AN ECONOMIC EVALUATION OF REDUCED TILLAGE WHEAT PRODUCTION IN OKLAHOMA

By

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AN ECONOMIC EVALUATION OF REDUCED TILLAGE

WHEAT PRODUCTION IN OKLAHOMA

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CHAPTER I

INTRODUCTION

General Problem

Since the late 1800's, American agriculture has made huge advances in the production of food and fiber. During this period, farmers have witnessed the passing of horse drawn equipment, the evolution of petroleum powered farm machinery, and the pioneering of farm micro-computers. These changes coupled with scientific advances in plant and animal husbandry have made it possible for a shrinking agricultural work force to produce larger quantities of farm products.

In the last 50 years agricultural production has been increased mainly by using more inputs purchased off the farm (Tweeten, 1979). This trend has made farmers more dependent upon other sectors of the economy and has greatly added to the cash cost of production. In the past, yield responses and product prices were large enough to easily cover added input costs. However, in 1976 Tweeten and Griffin found that prices paid by farmers for farm inputs were inflating faster than prices received by farmers. This trend has placed farmers in a price-cost squeeze and applied downward pressure on farm income. As a result of changes in the relative price ratios of farm inputs and farm output, farmers are interested in the possiblity of changing resource mixes. By finding less costly means of production, farmers may find temporary relief from the price-cost squeeze.

Another problem faced today by agriculture is the need for better soil and water conservation. This chronic problem has plagued farmers ever since the first plow was used in the colonies. At that time the land was naturally protected from erosive rains by a thick sod or leaf canopy. As more land was brought into production, larger areas of soil were left exposed. Consequently, huge amounts of our most productive soils have been lost to erosion. Even with the extensive work to bring soil erosion under control, it is estimated that the United States loses 2.7 billion tons of soil solid material each year (Heath, Metcalfe, and Barnes, 1973). This is equivalent to losing the top six inches of top soil from 2.7 million acres, which is nearly the size of Connecticut.

Farmers' cultural tillage practices are greatly responsible for soil erosion losses. Even with well designed terrace and waterway systems, exposed soil is eroded faster than it is formed by crop residue. If farmers could leave more crop residue on the soil surface, soil erosion would be greatly reduced. Thus, crop residues offer a means to complement existing investments in terrace and waterway construction. It is even possible that in certain situations crop residues may be a substitute for the large investments in terraces and waterways.

Specific Problem

At this point in time, little if any research has been conducted to estimate the production costs of reduced tillage wheat in Oklahoma. As farmers evaluate the need for conventional tillage operations, more and more questions are raised about the machinery cost reductions realized with reduced tillage wheat production. Little is known about how increased herbicide usage affects the size of a farmer's machinery set.

As a result of these questions more economic information is needed to better understand existing input price relationships and the substitution of chemical herbicide applications with tillage operations.

Reduced tillage wheat production systems are not new to Oklahoma wheat farmers. Agricultural researchers began working with reduced tillage wheat in 1930 at the Wheatland Conservation Experiment Station near Cherokee, Oklahoma (Daniel, Elwell, and Cox, 1947). Unfortunately, it was too late to prevent the tremendous soil losses suffered during the "Dust Bowl" period of the late 1930's. Their research, conducted over a period of 17 years, studied traditional clean tillage wheat against a newly conceived stubble mulch system. They found that the stubble mulch system greatly reduced run-off and soil erosion, but consistently yielded less wheat than the clean tillage systems. These yield differences were largely attributed to weed control problems in the stubble mulch systems.

Since then several chemical herbicides have been developed and labeled for use on wheat. These chemicals have the potential to help control problem weeds and made reduced tillage wheat production more promising. As reduced tillage wheat has become more technically possible, soil conservationists have become more interested in it as a means to reduce soil erosion. Farmers are also interested in ways to reduce production costs. However, the acceptance or rejection of reduced till-wheat production depends partly upon its costs relative to cost of conventional tillage wheat production.

Purpose of the Study

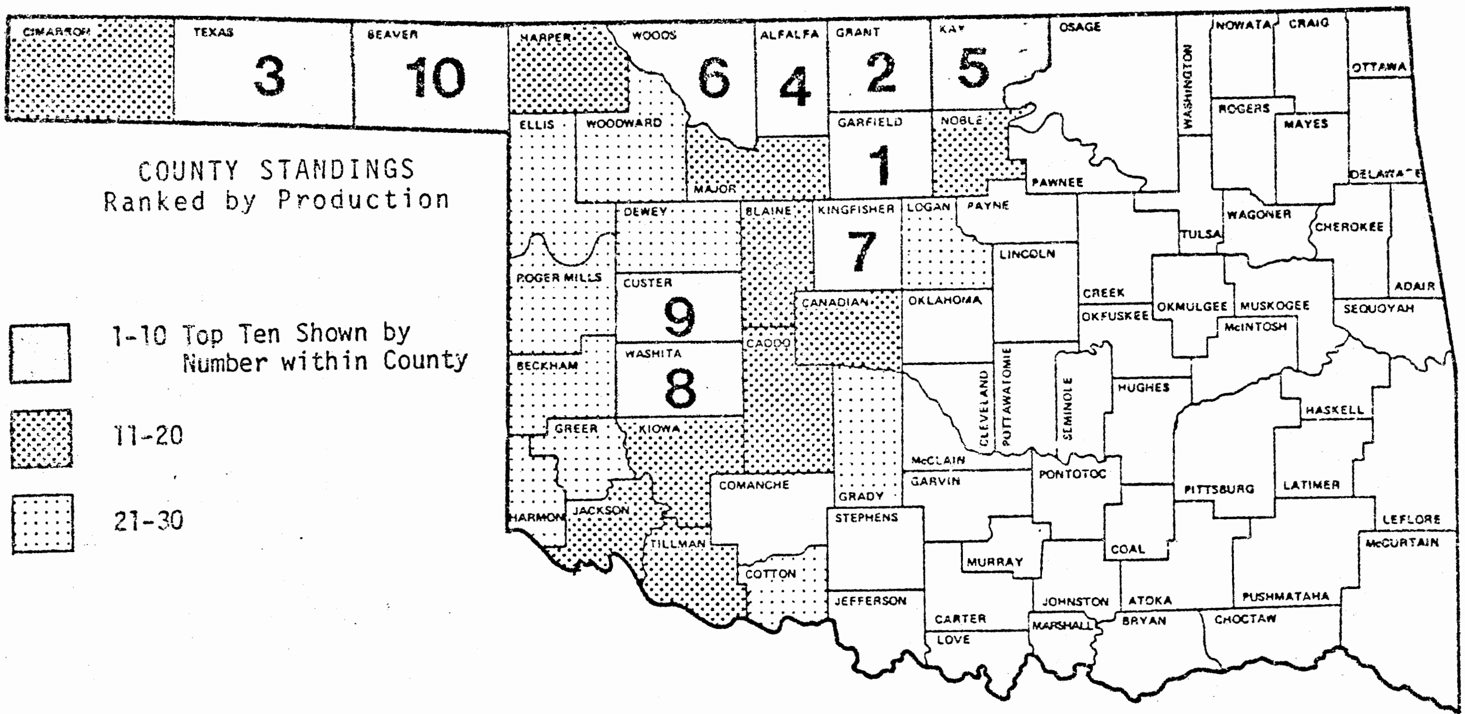
The overall objective of this study is to investigate whether "experimental" reduced tillage wheat production systems are less costly than more conventional methods of producing wheat in Oklahoma. More specifically the objectives are:

1. Identify various wheat production systems.
2. Estimate the machinery requirements and optimal machinery complements for each system.
3. Estimate the variable costs and fixed costs for each system.
4. Investigate the sensitivity of the systems' costs to changes in key parameters.

Study Area

Wheat production systems vary greatly across Oklahoma depending upon soil types, precipitation patterns, and individual farmers' attitudes. In order to help bound these variables, Garfield County in North Central Oklahoma was chosen as the area of study. Farm size also varies greatly and affects the machinery complement size and cost. For the purpose of this study, farm size was fixed at two sections of land or 1,280 acres. This land is used to produce 1,240 acres of continuous winter wheat with 40 acres of improvements, waterways, and waste.

Garfield County is in the heart of the Oklahoma wheat belt shown in Figure 1. In 1980, Garfield County was the leading wheat producing county in the State, producing 13.89 million bushels (Oklahoma Crop and Livestock Reporting Service, 1981). Wheat in 1980 was produced on 57.8 percent of the 675 thousand acres in the county. Thus, wheat is by far the largest single crop produced in the county. Due to this large



Source: Oklahoma Crop and Livestock Reporting Service, Oklahoma Agricultural Statistics, 1980.

Figure 1. Map of Oklahoma Showing the Area of Study and County Wheat Production Ranking in 1980.

county wheat acreage it was felt that Garfield County farmers would have the largest potential to use reduced tillage wheat production.

Garfield County has a continental, temperate, subhumid climate. This climate is dominated by warm moist air flowing from the Gulf of Mexico, which frequently causes dramatic weather changes as it meets drier and colder air from the north. The rainfall data collected from 1931-1960 show an average annual precipitation rate of 29.15 inches (Table 1). The annual precipitation has ranged from a low in 1956 of 13.42 inches to a high in 1957 of 51.46 inches. Over this period of years, the annual rainfall was distributed about 12 percent in winter, 30 percent in spring, 35 percent in summer, and 23 percent in fall (U.S. Department of Agriculture, 1967). With 58 percent of the annual precipitation falling during summer and fall, ti led wheat fields are very vulnerable to soil erosion losses.

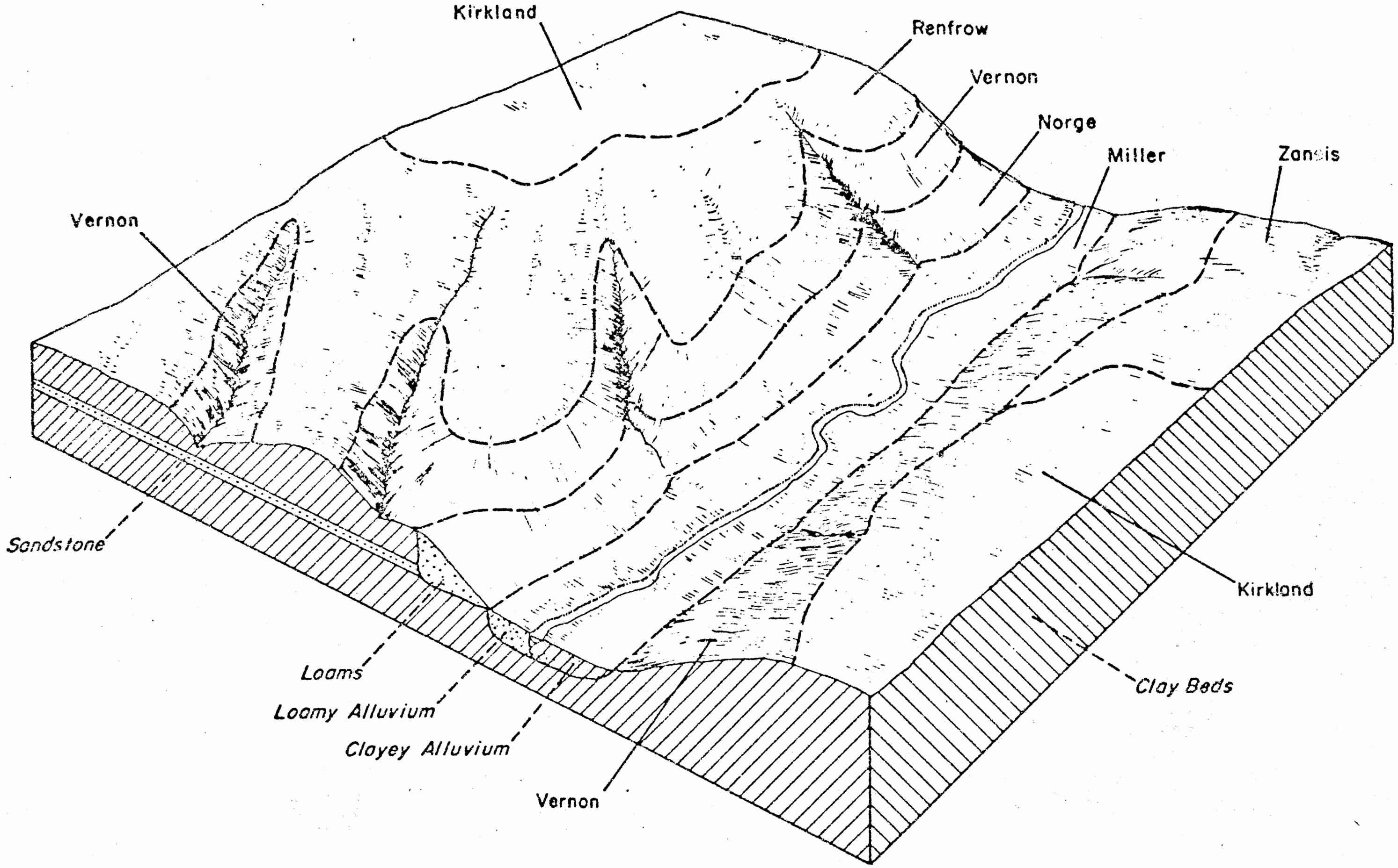
Garfield County is located near the eastern edge of the Great Plains in what is called the red-bed plains of northcentral Oklahoma. The streams flow southeastward with drainage channels dissecting the county at approximately one mile intervals. These drainage channels give the land a contour.

Soil type is an important variable in machinery selection problems. The machinery sizes used in this study were selected for use on clay-loam soils, such as the Renfrom-Vernon-Kirkland Association (Figure 2). These soils are found on the sides of drainage channels and cover about 23 percent of Garfield County. About nine-tenths of this association is cultivated, mainly to wheat. Due to their clayey subsoil, these soils absorb moisture slowly and require good soil conservation practices.

Table 1. Garfield County Monthly Average Precipitation From 1931-1960

Month	One Year in 10 Will Have Less Than - (inches)	One Year in 10 Will Have More Than - (inches)	Average Total (inches)
January	0.1	2.4	1.02
February	0.3	2.4	1.20
March	0.4	3.4	1.58
April	0.7	6.9	2.93
May	1.2	8.2	4.37
June	1.0	7.6	3.86
July	0.2	6.2	2.76
August	0.6	6.7	3.46
September	0.4	5.9	2.96
October	0.4	5.4	2.27
November	0.0	4.2	1.43
December	0.1	3.1	1.31
Year	18.5	40.3	29.51

Source: U.S. Department of Agriculture. Soil Survey of Garfield County, Oklahoma.



Source: U.S. Department of Agriculture. <u>Soil Survey of Garfield County, Oklahoma</u>.

Figure 2. Typical Pattern of Soils in Renfrow-Vernon-Kirkland Association.

Summary of Procedures

With the help of agronomists, a series of wheat production systems will be defined. This series of systems will range from conventional clean tillage systems to zero-tillage systems. The conventional tillage systems rely on mechanical tillage operations to control weeds, whereas the zero-tillage systems rely on chemical herbicides. Between these extreme types of systems, are a number of systems which use various levels of herbicides and tillage operations. Given the system definitions, the required field operations and operating inputs are identified for each system.

Using these system definitions, a set of machinery or a machinery complement will be selected for each wheat production system. Each machinery complement will be capable of performing the required field operations in the time that is available on the case study farm. These machinery complements will be selected by an integer linear programming model, which minimizes total machinery costs. Therefore, the complements are not only capable of performing the required field operations, but perform the services at the least-cost.

Once the optimal machinery complements are selected, the tractor-implement combinations for each field operation can be identified. These tractor-implement combinations are entered into enterprise budgets along with operating input information. Given these data, enterprise budgets are formulated for each wheat production system. These budgets illustrate how costs change between the systems. Of particular interest is the trade-off between machinery costs in the conventional systems with the herbicide costs in the reduced tillage systems. The budgeting process will also provide useful estimates of fuel, labor, and capital requirements of the systems.

The final procedure in the study is to expand the base set of budgets to reflect the costs of the systems when interest rates, fuel prices, and wage rates change to several levels. Based on this information, inferences can be drawn as to future acceptability of reduced tillage wheat production. These budgets also make the study's results adaptable to many different situations.

Literature Review

A computerized search of available data bases (CAB, CRIS, AGRICOLA) revealed few references on the subject of reduced tillage wheat production. Of the references found, a majority were from international information sources. It appeared from these references that most work on reduced tillage wheat production has been published in Canada. One such study by Rowell, Osborn, and Matthews (1977) reported the results of a seven year experiment dealing with the effects of reduced cultivation on wheat yields in New South Wales. The study began in 1967 and was designed to study the value of bipyridilium herbicides as substitutes for mechanical weed control. They found the direct drill plots averaged 1.97 tons of grain per hectare compared to 2.02 tons of grain per hectare for the conventional tillage plots. Although the reduced tillage plots averaged lower yields, the difference was not statistically significant. An additional observation made in the study was the tendency for grass weeds to build up under the minimum cultivation techniques.

In the United States limited research has been conducted on reduced tillage wheat production since 1930. In 1930, agricultural researchers at the Oklahoma Experiment Station were studying a newly conceived method of wheat production called "stubble mulching". They believed this system could be the answer to the serious soil conservation problems suffered in the "dust bowl" days. Since this research, Texas, Nebraska, and Oregon Experiment Stations have participated in reduced tillage wheat production studies. These studies were designed mainly by agronomists and soil scientists. As a result, the literature published addresses agronomic issues in reduced tillage wheat production; such as herbicide effectiveness, soil water storage and runoff, weed control problems, and crop yield. The studies also deal mainly with winter wheat-fallow rotations. In these systems the production cycle is two years. Therefore the studies have limited value to Oklahoma where continuous winter wheat is grown. Only one economic study on reduced tillage wheat production was found in the literature.

In 1951 Daniel, Elwell, and Cox reported the results of a 21 year research project on stubble mulch wheat production. The research was conducted at the Red Plains Station of the Oklahoma Experiment Station. The researchers found that bare fallowed land generated 986 times more soil erosion losses than Bermuda grass pasture land. Over an eight year period from 1942-1950, the researchers reported the stubble mulch systems averaged 14.8 bushels per acre compared to the one-way plow systems' average yield of 18.5 bushels per acre. These yield differences were largely attributed to consistently heavy infestations of cheat and weeds in the stubble mulch systems.

Wiese, Bond, and Army reported in 1960 the results of a chemical fallow study from 1955-1958. The study was conducted at Bushland, Texas and was designed to evaluate herbicides for chemical fallow and to determine the effects of chemical fallow on moisture storage, crop yields, and residue conservation. They found 2,4-D successfully controlled broadleaf weeds, but could not find a herbicide to adequately control grasses. They concluded that when good weed control was possible, the reduced tillage systems could obtain moisture storage and crop yields comparable to present dryland tillage practices. They discounted the possibility of increasing either yields or moisture storage by using chemical fallows.

Another research project on chemical fallows was conducted at the Nebraska Experiment Station from 1959-1962 (Fenster, Burnside, and Wicks, 1965). This study was designed to test the feasibility of several herbicides for use in chemical fallows. In the trial, Atrazine or Prometone at four pounds per acre controlled 100 percent of the weeds during the fallow period. However, these chemicals also tended to persist in the soil for a longer than desired period of time. As a result the wheat plants frequently suffered serious injury. The researchers concluded that more suitable herbicides or cropping rotations must be devised before the reduced tillage systems could be feasible.

The effects of no-tillage and different times of stubble mulch tillage operations on moisture storage, nitrate accumulation, and wheat yields were studied at the Oregon Experiment Station from 1962-1965. Oveson and Appleby (1971) reported the no-till systems stored significantly less moisture in the top 15 centimeters than the conventional tillage systems. However, at a depth of 1.8 meters the systems were comparable at storing moisture. The yields for the chemical fallow systems generally were lower than the conventional tillage plots, although the differences were not statistically significant. The authors did not make any comments about weed control problems in the chemical fallow systems. Overson and Appleby were among the first to imply the need for economic analysis of chemical fallow systems, since weed control was becoming less of a problem.

At North Platte, Nebraska in 1963 a study was initiated to determine whether chemical fallow was feasible for the alternate winter wheat-fallow rotation commonly practiced in the central Great Plains (Wicks and Smika, 1973). In the experiment five fallow treatments were compared over a five year period. The principal herbicides used in the study included Atrazine, Amitrole, and Paraquat. The best weed control in the 14 month fallow was achieved by using herbicides, while the poorest control was realized in the plow and stubble mulch systems. In the six years of the study, wheat yields for all the systems were excellent. In this study the highest yields were achieved with the chemical fallow systems. The stubble mulch system and plow system yielded the poorest. The yields of the Paraquat plus Atrazine herbicide systems were statistically higher than the stubble mulch system.

