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by

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ABSTRACT: IMPLICATIONS OF SUSTAINABLE FARMING SYSTEMS IN THE NORTHERN GREAT PLAINS FOR FARM PROFITABILITY AND SIZE

Labor intensity and returns to labor and management are compared for sustainable (alternative), conventional, and reduced tillage farming systems in the Northern Great Plains, using 7 years of data from a study in South Dakota running through 1992. Implications for farm size of substituting sustainable for conventional systems are examined.

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IMPLICATIONS OF SUSTAINABLE FARMING SYSTEMS IN THE NORTHERN GREAT PLAINS FOR FARM PROFITABILITY AND SIZE

Central to the broadening and intensifying debate about "alternative" or "sustainable" farming systems is this question: Are these systems sufficiently profitable to make them attractive to farmers and would widespread adoption of such systems halt or reverse the trend of ever-increasing farm size? This question was examined in a series of hearings held by the U.S. Congress Joint Economic Committee in 1992 (e.g., Dobbs, 1992). In a recent issue of the American Agricultural Economics Association's Choices policy magazine, Smith (1992) asserts that the U.S. research system has tended to produce technologies which have the effect of moving economic activity off of farms, thereby causing or reinforcing the trend to larger farm size. Smith's argument is that farmers have adopted the technologies which were available and profitable, and that the aggregate result is a structure of agriculture consisting of fewer, larger farms. Does it necessarily follow, however, that movement to sustainable farming systems, characterized by greatly reduced use of chemical inputs and greater use of crop rotations for fertility and pest control, hold potential for stabilizing or reducing farm size while maintaining profitability? Bird (1992), in an even more recent issue of Choices, argues that adoption of farming systems which are friendly to the environment would likely result in even larger farms in the Great Plains region. He sees economies of size in adoption of crop rotations and various other conservation measures and in making the best use of fertilizers and pesticides. Bird envisions the possibility of "virtual large farms" like ones found in Australia.

One component of the question posed at the outset concerns profitability. Dobbs (1992), Fox, et al. (1991), and Lee (1992) have each

recently reviewed available literature on comparable profitability of sustainable and more conventional farming systems in the U.S. (or North America, in the case of Fox, et al.). Results vary according to agro-climatic conditions, assumptions about Federal farm policy, and availability of organic price premiums (when the sustainable systems under study are completely chemical free). Taken as a whole, the available literature tends to indicate that sustainable systems presently are more likely to be competitive with conventional systems in the western, drier, wheat growing areas of the U.S. than in higher rainfall areas of the central and eastern Corn Belt. This pattern appeared on a smaller geographic scale in a set of case farm studies recently completed within South Dakota (Dobbs, et al., 1991 and 1992), where corn and soybeans are predominant in the east-central and southeastern parts of the State and wheat is predominant in the central and western parts.

The second component of the question deals with farm size. Relative labor intensity of farming systems, together with relative returns to labor and management, are critical to addressing that part of the question. Preliminary findings of a multi-State (Iowa, Minnesota, North Dakota, Montana, and Oregon) study supported by the Northwest Area Foundation indicate that sustainable farming systems "appear to require more labor per acre" than conventional farming systems (Miller, 1992, p. 9). Dobbs and Cole (1992) found relative labor intensity to vary across agro-climatic areas within South Dakota. In the South Dakota corn-soybean area in which alfalfa hay was part of a case study sustainable system, labor intensity was greater in the sustainable system than the conventional system with which it was compared. On the other hand, in the corn-soybean area comparison in which a green manure legume rather than an alfalfa hay legume was part of the sustainable system,

labor intensity was about the same for the case conventional and sustainable systems. Labor use per acre was actually greater for the conventional systems in the case comparisons in wheat growing areas of South Dakota.

How do returns to labor and management for sustainable and conventional systems compare, however? That issue receives special attention in this paper. Using data from a recently completed 8-year agronomic and economic study in northeastern South Dakota, relative profitabilities of sustainable, conventional, and reduced tillage farming systems are compared in two ways: (a) with an opportunity cost assigned to all labor, but not to land, thereby resulting in a residual "net return per acre to land and management"; and (b) with a market value assigned to land, but not to labor, resulting in a residual "net return per hour to labor and management". Insights from the results are used to generate observations about the potential impacts of sustainable agriculture on farm profitability and size.

