Wheat Residue Management In Arkansas Double-Cropped Soybeans

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ABSTRACT

Residue management is the central issue in conservation compliance. While the compliance legislation encourages residue retention, growers ~eemto prefer burning crop residues. Little information exists on the impact of these residue management options on the viability of different crop production systems. The objective of this study was to investigate the economic implications of leaving or burning wheat *(Triticum aestivum)* stubble on the production of double-cropped soybean *(Glycine max).* Data from stubble management experiments conducted at various locations in Arkansas between 1992 and 1995 were used for this study. Net returns to different production systems were estimated from enterprise budgets and stochastic dominance analyses were used to identify risk-efficient strategies. Results indicated that the effect of leaving or burning wheat stubble would be contingent upon the full complement of production practices employed. Depending on the production systems, experimental location, and year, net returns to soybean could range from a net loss of about $45 to a profit of $17l/a. However, stubble retention generally improved returns in fields that were tilled prior to planting while burning wheat stubble was a superior strategy in no-till systems. Stochastic dominance analyses uniquely identified a production system comprising pre-plant tillage and stubble retention under narrow row-system as the overall dominant and risk-efficient strategy. Also, no production system without pre-plant tillage ever dominated those with tillage.

INTRODUCTION

Crop residue management is the centerpiece of conservation compliance requirements. Research has consistently shown that farming systems which retain crop residues continuously on the soil surface reduce water erosion losses when compared to practices that leave residue for only a portion of the year (Alberts and Neibling, 1994). Prior to the enactment of conservation security act, voluntary participation and incentives were compliance (CC) provisions of the 1985 U.S. food preferred policy initiatives for promoting conservation practices (Zinn, 1994). The failure of these voluntary initiatives in maintaining a satisfactory level of erosion control made the introduction of CC provisions inevitable.

The Soil Conservation Policy Task Force of the American Agricultural Economics Association (AAEA) offered two reasons why an enabling legislation was required to protect soil productivity (Harman, 1994). The first reason, which is economic, is the failure of the market to signal farmers that investments to protect productivity are needed. The second reason is a philosophical one. It holds the present generation responsible for maintaining resource productivity for the sake of future generations. Consistent with these views, the CC provisions of 1985 food security act required farmers who produce agricultural commodities on highly erodible soils to fully implement approved conservation plans by January 1995. Noncompliance with this requirement leads to termination of govemment farm program participation. While the conservation provisions of the1996 farm bill have been simplified in order to enhance efficiency and flexibility, the bill has retained the essential features of 1985 CC provisions.

The whole experience with the implementation of compliance requirements suggests that it may be appropriate to reevaluate the appeal of compliance legislation. The main criticism of CC legislation centers on its lack of adequate enforcement capabilities. In a survey, Consolidated Farm Service Agency found only 1944 producers in violations of CC provisions since its enactment in 1985 to 1992 (Zinn, 1994). However, the 1995 Annual Tillage Surveys conducted by Conservation Technology Information Center (CTIC) put the estimates of total acreage under conservation tillage at 98.8 million, or 35% of the total cropland acreage of 278.6 million (CTIC, 1996).

Conservation compliance can be in further jeopardy as farm support programs are scaled back since the denial of participation in government programs is the current penalty for violations. For this reason, alternative

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strategies for supplementing mandatoly legislation may be needed to d a n c e the attractiveness of conservation strategies, especially on highly-erodible soils. Strategies for promoting the appeal of conservation practices need to address the economic concerns raised by AAEA. In essence, the conservation production practices should demonstrate, especially in the short run a potential for superior profitability relative to conventional practices. Unfortunately, the often touted benefits of conservation tillage (Harman, 1994; CTIC, 19%) are rather intangible and fall within the class of social benefits. However, the decision making process of growers is often driven by private benefits and costs. In fact, the compliance legislation will be redundant if there are conservation -production practices that are clearly superior to conventional methods in terms of profit potential and efficient risk management.

Harman (1994) provides a detailed review of economic studies of residue management over the past several decades. While there is no conclusive evidence as to the economic advantage or disadvantage of conservation practices compared to the conventional ones, a key observation is the fact that both practices respond differently to alternative resource conditions and production environment. Consequently, the objective of this study is to investigate the economic effects of leaving or burning wheat *(Triticum aestivum* [L.] em Thell) straw on production of double-cropped soybeans *(Glycine* max [L.] Merr.) These competing wheat residue management options will be investigated under alternative cropping systems and row spacing arrangements.