Retzlaff and Hofman (1980) conducted an economic study of the energy requirements of six wheat production systems. They argued that while energy conservation is important, drastic energy conservation measures in the farm sector would hardly be detectable in the total U.S. energy budget. This is because the production of farm commodities accounted for only 2.9 percent of total U.S. energy consumption in 1976. In the study six wheat production systems were defined: two conventional, two ecofallow, and two chemical tillage. The energy requirements for chemical production were roughly estimated at one gallon of diesel fuel per pound of active chemical ingredient. The study concludes that three to four gallons per acre of diesel fuel could be saved by moving from a conventional to a chemical fallow system.

Although Retzlaff and Hofman do a fairly adequate job of estimating fuel requirements for various wheat production systems, no estimates are made with respect to chemical and/or machinery costs. It is evident from the literature that reduced tillage wheat production may be technically possible with todays chemical herbicides. But the lack of economic literature in the area certainly points to the need for a thorough economic evaluation of reduced tillage wheat production.

CHAPTER II

THE MODEL

Introduction

In this chapter a general model is developed and applied to the case study farm. This general model is designed as a means of accomplishing the objectives of the study. The major components of the general model correspond closely to the procedures outlined in Chapter I.

This chapter is organized into two major sections. In the first section, the question of reduced tillage versus conventional tillage wheat production will be addressed in the context of economic theory. The question will be presented as an economic problem and developed in an economic framework.

Based on this economic theory, a general model will be developed in the second major section of the chapter. In addition to the general model and procedures, this section will outline the data requirements. The results from the general model are discussed in the next chapter.

Alternative Wheat Production Systems:
An Economic Problem

Economic problems deal with allocating scarce resources among competing wants in such a manner as to satisfy the wants as fully as possible. Included in this definition are three major components that characterize economic problems. The first important characteristic found in an economic problem is scarcity of resources. Scarcity implies that the quantities of most resources are limited within a given period of time. Because resources are limited, they have a value which is measured by a price. This price helps guide the allocation of resources. The allocation dilemma of scarce resources is the second characteristic of economic problems. Resources have many alternative uses and human wants always surpass what the resources can provide. Therefore, resources must be allocated among competing alternatives to obtain the "best" use of the fixed quantities of resources. Best depends upon some type of criteria, which is the third characteristic of economic problems. A criteria is an important standard against which alternative allocations of resources can be judged. Thus, economics provides a framework in which resource allocation problems can be studied to achieve maximal goal achievement. For these reasons, Doll and Orazem (1978) summarize economics as the science of choice making.

The question of reduced tillage versus conventional tillage wheat production has these attributes of an economic problem and can be studied in an economic framework. This problem can be viewed as an allocation of two scarce and costly resources, chemical herbicides and farm tillage operations. Through a better allocation of these resources, producers may find a resource mix that increases net returns from their wheat enterprise.

The Factor-Factor Model

Allocation problems of this type can be studied by using a factor-factor production economics model. Figure 3 graphically depicts the economic relationships of a factor-factor model, with curves Y_1 and Y_2 representing two individual isoquants from an infinite family of isoquants. Each isoquant represents the set of all possible combinations of X_1 and X_2 that yield a fixed quantity of output. For example, a_1 and b_1 quantities of resource X_1 and X_2 yield output Y_1. By moving along the curve Y_1, the quantities of X_1 and X_2 will change as one resource is substituted for the other. Although the level of production (Y_1) does not change as movement is made along the isoquant, the total variable costs will change. Total variable costs are minimized for each isoquant at the combination of X_1 and X_2 where the marginal rate of substitution between the two resources is equal to the ratio of the resource prices (Leftwich, 1979). The set of all these least-cost combinations form a line called the expansion path. The least-cost combination to produce Y_1 in Figure 3 is the point of intersection of the expansion path and the Y_1 isoquant.

Application of the Factor-Factor Model

The factor-factor model is helpful to conceptualize the problem of reduced tillage versus conventional tillage wheat production. Chemical herbicides and tillage operations can be viewed as two competitive resources used to control weeds. Since both resources are factor of production and used to control weeds, a trade-off exists between the resources. One farmer may choose to produce wheat with the more

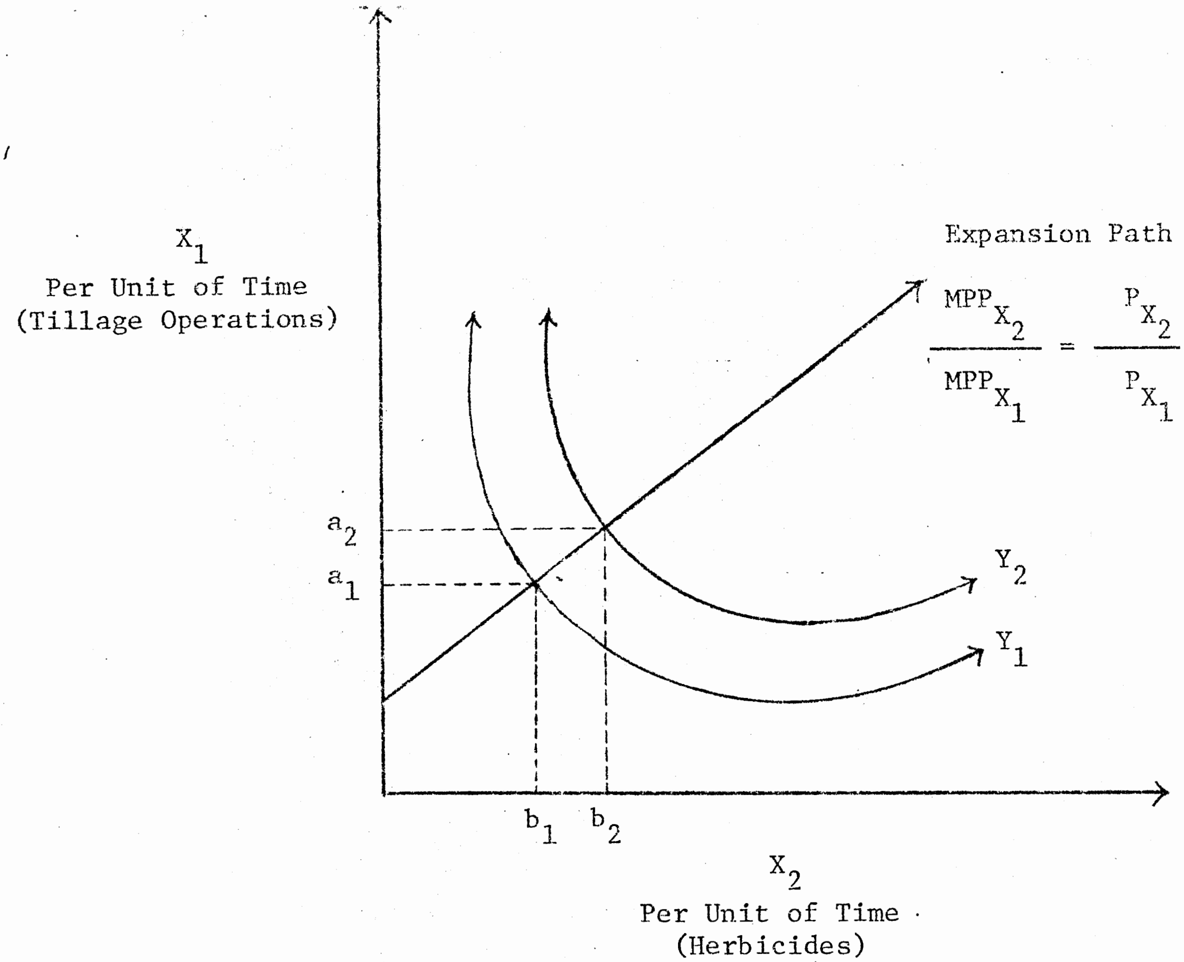


Figure 3. Factor-Factor Production Economics Model

traditional method of intense tillage, while another farmer may choose to apply more chemical herbicides and reduce the number of tillage operations. If both farmers produce equal amounts of wheat, ceteris paribus, the two wheat production systems represent two points on an isoquant. Because the two resources are substitutes, the isoquants have negative slopes as illustrated in Figure 3.

If researchers knew precisely the production function of wheat, this allocation problem could be quickly resolved. Based on the wheat production function, the factor-factor model would indicate the number of tillage operations and the quantity of herbicides that should be used. Unfortunately, the real production function of wheat is a vastly more complex relationship. A large number of factors interact to produce each bushel of wheat. For this reason, it is impossible to estimate a simple mathematical function which accounts for all the factors and interactions. Without the production function, marginal physical products and marginal rates of substitution cannot be estimated. Therefore, the factor-factor model cannot be used to find a global profit maximum.

Enterprise Budgets

Enterprise budgets can be used to analyze factor-factor relationships of complex production functions. An enterprise budget is a statement of the expected outcome from a particular production practice (Jobes, 1978). Each enterprise budget projects the total factor costs and total revenue for one point on the production surface. By formulating enterprise budgets with different resource combinations, many different production possibilities can be studied.

Enterprise budgets will be used to model a number of alternative wheat production systems. A series of wheat production systems can be designed with various mixes of herbicide applications and tillage operations. By experimentally designing these systems with varying levels of herbicide and tillage usage, enterprise budgets can be used to compare total costs between the systems.

Due to the experimental nature of these systems, little data are available on yield responses to changing levels of herbicide applications and tillage operations. Research is currently under way to investigate these yield responses. But for this study, yields are ignored. If each system results in identical wheat yields, the budgets would reflect points on one isoquant. In this case, the budgets could be used to solve for, or approximate, the least-cost combination of resources. However, it is probably more realistic that yield differences do exist between systems. This will in the future require an analysis to include both changes in marginal cost and marginal revenues between the experimental system. Since yield data are not available, the enterprise budgets in this study will be used to find the production possibility point in the series of systems with the least total cost.

Model Development and Data Requirements

In this second section of Chapter II, a general model is developed to economically evaluate conventional and reduced tillage wheat production systems. This general model embodies the procedures discussed in Chapter I. By building the procedures into a general model, the sequence and interactions of the procedural steps can be more easily grasped. In addition to the general model, this section presents various data required by the model to describe the case farm situation.

Outline of Model and Procedures

Since enterprise budgets are a means of economically evaluating various wheat production systems, their formulation is an important part of the general model. To formulate these budgets, four major steps are used.

The first step is to define a series of wheat production systems in terms of operating inputs and tillage requirements. The operating inputs include items with variable costs of production, such as seed, fertilizer, and herbicides. In addition to specifying the quantities and prices of these items, the timing of their application is also important for annual operating capital charges. The second part of each system definition is the tillage requirements. The tillage requirements refer to the timing and type of each field operation required by a system. Therefore each system has a unique combination of operating inputs and tillage requirements.

The second step in the general model is to identify tractor-implement combinations. Based on the tillage requirements in the systems, tractors and implements must be selected for each field operation. Since the cost of a field operation depends on which tractor-implement combination is selected, these costs are very illusive. To solve this problem, a machinery selection routine is used to find a least-cost machinery complement. This set of machinery provides the field operations for a given system with the least total costs. The machinery selection routine selects the machinery complements from a list of alternative machinery items. This model also formulates constraints based on field work days and timeliness levels. This machinery selection model will be discussed in more detail later.

The third step in the general model is to formulate the enterprise budgets. In this step, the cost of the operating inputs are summed along with the various machinery fixed costs. To facilitate the speed and accuracy of this step, a computerized budget generator is used.

The fourth step in the general model is to modify the enterprise budgets. These modified budgets project the total costs of the base budgets for many different fuel price, interest rate, and wage rate situations. From these final budgets, inferences can be drawn about how reduced tillage wheat production systems can compete with conventional methods.

These four major steps in the general model are shown in a schematic diagram in Figure 4. Flowchart notation is used to outline the different data requirements and steps in the general model. Input data and output material at each step are represented by non-rectangular parallelograms. The four major processing steps are represented by rectangles, while arrows indicate the flow into and from each step.

The remainder of Chapter II is organized into four parts, each covering one of the four steps in the general model. First the systems will be defined in terms of operating inputs and tillage requirements. The second part in this section deals with the machinery selection model. The remaining two parts of Chapter II discuss the computerized budget generator and derive the sensitivity model. This sensitivity model is used to modify the base budgets.

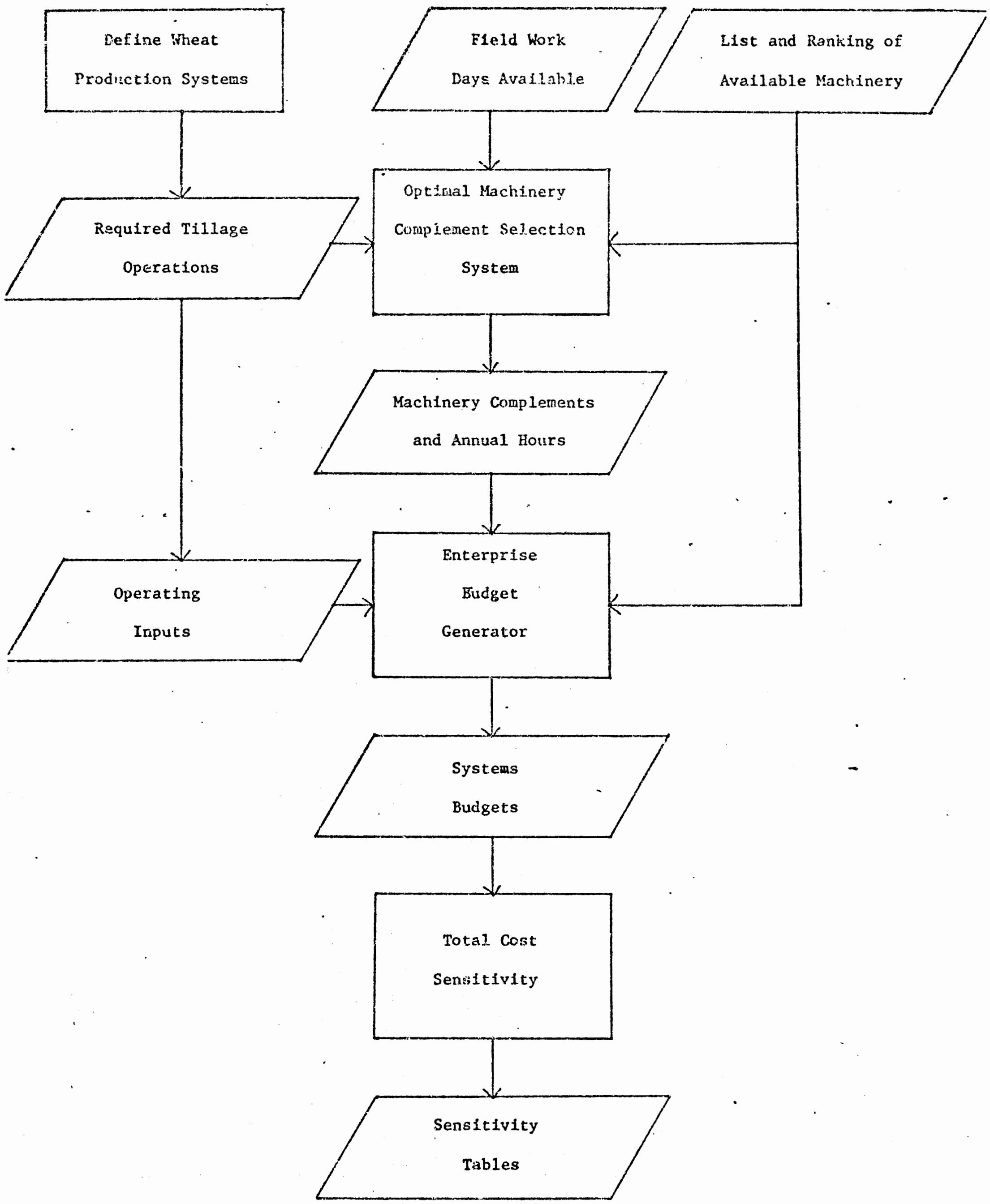


Figure 4. Flow Chart of General Model

Wheat Production Systems

The term "wheat production system" is defined in this study as a unique combination and timing of field operations and operating inputs used to produce wheat. Any variation in the number, timing or quantity of operating inputs and field operations constitutes a different wheat production system. The wheat production systems are defined within a period of one year. Based on this definition, each wheat production system can be represented by one unique enterprise budget.

In this study, 22 systems are defined ranging from three conventional clean tillage systems to two zero tillage systems. The zero tillage name may be misleading since a stubble drill is used which slightly tills the soil. However, the nomenclature is consistent with the industry jargon. Thus, the stubble drill operation will not be included in references made to the number of tillage operations for each system. Three conventional systems are identified to represent wheat production systems in use in Oklahoma. The term conventional is used to denote those systems in widespread use. The major difference between two of these conventional systems is that one uses a moldboard plow as the major tillage implement, while the other uses a chisel plow. The third conventional system is formed by using a combination of the moldboard and chisel plow systems.

Ranging between the conventional and zero tillage systems are four systems which use various levels of herbicides and tillage operations. The systems were designed by an interdepartmental research team at Oklahoma State University. With the aid of agronomists from this team, the systems in this study are designed to closely parallel systems under consideration for test plot experiments by the research team (Peeper, 1981). One of the objectives of this research team is to collect yield data from reduced tillage wheat plots. These data will someday provide estimates of yield differences among the systems.

Tillage Requirements

The field operations for the first eight systems, which range from conventional tillage to zero tillage, are shown in Table 2. All the field operations used in the various systems are shown. The symbol 'XX' in the systems column indicates which field operations are used in each system. Along with the field operations, the timing of each field operation is shown. The first two field operations in Table 2 are insecticide and herbicide applications. Parathion and 2,4-D are used across all the systems to control greenbug and winter annual broadleaf weeds, respectively. In discussions held with agronomists (Peeper, 1981), it was expressed that these two operations are good management practices in any wheat production system for North Central Oklahoma. Herbicide brand names are used in Table 2 and in this study help facilitate communication. The use of brand names is not intended to endorse the use of any particular product.

The eight systems in Table 2 form a base set of systems from which combinations are formulated. Fourteen such (50-50) combinations are formulated to bring the total number of systems identified in the study to 22. Each combination uses one of the base systems (Table 2) on 50 percent of the acreage and another system on the remaining acreage.

Table 2. Required Field Operations of Wheat Production Systems 1-8

		Systems							
Alternatives Field Operations	Time Period	1	2	3	4	5	6	7	8
Aerial Insecticide Application	Feb. 15 - March 15	XX	XX	XX	XX	XX	XX	XX	XX
Spray 2-4-D	Feb. 15 - March 15	XX	XX	XX	XX		XX	XX	XX
Aerial Surflan + MCPA Application	April 1 - 15					XX			XX
Spray Bladex + Paraquat	June 16 - 30				XX			XX	
Sweep Applying Bladex	June 16 - 30			XX					
Sweep Applying Bladex and NH_3	June 16 - 30						XX		
Off-Set Disk (first time over)	June 16 - July 15	XX	XX						
Moldboard Plow	June 16 - July 15	XX							
Chisel Plow (first time over)	June 16 - July 15		XX						
Chisel Plow (second time over)	July 16 - 31		XX						
Spread Dry Fertilizer	August 1 - 15	XX	XX						
Off-Set Disk (second time over)	August 1 - 16	XX							
NH_3 Knife Applicator	August 17 - Sept. 15	XX	XX						
Sweep Applying NH_3	August 17 - Sept. 15			XX	XX	XX			
Liquid Nitrogen Applicator	August 17 - Sept. 15							XX	XX
Spray 2-4-D (1/2 total acreage)	August 17 - Sept. 15			XX	XX	XX	XX	XX	XX
Field Cultivator (first time over)	August 1 - 15		XX						
Field Cultivator (first time over)	Sept. 16 - 30	XX							
Field Cultivator (second time over)	Sept. 16 - 30		XX						
Spray Paraquat	Sept. 16 - 30						XX	XX	XX
Conventional Drill	Sept. 16 - 30	XX	XX						
Stubble Drill	Sept. 16 - 30			XX	XX	XX	XX	XX	XX

In the following discussion, the 22 systems are defined in terms of tillage requirements. Since the combination systems are developed from the eight base systems, only the tillage requirements of the first eight systems are discussed in detail. After these eight systems are defined in terms of tillage requirements, the 14 combination systems are identified with respect to their component systems. Given these tillage requirements, the systems are further defined in terms of operating inputs. In the following discussion, each system is named and given an identification number. These system numbers will be used to address the systems in the remainder of the study.