Case Farming Systems

The case farming systems featured in this article are ones representing some present possibilities in east-central and northeastern South Dakota. The study area is in the transition zone between the western edge of the "corn, soybeans, hogs" region and the eastern edge of the "cattle, wheat, sorghum" region (map on p. 5 of Sommer and Hines, 1991). Thus, the cases provide insights into the potential implications of sustainable agriculture for both the western Corn Belt and the Northern Great Plains spring wheat region.

Data for the case farming systems come from a research project which started in 1985 at South Dakota State University's Northeast Research Station, north of Watertown in Codington County. The project consisted of two sets of

comparative studies. In Study I, "Alternative" (or sustainable), "Conventional", and "Ridge Till" farming systems were compared. The Alternative system consisted of a 4-year oats-alfalfa-soybeans-corn rotation, in which no chemical fertilizers or pesticides were applied. Limited amounts of livestock manure were applied on the oats stubble portion of the rotation. The Conventional and Ridge Till systems each consisted of 3-year corn-soybeans-spring wheat rotations, in which chemical fertilizers and herbicides were applied each year at rates recommended by agronomists in light of current soil test results, weed populations, and other related agronomic conditions. The moldboard plow was used (following small grain harvest) only in the Conventional system.

In Study II, small grains received more emphasis and no corn was present in any of the rotations. The "Alternative" (or sustainable) system in that study consisted of a 4-year oats-clover-soybeans-spring wheat rotation, in which no commercial chemical inputs were applied. The clover (a combination of sweet and red clover) was turned under as a green manure, rather than harvested as forage. "Conventional" and "Minimum Till" farming systems in Study II each were 3-year rotations of soybeans, spring wheat, and barley. As in Study I, recommended amounts of chemical fertilizers and herbicides were applied to these two systems, and the moldboard plow was used only in the Conventional system.

Study I was concluded at the Northeast Station at the end of the 1992 crop year, and Study II will conclude after the 1993 crop year. Preliminary budget simulations for these farming systems were reported several years ago (Dobbs, et al., 1988), and agronomic and economic analyses of the "transition years" (1985-1989) were reported by Smolik and Dobbs (1991). The Smolik and

Dobbs article also contained details of the herbicide and tillage procedures for each system.

In the present article, data for the period 1986-1992 are used. Data from 1985 were dropped from the analysis, since some cultural practices that year (e.g., clear-seeding of alfalfa) were not repeated in subsequent years. The analysis of labor returns and farm size featured in this article has not previously been reported.

Results

Results of the net return analyses for the 7-year (1986-1992) study period are summarized in Table 1. Net return to land and management are shown in the first column. In calculating this net return, all fixed and operating costs except a charge for land and any charge for management were deducted. Time spent on field operations--whether by the farmer, by his or her family, or by hired labor--was all charged an opportunity cost wage and included with other operating costs. In other words, this return is a residual to land and the "planning and risk taking" elements of management. Federal farm program payments and set-aside requirements were factored into the gross and net return calculations, thus, in effect, simulating whole-farm situations before reducing the results to per acre averages.

In Study I, the Alternative (or sustainable) system had the highest net return to land and management ($63/acre). The Conventional system was next ($49/acre), and the Ridge Till system was lowest ($32/acre). Although land devoted to alfalfa did not qualify for government deficiency payments, the hay market was relatively strong in eastern South Dakota during 4 of the 7 study years. Average hay prices during the 7-year study period were 12 percent

higher than the 20-year (1973-92) average. (We did not assume that the simulated farm was enrolled in the recently introduced Integrated Farm Management Program Option; otherwise, a portion of the alfalfa hay land could have qualified for payments during 1991 and 1992.) Thus, under the crop yield, market price, and Federal farm program provisions in existence over the course of the 7-year study period, the Alternative system which substituted a forage legume and certain tillage practices for agricultural chemicals performed quite well.

The Alternative system in Study II also performed reasonably well in terms of net return to land and management ($38/acre) compared to the Conventional system with which it was compared ($39/acre), and quite well relative to the Minimum Till system ($20/acre). Thus, under conditions of this study, sustainable systems incorporating a green manure crop for some of the fertility and weed control appear to have reasonably good economic promise in Northern Great Plains small grain areas.