Like in some other southern states, growers in Arkansas double-crop almost all their wheat acreage with soybeans. The usual practice is to bum the wheat straw which is followed by disking and planting. The study is expected to help growers adopt profitable production practices that address both the conservation and safety concerns implicit in both federal and certain state regulations. Specifically, the analysis would aid the identification of the set of production practices and resource conditions under which the conservation practice of leaving wheat straw is more profitable than the conventional practice of burning.

MATERIALS *AND* METHODS

Agronomic

Data for the study were obtained from stubble management experiments conducted at the experimental sites of Cotton Branch Experiment Station and Northeast Research and Extension Center of the University of Arkansas in Arkansas between 1992 and 1995. The soils were a silty clay, a silt loam, and a very fine sandy loam.

Experimental design in all locations was a randomized complete block with four replications. The treatment design was a split-split plot with four replications. The main plot sizes of 25.3 ft by 80 ft were established for two tillage treatments: till and no-till (NT). The first split (sub-plot) was used for row spacing treatments which comprised wide row (WR) spacings (of between 19 and 22.5 in) and narrow row spacings (NR) (less than 15 in.). In the second split, two wheat residue treatments, i.e., burning of wheat straw and leaving the straw on the soil surface, were imposed.

All pre-plant NT plots received a burndown treatment of glyphosate (Roundup) at 0.9 lb ai/a. Till plots were disked once with imazequin (Scepter) at 0.28 Ib ai/a being incorporated on the second disking. Subsequent post-plant weed control decisions followed Arkansas Cooperative Extension Service recommendations on a plot-by-plot basis. No fertilizer was applied in any of the years as the management practices were tailored to the prevalent growers' practices in the study area.

Harvesting of soybean yields in all plots was undertaken with the aid of a small-plot combine harvester. Soybean yields adjusted to 13% moisture content were determined from the harvest. Analysis of variance tests were conducted in order to detect the statistical significance of various treatments. Significant year and treatment interactions occurred for tillage, stubble management, and row spacing treatments. Therefore, the data were analyzed and presented separately for these treatments in each year. *Also,* for the treatments whose effects were significant mean separation was done with Fisher's protected least square difference (LSD) test at a = 0.5.

Economic

The enterprise budgeting t e c h q u e was used to assess the economic perfonnance of alternative stubble management practices under different row spacing and tillage systems for soybean production. The budgets, which set out the structure of costs and returns associated with these practices, were generated with the aid of Mississippi State Budget Generator (MSBG) developed by Spurlock and Laughlin (1992). MSBG is a computer-based budgeting program that can produce the cost and returns for specified crop or livestock enterprises. The program is driven by user-specified data regarding the input quantities and prices as well as output levels and prices.

The 10-yr average of seasonal prices of soybeans in Arkansas from 1985 to 1994 (Anon., 1994). was applied to the respective yields in each year to obtain gross returns per acre. This uniform average price was used, rather than the seasonal price that prevailed in each year, so that differences in returns could be solely attributed to the effects of alternative production systems under consideration.

Relevant input costs were obtained from the production cost estimates produced annually by the University of Arkansas Cooperative Extension Service (Windham et al., 1992). Variable *costs* were direct expenses that are dependent on a particular production system. These expenses were estimated from average published costs for seeds fertilizer, pesticides, custom hire, repairs, maintenance, fuel, and other operating expenses. Fixed costs included depreciation, insurance, property taxes and interest on capital invested in farm machinery. Total costs included both the fixed and variable costs. However, total *costs* did not include charges for land, risk, overhead, crop insurance, real estate taxes or management. Uniform cost structures were assumed for farm operations that are similar and cut across all strategies but the costing process duly recognized the differences in input requirements of various systems. For example, planting and seeding costs were higher for narrow row systems but no post-plant tillage costs were incurred.

Economic evaluation based solely on yields and associated profits has implicitly assumed that the outcome of the decision-making process is known with certainty. However, if a conservation practice of NT system or leaving the wheat straw is expected to gradually replace conventional practices as preferred strategies for residue management, the attitude of growers towards risk becomes an important consideration in the evaluation. Information on both the magnitude and variability of outcomes could be used to identify optimal production practices for decision makers of different risk classes.

Stochastic dominance methods were used to identify efficient production systems for decision makers of different risk groups. These methods are often preferred for their relative ease of use and because they do not require the restrictive assumptions of normality or explicit specification of the utility models. Generalized stochastic dominance (GSD), otherwise called stochastic dominance with respect to a function (SDRF), which is a more general and flexible type of stochastic dominance measures, can evaluate strategies for a broad group of decision makers ranging from those who are risk-loving to risk-averse. Further information on the intricacies of stochastic dominance measures is presented elsewhere in Meyer (1977) and King and Robison (1981). For practical implementation, a computer program, GSD, developed by Raskin and Cochran (1986) and based on Meyer's (1977) method, was employed in this study.