System 1 - Conventional Tillage (Plow). System 1 is one of three conventional systems identified. This system used a moldboard plow as the major tillage tool. Plowing is preceded by an offset disk operation. The offset disk is used to slow the hardening of the soil due to drying. By tilling the soil as quickly as possible with an offset disk, later deep tillage operations can be performed over a longer period of time. After the plow, the off-disk is used a second time to level and firm the soil. Dry starter fertilizer is applied with a fertilizer spreader and incorporated with a field cultivator. The starter fertilizer, 18-46-0, is used to satisfy the phosphate requirement and some of the nitrogen requirement. The remainder of the nitrogen requirement is filled by anhydrous ammonia, which must be knifed into the soil. The field cultivator is used to perform the final seedbed preparation. The wheat is seeded with a conventional drill. The timing of these field operations is shown in Table 2.

System 2 - Conventional Tillage (Chisel). System 2 is the second of the three conventional systems identified and uses a chisel plow as its major tillage tool. As in System 1, an offset disk is the first tillage tool used after harvest. Unlike the plow, the chisel is used twice during June and July. After the second chisel operation, starter fertilizer is spread using a dry fertilizer spreader. The fertilizer is then incorporated into the soil with a field cultivator. This incorporation is necessary because phosphate is not mobile in the soil profile. Next, anhydrous ammonia is applied with a knife applicator. Final seedbed preparation is accomplished with a field cultivator. The field cultivator is followed by a conventional drill to sow the wheat.

System 3 - Two Tillage (Bladex + Sweep, Sweep). This system uses two tillage operations with a stubble mulch or sweep plow. The sweep is the major tillage tool and is used for tillage, spray application, and anhydrous ammonia application. The first sweep operation is performed immediately after harvest. This operation controls existing weeds by severing the roots below the soil surface. During this operation, a residual herbicide, Bladex, is applied. Bladex should control weeds, and in particular grasses through the summer months. The second sweep operation occurs in late August or early September. Anhydrous ammonia is applied simultaneously. This tillage should be performed late enough to control volunteer wheat as well as other weeds. This system also uses spot treatments of 2,4-D over one-half of the acreage to help control broadleaf weed problems.

A "stubble" drill is required by the reduced tillage systems. This drill is much heavier than a conventional drill. Since the soil has not been extensively tilled, fluted colters on the stubble drill penetrate through the wheat straw and till a small band of soil for seed placement. These fluted colters are specially adapted rolling cutters similar to disk blades. The stubble drill is also equipped with fertilizer boxes so that starter fertilizer, 18-46-0, can be applied through the drill.

System 4 - One Tillage (Bladex + Paraquat, Sweep). This system is identical to System 3 except that the first sweep operation is replaced with a herbicide application. Paraquat is used in a tank mix with Bladex and applied with a ground spray rig. Paraquat is a contact herbicide and controls existing vegetation just as the sweep in System 3. Bladex should control weeds through the summer months.

System 5 - One Tillage (Surflan + MCPA, Sweep). System 5 uses an experimental residual herbicide, Surflan, in early April to control weeds throughout the summer. This herbicide is in the later stages of development and testing and is not commercially available. However the chemical is expected to be available in the near future. Surflan is applied over the standing wheat crop as a pre-emergent herbicide. The first 2,4-D application in late February or early March is substituted in this system by a MCPA application. MCPA is similar to 2,4-D except that wheat plants are more tolerant of MCPA. This tolerance allows application of MCPA later in the growing season with less danger of plant injury. It also allows the MCPA to be applied in a tank mix with Surflan for aerial application. This eliminates one spray operation that the systems without Surflan require. In late summer, anhydrous ammonia is applied with the sweep, which should control existing weeds.

As with the other reduced tillage systems, 2,4-D is spot applied over one-half the acreage. The starter fertilizer is applied through the stubble drill.

System 6 - One Tillage (Bladex + NH_3 + Sweep, Paraquat). This system used only one tillage operation. A specially equipped sweep is used to apply both Bladex and anhydrous ammonia simultaneously in late June. The sweep will control any existing weeds and the Bladex should control weeds through the summer. In August and September 2,4-D is used on one-half the acreage to control any problem broadleaf weeds. Paraquat is used to control all the vegetation in the field before the stubble drill operation. The wheat is sown and starter fertilizer is applied with a stubble drill.

System 7 - No Tillage (Bladex + Paraquat, Paraquat). This system is similar to Systems 3 and 4. In System 7, the sweep is totally replaced by herbicide applications. In late June, after harvest, a tank mix of Bladex and Paraquat is applied to control existing and emerging weeds. Liquid nitrogen is used as the second source of nitrogen since anhydrous ammonia cannot be applied without some type of tillage operation. Broadleaf weeds are spot controlled with 2,4-D over one-half the acreage. Paraquat is used to control weeds ahead of the stubble drill, which applies the starter fertilizer.

System 8 - No Tillage (Surflan + MCPA, Paraquat). System 5 is very similar to this system. The sweep used in System 5 is replaced by herbicide applications. Surflan is applied over the standing wheat crop as a pre-emergent herbicide. Liquid nitrogen is used as the second source of nitrogen since anhydrous ammonia cannot be applied without some type of tillage operation. Broadleaf weeds are spot controlled with 2,4-D over one-half the acreage. Paraquat is used to control weeds ahead of the stubble drill, which applies the starter fertilizer.

Combinations. Fourteen combinations are formulated using the eight wheat production systems. In each combination, two systems are used. Each of these two systems is used on 50 percent of the total acreage and alternated between fields each year. Thus, one field never has the same system two years in a row. Combinations are helpful to control weeds which present problems in one system, but are easily controlled by another system. They also offer the possibility of spreading the work load more evenly throughout the year. If two systems have different critical time periods, savings may be realized due to smaller labor and machinery requirements.

Most of the combinations in this study were designed to reduce the total number of acres covered in the later part of June. Systems 1, 2, 3, and 6 require a great deal of field work in the second half of June. Because of this time constraint, machinery must be selected for these systems large enough to perform the field operations in a short period of time. Systems 4, 5, 7, and 8 are not machinery intensive in June. Therefore, most of the combinations were designed to include a system that is machinery intensive and a system that is machinery non-intensive in June. The combinations designed are as follows:

System 9 - 50% System 1 - Conventional Tillage (Plow)
- 50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

System 10 - 50% System 1 - Conventional Tillage (Plow)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

System 11 - 50% System 1 - Conventional Tillage (Plow)
50% System 7 - No Tillage (Bladex + Paraquat, Paraquat)

System 12 - 50% System 1 - Conventional Tillage (Plow)
50% System 8 - No Tillage (Surflan + MCPA, Paraquat)

System 13 - 50% System 2 - Conventional Tillage (Plow)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

System 14 - 50% System 2 - Conventional Tillage (Chisel)
50% System 5 - No Tillage (Surflan + MCPA, Sweep)

System 15 - 50% System 2 - Conventional Tillage (Chisel)
50% System 7 - No Tillage (Bladex + Paraquat, Paraquat)

System 16 - 50% System 2 - Conventional Tillage (Chisel)
50% System 8 - No Tillage (Surflan + MCPA, Paraquat)

System 17 - 50% System 3 - Two Tillage (Bladex + Sweep, Sweep)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

System 18 - 50% System 3 - Two Tillage (Bladex + Sweep, Sweep)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

System 19 - 50% System 6 - One Tillage (Bladex + NH_3 + Sweep, Paraquat)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

System 20 - 50% System 6 - One Tillage (Bladex + NH_3 + Sweep, Paraquat)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

System 21 - 50% System 1 - Conventional Tillage (Plow)
50% System 3 - Two Tillage (Bladex + Sweep, Sweep)

System 22 - 50% System 1 - Conventional Tillage (Plow)
50% System 2 - Conventional Tillage (Chisel)

Operating Inputs

The quantities and prices of the operating inputs applied in each of the 22 systems are shown in Table 3. The operating inputs in Table 3 comprise the majority of the total variable costs for each system. The remaining variable cost components include annual operating capital, labor charges, fuel, lubrication, and machinery repairs. These variable costs are estimated in the budgeting process and are therefore not

Table 3. Operating Inputs Used in Wheat Production Systems

Operating Inputs	Units	Price	Systems 1	2	3	4	5	6	7	8	9 1+4	10 1+5	11 1+7
Parathion	Oz.	0.086	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Aerial Insecticide Application	ACRE	3.00	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 - 4 - D	Pt.	1.70	0.75	0.75	1.125	1.125	0.375	1.125	1.125	0.375	0.94	0.565	0.94
Surflan	Lbs.	10.40					1.25			1.25		0.625	
MCPA	Pt.	2.09					0.75			0.75		0.375	
Aerial Herbicide Application	ACRE	3.00					1.0			1.0		0.4	
Bladex	Lbs.	3.77			2.5	2.5		2.5	2.5		1.25		1.25
Paraquat	Pt.	5.85				1.0		1.0	2.0	1.0	0.5		1.0
18 - 46 - 0 Dry Fertilizer	Cwt.	14.50	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Dry Fertilizer Spreader Rental	Cwt.	0.12	0.88	0.88							0.44	0.44	0.44
Anhydrous Ammonia (NH_3)	Lbs.	0.15	103.0	103.0	103.0	103.0	103.0	103.0			103.0	103.0	51.5
Liquid Nitrogen (N)	Cwt.	6.75							3.01	3.01			1.50
Liquid N Applicator Rental	Cwt.	0.30							3.01	3.01			1.50
Seed Treatment/Bushel Seed	Bu.	0.50			1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.5	0.5
Seed	Bu.	5.00	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table 3. (Continued)

Operating Inputs	Units	Price	Systems 12 1+8	13 2+4	14 2+5	15 2+7	16 2+8	17 3+4	18 3+5	19 6+4	20 6+5	21 1+3	22 1+2
Parathion	Oz.	0.086	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Aerial Insecticide Application	ACRE	3.00	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2 - 4 - D	Pt.	1.70	0.565	0.94	0.565	0.94	0.565	1.125	0.75	1.125	0.75	0.94	0.75
Surflan	Lbs.	10.40	0.625		0.625		0.625		0.625		0.625		
MCPA	Pt.	2.09	0.375		0.375		0.375		0.375		0.375		
Aerial Herbicide Application	ACRE	3.00	0.5		0.5		0.5		0.5		0.5		
Bladex	Lbs.	3.77		1.25		1.25		2.5	1.25	2.5	1.25	1.25	
Paraquat	Pt.	5.85	0.5	0.5		1.0	0.5	0.5		1.0	0.5		
18 - 46 - 0 Dry Fertilizer	Cwt.	14.50	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88	0.88
Dry Fertilizer Spreader Rental	Cwt.	0.12	0.44	0.44	0.44	0.44	0.44					0.44	0.88
Anhydrous Ammonia (NH_3)	Lbs.	0.15	51.5	103.0	103.0	51.5	51.5	103.0	103.0	103.0	103.0	103.0	103.0
Liquid Nitrogen (N)	Cwt.	6.75	1.50			1.50	1.50						
Liquid N Applicator Rental	Cwt.	0.30	1.50			1.50	1.50						
Seed Treatment/Bushel Seed	Bu.	0.50	0.5	0.5	0.5	0.5	0.5	1.0	1.0	1.0	1.0	0.5	
Seed	Bu.	5.00	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

required as input data. The quantities of the operating inputs used were based on recommendations by agronomists (Peeper, 1981). Prices used for the operating inputs indicate statewide acreages in Oklahoma as of July 1, 1981 (Peeper, 1981).

Several of the operating inputs (Table 3) were held constant across the systems. Ten ounces of Parathion were aerially applied to all systems. The Parathion application helped to protect the wheat in each of the systems from potentially damaging greenbug infestations. An attempt was also made to maintain equal fertilization rates across the systems. Approximately 40 pounds of phosphate was supplied to each of the systems via the 18-46-0 starter fertilizer. Since this fertilizer contains only 46 percent phosphate by weight, 88 pounds were required.

The mode of application for the starter fertilizer varied among systems depending upon the type of tillage practices. Because phosphate is not a mobile nutrient in the soil profile, it must be incorporated into the root zone. Thus in Systems 1 and 2, and any combinations using Systems 1 and 2, starter fertilizer was broadcast with a rented dry fertilizer spreader. The fertilizer was then incorporated using a field cultivator or an offset disk. The advantage of this application mode is speed. The dry fertilizer spreader can apply fertilizer to 25 acres per hour. The other mode of starter fertilizer was through the stubble drill. The stubble drill was equipped with a fertilizer attachment which allowed placement of the fertilizer in a band next to the seed. This mode was used in the reduced tillage system since incorporation with tillage tools was not available. The stubble drill mode is usually less desirable because it decreases field efficiency in a critical time period.

Each system was also supplied 100 pounds of actual nitrogen, 15.8 pounds of which was supplied by starter fertilizer. The remainder of the nitrogen was supplied by applying 103 pounds of anhydrous ammonia (NH_3) or 301 pounds of liquid nitrogen. Since liquid nitrogen is more expensive than NH_3 as a source of nitrogen, it was used only in the no-tillage systems. Potassium fertilizer was not applied to any of the systems because of its natural abundance in western Oklahoma soils.

All of the wheat production systems were seeded at a rate of one bushel per acre. Seed treatment was used on the reduced tillage systems to offer additional protection from insects, fungus, and rodents. These pests are likely to be more of a problem in reduce tillage systems due to additional crop residues.

The herbicide rates found in Table 3 correspond to label recommendations. Surflan was applied at a rate of 1.25 pounds per acre. This herbicide was applied by air in a tank mix with 0.75 pints of MCPA. Aerial application charges for either herbicide or pesticide application totaled to $3.00 per acre. When MCPA was not applied, 0.75 pints of 2,4-D were used in early spring to control winter annual broadleaf weeds. 2,4-D was also used over 50 percent of the reduced tillage acreage in late summer. This application of 2,4-D was used to control problem areas of broadleaf weeds. In the systems requiring Bladex, a 2.5 pound per acre application rate was used. Each application of Paraquat for any of the systems contained 1.0 pint of Paraquat per acre.

Selecting Tractor-Implement Combinations

One difficulty in using enterprise budgets to evaluate different wheat production systems is selecting tractor-implement combinations. Each tillage operation for any wheat production system requires the use of one tractor and one implement. The difficulty arises in selecting which tractor size and implement width should be used for a given field operation.

This selection problem is usually thought of in a whole farm context. Any given farm requires a set of machinery capable of performing the tillage operations in the field days available. Such a machinery set is often referred to as a machinery complement. The tillage operations can be thought of as a flow of services from a machinery complement. Therefore, a machinery complement must be found for each system before the enterprise budgets can be formulated. When the machinery complements are found, the tractor-implement combinations can be entered into the enterprise budgets for machinery cost calculations.

Because of the large number of machinery sizes available, there are many machinery complements that can perform the required tillage operations. However, the costs of the tillage operations vary greatly depending upon the machinery complement used. It therefore becomes very important to the study to find the machinery complement for each system that provides the tillage operations with the least cost. By comparing the costs of tillage operations with optimal machinery complements, a more consistent view of tillage cost can be generated.

An optimal machinery complement is defined as a set of machinery that can perform the required tillage operation in the field working days available with the least total cost. By definition, it requires a machinery selection process where total machinery costs are minimized. Total machinery costs include both fixed and variable cost components.

Mixed Integer Programming

Mixed integer programming (MIP) can be used to select an optimal machinery complement. MIP is a mathematical programming procedure where certain variables are constrained to integer values. The capability of using integer variables is an important characteristic for a machinery selection model. These integer variables allow the model to select machinery items into a machinery complement in whole units.

Previous to the development of MIP, machinery selection studies used nonoptimizing systems simulations, least-cost comparisons, or systematic search techniques. Griffin (1980) summarizes much of the literature in these areas. However, machinery selection alternatives quickly become quite numerous even when a small number of tractor and implement sizes are considered for several field operations in several periods. Due to the large number of alternatives, these procedures are easily overwhelmed. As a result, these procedures required assumptions which so strictly bound the problem that little practical information can be gained from their solutions.

In addition to the nonoptimizing procedures, attempts have been made to use linear programming to select least cost machinery complements (Armstrong and Faris, 1964). These linear programming models were capable of efficiently evaluating large machinery selection problems. However, the integer nature of machinery selection problems violate the assumptions of infinitely divisible resources and activities in linear programming. A linear programming solution using fractions of tractors and implements fails to answer the questions of which machine to include in a complement. The problem of fractional machinery items was largely the reason for using non-optimizing techniques in machinery selection problems. Thus, machinery selection models used either non-optimizing procedures, which could solve only small integer problems, or linear programming, which could solve large problems with non-integer values.

The development of MIP offered the advantages of linear programming, while maintaining the integer nature of machinery selection problems. In 1970 IBM introduced an algorithm to solve mixed integer programming problems (IBM Corporation, 1973). The package, called Mathematical Programming Systems Extended (MPSX), offered the capability of Mixed Integer Programming (MIP). This package was a significant achievement in the field of integer programming. When properly used, MPSX-MIP offers a means to efficiently solve large scale mixed integer linear programming problems.

Mixed integer programming problems are a more constrained form of a linear programming problem. Additional constraints are necessary to require certain variables to maintain integer values. Due to these integer constraints, some of the mathematical properties found in continuous linear programming problems are lost. This loss makes integer programming problems more difficult to solve than non-integer programming problems.

One important mathematical property lost in integer programming is convexity of the feasible region. In general, when dealing with continuous problems, in a non-dimensional space, a feasible region is a closed convex set and has n + 1 corner points (Agrawal and Heady, 1972). Each corner point is a basic feasible solution to the set of constraints. Thus, in linear programming problems, optimization occurs by evaluating the objective function at corner points and selecting the maximum (or minimum) value. In integer programming the solution region is neither convex nor continuous. Loss of these mathematical properties make it difficult to find feasible integer solutions. These integer points no longer have to be extreme or corner points.

One solution technique used to solve integer programming problems is a branch and bound routine (Hillier and Lieberman, 1974). This type of integer programming algorithm is used by the MPSX-MIP software package. The procedure starts by finding a continuous solution to the LP problem. At this step, if all the variables required to be integers have integer values, the procedure stops because the continuous solution meets the integer constraints. If any of the integer variables in the continuous solution have non-integer values, the program selects one of the variables to integerize. The variable's value is set to two integer values by rounding the fraction of the continuous value up to and down to the nearest integer value. This is called a branch and the non-integer problem is now split into two new LP problems. Each of the new LP problems has an additional constraint which fixes the selected variable to one of two integer values. Each new LP problem is solved with the additional integer constraint. The problem with the smallest objective function value (in minimization problems) is selected for further iterations. At each iteration, an additional variable is integerized, creating two more LP problems. The problems are evaluated and the problem with the integer value yielding the smallest objective function is a candidate for further branching. This branching procedure is iterated and constraints are added until all the required variables are integerized. In this manner, the branch and bound technique finds integer solutions.

In general, mixed integer programming minimization problems can be stated (Hillier and Lieberman, 1974) as:

$$\text{Minimize } Z = \sum_{j=1}^{n} C_j X_j$$

subject to

$$\sum_{j=1}^{n} A_{ij} X_j \leq b_i, \text{ for } i = 1, 2, \ldots, m,$$

and

X_j integer, for $j = 1, 2, \ldots, I$ $(I \leq n)$,

$X_j \geq 0$, for $j = 1, 2, \ldots, n$,

where

Z = objective function value,

n = number of activities,

C_j = prices or other weights for the objective function,

X_j = decision variables,

A_{ij} = technical coefficients,

b_i = resource or other constraints,

m = number of constraints.

If $I = n$ the programming problem is a "pure" integer problem. This formulation is useful to conceptualize how integer programming can be used to select a machinery complement which minimized total machinery costs. In a machinery selection problem each tillage operation can be divided into two activities. One activity accounts for the variable costs incurred by using a certain tractor-implement combinations. The second activity accounts for the fixed costs of each tractor-implement combination. This second activity can be constrained to integer values so that tractors and implements enter the complement at integer levels. Thus, once a machine enters the complement it has fixed ownership costs regardless of its usage. The problem can be constrained by the number of hours available to complete desired field operations. In this manner, MIP allows machinery to be selected which minimized the total cost of performing tillage operations.