Let us now look at net return from the standpoint of labor, rather than land. First, observe the relative labor intensity of the different systems in the second column of data in Table 1. Differences in labor intensity between the systems result from a combination of crop mix and field operation effects. Although there is some hand weeding of soybeans, most of the labor is involved with tractor or self-propelled machine operations. The Alternative system was the most labor intensive (1.93 hours/acre) of the systems in Study I, partly because of the haying operations associated with that system and partly because the absence of chemical pesticides necessitated somewhat more mechanical tillage. The Ridge Till system involved the fewest tillage operations, thereby resulting in the lowest labor intensity (1.52 hours/acre)

in Study I. Relative labor intensity was very different in Study II. There, the Alternative system was the least labor intensive (1.58 hours/acre), due largely to the very limited number of field operations associated with green manure clover. The Minimum Till system was less labor intensive (1.63 hours/acre) than the Conventional system (1.70 hours/acre) because, in effect, additional chemical pesticides were substituted for some tillage in the Minimum Till system.

We can see how all of this translates into net return to labor and management in the last column of Table 1 data. In calculating this net return, an opportunity cost for land was charged (the same charge for all systems), but no charge for labor (regardless of source) was deducted. As in the case of net returns to land and management, no charges for the planning and risk taking elements of management were deducted. Thus, we are left in the last column with a residual return to labor and management, expressed on a per hour of labor(rather than per acre) basis.

Even though labor intensity was highest for the Alternative system in Study I, per hour net return to labor and management was also highest for that system ($26/hour). Conversely, labor intensity and per hour return ($8/hour) to labor both were lowest for the Ridge Till system. In Study II, though per acre returns to land were quite close for the Alternative and Conventional systems, the rank order was reversed for returns to labor, with the Alternative system being slightly higher ($14/hour) than the Conventional system ($13/hour). This reversal is due to the relatively low labor intensity of the Alternative system in Study II. The Minimum Till system in Study II, which was a heavy user of chemical pesticides, averaged only $1/hour in net return to labor and management after deducting all other costs.

Discussion

Let us return now to that portion of the original question dealing with implications of sustainable agriculture for farm size. The data just presented indicate that some sustainable farming systems have potential for being economically competitive with conventional systems in the Northern Great Plains. The case sustainable (Alternative) systems were found to be competitive from the standpoints of both return to land and return to labor. The sustainable system was the most labor intensive in one comparison (Study I) and the least labor intensive in the other (Study II). Table 2 contains data placing these findings in the context of farm size. Since the Ridge Till and Minimum Till systems were weakest in terms of both net return measures, those systems are not included in the remaining comparisons.

The first two columns show net return to labor and management and total labor use on hypothetical farms using each system for 600 acres of cropland. These farms would be near the mean and also near the midpoint of the modal range for farm size in Codington County, South Dakota, where research on the systems was conducted. A farm of this size using the Alternative system of Study I would generate $30,018 in net return to 1,158 hours of labor, compared to less than $20,000 for 1,002 hours of labor with the Study I Conventional system. Slightly more than $13,000 would be generated by a 600-acre farm using either system in Study II, with the Conventional system using 8 percent more labor than the Alternative system (1,020 hours compared to 948 hours).

Many factors combine to influence farm size. However, it is well understood that goals for family income levels are among those factors. Suppose a family goal exists in this case for the farm's crop system to generate $40,000 annually in net return to family labor and management. First

assuming no limits in available family labor, farm sizes (in acres) necessary to generate that much income are shown for each system in the third column of Table 2. In the Study I comparison, the farm size would be approximately one-third smaller with the Alternative system (797 compared to 1,260 acres). Farm size would be about the same (around 1,800 acres) for both systems in Study II.

However, unlimited family labor is an unrealistic assumption. For the sake of demonstration, let us assume 1,200 hours of family labor (40 hours/week) to be available for field work over the April-October 7-month period in Study I and 1,040 hours over the April-September 6-month period in Study II. The calculations for the last column of Table 2 include an assumption that each of the 1,200 hours of family labor in Study I and the 1,040 hours in Study II generate the net hourly return shown for each farming system in the last column of Table 1. For example, with the Alternative system of Study I, 1,200 hours of labor at $26/hour generate $31,200 in net return to labor and management. That leaves the family $8,800 short of its income goal, which I assume can be met by expanding farm size. Expanding farm size would involve hiring labor, at an assumed cost (including fringe benefits) of $8/hour. Thus, for each hour of labor hired (and associated additional acres farmed), the net return to the farm family using Study I's Alternative system increases by $18 ($26 minus $8) . It would therefore require an addition of 489 hours in labor ($8,800/$18 per hour)--to farm 253 more acres of cropland (489 hours/1.93 hours per acre)--to reach the $40,000 income goal. That would bring farm size for the Study I Alternative system to 875 acres (1,689 hours/1.93 hours per acre).