Stochastic dominance methods have been widely used in studies that evaluate both profits and risk in crop production management. Similar studies that have employed these tools include Williams et al. (1990), Weersink et al. (1992), and Epplin et al. (1 993). In this study, stochastic dominance criteria were applied to the cumulative probability distribution of net returns associated with eight production systems in order to determine the risk-efficient ones. These practices were: NTLNAR (no-till, left wheat stubble, and narrow row), NTBNAR (no-till, burned wheat stubble, and narrow row), NTLWIDE (no-till, left wheat stubble, and wide row), NTBWIDE (no-till, burned wheat stubble, and wide row), TLNAR (tilled, left wheat stubble, and narrow row), TBNAR (tilled, burned wheat stubble, and narrow row), TLWIDE (tilled, lef? wheat stubble, and wide row) and TBWIDE (tilled, burned wheat stubble, and wide row).

RESULTS AND DISCUSSION

While the yield information provides a means of assessing the agronomic performance of alternative practices, the overall economic implications will depend also on the magnitude of *costs* and returns associated with these practices.

Yields

Table 1 presents mean soybean yields associated with alternative tillage and stubble management practices in all locations and years. Pre-plant tillage generally resulted in a yield increase which ranged from about 0 to 25 bu/a, although there were few instances when NT yields surpassed tillage yields, especially when the production system included burning of wheat stubble. In a similar vein, narrowing the rows also resulted in general yield improvement which could be as high as 18 bu/a. However, there were several occasions when wide-row yields exceeded narrow-row yields. This finding is consistent with the lack of conclusive evidence reported in earlier studies (Boquet et al., 1982; Board et al., 1990) concerning the superiority of narrow row production systems for determinate soybean cultivars that are common in the southern USA.

The effect of leaving or burning wheat straw was also largely driven by the full complement of production practices used. For instance, for NT plots, burning the wheat straw, rather than leaving it, was clearly a superior strategy regardless of whether the rows were wide or narrow. However, narrowing the rows generally provided an opportunity to improve the yield.

Conversely, for plots that were subjected to pre-plant tillage, leaving the wheat straw on the soil surface, rather than burning it, enhanced yield. Also, narrowing the rows did have positive effect on the yields. This suggests that growers should not be expected to combine both conservation practices of NT practices and leaving straw for maximum soybean yield production. The yield loss from such practices may be the result of the attendant heavy straw load and for high weed pressures. Therefore, a choice might be necessary between NT *systems* and wheat straw retention. This choice would be influenced by whichever conservation strategy displays a higher potential for optimal yield and minimal soil erosion and other disturbances.

Comparing the growers' present practice of burning the straw under narrow row, tillage system one can see from Table 1 that the production system of leaving the straw was in fact superior because of its yield advantage. However, the growers have possibly assumed that this yield increase would not be high enough to offset the potential risks of sustaining high yield losses from wheat residue retention under undue stress situations. The difference between the yields of both strategies can be perceived as the yield premium the growers are willing to sacrifice to avoid such a risky prospect.

Net Returns

Comparisons of strategies based purely on yield considerations may sometimes be biased in favor of production practices which result in high yields but which also display high production costs. For instance, the additional costs of tillage may account for the increased yields associated with this practice. Also, the increased plant populations as a result of additional seeding and planting costs may account for the yield advantage of narrow systems. For this reason, these extra costs were considered while determining the net returns that are shown in Table 1. In general, the net returns follow the same pattern as yields except that it is now possible to observe instances when economic losses would be sustained if certain production practices were used.

The NT system does not seem like a preferred strategy for profitable soybean production under extreme stress conditions, e.g., drought. The net returns for Marianna experiments in 1993 are particularly striking where negative returns would be realized under NT system regardless of row width and stubble management practices. The results at Marianna in 1993 were influenced by a 3-wk drought in late June and early July and another 2-wk drought about the first of September. Also, positive returns were reported only in tilled plots where the stubble was retained in Marianna in 1993. This evidence is at variance with farmers' preference for burning wheat stubble to hedge against yield fluctuations under adverse conditions.

Risk Analysis

Table 2 presents the preferred complements of production practices as ranked by FSD, SSD, and GSD. The results show that when all eight Combinations are considered, FSD identifies two dominant strategies, TLNAR, and TBNAR that belong to its efficient class. SSD which assumes risk neutrality or aversion of decision makers improves upon the ranking ability of FSD. It uniquely identifies TLNAR as the dominant complement of production practices. GSD affirms the choice of TLNAR for moderate degrees of risk preference and all degrees of risk aversion. This ranking is preserved when the stochastic dominance analysis focused exclusively on four complement of production practices for tilled plots.