Optimal Machinery Complement Selection System

The Optimal Machinery Complement Selection System was developed by Griffin (1980) and represents one of the first machinery selection models to harness the power of IBM's MPSX-MIP package. Using this model, a machinery complement can be selected which provides the required tillage services with the least cost. Therefore, OMCSS is an important tool to find the tractor-implement combinations for enterprise budgets. Once the tractor-implement combinations are found for each field operation, the machinery costs can be calculated for the wheat production systems.

The Optimal Machinery Selection System (OMCSS) approaches a machinery selection problem in two steps. First, OMCSS uses a matrix generator to create a linear programming matrix for a particular machinery selection problem. The second step uses MPSX-MIP to select a machinery complement from the matrix which minimizes total machinery costs.

The OMCSS matrix generator requires three sets of input data to calculate machinery costs and build the linear programming matrix. First, the field operations for wheat production system must be identified (Table 2). The second set of input data required is a list and ranking of alternative machinery items from which the machinery complements can be selected (Tables 4 and 6). These data include various information about each machine's cost curves, field capacity, and power requirements. The third set of data required by OMCSS is the field work days available in each period (Table 7). Field work days are the expected number of days in a given period when field conditions are dry enough to perform tillage operations. These data requirements are discussed in more detail later in this section.

Based on these data, the OMCSS matrix generator calculates fixed and variable costs for each alternative machinery item. The fixed costs include charges for depreciation, interest on machinery investments, taxes, and insurance. Total variable costs are calculated on an hourly basis and include fuel, lubrication, and repair expenses. These cost calculation procedures are based on work done by Bowers (1970).

After the machinery cost calculations, the matrix generator creates linear programming activities for each possible machinery item. For example, consider a spray operation in one time period. In a hypothetical list of alternative machinery items, say there are two sprayer sizes and five tractor sizes, which are all capable of pulling either sprayer. The matrix generator would approach this selection problem by creating four sprayer activities and 15 tractor activities. Two of the sprayer activities account for the total variable costs per hour of each sprayer. The remaining two sprayer activities are integer machinery purchase activities. Of the 15 tractor activities, the first five activities account for the total variable costs of the tractors pulling the first sprayer. The second five tractor activities account for total variable costs of the tractors pulling the second sprayer. The remaining five tractor activities are integer tractor purchase activities. These integer purchase activities allow machinery items to enter the machinery complement at integer values. Once a machine enters the machinery complement, it supplies a limited number of machine hours with certain fixed costs. These fixed costs are incurred regardless of how many hours a machine is used. The total variable and fixed cost per hour are accounted for in the objective function as C_j values. In this manner, the matrix generator sets up linear programming activities which account for the total variable and fixed costs of each possible tractor-implement combination. The matrix generator also formulates the necessary linear programming constraints. These constraints require the designated operations to be performed in the field hours available. The constraints also tie the tractor-implement combinations together according to the machinery ranking. For a more detailed discussion of the constraints see Handke (1982).

As previously discussed, OMCSS requires three sets of input data for a particular machinery selection problem. The discussion on selecting tractor-implement combinations will conclude by presenting in detail these data sets required by OMCSS. Since the tillage operations for each system have been defined, there is no need to repeat the system definition at this point. Therefore, only the list and ranking of available machinery items along with the field work days available are presented.

<u>List and Ranking of Available Machinery</u>. The second set of input data required is the machinery available for selection of the least cost machinery complement. This list of machinery is shown in Table 4.

The linear programming model selects from this list of machinery the least cost machinery complement for each system.

In Table 4, 14 different types of machinery implements are listed. Most types of machinery implements have several sizes. Eight tractor sizes are included and replicated in the list. The tractors are replicated to permit two tractors of the same size to be selected into one machinery complement. The two smallest tractors are not available with cabs and the largest tractor is a four-wheel drive model. With the different tractor and implement sizes available, the number of possible tractor-implement combinations is extremely large.

Along with each machinery item in the list, are 15 columns of coefficients. These coefficients are used by OMSCS and in the budgeting process for machinery cost computations. The machinery sizes and initial list prices were collected from John Deere retail price books as of July, 1981. By pricing one line of machinery, the cost of increasing machinery size is reflected in the price structure. Endorsement of this machinery line is not intended, but it was chosen because price data were available. The purchase price of the machinery is fixed at 90 percent of the list price. The remaining coefficients in Table 4 correspond to values commonly used in representative machinery complements maintained for the Budget Generator (Kletke, 1979).

Along with the list of machinery items, the model requires the machinery items to be ranked. Ranking refers to the matching of implement widths to tractor sizes. The tractor must be large enough to pull the implement at a desirable speed and depth.

The maximum width a tractor can pull is a function of four variables (Jones and Bowers, 1977). The first variable is a measure of

Table 4. Selection List of Available Machinery Items

NAME OF MACHINE (COLUMN)	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	17761.	3.	12000.	70.
TRACTOR NC 81	2.	81.0	23401.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	21061.	3.	12000.	81.
TRACTOR 91	3.	91.0	33332.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	30043.	3.	12000.	91.
TRACTOR 111	4.	111.0	37000.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	33300.	3.	12000.	111.
TRACTOR 131	5.	131.0	41256.	0.0	0.38	1.25	0.000631	1.60	600.	10.0	0.630	0.920	37130.	3.	12000.	131.
TRACTOR 156	6.	156.0	43847.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	43963.	3.	12000.	156.
TRACTOR 180	7.	180.0	54563.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	49106.	3.	12000.	180.
TRACTOR 229	8.	229.0	73661.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	70795.	3.	12000.	229.
	9.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
TRACTOR NC 70	10.	70.0	19734.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	17761.	3.	12000.	70.
TRACTOR NC 81	11.	81.0	23401.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	21061.	3.	12000.	81.
TRACTOR 91	12.	91.0	33332.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	30043.	3.	12000.	91.
TRACTOR 111	13.	111.0	37000.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	33300.	3.	12000.	111.
TRACTOR 131	14.	131.0	41256.	0.0	0.38	1.25	0.000631	1.60	600.	10.0	0.630	0.920	37130.	3.	12000.	131.
TRACTOR 156	15.	156.0	43847.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	43963.	3.	12000.	156.
TRACTOR 180	16.	180.0	54563.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	49106.	3.	12000.	180.
TRACTOR 229	17.	229.0	73661.	0.0	0.38	1.20	0.000631	1.60	600.	10.0	0.630	0.920	70795.	3.	12000.	229.
	18.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	19.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	20.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	21.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	22.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	23.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	24.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	25.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	26.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	27.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	28.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	29.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
M.B. PLOW 314	30.	3.5	1845.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	1660.	0.	2000.	0.
M.B. PLOW 316	31.	4.0	1876.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	1688.	0.	2000.	0.
M.B. PLOW 414	32.	4.7	2475.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	2228.	0.	2000.	0.
M.B. PLOW 416	33.	5.3	2526.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	2273.	0.	2000.	0.
M.B. PLOW 516	34.	6.7	4150.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	3735.	0.	2000.	0.
M.B. PLOW 616	35.	8.0	4892.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	4403.	0.	2000.	0.
M.B. PLOW 513	36.	9.0	5194.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	4675.	0.	2000.	0.
M.B. PLOW 318	37.	12.0	7201.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	6480.	0.	2000.	0.
M.B. PLOW 314	38.	3.5	1845.	5.0	0.75	2.00	0.000251	1.30	280.	10.0	0.600	0.885	1660.	0.	2000.	0.
CHISEL PLOW	39.	8.0	2217.	4.5	0.75	1.20	0.000251	1.80	427.	10.0	0.600	0.885	1995.	0.	2000.	0.
CHISEL PLOW	40.	10.0	2426.	4.5	0.75	1.20	0.000251	1.80	427.	10.0	0.600	0.885	2183.	0.	2000.	0.
CHISEL PLOW	41.	12.0	2609.	4.5	0.75	1.20	0.000251	1.80	427.	10.0	0.600	0.885	2343.	0.	2000.	0.
CHISEL PLOW	42.	14.0	2927.	4.5	0.75	1.20	0.000251	1.80	427.	10.0	0.600	0.885	2635.	0.	2000.	0.
CHISEL PLOW	43.	16.0	3194.	4.5	0.75	1.20	0.000251	1.80	427.	10.0	0.600	0.885	2874.	0.	2000.	0.
CHISEL PLOW	44.	20.0	3719.	4.5	0.75	1.20	0.000251	1.80	427.	10.0	0.600	0.885	3347.	0.	2000.	0.
	45.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
OFF-SET DISK	46.	7.8	7602.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	6842.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	6955.	0.	2000.	0.
OFF-SET DISK	48.	13.5	8460.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	7614.	0.	2000.	0.
OFF-SET DISK	49.	16.8	9936.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	8943.	0.	2000.	0.
OFF-SET DISK	50.	20.3	12094.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	10885.	0.	2000.	0.

Table 4. (Continued)

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
OFF-SET DISK	51.	27.0	21638.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	19475.	0.	2000.	0.
	52.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
TANDEM DISK	53.	12.7	4533.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	4080.	0.	2000.	0.
TANDEM DISK	54.	14.3	5654.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	5089.	0.	2000.	0.
TANDEM DISK	55.	15.7	7507.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	6757.	0.	2000.	0.
TANDEM DISK	56.	19.9	11003.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	9903.	0.	2000.	0.
TANDEM DISK	57.	22.8	12883.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	11595.	0.	2000.	0.
TANDEM DISK	58.	27.1	16778.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	15100.	0.	2000.	0.
TANDEM DISK	59.	30.1	17950.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	16153.	0.	2000.	0.
TANDEM DISK	60.	40.3	26291.	5.5	0.75	0.65	0.000251	1.80	132.	10.0	0.600	0.885	23662.	0.	2000.	0.
	61.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
SWEEP & SF	62.	15.0	9494.	5.5	0.55	0.65	0.000251	1.80	137.	10.0	0.600	0.885	8545.	0.	2000.	0.
SWEEP & SF	63.	20.0	14283.	5.5	0.55	0.65	0.000251	1.80	137.	10.0	0.600	0.885	12355.	0.	2000.	0.
SWEEP & SF	64.	25.0	16528.	5.5	0.55	0.65	0.000251	1.80	137.	10.0	0.600	0.885	14875.	0.	2000.	0.
SWEEP & SF	65.	30.0	20437.	5.5	0.55	0.65	0.000251	1.80	137.	10.0	0.600	0.885	18393.	0.	2000.	0.
SWEEP & SF	66.	35.0	23376.	5.5	0.55	0.65	0.000251	1.80	137.	10.0	0.600	0.885	21038.	0.	2000.	0.
	67.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	137.	10.0	0.600	0.885	6344.	0.	2000.	0.
SWEEP & F	69.	20.0	11905.	5.5	0.65	0.65	0.000251	1.80	137.	10.0	0.600	0.885	10714.	0.	2000.	0.
SWEEP & F	70.	25.0	14026.	5.5	0.65	0.65	0.000251	1.80	137.	10.0	0.600	0.885	12623.	0.	2000.	0.
SWEEP & F	71.	30.0	17386.	5.5	0.65	0.65	0.000251	1.80	137.	10.0	0.600	0.885	15647.	0.	2000.	0.
SWEEP & F	72.	35.0	20201.	5.5	0.65	0.65	0.000251	1.80	137.	10.0	0.600	0.885	18180.	0.	2000.	0.
FIELD CULTIVATOR	73.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	1432.	0.	2000.	0.
FIELD CULTIVATOR	74.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	1432.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	1800.	0.	2000.	0.
FIELD CULTIVATOR	76.	13.5	2170.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	1953.	0.	2000.	0.
FIELD CULTIVATOR	77.	16.5	3549.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	3194.	0.	2000.	0.
FIELD CULTIVATOR	78.	19.5	4812.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	4330.	0.	2000.	0.
FIELD CULTIVATOR	79.	23.5	5732.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	5159.	0.	2000.	0.
FIELD CULTIVATOR	80.	27.5	9208.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	8287.	0.	2000.	0.
FIELD CULTIVATOR	81.	36.5	11450.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	10305.	0.	2000.	0.
	82.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
ANHYDROUS APPLIE	83.	15.0	3072.	5.5	0.67	1.00	0.000631	1.60	137.	10.0	0.600	0.885	2765.	0.	1000.	0.
ANHYDROUS APPLIE	84.	22.0	4092.	5.5	0.67	1.00	0.000631	1.60	137.	10.0	0.600	0.885	3683.	0.	1000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	137.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	133.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	133.	10.0	0.600	0.885	23542.	0.	1000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	133.	10.0	0.600	0.885	35520.	0.	1000.	0.
	89.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
DRILL W/O FERT.	90.	20.0	7062.	4.5	0.70	0.65	0.000251	1.80	133.	10.0	0.600	0.885	6356.	0.	1000.	0.
DRILL W/O FERT.	91.	24.0	9182.	4.5	0.70	0.65	0.000251	1.80	133.	10.0	0.600	0.885	8264.	0.	1000.	0.
DRILL W/O FERT.	92.	30.0	10898.	4.5	0.70	0.65	0.000251	1.80	133.	10.0	0.600	0.885	9303.	0.	1000.	0.
DRILL W/O FERT.	93.	32.0	12445.	4.5	0.70	0.65	0.000251	1.80	133.	10.0	0.600	0.885	10915.	0.	1000.	0.
DRILL W/O FERT.	94.	40.0	14372.	4.5	0.70	0.65	0.000251	1.80	133.	10.0	0.600	0.885	12935.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	50.	10.0	0.560	0.885	0.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	50.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	97.	30.0	3535.	5.5	0.65	0.65	0.000251	1.80	50.	10.0	0.600	0.885	3226.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	50.	10.0	0.600	0.885	3447.	0.	1000.	0.
	99.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.
	0.	0.0	0.	0.0	0.0	0.0	0.0	0.0	0.	0.0	0.0	0.0	0.	0.	0.	0.

the tractor PTO horsepower. Secondly, an estimate of the usable horsepower conversion factor is required. Usable horsepower refers to the amount of power that is available to pull an implement under certain conditions. The most notable condition that influences this conversion factor is soil density. For example, if a soil is very "loose", such as after plowing, a great deal of power is lost due to wheel slippage. The third variable that affects implement ranking is soil resistance. Soil resistance is measured by pounds of draft per foot of implement. Implement draft is largely influenced by soil type, tillage depth, and soil moisture. The fourth important variable is the field speed of the implement. These variables can be formulated into a mathematical equation to solve for the maximum implement width as follows:

$$\text{WIDTH} = \frac{\text{PTO x HCF x 375}}{\text{MPH x DRAFT}}$$

where:

WIDTH = maximum implement width in feet,

PTO = power take-off horsepower,

HCF = horsepower conversion factor (%/100),

MPH = field speed in miles per hour,

DRAFT = pounds per foot of implement,

375 = units conversion constant (MPH pounds/HP).

This equation was used to estimate the maximum implement width for each tractor size in Table 5. Field speed, draft per foot of implement, and the usable horsepower conversion factor were estimated by agricultural engineers (Bowers, 1970). The field speeds were set at a level which may appear to be rather fast. However, Bowers (1970) and other extension agricultural engineers advise that field operations

Table 5. Maximum Implement Widths by Tractor Sizes

Field Operations	Field Speed (MPH)	Field Efficiency (%/100)	Draft/ft. of Implement (Lbs.)	H.P. Conversion Factor (%/100)	Tractor Sizes (H.P.) / Maximum Implement Width (ft.) 70	81	91	111	131	156	180	229
Moldboard Plow	5.0	0.75	800	0.55	3.6	4.2	4.7	5.7	6.8	8.0	9.3	11.8
Chisel Plow	4.5	0.75	500	0.55	6.4	7.4	8.3	10.2	12.0	14.3	16.5	21.0
Off-Set Disk	5.5	0.75	400	0.64	7.6	8.8	9.9	12.1	14.3	17.0	19.6	25.0
Sweep Applying Spray and NH_3	5.5	0.55	275	0.64	11.1	12.9	14.4	17.6	20.8	24.8	28.6	36.3
Sweep Applying Spray	5.5	0.65	275	0.64	11.1	12.9	14.4	17.6	20.8	24.8	28.6	36.3
Sweep Applying NH_3	5.5	0.65	275	0.64	11.1	12.9	14.4	17.6	20.8	24.8	28.6	36.3
Sweep	5.5	0.75	275	0.64	11.1	12.9	14.4	17.6	20.8	24.8	28.6	36.3
NH_3 Knife Applicator	5.5	0.67	150	0.55	17.5	20.3	22.8	27.8	32.8	39.0	45.0	57.3
Field Cultivator	5.5	0.75	250	0.55	10.5	12.2	13.7	16.7	19.7	23.4	27.0	34.6
Stubble Drill	4.5	0.65	225	0.65	16.9	19.5	21.9	26.7	31.5	37.6	43.3	55.1
Conventional Drill	4.5	0.70	150	0.55	21.4	24.8	27.8	33.9	40.0	47.7	55.0	70.0

should be performed with smaller implement widths at faster speeds. This reduces wear on the tractor drive train and allows operators the flexibility of gearing down to pull through exceptionally "hard" areas. Field efficiency factors were also estimated for each operation by Bowers (1981). These efficiency factors are used to determine the acres per hour each implement can cover. They do not affect the machinery ranking.

Once these maximum widths are found, the machinery items can be ranked. Each tractor is matched with the largest implement width available, subject to the maximums listed in Table 5. Thus, tractors can only pull implement widths which are commercially available. This sometimes leads to poor tractor-implement matching. If a tractor has more horsepower than required by a certain implement width, the total cost of the field operation will be greater than for a properly matched tractor-implement combination. Therefore, it is important to match tractor sizes with implements widths as close as possible to the maximum widths.

The matching of tractor sizes to available implement widths is shown in Table 6. The maximum available width for each type of implement is shown under the eight different tractor size columns. Each tractor can pull any implement width in its column and to the left of it. For example, the 229 horsepower tractor cannot only pull the implement widths in its column, but any smaller width to the left. This distinction allows a larger tractor to pull a smaller ranked machine. This is sometimes feasible if a complement requires a large tractor and it is less costly to use an oversized tractor than purchase a smaller tractor for the one operation.

Table 6. Commercially Available Maximum Implement Widths by Tractor Sizes

Field Operations	Field Speed (MPH)	Field Efficiency (%/100)	Draft/ft. of Implement (Lbs.)	H.P. Conversion Factor (%/100)	Tractor Sizes (H.P.) Available Implement Width (Ft.) 70	81	91	111	131	156	180	229
Moldboard Plow	5.0	0.75	800	0.55	3.5	4.0	4.7	5.3	6.7	8.0	9.0	12.0
Chisel Plow	4.5	0.75	500	0.55			8.0	10.0	12.0	14.0	16.0	20.0
Off-Set Disk	5.5	0.75	400	0.64	7.8	7.8	7.8	12.5	13.5	16.8	20.3	27.0
Sweep Applying Spray and NH_3	5.5	0.55	275	0.64			15.0	15.0	20.0	25.0	30.0	35.0
Sweep Applying Spray	5.5	0.65	275	0.64			15.0	15.0	20.0	25.0	30.0	35.0
Sweep Applying NH_3	5.5	0.65	275	0.64			15.0	15.0	20.0	25.0	30.0	35.0
Sweep	5.5	0.75	275	0.64			15.0	15.0	20.0	25.0	30.0	35.0
NH_3 Knife Applicator	5.5	0.67	150	0.55	15.0	15.0	22.0	28.0	28.0	28.0	28.0	28.0
Field Cultivator	5.5	0.75	250	0.55	9.5	12.5	13.5	16.5	19.5	23.5	27.5	34.5
Stubble Drill	4.5	0.65	225	0.65	13.2	13.2	13.2	26.4	26.4	26.4	39.6	39.6
Conventional Drill	4.5	0.70	150	0.55	20.0	24.0	24.0	32.0	40.0	40.0	40.0	40.0

Field Work Days Available. One problem which complicates machinery selection is the uncertainty of weather conditions. Weather plays an important role in determining the size and therefore the cost of a machinery complement. In general, as precipitation increases, the number of field days in a given time period decreases. Field days refer to days when the soil moisture content is satisfactory to perform field operations.

Not only is the total number of field days in one year important, but also the distribution of those days through the year. The distribution of field days is important because most field operations must occur in some critical period. If the operations are performed outside this period, yield penalties are usually suffered. These losses may result from fewer growing days or perhaps from poor timing of operating input application. Therefore, the number of field days available in critical periods of the year are most important. The most constrained period, in terms of field work days, greatly influences the required size of a machinery complement.

