The economics of alternative tillage methods and cropping systems: Major land resource area 53A, northeast Montana. Montana State Univ. Coop. Ext. Serv. Bull. 1350.

Jones, O.R., and G.L. Johnson. 1993. Cropping and tillage systems for dryland grain production. USDA-ARS Conserv. and Prod. Res. Lab. Rep. no. 93-10, Bushland, TX.

Jones, O.R., A.F. Wiese, and G.L. Johnson. 1988. Tillage and crop sequence effects on dryland crop production. p. 826–829. *In* P.W. Unger et al. (ed.) Proc. Int. Conf. on Dryland Farming, Amarillo, TX. 15–17 Aug. Texas Agric. Exp. Stn., College Station.

Langemeier, L.N., and F.D. DeLano. 1989–1993. The enterprise analysis report—Management information. Kansas State Univ. Dep. of Agric. Econ. Coop. Ext. Serv.

Nilson, E.B., P.W. Stahlman, C.A. Thompson, R.E. Gwin, C.A. Norwood, F.R. Lamm, and M.E. Mikesell. 1985. Wheat-grain sorghum-fallow using reduced tillage with herbicides. Kansas State Univ. Agric. Exp. Stn. Rep. of Prog. 482.

Norwood, C.A. 1994. Profile water distribution and grain yield as affected by cropping system and tillage. Agron. J. 86:558–563.

Norwood, C.A., and K.C. Dhuyvetter. 1993. An economic comparison of the wheat-fallow and wheat-sorghum-fallow cropping systems. J. Prod. Agric. 6:261–266.

Norwood, C.A., A.J. Schlegel, D.W. Morishita, and R.E. Gwin. 1990. Cropping system and tillage effects on available soil water and yield of grain sorghum and winter wheat. J. Prod. Agric. 3:356–362.

Peterson, G.A., D.G. Westfall, L. Sherrod, R. Kolberg, and B. Rouppet. 1994. Sustainable dryland agroecosystem management. USDA-ARS Tech. Bull. TB94-1.

Peterson, G.A., D.G. Westfall, N.E. Toman, and R.L. Anderson. 1993. Sustainable dryland cropping systems: Economic analysis. USDA-ARS Tech. Bull. TB93-3.

Smika, D.E. 1990. Fallow management practices for wheat production in the Central Great Plains. Agron. J. 82:319–323.

Tanaka, D.L., and J.R. Williams. 1994. Economic evaluation of topsoil loss for sustainable spring wheat production in the Northern Plains. p. 51–57. *In* D. Lyon (ed.) Proc. Great Plains Residue Manage. Conf., Amarillo, TX. 15–17 Aug. Great Plains Agric. Council Bull. no. 150.

Wicks, G.A., D.F. Smika, G.W. Hergert. 1988. Long-term effects of no-tillage in a winter wheat (*Triticum aestivum*)-sorghum (*Sorghum bicolor*)-fallow rotation. Weed Sci. 36:383–393.

Wiese, A.F., W.L. Harman, B.W. Bean, and C.D. Salisbury. 1994. Effectiveness and economics of dryland conservation tillage systems in the southern Great Plains. Agron. J. 86:725–730.

Williams, J.R. 1988. A stochastic dominance analysis of tillage and crop insurance practices in a semiarid region. Am. J. Agric. Econ. 70:112–120.

Williams, J.R., R.V. Llewelyn, and G.A. Barnaby. 1990. Risk analysis of tillage alternatives with government programs. Am. J. Agric. Econ. 72:172–181.