Focusing on the no-till strategies, results shown in Table 2 indicate that FSD does not exist for any complement of production practices. NTLNAR and NTBNAR are dominant practices according to the SSD criteria. GSD uniquely identifies NTBNAR only for decision makers whose degrees of risk aversion range from moderate to high.

The results of these stochastic dominance analyses have some important remifications. First, it is instructive to observe that no combination of production practices without pre-plant tillage ever dominated those with tillage. Therefore, conservation advocates need to recognize that no-till systems may not be profitable or risk efficient enough to expect widespread use of this practice without additional incentives. From the conservation standpoint, it is gratifying to notice that production practices that involve stubble retention dominate burning of wheat stubble for tilled systems. Conversely, for no-till *systems,* the unique dominant practice includes the burning of wheat straw. Therefore, the stochastic dominance analyses further confirm the earlier observation that a choice has to be made between a conservation practice of either no-till or residue retention for optimal crop production management. Finally, the growers' popular practice of TBNAR **is** not among the risk efficient strategy identified by FSD, SSD, or GSD. There are two possible reasons for this choice. One probable reason is that the decision making environment of the growers is not characterized by risk aversion. A rather more compelling argument is that the growers do not have perfect knowledge of the risk implications of all strategies which may account for their erroneous preference for TBNAR production practices.

CONCLUSIONS

Mandatory legislation for enforcing conservation practices may be unnecessary once profitable and risk-efficient ones are identified. Results from this study indicate that the conservation practice of retaining wheat stubble can be an optimal and risk-efficient strategy for double-cropped soybean production. The profitability of this practice is further enhanced if it is complemented with tillage and narrow row systems. The study finds no justification for growers' preference for burning wheat stubble except under no-till systems.

Non-optimal returns were obtained when dual conservation practices of no-till soybean production and the retention of wheat residue were combined. Therefore, conservation advocates may need to make a choice between both practices depending on their potential to increase profitability and soil productivity. On the basis of net returns, stubble retention appears to be a superior strategy.

The relevance of these findings lies in the potential to promote conservation practices that are consistent with growers' objective of optimal returns. Therefore, future research aims at validating these results for different cropping systems will be germane.

LITERATURE CITED

Alberts, E. E., and W. H. Neibling. 1994. Influence of crop residue on water erosion. pp. 19-39. *In* P. W. Unger (ed.). Managing Agricultural Residue. Lewis Publishers

Anonymous. 1994. 1988-1994. Arkansas Agricultural Statistics. Arkansas Agr. Statistics Service, Arkansas Agr. Exp. Sta. Report Series, University of Arkansas, Fayetteville, AR.

Anonymous, 1996. Conservation Tillage: A Checklist for US farmers. CTIC (Conservation Technology Information Center).

Binswanger, H.P. 1980. Attitudes toward risk: experimental measurement in rural india. Amer. J. Agr. Econ. 62:395-407.

Board, J.E., B.G. Harville, and A.M. Saxton. 1990. Narrow row seed-yield enhancement in determinate soybean. Agron. J. 82:64-68.

Boggess, W.G., and J.T. Ritchie 1988. Economic and risk analysis of irrigation decisions in humid regions. J. Prod. Agric. 1:116-122

Boquet, D. J., K.L. Koonce, and D. M. Walker. 1982. Selected determinate soybean cultivar yield responses to row spacings and planting dates. Agron. J. 74:136-138.

Day, R. 1965. Probability distributions of field crop yields. J. Farm Econo. 47:713-741.

Epplin, F.M., D. E. Beck, E. G. Krenzer, Jr., and W.F. Heer. 1993. Effects of planting dated and tillage systems on the economics of hard red winter wheat production. J. Prod. Agric. 6:57-62.

Harman, W. L. 1994. Economics of residue management in agricultural tillage systems. pp. 377-423. *In* P. W. Unger *(ed.)* Managing Agricultural Residue. Lewis Publishers.

King, R.P., and L.J. Robison. 1981. An interval approach to measuring decision maker preferences. Amer. J. Agr. Econ. 63:510-520.

Knowles, G. J. 1984. Some econometric problems in the measurement of utility. Amer. J. Agr. Econ. 66:505-510.

Meyer, J. 1977. Choice among distributions. J. Econ. Theory 14:326-336.

Pratt, J.W. 1964. Risk aversion in the small and in the large. Econornetrica 32: 122-136.