One way to approach the problem of uncertain weather conditions is to build a model which considers the historical pattern of rainfall. Reinschmiedt (1971) developed a methodology to estimate a distribution of available field work days. The procedure uses historical rainfall simulator to simulate daily rainfall amounts for a large number of years. The second ingredient Reinschmiedt used in the model was a time-loss tableau. This tableau was formulated to estimate how differing rainfall amounts altered field conditions. The tableau summarized information about the relationship between varying rainfall amounts and field time lost. Reinschmiedt then developed a computer algorithm which merged the daily rainfall and time-loss tableaus. By evaluating these data, the program estimated cumulative percentage distributions of available field days in 24 half-month periods.

Fifty years of daily rainfall data were collected by Bonnett (1973) from the Enid weather reporting station. The data were composed of daily rainfall amounts since January 1, 1925. These data were then used in the rainfall simulator to project rainfall amounts for the next 100 years. Based on this simulation, the probable field work days for four probability levels were estimated. In Table 7, these probable field work days are shown for 19 half-month periods from January 1 to October 16.

Timeliness levels refer to the probabilities of the available field work days in each half-month period. For example in Table 7, during the second half of June there are a maximum of 15 days and 13.25 available field work days at a 50 percent timeliness level. This means that if a farmer has a machinery complement that requires 13.25 field days in the second half of June, in only five out of 10 years on the average will sufficient field days be available to complete the field work. Likewise, if the farmer wants to complete his field work nine out of 10 years, he should plan for 9.5 available field work days in the second half of June. As the timeliness level is increased, fewer field work days are available and a larger machinery complement is required to perform the field operations.

Given the available field work days, an operator must decide how many hours per day he is willing to work. Available field work hours determines more precisely the amount of time available in each period. This value is arrived at by multiplying the field days available by the

Table 7. Enid Area Available Field Work Days

Time Periods	Maximum Number of Days	Timeliness Level 50% (Days)	80% (Days)	90% (Days)	98% (Days)
January 1-16	16	15.25	14.25	13.00	10.75
January 17-31	15	15.00	13.25	12.50	8.75
February 1-14	14	13.25	12.75	11.00	8.75
February 15-28	14	13.25	12.25	11.75	10.00
March 1-16	16	14.75	13.00	11.25	7.50
March 17-31	15	14.00	11.75	9.50	7.50
April 1-15	15	13.00	10.75	8.75	7.75
April 16-30	15	12.75	10.00	8.75	5.75
May 1-16	16	13.00	10.25	8.25	6.00
May 17-31	15	12.00	8.50	6.25	3.50
June 1-15	15	12.50	9.75	7.50	4.75
June 16-30	15	13.25	10.50	9.50	7.50
July 1-16	16	14.25	11.75	10.50	8.25
July 17-31	15	13.75	12.25	10.75	7.50
August 1-16	16	14.75	12.25	11.00	8.25
August 17-31	15	13.75	11.75	10.00	6.75
September 1-15	15	13.50	10.50	8.75	5.50
September 16-30	15	13.25	9.25	6.75	4.00
Ocotber 1-16	16	14.00	12.25	11.00	8.00

hours per day an operator is willing to work. By increasing the field hours per day, an operator can increase the available field work hours and use smaller equipment.

For the purpose of this study, the timeliness level was set at 80 percent with 10 hour work days. This means that a farmer can complete the field operations eight out of 10 years on the average by working 10 hour days. The timeliness level chosen was somewhat lower than one might expect. However, only 10 hour field work days were used. This allows some flexibility for longer work days when inclement weather reduces the number of field work days.

Enterprise Budget Formulation

The third step in the general model (Figure 4) is to formulate enterprise budgets for the wheat production systems. These enterprise budgets summarize all the annual operating expenses and machinery costs. The total annual operating costs are found in the budgets by merely summing the input costs. In a similar manner, total machinery costs can be calculated for each field operation given the tractor-implement combination. These costs are then summed over all the field operations to find total machinery costs. The quantities, prices, and timing of the operating inputs for the systems can be found in Appendix A. Likewise, the tractor-implement matchings and machine annual hours can be found for each system in Appendix A.

Since the formulation of enterprise budgets entails many repetitive calculations, a computerized budgeting routine can greatly speed up the budgeting process. One such computerized budget generator was developed at Oklahoma State University and is called the Enterprise Budget

Generator. This program was used in the study to quickly and efficiently generate enterprise budgets for the wheat production systems. The Enterprise Budget Generator (EBG) consists of a main program and numerous subroutines which are called to input data, perform calculation, and output information. The output information consists of detailed or summarized reports of enterprise expenses and receipts. By programming the EBG in numerous subprograms, the model has considerable flexibility. The major advantage of this flexibility is that it allows the user to select which output to print.

Two powerful features of the EBG are capability of calculating total machinery costs and annual operating capital charges. The EBG uses standard procedures for estimating machinery costs (Bowers, 1970). These procedures are quite straight forward and can be computed on a handheld calculator. The advantage of using the EBG to estimate total machinery costs is its speed, accuracy, and consistency. Although the machinery costs equations are straight forward, a large volume of calculations are quickly and accurately made in the EGB program.

Annual operating capital charges also have similar characteristics which make computerized computation advantageous. Annual operating capital refers to the "annualized" amount of short term capital required to finance expenses during the production cycle. Since equity capital has an opportunity cost, an interest charge is incurred regardless of the capital's source. The quantity of operating capital depends upon the size of the expenses, and the length of time from when the expense is incurred until it is paid. This time factor makes the computation of operating capital charges rather tedious work with a hand-held calculator.

Normally the EBG assumes an annual operating capital month where all the expenses are paid. This month is usually the harvest month, which in the case of Oklahoma wheat is June. In June, the EBG assumes all expenses are paid with revenue from crop sales. This creates a budgeting problem with expenses and operating capital charges for Surflan plus MCPA applications before June and any tillage operation performed in June. With the annual operating month assumption, the EBG charges these expenses against the harvested crop instead of accumulating the charges against the following years crop. Therefore, charges are not correctly expensed against the correct crop.

Normally this problem has only a trivial impact on annual operating capital charges. However, when comparing conventional wheat production systems, which are tillage intensive in June, against reduce tillage system, the EBG does not accurately reflect differences in annual operating capital. This discrepancy was large enough to justify modification of the EBG. The budgets in this study were generated with a modified EBG. The modification allows the flexibility of carrying expenses longer than 12 months. The modification is especially important in the Surflan system where a relatively large expense required financing for 14 months. Without the modification, the EBG would finance this expenditure only two months.

Another advantage of the EBG, is that once a budget is built and stored it can be quickly retrieved and modified. This was an important reason for using the EBG in this study. Many times it was difficult to estimate at the onset of a study how many budgets will be required. Thus, the EBG offers a way to quickly, accurately, and consistently generate enterprise budgets. For more detailed information regarding the EBG program, see Kletke (1979).

Total Cost Sensitivity

The final processing step in the general model (Figure 4) estimates changes in the systems' total costs when wage rates, interest rates, and fuel prices change. This processing step is useful to extrapolate the results of the EBG to "what if" future situations. While it is possible to use the EBG for this purpose, a total cost sensitivity model is a more straight forward approach. The model also is helpful to more clearly visualize the interaction of fuel prices and the quantity of annual operating capital.

The steps used to derive the sensitivity model are shown in equations one through 10. The sensitivity model uses the results of the enterprise budgets to show how total costs change as fuel prices, wage rates, and interest rate change. Therefore, the sensitivity model begins with the total cost values found with the enterprise budgets. Given these total costs, equation (1) expresses total costs (TC) as a function of the prices of labor (P_L), capital (P_c), and fuel (P_F). Thus, in equation (1), only three price parameters are allowed to vary. The remaining factors which contribute to TC are fixed and grouped into a constant (K). Equation (2) further expands the cost function into a more explicit form where Q_L is the quantity of labor, Q_C is the quantity of capital, Q_{FL} is the quantity of fuel and lubrication. In this form, it is evident that only the prices and quantities of fuel, labor, and capital are important to the sensitivity model. The remaining factors which contributed to total costs are held constant in the model. Since the EBG assumes lubrication costs are 15 percent of fuel costs, Q_{FL} is equal to 1.15 times the quantity of fuel consumed.

Of these three quantities, the quantity of capital must be further defined in equation (3). The total quantity of capital is composed of capital invested in machinery (Q_{MC}) and annual operating capital (Q_{AOC}). The annual operating capital is further complicated because it is in itself a function of the fuel price. In equation (4), annual operating capital (Q_{AOC}) is shown as a function of the price of fuel (P_F) and the quantity of annual operating fuel and lube (Q_{AOF}). The annual operating fuel and lube (Q_{AOF}) is defined as the average annual investment in fuel and lubrication material. In equation (5), F_i is gallons of fuel use in month i (M_i), and M_{AO} is the annual operating month when all expenses are paid.

(1) $TC = F(P_L, P_C, P_F)$

(2) $TC = P_L Q_L + P_C Q_C = P_F Q_{FL} + K$

(3) $Q_C = Q_{MC} + Q_{AOC}$

(4) $Q_{AOC} = P_F Q_{AOF} + K$

(5) $Q_{AOF} = \frac{1}{12} \sum_{i=1}^{12} 1.15 F_i (M_{AO} - M_i)$

The second step in deriving the sensitivity model is to find the total derivative of equation (1). Since there are three variables in equation (1), the total derivative contains three partial derivatives (equation 6). After taking the partial derivatives from equation (2), equation (6) can be rewritten as equation (7). At this point, the derivative of annual operating capital with respect to fuel prices is required (equation 8). Substituting for dP the actual price changes, where P'_L, P'_C, and P'_F are new prices, equation (9) is formulated.

Thus, a new total cost (TC') in equation (10) is the sum of the old total cost value plus any changes in total cost (dTC) due to changes in wage rates, interest rates, and/or fuel prices.

$$(6)\quad dTC = \frac{TC}{P_L} dP_L + \frac{TC}{P_C} dP_C + \frac{TC}{P_F} dP_F$$

$$(7)\quad dTC = Q_L dP_L + Q_C dP_C + (Q_{FL} + P_C \frac{dQ_{AOC}}{dP_F})\ dP_F$$

$$(8)\quad \frac{dQ_{AOC}}{dP_F} = Q_{AOF}$$

$$(9)\quad dTC = Q_L(P'_L - P_L) + Q_C(P'_C - P_C) + (Q_{FL} + P_C Q_{AOF})\ (P'_F - P_F)$$

$$(10)\quad TC' = TC = dTC$$

In the study, equations (9) and (10) are used to show the sensitivity of the total cost of each system to changes in wage rates, interest rates, and fuel prices. Since the systems use different quantities of labor, fuel and capital, without such a model it is difficult to judge the impact of changes in these parameters. For the purpose of this study, three levels of each parameter were chosen. The systems total costs were then recalculated under 27 different states of nature with the sensitivity model. The results of this processing step are shown in tables in Chapter III.

CHAPTER III

MODEL RESULTS AND ANALYSIS

Introduction

In this chapter the results from the application of the general model to the case study situation are presented and analyzed. The results are grouped according to the three output steps in the general model's flowchart (Figure 4). Tables are presented for each output step to summarize results and facilitate analysis. These output steps are from the major topics of the chapter and are discussed in the following order. First, the optimal machinery complements are presented for each of the wheat production systems. Enterprise budgets, which use the optimal machinery complements, are then presented and analyzed. Finally the results from the sensitivity processing step are presented to extrapolate the budgets to a "what if" situation in the future.

Machinery Complement Selection

The machinery complements selected by OMCSS are optimal machinery complements in the sense that each machinery complement provides the required annual flow of tillage services at the least possible total cost. These least cost complements are important to the study because the machinery requirements are compared at a long run equilibrium. These optimal complements (Table 8) should be representative of the

Table 8. Optimal Machinery Complements of the Wheat Production Systems

	Systems							
Machines	1	2	3	4	5	6	7	8
Sprayer[a]	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0
Off-Set Disk	20.3	13.5						
Moldboard Plow (1)	4.0							
Moldboard Plow (2)	4.7							
Moldboard Plow (3)	9.0							
Chisel Plow (1)		12.0						
Chisel Plow (2)		16.0						
Dry Fert. Spreader	60.0	60.0						
Liquid Fert. Spreader							40.0	40.0
Knife NH_3 Applicator	22.0	28.0						
Sweep (1)			30.0	15.0	15.0	15.0		
Sweep (2)						25.0		
Field Cultivator (1)	12.5	27.5						
Field Cultivator (2)	13.5							
Conventional Drill	40.0	40.0						
Stubble Drill (1)			39.6	13.2	13.2	39.6	39.6	39.6
Stubble Drill (2)				26.4	26.4			
Tractor (1)[b]	81	131	180	70	70	91	70	70
Tractor (2)	91	180		111	111	180	180	180
Tractor (3)	180							

Table 8. (Continued)

Machines	Systems 9 1+4	10 1+5	11 1+7	12 1+8	13 2+4	14 2+5	15 2+7	16 2+8
Sprayer[a]	47.0	47.0	47.0	47.0	47.0	47.0	47.0	47.0
Off-Set Disk	12.5	12.5	12.5	12.5	16.8	16.8	13.5	12.5
Moldboard Plow (1)	3.5	3.5	4.0	4.0				
Moldboard Plow (2)	5.3	5.3	5.3	5.3				
Moldboard Plow (3)								
Chisel Plow (1)					16.0	16.0	12.0	16.0
Chisel Plow (2)								
Dry Fert. Spreader	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Liquid Fert. Spreader			40.0	40.0			40.0	40.0
Knife NH_3 Applicator	28.0	28.0	28.0	28.0	15.0	15.0	15.0	28.0
Sweep (1)	15.0	15.0			15.0	15.0		
Sweep (2)								
Field Cultivator (1)	9.5	9.5	12.5	12.5	12.5	12.5	12.5	16.5
Field Cultivator (2)	9.5	9.5						
Conventional Drill								
Stubble Drill (1)	13.2	13.2	13.2	13.2	39.6	39.6	13.2	39.6
Stubble Drill (2)	26.4	26.4	26.4	26.4			26.4	
Tractor (1)[b]	70	70	70	70	81	81	70	111
Tractor (2)	70	70	81	81	180	180	81	180
Tractor (3)	111	111	111	111			131	

Table 8. (Continued)

Machines	Systems 17 3+4	18 3+5	19 6+4	20 6+5	21 1+3	22 1+2
Sprayer[a]	47.0	47.0	47.0	47.0	47.0	47.0
Off-Set Disk					12.5	20.3
Moldboard Plow (1)					3.5	6.7
Moldboard Plow (2)					3.5	
Moldboard Plow (3)						
Chisel Plow (1)						16.0
Chisel Plow (2)						
Dry Fert. Spreader					60.0	60.0
Liquid Fert. Spreader						
Knife NH_3 Applicator					28.0	28.0
Sweep (1)	15.0	15.0	20.0	25.0	15.0	
Sweep (2)						
Field Cultivator (1)					9.5	27.5
Field Cultivator (2)					9.5	
Conventional Drill						40.0
Stubble Drill (1)	13.2	13.2	13.2	39.6	13.2	
Stubble Drill (2)	26.4	26.4	26.4		26.4	
Tractor (1)[b]	70	70	70	180	70	131
Tractor (2)	111	111	131		70	180
Tractor (3)					111	

[a] Implement widths in feet
[b] Tractor sizes in horsepower

complements found on well managed farms dedicated to any of the wheat production systems and similar in nature to the case study farm.

Machinery Complements for Systems 1-8

The power and machinery requirements vary widely among the first eight wheat production systems. For comparison purposes, power requirements can be expressed in annual horsepower hours (AHPH), which are equivalent to the sum of each tractor's horsepower multiplied by its hours of annual use. The annual hours for each tractor in the various systems can be found in Appendix A. The power requirements vary from approximately 179 thousand AHPH for System 2 to 31 thousand AHPH for System 8. As most would expect, the power requirements for the reduced tillage systems are considerably less than for the conventional tillage systems. The machinery complements for Systems 1 through 8 are illustrated in Table 8.

The machinery complement for System 1 includes an 81, 91, and 180 horsepower tractor. The 180 horsepower tractor provides the power to pull the 20.3 foot offset disk, or a six-18 inch bottom plow, or a 40 foot conventional drill. The 91 horsepower tractor is used to pull a four-14 inch bottom plow, a 22 foot anhydrous ammonia applicator, and a 13.5 foot field cultivator. The 81 horsepower tractor is used to power a sprayer, three-16 inch bottom plow, dry fertilizer spreader, and 12.5 foot field cultivator. The tractors log 469, 489, and 445 hours annually, respectively, and the system uses approximately 165 thousand AHPH.

The machinery complement for System 2 is powered by two tractors. The large 180 horsepower tractor is used to pull a 16 foot chisel and a 27 foot field cultivator. During these two operations the tractor logs 542 hours. The remaining operations in System 2 are powered by a 131 horsepower tractor, which logs 624 hours annually. These operations include the use of a sprayer, a 13.5 foot offset disk, a 12 foot chisel, a 28 foot anhydrous ammonia applicator, and a 40 foot conventional drill.

The machinery items in System 3 are powered by a 180 horsepower tractor. This tractor logs 416 annual hours and supplies approximately 75 thousand AHPH. This power is consumed by spraying, sweeping, and drilling operations.

Systems 4 and 5 use the same machinery items in their optimal machinery complements. The complements differ only in the numbers of annual hours for the sprayer and the tractor pulling the sprayer. This difference arises because the Bladex plus Paraquat spray operation in System 4 is replaced in System 5 by an aerial application of Surflan. The complements are powered by 71 and 111 horsepower tractors. The smaller tractor is used to pull the sprayer and 13.2 foot stubble drill. The 111 horsepower tractor is the power unit for a 15 foot sweep and a 26.4 foot stubble drill. System 4 requires approximately 53 thousand AHPH and System 5 requires 43 thousand AHPH.

System 6 has tillage requirements similar to System 3. Both systems apply Bladex plus Paraquat and anhydrous ammonia with a sweep, but in System 6 all the materials are applied in one operation after harvest. Due to reduced field efficiency, System 6 requires an additional tractor and sweep to complete the operation in the allowed time. System 6 uses 91 and 180 horsepower tractors, which supply approximately 60 thousand AHPH. The 91 horsepower tractor is used to pull the sprayer and 15 foot sweep. The 180 horsepower tractor supplies power to the 25 foot sweep and 39.6 foot stubble drill. The tractors log 237 and 213 annual hours, respectively.

Systems 7 and 8 have identical optimal machinery complements. In these zero tillage systems, a 70 horsepower tractor is used to pull a sprayer and liquid nitrogen applicator. The wheat is seeded using a 39.6 foot stubble drill pulled by a 180 horsepower tractor. The systems differ slightly in annual hours because of the substitution of a spray operation in System 7 for an aerial spray application in System 8. As a result of the annual hour differences, System 7 requires approximately 41 thousand AHPH compared to 31 thousand AHPH for System 8.

Machinery Complements for Combination Systems

The combination systems can easily be divided into two sets. The first set contains Systems 9 through 16, inclusive. These systems were designed by mixing two conventional systems with those reduced tillage systems which were not tillage intensive through June. The second set of systems include Systems 17 through 22. These systems consist of potential combinations of reduced tillage systems and two systems which incorporate System 1.

In the first set, the eight systems use five different machinery complements. Systems 9 and 10, 11 and 12, and 13 and 14 use the same machinery items in their complements with differences arising only in machinery annual hours. The reason for the similarities in complements is because the Bladex systems and the Surflan systems have nearly identical machinery requirements. In both the one tillage systems (4 and 5) and the zero tillage systems (7 and 8), a Bladex application is replaced by an aerial Surflan application. Thus, the only machinery requirement difference between System 4 and System 5 is one spray operation, and likewise for Systems 7 and 8.

Since the sprayer can be pulled by any tractor and occurs in a period with unused field hours, the machinery complements usually do not change as a result of adding or deleting a spray operation.

An exception to this general observation is System 15 and 16. These two systems mix the conventional chisel system, System 2, with the zero tillage Systems 7 and 8. In the case of Systems 15 and 16, the deletion of a spray operation is the only machinery requirement difference. However, this difference greatly affects the machinery complements selected. By eliminating one spray operation in System 16, it becomes more attractive to use a larger tractor, anhydrous ammonia applicator, field cultivator, and stubble drill. Thus, System 16 uses fewer and larger machinery items than System 15.