This same approach was used for calculating the other three acreages in the last column of Table 2. These data show that farm size would be cut roughly in half if the Alternative system replaced the Conventional system of Study I (875 acres compared to 1,655 acres). In Study II, the target income could be reach with an Alternative system farm that is about 10 percent smaller than the Conventional system farm (3,342 acres compared to 3,727 acres).

Study I contains combinations of corn, soybeans, and small grains. These farming systems represent the western edge of the Corn Belt in the Northern Great Plains. Here, it appears that widespread adoption of sustainable farming systems would tend to halt or reverse the trend of ever-increasing farm size.[4]

The evidence is less clear in predominantly small grain areas of the Northern Great Plains, which farming systems in Study II represent. Labor intensity is less for some sustainable systems than for conventional systems in the wheat regions, which might imply larger farm size for the sustainable systems. However, the analysis in this paper demonstrates that net returns to labor and family income goals could enable sustainable farms to meet income goals with acreages of similar or slightly smaller size than conventional farms.

Although the reduced tillage (Ridge Till and Minimum Till) systems were not included in Table 2, the combination of their relatively low labor intensities and low net returns to labor and management (Table 1) suggests

[4]Readers should keep in mind, however, that most recent studies in the Corn Belt have shown that more diverse, low-input/sustainable farming systems tend to be less profitable than conventional corn-soybean rotation systems--given the economic and policy environment of the late 1980s and early 1990s (Dobbs, 1992).

that quite large reduced tillage farm sizes might be required to achieve family income goals in the Northern Great Plains. Thus, if soil conservation continues to be pursued primarily through chemical intensive reduced tillage, a structure of agriculture could emerge in the Northern Great Plains that involves even larger farms than under conventional agriculture.

Differences between systems in their management demands have not been addressed in this analysis, because those differences are very difficult to quantify. To the extent expanding farm size with hired labor is necessary to achieve family income goals, expansion may be more feasible with conventional and reduced tillage systems than with sustainable systems. Sustainable systems tend to require more detailed attention to soil, weed, and insect conditions and more precise timing of field operations. It is hard to delegate that management attention to hired laborers, except under special conditions where long-term, trusted individuals are employed. At the other extreme, reduced tillage systems that are heavily dependent on prescription chemical approaches to fertility and pest control enable management to be spread over large acreages, using hired labor or custom operators for many of the field operations. Lower demands on management time with reduced tillage and conventional systems, relative to sustainable systems, can partially offset the sometimes lower net returns to "labor and management" of those systems. Thus, where returns to labor and management are not substantially lower for conventional and reduced tillage systems, those systems might continue to prevail over sustainable systems and average farm size could continue to increase.

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Table 1. South Dakota Farming Systems Comparisons: 1986-1992 Averages

System	Net Return to Land & Mgmt. ($/acre)	Labor Intensity (hours/acre)	Net Return to Labor & Mgmt. ($/hour)
Farming Systems Study I			
1. Alternative (oats-alfalfa-soybeans-corn)	$63	1.93	$26
2. Conventional (corn-soybeans-s. wheat)	$49	1.67	$19
3. Ridge Till (corn-soybeans-s. wheat)	$32	1.52	$ 8
Farming Systems Study II			
1. Alternative (oats-clover-soybeans-s. wheat)	$38	1.58	$14
2. Conventional (soybeans-s. wheat-barley)	$39	1.70	$13
3. Minimum Till (soybeans-s. wheat-barley)	$20	1.63	$ 1

Note: All dollar values in the table were rounded to the nearest whole number.

Table 2. Implications for Farm Size

System	600-acre Farm		Farm Size Needed to Generate $40,000 in Net Return to Family Labor & Mgmt.	
	Net Return to Labor & Mgmt. ($)	Total Labor (hours)	No Limit on Family Labor (acres)	Family Labor Limited* (acres)
Farming Systems Study I				
1. Alternative	$30,108	1,158	797	875
2. Conventional	$19,038	1,002	1,260	1,655
Farming Systems Study II				
1. Alternative	$13,272	948	1,808	3,342
2. Conventional	$13,260	1,020	1,810	3,727

*Limit = 1,200 hours in Study I and 1,040 hours in Study II.