Raskin R., and M. J. Cochran. 1986. Interpretations and transformations of scale for the Pratt-Arrow absolute risk aversion coefficient: implications for generalized stochastic dominance. Western J. Agr. Econ. 11:204-210.

Spurlock, S.R., and D.H. Laughlin. 1992. Mississippi State budget generator user's guide version 3.0. Agricultural Economics Technical Publication No. 20 Mississippi Agr. And Forestry Exp. Sta., Mississippi State, MS.

Williams, J.R., L.K. Gross, M.M. Claassen, and R.V. Llewelyn. 1990. Economic analysis of tillage for corn and soybean rotations with government commodity programs. J. Prod. Agric. 3:308-316.

Windham, T. E., C. A. Stuart, and B. E. Herrington (Jr). 1992. Estimating 1992 Production Costs in Arkansas: Soybeans. Extension Technical Bulletins 149-157, Cooperative Extension Serv., Univ. Of Arkansas, Fayetteville, AR.

Zinn, J. 1994. Conservation Compliance: Policy Issues for the 1995 Farm Bill. Congressional Research Service: Report for Congress No. 95-6 ENR.

Table 1. Average Yields and Net Returns Associated with Alternative Practices

		Without pre-plant tillage (No-Till)							
		Narrow Rows				Wide Rows			
		Burned		Left		Burned		Left	
Location	Year	Yield	Net Returns	Yield	Net Returns	Yield	Net Returns	Yield	Net Returns
		Bu/a	$la	Bu/a	$la	Bu/a	$la	Bu/a	$la
Keiser	1994	38.20	111.55	34.00	84.59	38.80	130.68	39.40	134.49
	1995	41.70	129.91	43.80	142.60	35.20	103.94	36.30	110.71
Little Rock	1992	31.50	71.89	23.90	27.16	21.30	21.65	13.70	-23.08
Marianna	1992	27.50	45.62	22.90	18.87	16.70	-0.15	11.30	-31.86
	1993	13.90	-34.21	17.00	-16.05	10.10	-44.65	12.40	-30.78
Pine Tree	1994	22.30	15.06	20.50	4.67	17.10	-3.21	15.10	-14.80
	1995	20.30	3.22	21.00	7.63	16.90	3.24	16.50	1.13
		With Pre-Plant Tillage (Tilled)							
Keiser	1994	33.00	88.44	36.60	110.01	33.40	101.10	38.2	129.77
	1995	45.30	161.26	39.50	127.18	34.10	103.87	39.9	138.47
Little Rock	1992	44.70	152.56	47.90	176.91	26.60	60.84	34.2	106.09
Marianna	1992	24.20	36.34	28.30	60.87	15.20	-6.65	19.4	18.48
	1993	16.00	-12.20	23.20	30.68	16.10	-1.32	19.3	17.88
Pine Tree	1994	27.20	54.10	25.00	41.34	20.30	22.18	19.8	19.48
	1995	23.20	30.42	22.20	24.76	17.10	4.60	16.1	-1.06

Table 2: Stochastic Dominance Rankings of Alternative Soybean Production Systems

Efficiency Criterion	Absolute risk-aversion Coefficient† Lower Bound	Upper Bound	Set of Dominant Strategies‡ Overall	Tilled	No-Till
FSD	-∞	∞	TLNAR TBNAR	TLNAR TBNAR	NTLNAR NTBNAR NTLWIDE NTBWIDE
SSD	0.000	∞	TLNAR	TLNAR	NTBNAR NTLNAR
GSD:					
Risk Preferring	-0.005	0.000	TLNAR	TLNAR	NTBNAR NTLNAR
Risk Neutral	0.000	0.000	TLNAR	TLNAR	NTBNAR NTLNAR
Slightly risk averse	0.002	0.005	TLNAR	TLNAR	NTBNAR NTLNAR
Moderately risk averse	0.005	0.009	TLNAR	TLNAR	NTBNAR
Highly risk averse	0.009	0.020	TLNAR	TLNAR	NTBNAR

† The **absolute risk** aversion function coefficients have been scaled to allow comparisons on net returns per acre basis (Raskin and Cochran, 1986; Boggess and Ritchie, 1988).
‡ TLNAR = tilled, retained wheat residue, narrow **row,** TBNAR = tilled, burned wheat residue, narrow row; NTLNAR = **no-till**, retained wheat residue, narrow **row,** NTBNAR = no-till, burned wheat residue, narrow row; NTLWIDE = no-till, retained wheat residue, wide row NTBWIDE = no-till, retained wheat residue, wide row.