It is also interesting to note the changes in machinery complements between the one tillage systems and the zero tillage systems used in combination with System 1. If you compare System 9 with System 11, the machinery complements appear very similar (Table 8). Both systems use the same three sizes of tractors. When changing from System 9 to System 11, the sweep is no longer required and not included in the complement of System 11. Since a sweep is not required, the machinery complement for System 11 contains larger plows and a larger field cultivator. The remaining machinery sizes are unaffected by moving from a two tillage system to a one tillage system in combination with System 1. The combination complements seem to be dominated by either System 1 or System 2.

Thus Systems 9 through 12 and Systems 13 through 16 complements are very similar even though different reduced tillage systems are used.

The first set of combination systems also has a noticeable increase in the number of machines per complement compared to Systems 1 through 8 (Table 8). This increase is due to the increased types of tillage operations for these combinations. A farm using a combination system must stock all the types of tillage implement required for both a conventional and reduced tillage systems. Although these combinations use more machine items per complement, the size of the machines are generally smaller. The economic viability of the combinations then becomes sensitive to the trade-off in costs between machinery size and machine number.

The second set of combinations includes Systems 17 through 22. The first four of these combinations, or Systems 17 through 20, use a mixture of two reduced tillage systems. These systems have smaller machinery complements which include a sprayer, sweep, liquid fertilizer applicator, stubble drill, and tractor. Systems 17 and 18 use a one tillage and two tillage system. Systems 19 and 20 use two one tillage systems. Since Systems 3 and 6 are tillage intensive in June, Systems 5 and 6 were used to reduce the work load in June. Systems 21 and 22 were two other possible combinations using System 1.

Summary of Machinery Selection

Several patterns can be observed from the results of the machinery selection in Table 8. First note that no four wheel drive tractors, with 229 horsepower, are included in any machinery complement. The absence of four wheel drive tractors indicate the tractors are a more expensive source of power than two wheel drive tractors for the case farm. Several factors work together in the model to make the four wheel drive tractor a more expensive alternative. With a purchase price of $72,000, the four wheel drive tractors cost about $22,000 more than a 180 horsepower tractor. Since an 81 horsepower tractor costs only $21,000, the additional 48 horsepower gained by moving up to a four wheel drive tractor is usually more costly than selecting another small tractor.

The four wheel drive tractors also suffer considerable penalties for the equipment they are matched to. As equipment widths increase, their average cost per foot usually increases. These increased costs are due to additional wheels, folding mechanisms, and additional structural supports.

It should be noted that four wheel drive tractors are partially discriminated against in the study due to relatively cheap operator labor. In the machinery selection procedure, it is assumed that any quantity of tractor operator labor is available at $4 per hour. Kletke and Griffin (1977) found that as wage rates increase, farmers may substitute capital for labor. This substitution results in larger implements with fewer but larger tractors. Therefore, four wheel drive tractors may be feasible at higher wage rates.

The machinery selection results also point out which time periods are the most critical. The critical time periods refer to the time periods during the production cycle when the machinery selection problem is most constrained with respect to field work hours. These critical time periods determine to a large extent the machinery sizes in a given complement. In the conventional systems the second half of June is the most critical period, while the last half of September is the most critical period for the reduced tillage systems.

Regardless of the number of drills, in the second half of September all the systems require a total of 40 feet of drill to accomplish the seeding operation. This requirement can be met by using one large 40 foot drill or perhaps two smaller drills having a total width of more than 40 feet. In the conventional systems, the drill requirement is met by using one large drill pulled by at least a 111 horsepower tractor. However, the stubble drills have a power requirement considerably larger than the conventional drills. As a result, the reduced tillage systems use either a 39.6 foot stubble drill pulled by a 180 horsepower tractor, or two smaller drills pulled by 70 horsepower and 111 horsepower tractors. Thus, in the reduced tillage systems the drill operation largely determines the tractor sizes in the complements. In the conventional systems, the early tillage operations determine tractor sizes more than the drill operation. The conventional drill is less constrained mainly because the power requirements per foot of a conventional drill are smaller than a stubble drill. In the model, a 111 horsepower tractor is capable of pulling a 40 foot conventional drill whereas a 40 foot stubble drill requires a 180 horsepower tractor.

It is also easy to observe from Table 8 that the complements for Systems 9 through 16 contain a large number of machines. These combinations incorporate a conventional system with a reduced tillage system. The additional machines required in these combinations are a result of the number of different operations required. Very few of the machines can substitute for each other when conventional and reduced tillage systems are combined. As a result, the complements contain a large number of specialized machines. This fact tends to offset the advantages the combinations offer. Thus, the combinations are an effective means of reducing time constraints in June, but require more diverse complements containing a larger number of specialized machines.

Annual Hours

OMCSS supplies additional information regarding each machinery complement in terms of annual hours. Due to accounting rows, OMCSS not only selects the machines for an optimal complement, but also accounts for the hours each machine is used annually. These annual hour estimates are important for accurate fixed cost allocation in the Budget Generator.

Fixed costs estimated by the Budget Generator (BG) include depreciation insurance, taxes, and machinery investment opportunity costs. Of these items, depreciation and interest account for the largest share of fixed cost. In the BG, depreciation calculations follow the straight line depreciation method. Usually fixed costs refer to costs on a firm level which do not vary with output. However, the BG calculations budgets on a per acre basis. Therefore, the BG must use some allocation method to allocate the total fixed costs of a machinery complement to a per acre basis. Thus, the calculations of fixed costs require estimates of annual hours and life of the machines, but allocation of fixed costs to a per acre basis is very dependent upon farm size.

Normally, fixed costs per acre can easily be averaged by calculating a machinery complement's total fixed costs and dividing by the number of acres per farm. However, the BG uses a more indirect method of allocating fixed costs, which makes machine annual hours important. In the BG, farm size is indirectly implied by the number of hours a machine is used annually. By specifying the number of times each machine covers an acre, the BG uses the width, speed, and field efficiency factors to calculate the number of hours per acre each machine is used. If annual hours for each machine are divided by the machine hours per acre, the units cancel leaving total annual acres, or farm size.

The unit cancellations in equations (11 through 14) more clearly demonstrate how the BG allocates total fixed costs on a per acre basis using annual hours and hours per acre values. In equation (11), total fixed costs (TFC) are expressed on a per hour (HR) basis by dividing TFC by the machine annual hours. The total fixed cost per hour (TFC/HR) are converted to a per acre basis by multiplying by hours per acre (equation 12). Equation (13) shows more clearly how the hour units cancel out and TFC/HR are converted to TFC/ACRE. Notice that when HRS/ACRE are divided by MACHINE ANNUAL HRS in equation (14), the reciprocal of annual acres is formed. Thus, multiplying TFC by hours per acre and then dividing by annual hours is equivalent to dividing TFC by acres per year.

$$(11)\quad \text{TFC/HR} = \text{TFC/MACHINE ANNUAL HRS}$$

$$(12)\quad \text{TFC/ACRE} = \text{TFC/HR} \times \text{HRS/ACRE}$$

$$(13)\quad \text{TFC/ACRE} = \frac{\text{TFC}}{\text{MACHINE ANNUAL HRS}} \times \text{HRS/ACRE}$$

$$(14)\quad \frac{1}{\text{ANNUAL ACRES}} = \frac{\text{HRS/ACRE}}{\text{MACHINE ANNUAL HRS}}$$

In this manner, the BG allocates fixed costs on a per acre basis. Thus, estimates of annual hours of use and machine life are very important to fix farm size. By fixing farm size, the per acre budgets from the BG accurately reflect changes in fixed costs between the tillage systems. Since fixed costs are an important issue when comparing conventional with reduced tillage systems, the annual hour estimates supplied by OMCSS are important to the study. The machinery combinations and the annual hours of each machine for the 22 systems can be found in Appendix A.

Enterprise Budgets

In this section of the chapter the results from the Budget Generator are presented and summarized. Each budget reflects the costs of the operating inputs shown in Table 7 and the machinery selected by OMCSS. The timing of the operations and inputs, tractor-implement matching, and machinery annual hours can be found in Appendix A for each system. In addition to the summary of the costs for each system, the quantities of labor, fuel, and capital are presented. These resource quantities provide additional insights into the advantage and disadvantages of reduced tillage wheat.

Operating Input Costs

Operating input costs include those costs which are commonly thought of as variable costs. The operating inputs in Table 9 contain one group of inputs fixed across the systems and three groups of inputs which interact to change total operating costs between systems. The first group of constant inputs include insecticide and application, seed, and custom combine and hauling activities. These inputs are common to all systems.

The second group of inputs change very little between systems. They include fertilizers and fertilizer spreading equipment rental. In

Table 9. Total Costs of Wheat Production Systems in Dollars Per Acre

	Systems							
	1	2	3	4	5	6	7	8
OPERATING INPUTS:								
Parathion	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Aerial Spray Charge	3.00	3.00	3.00	3.00	6.00	3.00	3.00	6.00
2-4-D	1.27	1.27	1.91	1.91	0.64	1.91	1.91	0.64
Surflan					13.00			13.00
MCPA					1.57			1.57
Bladex			9.43	9.43		9.43	9.43	
Paraquat				5.85		5.85	11.70	5.85
18-46-0	12.76	12.76	12.76	12.76	12.76	12.76	12.76	12.76
Fertilizer Spreader Rental	0.11	0.11						
Anhydrous Ammonia (NH_3)	15.45	15.45	15.45	15.45	15.45	15.45		
Liquid Nitrogen (N)							20.32	20.32
Liquid N Spreader Rental							0.90	0.90
Seed	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Seed Treatment			0.50	0.50	0.50	0.50	0.50	0.50
Custom Combine	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Custom Haul	4.48	4.48	4.48	4.48	4.48	4.48	4.48	4.48
Annual Operating Capital	6.85	7.11	7.60	8.24	8.68	8.49	9.66	10.08
Labor Charges	4.98	4.13	1.61	2.06	1.55	1.59	1.53	1.01
Fuel, Lube, Repairs	13.42	15.24	8.45	5.95	4.81	6.23	5.09	3.69
TOTAL OPERATING COSTS	84.19	85.42	87.04	91.49	91.30	91.55	103.14	102.66
FIXED COSTS								
Machinery								
Interest at 17%	12.68	11.27	9.83	8.36	8.35	12.33	9.22	9.22
Depr., Taxes, Insur.	9.84	8.81	8.09	6.77	6.77	9.91	7.28	7.28
TOTAL FIXED COSTS	22.52	20.08	17.92	15.13	15.12	22.24	16.50	16.50
TOTAL COSTS	106.11	105.50	104.96	106.62	106.42	113.79	119.64	119.16

Table 9. (Continued)

	Systems						
	9 1+4	10 1+5	11 1+7	12 1+8	13 2+4	14 2+5	15 2+7
OPERATING INPUTS:							
Parathion	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Aerial Spray Charge	3.00	4.50	3.00	4.50	3.00	4.50	3.00
2-4-D	1.60	0.96	1.60	0.96	1.60	0.96	1.60
Surflan		6.50		6.50		6.50	
MCPA		0.78		0.78		0.78	
Bladex	4.71		4.71		4.71		4.71
Paraquat	2.93		5.86	2.93	2.93		5.86
18-46-0 Fertilizer	12.76	12.76	12.76	12.76	12.76	12.76	12.76
Fertilizer Spreader Rental	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Anhydrous Ammonia (NH_3)	15.45	15.45	7.72	7.72	15.45	15.45	7.72
Liquid Nitrogen (N)			10.13	10.13			10.13
Liquid N Spreader Rental			0.45	0.45			0.45
Seed	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Seed Treatment	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Custom Combine	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Custom Haul	4.48	4.48	4.48	4.48	4.48	4.48	4.48
Annual Operating Capital	7.61	7.85	8.30	8.35	7.79	8.00	8.40
Labor Charges	4.30	4.05	3.98	3.34	3.42	3.17	3.95
Fuel, Lube, Repairs	10.12	9.61	9.61	7.95	11.33	10.70	10.28
TOTAL OPERATING COSTS	89.12	89.10	94.76	93.01	89.63	89.46	95.50
FIXED COSTS							
Machinery							
Interest at 17%	11.34	11.33	11.13	10.20	11.46	11.45	11.31
Depr., Taxes, Insur.	9.22	9.20	8.93	8.21	9.27	9.27	9.04
TOTAL FIXED COSTS	20.56	20.53	20.06	18.41	20.73	20.72	20.35
TOTAL COSTS	109.68	109.63	114.82	111.42	110.36	110.18	115.85

Table 9. (Continued)

	Systems						
	16 2+8	17 3+4	18 3+5	19 6+4	20 6+5	21 1+3	22 1+2
OPERATING INPUTS:							
Parathion	0.86	0.86	0.86	0.87	0.86	0.86	0.86
Aerial Spray Charge	4.50	3.00	4.50	3.00	4.50	3.00	3.00
2-4-D	0.96	1.91	1.27	1.91	1.27	1.60	1.27
Surflan	6.50		6.50		6.50		
MCPA	0.78		0.78		0.78		
Bladex		9.43	4.71	9.43	4.71	4.71	
Paraquat	2.93	2.93		5.86	2.93		
18-46-0 Fertilizer	12.76	12.76	12.76	12.76	12.76	12.76	12.76
Fertilizer Spreader Rental	0.05					0.05	0.11
Anhydrous Ammonia (NH_3)	7.72	15.45	15.45	15.45	15.45	15.45	15.45
Liquid Nitrogen (N)	10.13						
Liquid N Spreader Rental	0.45						
Seed	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Seed Treatment	0.25	0.50	0.50	0.50	0.50	0.25	
Custom Combine	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Custom Haul	4.48	4.48	4.48	4.48	4.48	4.48	4.48
Annual Operating Capital	8.61	8.01	8.13	8.35	8.62	7.30	6.94
Labor Charges	2.81	2.51	2.05	1.85	1.13	4.93	3.93
Fuel, Lube, Repairs	9.75	7.67	6.31	5.98	5.88	11.24	14.20
TOTAL OPERATING COSTS	94.54	90.51	89.30	91.43	91.39	87.63	84.00
FIXED COSTS							
Machinery							
Interest at 17%	12.08	9.04	8.35	9.20	8.86	11.74	11.67
Depr., Taxes, Insur.	9.62	7.31	6.76	7.47	7.27	9.54	9.16
TOTAL FIXED COSTS	21.70	16.35	15.11	16.67	16.13	21.28	20.83
TOTAL COSTS	116.24	106.86	104.41	108.10	107.52	108.91	104.83

all the systems, 88 pounds of 18-46-0 fertilizer are applied. Small differences in total operating cost arise from the different modes of 18-46-0 application. Whenever possible, the fertilizer is applied with a rental spreader at a cost of $0.11 per acre. With the reduced tillage systems, 18-46-0 is applied through the stubble drill. Additional nitrogen in the form of anhydrous ammonia or liquid nitrogen is applied to each of the systems. If no tillage operations occur, such as in Systems 7 and 8, liquid nitrogen and a rented spreader are used. Since liquid nitrogen is a more expensive source of nitrogen, the liquid nitrogen application costs $21.22 per acre verses $15.45 for anhydrous ammonia. Thus, total operating cost for fertilizer varies slightly across systems unless liquid nitrogen is required.

The remaining two groups of inputs cause major differences in total operating input costs between the systems. The third group of operating inputs include herbicide spray materials such as 2,4-D, Surflan MCPA, Bladex, and Paraquat. Herbicide costs range from $1.27 per acre in Systems 1 and 2 to $23.04 per acre in System 7. As a result of additional herbicide costs, systems with fewer tillage operations have larger total operating costs.

The increase in herbicide costs for the reduced tillage systems are partially offset by the fourth set of operating inputs. The quantities of labor, fuel, lubrication, and repairs decrease as tillage operations decrease across systems. Although operating capital charges are usually higher for reduced tillage systems, the net effect of these inputs is to decrease operating costs as the systems become less tillage intensive. Therefore, changes in total operating costs across the systems arise from a trade-off between additional herbicides costs and reduced labor, fuel, lube, and repair costs. Normally, the additional herbicide costs are greater than the operating input savings. This causes the reduced tillage systems to have a total operating cost greater than the conventional tillage systems.

Looking at Table 9, the conventional Systems, 1 and 2, generate the smallest total operating cost of $84.19 and $84.42 per acre, respectively. Zero tillage Systems, 7 and 8, generate the largest total operating costs of $103.14 and $102.66, respectively. The total operating costs of Systems 4, 5, and 6 are approximately equal at $91.45 per acre. The total operating costs of the combinations usually fall between the operating cost range of their component systems. Several exceptions are Systems 18, 19, and 21 in which total operating costs of the combinations exceed the costs of either single system. System 22 is also an additional conventional tillage combination in which Systems 1 and 2 are mixed. In this combination, total operating input costs actually decrease slightly.

Total Fixed Costs

Total fixed costs (TFC) computed by the Budget Generator include depreciation, taxes, insurance, and an opportunity cost on the average machinery investment. The average investment concept is defined as the purchase price plus the salvage value divided by two. The average investment for an entire complement is merely the sum of the average investment for all the machines in the complement.

In contrast to the total operating costs, one would expect the conventional systems to incur larger fixed costs than the reduced tillage systems. Such is nearly the case as illustrated in Table 9.

Of the first eight systems, System 1, 6, and 2 have the largest TFC. System 1 requires a machinery complement capable of plowing 1,240 acres once during the second half of June through the first half of July. Since the chisels in System 2 have smaller power requirements than the plows of System 1, fewer tractors are required. This savings is reflected in lower fixed costs for System 2. But notice that System 2 has higher total operating costs because the chisels cover each acre twice compared to one time over for the plow.

System 6 represents a unique machinery selection problem which results in higher fixed costs. Bladex and anhydrous ammonia are applied by a sweep in one operation during June. Due to the additional spray and fertilizer application, the sweep operation loses considerable field efficiency. Since June is a critical time period, the additional loss of field efficiency translates into large equipment and higher fixed costs.

Systems 4 and 5 yield the lowest fixed cost in the first eight systems, followed closely by Systems 7 and 8. At first glance one would expect the zero tillage Systems 7 and 8 to have a lower TFC than the one tillage Systems 4 and 5. However, since time constrains operations, this is not the case.

It is also interesting to look at the fixed costs of combinations using Systems 1 and 2. In the first set of combinations (Systems 9 through 11), which incorporate System 1 with several reduced tillage systems, the TFC of the combinations are less than the TFC for System 1. The selection of smaller, more specialized equipment reduces TFC. Thus, the saving from using smaller equipment more than offsets the costs of having a larger number of specialized machinery items in the complement.

The situation is reversed for the second set of combinations (Systems 13 through 16), which incorporate System 2. In this case, the combinations have a higher total fixed cost than either component systems. Thus, the increased costs due to additional machine types in the complement more than offset reduced machine size savings.

Combination Systems 17 through 21 incorporate two reduced tillage systems. Systems 19 and 20 greatly reduce the TFC from System 6. By relaxing the critical time constraint in June, the combinations using System 6 require fewer tractors. Thus, System 6 is the most viable in combinations. System 19 incorporates Systems 3 and 5, and yield the smallest TFC of all the systems.

Total Costs

Total costs, shown in Table 9, present a clear picture of the net effect in changing variable and fixed costs. As just shown, the conventional systems incur higher fixed costs with relatively lower operating costs. On the other hand, the zero tillage systems incur relatively lower fixed costs and higher operating costs. The substitution of fixed and variable costs between the systems reflects the trade-off between machinery and herbicide costs.

The paramount question raised by this trade-off is whether additional operating costs are greater than fixed cost savings in the reduced tillage systems. The total cost row in Table 9 sheds light on the answer to this question. The total costs of the two zero tillage systems are approximately $13.50 per acre more than the total costs of the conventional systems. The one tillage systems, Systems 4, 5, and 6, also accumulate more total costs than either conventional system.

However, Systems 4 and 5 cost only about $1 per acre more than System 1. Systems 4 and 5 cost $106.62 per acre and $106.42 per acre, respectively, while Systems 1 and 2 cost $106.11 and $105.50 per acre. Due to added machinery fixed costs, the total cost for System 6, at $113.79 per acre, falls midway between the zero tillage systems and the other one tillage systems (Systems 4 and 5). Of the noncombination systems, System 3 offers the smallest total cost at $104.96 per acre, which is 54 cents per acre cheaper than the conventional chisel system. This two tillage system costs approximately $1 per acre less than System 1 and $1.50 per acre less than the two tillage Systems 4 and 5.

In summary, the total costs for the first eight systems range from $104.96 per acre to $119.64 per acre. When Systems 6, 7, and 8 are excluded, the range narrows considerably. Only $1.50 per acre, which is probably not statistically significant, separates the estimated total costs of the least and most expensive remaining systems. The conventional Systems 1 and 2, the one tillage System 3, and the two tillage Systems 4 and 5 generate nearly equal total costs. Since the total costs are comparable, Systems 3, 4, and 5 offer viable alternative means of producing wheat on a total cost basis.

The total costs of the combination systems can be discussed in two groups. The first group includes Systems 9 through 16 and incorporates Systems 1 and 2 with reduced tillage systems. Their total costs are considerably higher and range from $109.63 per acre to $116.42 per acre. Thus, when conventional and reduced tillage systems are combined, less machinery savings are realized. This fact makes these combinations less attractive than the first five systems on a total cost basis.

The second group of combinations includes Systems 17 through 22. Of these combinations, only Systems 17, 18, and 22 look promising. Systems 17 and 18 use two reduced tillage systems in combination. Since these systems incorporate systems with relatively low total costs, Systems 17 and 18 have relatively low total costs. Savings are also realized in System 22 where Systems 1 and 2 are combined. By using both plows and chisels in one complement, fixed costs are reduced in System 22 from their levels in System 1. This leaves System 22 with a total cost per acre of $104.83. Of the 14 combinations designed, only Systems 17, 18, and 22 appear to be competitive on a total cost basis.

Resource Requirements of the Systems

In addition to total costs, some systems may be particularly attractive to farmers with unique resource constraints. Labor, fuel, and capital resource requirements vary widely between the systems. If a farmer is particularly constrained in any of these areas, he may be more willing to accept a reduced tillage method of wheat production. Quantities of these three resources are estimated by the Budget Generator. These estimates have been summarized in the tables and discussion that follows.

Labor Requirements

Labor requirements are estimated in the Budget Generator by multiplying tractor hours by a factor of 1.1. Labor requirements in the systems range from 1.25 hours per acre in System 1 to 0.25 hours per acre in System 8 (Table 10). Of the two conventional systems, System 2 requires 0.22 labor hours per acre less than System 1. In the reduced

Table 10. Resource Quantities Per Acre Required by System

Systems	Labor (hours)	Fuel (Gallons)	Machinery Investments ($)	Herbicide Costs ($)	Total Operating Capital ($)
1	1.25	6.388	74.58	1.27	40.31
2	1.03	6.937	66.31	1.27	41.84
3	0.40	3.163	57.84	11.34	44.70
4	0.52	2.068	49.17	17.19	48.49
5	0.39	1.675	49.14	15.21	51.10
6	0.40	2.317	72.51	17.19	49.96
7	0.38	1.578	54.24	23.04	56.90
8	0.25	1.185	54.23	21.06	59.32
9	1.08	4.279	66.69	9.24	44.75
10	1.01	4.082	66.44	8.24	46.12
11	1.00	3.993	60.03	12.17	48.84
12	0.84	3.328	60.02	11.17	49.08
13	0.86	4.911	67.39	9.24	45.77
14	0.79	4.684	67.36	8.24	47.04
15	1.00	4.255	66.57	12.17	49.44
16	0.70	4.214	71.06	11.17	50.68
17	0.63	2.667	53.17	14.27	47.19
18	0.51	2.224	49.11	13.26	47.80
19	0.46	2.091	54.11	17.20	49.22
20	0.28	2.219	52.12	16.19	50.78
21	1.23	4.772	69.02	6.31	42.92
22	0.98	6.672	68.62	1.27	40.86

tillage systems, Systems 3 and 5 require approximately 0.40 labor hours per acre and System 4 requires 0.54 hours per acre. Although Systems 1 and 5 have comparable total costs, the reduced tillage systems require only half the labor demanded by the conventional systems.

Fuel Requirements

The fuel requirements of the 22 systems are shown in Table 9. These fuel requirements were estimated with the Budget Generator by using a fuel multiplier. A fuel multiplier, in this framework, is defined as the quantity of fuel consumed during each horsepower hour. In this study a fuel multiplier of 0.048 gallons per horsepower hour was selected. This fuel multiplier reflects an average load condition of 55 percent (Bowers, 1970). The fuel estimates for the systems range from 6.937 gallons per acre in System 2 to 1.185 gallons per acre in System 8. System 8 demands 5.75 gallons per acre less, or approximately one-sixth the fuel required in the conventional chisel system. Fuel consumption estimates for Systems 3, 4, and 5, which have total costs comparable to the conventional tillage systems are 3.163, 2.068, and 1.675 gallons per acre of fuel, respectively. Although these reduced tillage systems have comparable total costs, they demand only one-third to one-half the quantity of fuel required in the conventional systems.

Total fuel per acre estimates are further broken down into fuel estimates for each type of field operation (Table 11). Since many different tractor implement combinations are available for each field operation, the fuel estimates for each type of field operation contain some degree of variability. This variability in fuel estimates is largely a result of the inability of the Budget Generator to adequately

Table 11. Fuel Consumption Statistics by Field Operation

Field Operation	Observations	Diesel Fuel Gallons/Acre Mean	Range High	Range Low
Moldboard Plow	13	2.351	2.419	2.264
Chisel Plow	7	1.440	1.452	1.409
Off-set Disk	12	0.985	1.135	0.938
Sweep	14	1.023	1.462	0.864
NH_3 Knife Applicator	12	0.520	0.638	0.469
Field Cultivator	12	0.711	0.778	0.684
Stubble Drill	30	0.707	0.790	0.626
Conventional Drill	3	0.509	0.622	0.453
Sprayer	22	0.253	0.506	0.197
Dry Fertilizer Spreader	12	0.175	0.266	0.142
Liquid Fertilizer Spreader	6	0.234	0.338	0.213

reflect variable load conditions. In the Budget Generator, the fuel multiplier was calculated at a 55 percent average load. If implement and tractor sizes are properly matched, the fuel consumption for any operation should be nearly constant for anv tractor implement combination. However, OMCSS does not always pair tractor and implements to maintain a constant load factor. If, for example, a 180 horsepower tractor is the only tractor required in a complement, it would be used to pull both a sprayer or a chisel. Using the fuel multiplier method of fuel consumption estimation, both operations would require the same quantity of fuel per hour. Even though the sprayer and chisel load the tractor at different levels, the fuel estimates are equal because the horsepower hours per acre are equal. For this reason, fuel statistics are given in Table 11 for each field operation. The number of observations refers to the number of times each operation is found in the 22 systems. The mean and range establish how much variability occurs in each operation's fuel consumption estimate. Usually a large range in the fuel consumption estimates, infers that several different tractor sizes were used to pull one implement width.

Capital Requirements

Total capital requirements can easily be divided into short term and long term capital requirements. Short term capital refers to annual operating capital which is used to meet cash expenses during one production cycle. Long term capital refers to the capital which is invested into machinery items. These two types of capital also carry fixed and variable cost connotations. The charges accessed to annual operating capital are treated in the Budget Generator as variable costs. The charges for average machinery investments are treated as fixed costs. Since the conventional and reduced tillage systems have considerably different operating and machinery input requirements, their short term and long term capital requirements differ considerably.

Annual Operating Capital. In Table 10, the total annual operating capital (AOC) requirements for the systems are given. They range from $40.31 per acre in System 1 to $59.32 per acre in System 8. In the conventional systems, AOC is used to finance the purchases of fuel, fertilizer, seed, insecticides, 2,4-D and applicator rentals. In addition to these inputs, the reduced tillage systems also require AOC for purchases of Surflan plus MCPA, Bladex, and/or Paraquat. The costs of the herbicides used in each system are also given in Table 10. Except for fuel, the reduced tillage systems require the financing of nearly the same input costs as the conventional system plus additional herbicide expenses. Therefore, the reduced tillage system require up to $20 per acre more AOC.

Machinery Investments. These investments require long term capital to finance the purchase of a machinery complement. In the Budget Generator, machinery investment charges are assessed on the basis of the average investment required over the life of the machinery complement. The average machiney investments per acre for each complement are given in Table 10. The average machinery investments range from $74.58 per acre in System 1 to $49.11 per acre for System 18. Note that System 18 is composed of practices used in Systems 3 and 5, and all three systems use identical machinery complements. The complements differ only in the number of machine annual hours.

Perhaps a better indication of long term capital requirements is illustrated in Table 12. This table shows the initial machinery investment required by each wheat production system. In this case the initial investment requirement is equal to the total purchase price of the entire complement.

Since most fixed cost equations in the Budget Generator depend heavily on purchase price values, Table 12 illustrates why fixed costs differences arise between the Systems. The initial capital requirements range from $143,504 for System 1 to $96,454 for Systems 4, 5, and 18. Notice that System 1 requires an initial investment which is $15,500 more than System 2 and is closely rivaled by System 6 at $141,536. The complements for the combination systems which incorporate the practices of System 1 or 2, tend to require initial investments between that required by Systems 1 and 2. Thus, the combinations offer little if any savings in initial machinery investment.

Of particular importance in Table 12 is the impact of reduced tillage systems on initial investment requirements. In contrast to fuel and labor requirements, reduced tillage systems do not offer huge initial capital savings. In the case of fuel and labor, resource requirements decrease by one-half to two-thirds by using reduced tillage systems. However, initial capital requirements are reduced by one-third when changing from System 1 to System 4 or by one-fourth when changing from System 2 to System 4. Thus, while relatively large fuel and labor savings are generated by moving to reduced tillage systems, initial machinery investments are reduced proportionately less by reducing tillage operations.

Table 12. Initial Machinery Investment Requirements by System

System	Investment ($)	System	Investment ($)
1	143,504	12	127,659
2	128,013	13	132,360
3	106,466	14	132,360
4	96,454	15	129,028
5	96,454	16	138,668
6	141,536	17	98,155
7	105,834	18	96,454
8	105,834	19	106,295
9	132,239	20	99,948
10	132,239	21	133,327
11	127,659	22	132,671

Sensitivity Analysis

The sensitivity analysis is designed to show how changing wage rates, diesel fuel prices, and interest rates affect the total costs of each system. The results from the sensitivity analysis allow the system budgets to be extrapolated to many possible situations. Using three levels of each price parameter, the total costs of each system are calculated for 27 unique situations.

By modeling many different situations, considerable flexibility is added to the results of the study. This flexibility allows the system budgets to address general questions about how changing price levels might affect the future adoption of reduced tillage wheat production. If for example diesel fuel prices climb to $2.20 per gallon, the analysis offers estimates on how many dollars per acre could be saved by using a reduced tillage system. The analysis also offers the flexibility of tailoring the system budgets to more specific farm situations. For example, a farmer may value his labor at more than $4.00 per hour. The sensitivity analysis results can then be used to show how the total costs of the systems change as the price of labor increases. Likewise, the effects of additional capital constraints upon system selection can be shown by increasing the interest rate.

Results from the sensitivity model are shown in Tables 13, 14, and 15. Wage rates are held constant in each table while fuel prices and interest rates are allowed to vary. In this manner, total cost per acre are listed in Table 13 with $4.00 per hour labor, Table 14 with $7.00 per hour labor, and Table 15 with $10.00 per hour labor, while fuel prices and interest rates vary in each table. The total costs are also sorted in each column with the first two digits identifying the

Table 13. Ranked Total Costs Per Acre in Dollars With $4/Hour Labor and Identified by System Number

Diesel Fuel Prices ($/Gallon)																	
1.20						1.70						2.20					
Interest Rates																	
0.12		0.17		0.22		0.12		0.17		0.22		0.12		0.17		0.22	
22	99.36	13	104.41	18	109.25	18	100.98	18	105.88	18	110.79	18	102.40	18	107.36	13	112.32
18	99.56	22	104.84	3	110.08	3	101.83	3	107.03	3	112.24	5	103.54	5	108.64	5	113.74
3	99.83	3	104.95	22	110.31	5	102.48	5	107.53	5	112.59	3	103.83	3	109.12	4	114.32
2	100.10	2	105.50	2	110.91	4	103.05	4	107.98	4	112.91	4	104.36	4	109.34	3	114.40
1	100.96	5	106.42	5	111.44	17	103.54	17	108.62	17	113.71	20	105.19	17	110.39	17	115.55
5	101.41	4	106.62	4	111.50	22	103.62	20	108.99	20	114.19	17	105.24	20	110.45	20	115.71
4	101.74	1	106.71	17	111.88	20	103.79	22	109.28	19	114.71	19	105.60	19	110.87	19	116.14
17	101.84	17	106.86	1	112.45	19	104.27	19	109.49	22	114.93	22	107.89	22	113.72	22	119.55
20	102.38	20	107.52	20	112.67	2	104.53	2	110.12	2	115.72	2	108.96	2	114.74	2	120.52
19	102.94	19	108.11	19	113.28	1	105.05	1	110.96	1	116.88	1	109.13	10	115.07	10	120.92
21	103.32	21	108.91	21	114.51	21	106.37	21	112.09	21	117.82	10	109.21	1	115.22	21	121.12
10	104.00	10	109.64	9	115.25	10	106.61	10	112.35	10	118.10	21	109.42	21	115.27	9	121.16
9	104.11	9	109.68	10	115.27	9	106.84	9	112.52	9	118.20	9	109.57	9	115.36	1	121.31
14	104.46	14	110.18	14	115.90	14	107.46	14	113.30	14	119.15	12	110.21	12	115.84	12	121.46
13	104.70	13	110.36	13	116.01	13	107.83	13	113.62	12	119.17	14	110.45	14	116.42	14	122.39
12	105.97	12	111.42	12	116.88	12	108.09	12	113.63	13	119.41	6	110.61	5	116.85	13	122.81
6	107.66	6	113.79	6	119.91	6	109.14	6	115.32	6	121.50	13	110.97	13	116.89	6	123.10
11	109.10	11	114.82	11	120.53	11	111.65	11	117.47	11	123.29	11	114.20	11	120.12	11	126.05
15	110.06	15	115.86	15	121.66	15	112.77	15	118.69	15	124.60	8	114.98	8	120.72	8	126.46
15	110.15	16	116.24	16	122.33	16	112.84	16	119.04	16	125.24	15	115.49	15	121.51	7	127.34
8	113.48	8	119.16	8	124.84	8	114.23	8	119.94	8	125.65	16	115.53	7	121.71	15	127.54
7	114.08	7	119.64	7	125.20	7	115.08	7	120.67	7	126.27	7	116.08	16	121.84	16	128.15

Table 14. Ranked Total Costs Per Acre in Dollars With $7/Hour Labor and Identified by System Number

Diesel Fuel Prices ($/Gallon)																	
1.20						1.70						2.20					
Interest Rates																	
0.12		0.17		0.22		0.12		0.17		0.22		0.12		0.17		0.22	
3	101.03	18	105.94	18	110.78	18	102.51	18	107.41	18	112.32	18	103.93	18	108.89	18	113.85
18	101.09	3	106.15	3	111.28	3	103.03	3	108.23	3	113.44	5	104.71	5	109.81	5	114.91
22	102.30	5	107.59	5	112.61	5	103.65	5	108.70	5	113.76	3	105.03	3	110.32	3	115.60
5	102.58	22	107.78	4	113.06	4	104.61	4	109.54	4	114.47	4	105.92	4	110.90	4	115.88
2	103.19	4	108.18	22	113.25	20	104.63	20	109.83	20	115.03	20	106.03	20	111.29	20	116.55
20	103.22	20	108.36	20	113.51	17	105.43	17	110.51	17	115.60	19	106.98	19	112.25	17	117.44
4	103.30	2	108.59	17	113.77	19	105.65	19	110.87	19	116.09	17	107.13	17	112.28	19	117.52
17	103.73	17	108.75	2	114.00	22	106.56	22	112.22	22	117.87	22	110.83	22	116.66	22	122.49
19	104.32	19	109.49	19	114.66	2	107.62	2	113.21	2	118.81	6	111.81	2	117.83	2	123.61
1	104.71	1	110.46	1	116.20	1	108.80	1	114.71	1	120.63	2	112.05	6	118.05	10	123.95
14	106.83	14	112.55	21	118.20	10	109.64	10	115.38	10	121.13	10	112.24	10	118.10	12	123.98
21	107.01	21	112.60	14	118.27	14	109.83	14	115.67	9	121.44	12	112.73	12	118.36	6	124.30
10	107.03	10	112.67	10	118.30	21	110.06	9	115.76	21	121.51	9	112.81	9	118.60	9	124.40
13	107.28	9	112.92	9	118.49	9	110.08	21	115.78	14	121.52	14	112.82	14	118.79	14	124.76
9	107.35	13	112.94	13	118.59	6	110.34	12	116.15	12	121.69	1	112.88	21	118.96	21	124.81
12	108.49	12	113.94	12	119.40	13	110.41	13	116.20	13	121.99	21	113.11	1	118.97	1	125.06
6	108.86	6	114.99	6	121.11	12	110.61	6	116.52	6	122.70	13	113.55	13	119.47	13	125.39
11	112.10	11	117.82	11	123.53	11	114.65	11	120.47	11	126.29	8	115.73	8	121.47	8	127.21
16	112.25	16	118.34	16	124.43	16	114.94	8	120.69	8	126.40	11	117.20	7	122.85	7	128.43
15	113.06	15	118.86	15	124.66	8	114.98	16	121.14	16	127.34	7	117.22	11	123.12	11	129.05
8	114.23	8	119.91	8	125.59	15	115.77	15	121.69	7	127.41	16	117.63	16	123.94	16	130.25
7	115.22	7	120.78	7	126.34	7	116.22	7	121.81	15	127.60	15	118.49	15	124.51	15	130.54

Table 15. Ranked Total Costs Per Acre in Dollars With $10/Hour Labor and Identified by System Number

Diesel Fuel Prices ($/Gallon)																	
1.20						1.70						2.20					
Interest Rates																	
0.12		0.17		0.22		0.12		0.17		0.22		0.12		0.17		0.22	
3	102.23	3	107.35	18	112.31	18	104.04	18	108.94	18	113.85	18	105.46	18	110.42	18	115.38
18	102.62	18	107.47	3	112.48	3	104.23	3	109.43	3	114.64	5	105.88	5	110.98	5	116.08
5	103.75	5	108.76	5	113.78	5	104.82	5	109.87	5	114.93	3	106.23	3	111.52	3	116.80
20	104.06	20	109.20	20	114.35	20	105.47	20	110.67	20	115.87	20	106.87	20	112.13	20	117.39
4	104.86	4	109.74	4	114.62	4	106.17	4	111.10	4	116.03	4	107.48	4	112.46	4	117.44
22	105.24	17	110.64	17	115.66	19	107.03	19	112.25	19	117.47	19	108.36	19	113.63	19	118.90
17	105.62	22	110.72	19	116.04	17	107.32	17	112.40	17	117.49	17	109.02	17	114.17	17	119.33
19	105.70	19	110.87	22	116.19	22	109.50	22	115.16	22	120.81	6	113.01	6	119.25	22	125.43
2	106.28	2	111.68	2	117.09	2	110.71	2	116.30	2	121.90	22	113.77	22	119.60	6	125.50
1	108.46	1	114.21	1	119.95	6	111.54	6	117.72	14	123.89	2	115.14	12	120.88	12	126.50
14	109.20	14	114.92	14	120.64	14	112.20	14	118.04	6	123.90	14	115.19	2	120.92	2	126.70
13	109.86	13	115.52	13	121.17	1	112.55	10	118.41	10	124.16	12	115.25	10	121.13	10	126.98
10	110.06	10	115.70	10	121.33	10	112.67	1	118.46	12	124.21	10	115.27	14	121.16	14	127.13
6	110.06	9	116.16	9	121.73	13	112.99	12	118.67	1	124.38	9	116.05	9	121.84	9	127.64
9	110.59	6	116.19	21	121.89	12	113.13	13	118.78	13	124.57	13	116.13	13	122.05	8	127.96
21	110.70	21	116.29	12	121.92	9	113.32	9	119.00	9	124.68	8	116.48	8	122.22	13	127.97
12	111.01	12	116.46	6	122.31	21	113.75	21	119.47	21	125.20	1	116.63	21	122.65	21	128.50
16	114.35	16	120.44	8	126.34	8	115.73	8	121.44	8	127.15	21	116.80	1	122.72	1	128.81
8	114.98	8	120.66	16	126.53	16	117.04	7	122.95	7	128.55	7	118.36	7	123.99	7	129.62
11	115.10	11	120.82	11	126.53	7	117.36	16	123.24	11	129.29	16	119.73	16	126.04	11	132.05
15	116.06	15	121.86	7	127.48	11	117.65	11	123.47	16	129.44	11	120.20	11	126.12	16	132.35
7	116.36	7	121.92	15	127.66	15	118.77	15	124.69	15	130.60	15	121.49	15	127.51	15	133.54

system number. These total cost values are grouped by system in Appendix B. In this manner, one can easily identify how changing price parameters affect the total costs of one particular system.

At this point, several cautions should be raised about the results of the sensitivity analysis. First, the machinery complements were selected using $4.00 per hour labor, 17 percent interest on capital, and $1.20 per gallon of diesel fuel. Major changes in these prices could, and probably do, change the optimal machinery complements for the systems. These changes are not reflected in the sensitivity results. However, one could speculate that the reduced tillage system complements would be more stable than the conventional system complements to changes in these prices since the reduce tillage systems use less fuel, labor, and capital.

The second caution to keep in mind is that increased fuel prices and interest rates may affect herbicide and machinery prices. Certainly herbicide and machinery manufacturing and sales require energy and capital resources. Therefore, general price level increases may affect their costs. The costs of these items are fixed in the analysis.

Despite its shortcomings, several important general trends can be gleaned from the sensitivity analysis tables. These trends involve the way wage rates, fuel prices, and interest rates affect the comparative costs of reduced versus conventional wheat production systems. In the following discussion, emphasis will be given to the five least costly systems under various price conditions. Generally these sets contain some combination of Systems 1 through 5 and/or Systems 17, 18, 20, and 22. Of particular interest is the way these sytems change in rank as the price parameters are varied. Notice that Systems 1, 2 and 22 represent conventional systems, while the remaining systems are reduced tillage systems.

General Effects of Changing Interest Rates

The affects of changing interest rates can be viewed in either Tables 13, 14, or 15. Since labor charges are not included in the calculation of annual operating capital, the effects of changing wage rates and interest rates are independent from one another. Therefore, the effects of changing interest rates can be shown by using just one wage rate, such as Table 13.

In Table 13 the wage rate is set at $4.00 per hour, while diesel fuel prices vary from $1.20 to $2.20 per gallon. At each fuel price, interest rates are varied from 12 percent to 22 percent. Notice that at each fuel price level, changing the interest rate has very little impact on the ranking of the five least costly systems. Although total costs certainly increase, changing the interest rates seem to change the total costs of each system by approximately the same amount. In most cases, changing the interest rates from 12 percent to 22 percent increases total costs by approximately $10 per acre. Since the total costs all change by approximately the same amount, the ranking of the five least costly systems change very little.

The effects of interest rate changes are evenly distributed across the systems mainly because the systems have similar total capital requirements. The conventional systems require more long term capital and the reduced tillage system requires more short term capital, but toal capital requirements are very comparable. Thus, changing interest rates has little impact on the selection of a wheat production system.

General Effects of Changing Diesel Fuel Prices

In contrast to interest rates, the relative rankings of systems by total costs are greatly affected by changing diesel fuel prices. Again to fix the interactions of wage rates, Table 13 is selected to point out the general effects of changing diesel prices. In Table 13 notice that with $1.20 diesel and 12 percent interest the three conventional systems are included in the top five least costly systems. When fuel prices increase to $1.70 per gallon with 12 percent interest, each of the three conventional tillage systems drop five places in the ranking. This leaves System 2 and System 1 in the ninth and tenth places. This ranking is unchanged as fuel prices increase to $2.20 per gallon. As Systems 22, 2, and 1 drop out of the top five, Systems 18 and 3 move to first and second place, respectively, with a fuel price of $1.70 per gallon. These systems are joined by Systems 5, 4, and 17 in third, fourth, and fifth place, respectively. This ranking remains the same when fuel prices increase to $2.20 per gallon, except Systems 3 and 5 switch ranking. Thus, increasing fuel prices independent of other prices greatly impedes conventional tillage systems in competing with the reduced tillage systems on the basis of total costs.

General Effects of Changing Wage Rates

The general effects of changing wage rates are very similar to the effects of changing fuel prices on the ranking. This similarity is largely due to the way the Budget Generator estimates fuel and labor requirements. Both resource quantities are estimated as a function of tractor hours. Therefore a great deal of correlation exists between the two quantities.

The general effects of changing wage rates can be shown by comparing Tables 13, 14, and 15. In each of these tables, different wage rates are used ranging from $4.00 per hour to $10.00 per hour. To isolate the effects of wage rates, the interest rate and fuel price can be fixed at 12 percent and $1.20 per gallon. These combinations of interest rate, fuel price and wage rate are shown in the first column of Tables 13, 14, and 15.

Notice in Table 13 with $4.00 per hour labor, all three conventional systems are included in the five least costly systems. When wage rates increase to $7.00 per hour, System 5 replaces System 1 in the top five systems. The remaining conventional systems exit the top five when wage rates increase to $10.00 per hour. Systems 1 and 2 are replaced in the top five by Systems 20 and 4. Thus, increasing wage rates from $4.00 per hour to $10.00 per hour yields the same top five systems as increasing the diesel fuel price to $2.20 per gallon. However, the order of the top five systems is somewhat different. At 12 percent interest, $1.20 per gallon diesel fuel, and $10.00 per hour labor, the five least costly systems are Systems 3, 18, 5, 20, and 4, respectively from first to fifth. The total costs of conventional systems are greatly impacted by changing wage rates relative to reduced tillage systems.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Introduction

In recent times a great deal of material has been published in the popular farm press about the merits of reduced tillage crop production. Many claim this crop production method will reduce total costs per acre and consequently be the way of the future. Conservationists also jump on the reduced tillage band wagon claiming it conserves soil, water, and fossil fuels. Yet with all the talk about reduced tillage crop production, little economic work has been conducted in the area.

Certainly one can reason that herbicides reduce the need for tillage operations. But how does eliminating tillage operations affect a farm's machinery complement? Will farms realize enough savings in fixed and variable machinery costs to justify additional herbicide costs in reduced tillage crop production? These questions are addressed in the study as they relate to wheat production in Oklahoma.

In general, the objective of this study was to investigate whether reduced tillage wheat production systems are less costly than more conventional methods of producting wheat in Oklahoma. To pursue this objective, 22 wheat production systems were defined. These systems were designed by agronomists and ranged from conventional clean tillage systems to zero tillage systems. In addition to these, systems using various levels of herbicides and tillage operations were defined. Once the systems were defined, the required tillage operations and operating inputs were identified for each system.

Although the variable costs of the operating inputs were easily found, the machinery costs of the systems were much more difficult to estimate. These costs are illusive because a larger number of tractor-implement combinations are capable of performing one tillage operation. In addition to tractor-implement matching problems, machinery costs are also influenced by farm size, weather patterns, and soil types. Thus, to solve the machinery cost dilemma, an integer linear programming model was used to select a least cost machinery complement for each system on a given case farm. The case farm consisted of 1,240 acres and produced continuous winter wheat in Garfield County, Oklahoma. This farm was selected to fix any effects of farm size, weather patterns, and soil type on machinery costs. Using the programming model it was possible to compare the machinery costs of the systems in a long run equilibrium situation.

With the operating inputs, tillage operations, and optimal machinery complements identified, enterprise budgets were drawn up for each system. The Budget Generator was a useful tool to rapidly and accurately calculate these budgets. From these budgets, inferences were made with respect to the trade-off between herbicide and machinery costs. The budgets also provide useful estimates of fuel, labor, and capital requirements of the systems.

The final procedure in the study was to extrapolate the results of the system budgets to many possible fuel price, interest rate, and wage rate situations. From these projections, future insights may be gained as to the acceptability of reduced tillage wheat production.

Results and Conclusions

The results from the enterprise budget analysis indicate that several of the reduced tillage systems generate total costs comparable to the conventional tillage systems. Of the 22 systems evaluated, the total costs of the three conventional systems and five reduced tillage systems fell within a range of \$2.03 per acre. The three conventional systems included System 1 (moldboard plow system), System 2 (chisel plow system), and System 22 (a combination system using both moldboard and chisel plows). The reduced tillage systems included a two tillage system (System 3), a pair of one tillage systems (Systems 4 and 5), and a pair of systems (Systems 17 and 18) which used combinations of Systems 3, 4, and 5.

The major reason these three conventional and five reduced tillage systems generate comparable total costs is because of the substitution of fixed and variable costs between the systems. The three conventional systems use relatively large and expensive machinery complements. The conventional tillage complements required initial machinery investments ranging from \$128,013 to \$143,504. In contrast, the five reduced tillage systems required smaller machinery complements with initial investments ranging from \$96,454 to \$106,466. The complements generated total fixed costs per acre ranging from \$20.08 to \$22.52 in the three conventional systems, and \$15.11 to \$17.92 in the five reduced tillage systems. Thus, fixed cost savings of \$2.16 to \$7.41 per acre are realized by using one of the reduced tillage systems.

These fixed cost savings are nearly equal to the additional operating expenses incurred in the five reduced tillage systems. With the three conventional systems (Systems 1, 2, and 22), total operating cost range from $84.00 to $85.52 per acre. In contrast, the five reduced tillage systems accumulated considerably greater total operating costs ranging from $87.04 to $91.49 per acre. Thus, the three conventional systems offer operating cost savings of $1.52 to $7.49 per acre. As a result of the fixed cost savings in the reduced tillage systems and operating cost savings in the conventional systems, total costs vary only slightly between the eight systems.

The remaining 14 systems evaluated in the study generate total cost considerably larger than the eight systems just discussed. This occurs for several reasons. First, the 14 systems include many combination systems which incorporate Systems 1 and 2 with various reduced tillage systems. Since the combination systems demand many different types of field operations, large diverse machinery complements are required. These more diverse complements do not offer the machinery saving of reduced tillage systems. Therefore, the combination system accumulates relatively large total costs.

Secondly, the 14 more costly systems include several zero tillage systems. These systems generated extremely large herbicide costs. Since the stubble drill operation largely determines machinery complement size, the zero tillage systems realize machinery costs comparable to the one and two tillage systems. Saddled with large total operating costs and lacking any additional machinery savings, the zero tillage system generates total costs much larger than any of the five reduced tillage systems discussed earlier.

In addition to total cost information, estimates of fuel, labor, and capital requirements for the systems were made. Fuel requirements varied between the systems from 6.9 gallons of diesel per acre in System 2, to 0.25 gallons of diesel per acre in System 8. Perhaps of more interest are the three conventional systems (Systems 1, 2, and 22) and the five reduced tillage systems (Systems 3, 4, 5, 17, and 18) with comparable total costs. In these systems, fuel savings of 3.25 to 5.25 gallons of diesel fuel per acre could be realized by moving from a conventional to a reduced tillage system.

Labor requirements behave in a manner similar to fuel requirement. Labor requirements vary from 1.25 hours per acre in System 1 to 0.25 hours per acre in System 8. In the eight systems, labor requirements could be reduced by 0.35 to 0.76 hours per acre by moving from a conventional to a reduced tillage system.

In contrast to fuel and labor requirements, total capital requirements vary little between systems. Total operating capital requirements are larger for the reduced tillage systems. However, the conventional tillage systems require larger long term capital investments into machinery. Therefore, the capital requirements are very similar, with only the capital structure differing between systems.

These differences in fuel, labor, and capital requirements were further developed in the sensitivity analysis. The results from this analysis indicate that interest rates should have little impact on the selection of a wheat production system. If interest rates increase from 12 percent to 22 percent, the systems total costs increase approximately $10.00 per acre. Since the systems have comparable total capital requirements, the impact of increasing interest rates is distributed rather evenly across the systems.

Fuel price and wage rate changes have a more dramatic affect on the systems' total costs. Since the conventional systems require more fuel and labor, the total costs of the three conventional systems are more sensitive to fuel and labor prices. Increasing the diesel fuel price from $1.20 per gallon to $1.70 per gallon, forces the conventional systems to drop five places in the total cost ranking of the systems. Likewise, increasing wage rates from $4.00 per hour to $10.00 per hour causes the conventional systems to exit the group of five least costly systems.

In conclusion, it appears that on a total cost basis several reduced tillage systems are very competitive with conventional tillage methods of producing wheat. If the price of fuel and labor increase, the reduced tillage systems should offer considerable savings in total costs. These reduced tillage systems may also be particularly attractive under existing price relationships if labor is severely constrained.

Limitation of the Study

As with any study, it should be pointed out that certain limitations exist. These limitations generally arise from two sources. The first source is the general model itself. In the model several limitations are inherent to the optimal machinery selection procedure. The second major source of limitations arise from the manner in which the results are interpreted.

In the general model, OMCSS was used as an optimization procedure for selecting machinery complements. Although OMCSS finds the least cost complements, these complements are optimal only with respect to the alternative machinery items in the list of 100 machines. This list represents only a small sample of the machines actually available in the market today. In light of the various machinery brands, it is very difficult to accurately select and price a list of 100 machines which includes several brands. To simplify the machinery pricing problem, one full line machinery brand was priced. As a result, the list prices of the 100 machinery items do not reflect interbrand price differences. Therefore, a farmer who is willing to compare machinery prices between brands may compose a list of alternative machines including several machinery brands. This aggregate list may reflect a considerably different price structure than the list used in the study.

OMCSS is also limited in finding a truely optimal machinery complement because of the way fixed costs are allocated. In OMCSS fixed costs for each machine are allocated by the number of machine annual hours and machine hours per acre. Because the machines annual hours are specified in the list of 100 machines, they remain constant during the optimization procedure. Since machine hours per acre are determined during the optimization procedure, one never knows exactly how many acres a machine's fixed costs are allocated over. Thus, fixed costs for the machinery items in one machinery complement may be calculated using a variety of farm sizes. This modeling error inhibits OMCSS from finding the complement which minimizes both total fixed and variable costs.

A third limitation in the model deals with the accuracy of the machinery ranking used in OMCSS. Estimates of implement draft values are very important for proper machinery matching. Despite their importance, precise draft estimates were not available. As a result, draft values were selected for the study which fell in a range of values commonly expected by agricultural engineers.

The second major source of limitations deal with interpretation of the study's results. It is important to remember that while total cost is one decision criterion for selecting a wheat production system, many other decision criterion exist. For example, most farmers choose a system based on net returns. To estimate net returns, total costs and gross returns must be estimated. Gross returns are generated in a wheat production enterprise from two sources. The first and major source of income is the production and sale of grain. The second source of income is derived from the production of beef on wheat pasture. In the reduced tillage wheat production systems the planting date is delayed as long as possible in the Fall to aid in weed control. As a result, the reduced tillage systems are probably hindered in production of wheat pasture. Thus, yield differences between the systems arise from two sources. Since yield data do not exist for these systems, nothing can be concluded about which systems generate the largest net returns. The systems might also be evaluated on the basis of soil conservation. Although this is an important criterion, this issue is not addressed in the study.

Caution should also be exercised in generalizing the results of the study to farm situations which differ greatly from the case study farm. If economies of size exist it would be misleading to generalize the study's results to various farm sizes. Also weather patterns and soil types were fixed in the case study farm.

Finally, the study is limited in regards to machinery replacement strategies. OMCSS assumes a new complement is purchased and used until it is worn out. In most cases, machinery items are added to or replaced in a machinery complement rather than replacing an entire complement. Thus, the model cannot determine when or how to switch machinery complements.

Future Research Needs

The results and limitations of this study point to several pressing research needs. First, yield data for the systems could shed additional light on the future of reduced tillage wheat production. This study shows that certain reduced tillage systems generate total costs comparable to conventional methods of wheat production. But nothing can be said about how the systems compare on a net return basis. If wheat yield data could be collected for the various systems, conclusions could be drawn about net returns.

The study also points to the need for more and better estimates of implement draft requirements. This is particularly true in the case of the stubble drill. Since this operation largely determines the size of the machinery complements in the reduced tillage systems accurate draft estimates are essential. Likewise, the operations in the critical period of June have a major impact on conventional tillage machinery complements. Accurate draft estimates of these operations would add more accuracy to machinery costs estimates.

A SELECTED BIBLIOGRAPHY

Agrawal, R. C. and Earl O. Heady. Operations Research Methods for Agricultural Decisions. Ames: The Iowa State University Press, 1972.

Armstrong, David L. and J. Edwin Faris. Farm Machinery Costs, Performance Rates, and Combinations. Davis: Giannini Foundation of Agricultural Economics, University of California, Research Report 273, 1964.

Beneke, Raymond R. and Ronald Winterbore. Linear Programming Applications to Agriculture. Ames: The Iowa State University Press, 1973.

Bonnett, Michael W. "Study of Feasibility Between the John Deere 8630 Four-Wheel Drive Tractor and the John Deer 4630 Two-Wheel Drive Tractor." Unpub. M.S. Report, Oklahoma State University, 1974.

Bowers, Wendell. Modern Concepts of Machinery Management. Champaign, Illinois: Stripes Publishing Co. 1970.

Bowers, Wendell. Personal Interview. Stillwater, Oklahoma, September 7, 1981.

Daniel, H. A., H. M. Elwell and M. B. Cox. "Conservation and Land Use Investigations at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma, and the Wheatland Conservation Experiment Station, Cherokee, Oklahoma." Stillwater, Oklahoma: Oklahoma State Experiment Station Report. 1947.

Doll, John P. and Frank Orazem. Production Economics: Theory With Applications. Columbus, Ohio: Grid, Inc., 1978.

Fenster, C.R., D. C. Burnside, and G. A. Wicks. "Chemical Fallow Studies in Winter Wheat Fallow Rotations in Western Nebraska." Agronomy Journal, Vol. 57, 1965, pp. 469-470.

Handke, Steven. "Using the Optimum Machinery Complement Selection System." Unpub. Paper, Department of Agricultural Economics, Oklahoma State University, 1982.

Heath, M. E., D. S. Metcalfe and R. F. Barnes. Forages/The Science of Grassland Agriculture. Ames: The Iowa State University Press, Third Edition, 1973.

Hillier, Frederick S. and Gerald J. Lieberman. Operations Research. San Francisco, California: Holden-Day, Inc., 1974.

Horner, G. M. "The Effects of Cropping Systems on Runoff, Erosion, and Wheat Yields." Agronomy Journal, Vol 52, 1960, pp. 342-344.

IBM Corporation. Mathematical Programming Systems Extended (MPSX) Control Language User's Manual. White Plains: IBM Corporation Technical Publications Department, February, 1971.

IBM Corporation. Mathematical Programming System Extended (MPSX) Mixed Integer Programming (MIP) Program Description, 2nd Ed., White Plains: IBM Corporation Technical Publications Department, August, 1973.

Jobes, Raleigh A. "Use of Budgets in Farm Management." Stillwater: Oklahoma State University Cooperative Extension Services, OSU Extension Facts No. 139, October, 1978.

Jones, Ken and Wendell Bowers. "Matching Tillage Implements to Big Tractors." Stillwater: Oklahoma State University Cooperative Extension Service. OSU Extension Facts No. 1209, 1977.

Kletke, Darrel D. Operation of the Enterprise Budget Generator. Stillwater: Oklahoma State University Agricultural Experiment Station Research Report P-790, August 1979.

Kletke, Darrel D. and Steven G. Griffin. Machinery Complement Selection in a Changing Environment. Oklahoma State University, Department of Agricultural Economics Paper 7603, 1977.

Leftwich, Richard H. The Price System and Resource Allocation. 7th Ed. Hinsdale, Illinois: The Dryden Press, 1979.

Oklahoma Crop and Livestock Reporting Service. Oklahoma Agricultural Statistics, 1980. Oklahoma City: Oklahoma Department of Agriculture, 1981.

Pepper, Tom. Personal Interview. Stillwater, Oklahoma, October 14, 1981.

Reeves, T. G. and A. Ellington. "Direct Drilling Experiments with Wheat." Australian Journal of Experimental Agriculture and Animal Husbandry, Vol. 14, 1974, pp. 237-240.

Reinschmiedt, Lynn L. "Study of the Relationship Between Rainfall and Fieldwork Time Available and Its Effect on Optimal Machinery Selection." Unpub. M.S. thesis, Oklahoma State University, 1971.

Retzlaff, Robert E. J. and Vernon L. Hofman. "Economics of Energy Used in Fallow Systems for Winter Wheat-Fallow Rotations." Cooperative Extension Service-Great Plains. Great Plains Conservation Tillage Fact Sheet No. GPE 2804, September, 1980.

Rowell, D. L., G. J. Osborne, P. G. Matthews, W. C. Stonebridge, and A. A. McNeill. "The Effects in a Long-Term Trail of Minimum and Reduced Cultivation on Wheat Yields." Australian Journal of Experimental Agriculture and Animal Husbandry, Vol. 17, 1977, pp. 802-811.

Oveson, M. M. and A. P. Appleby. "Influence of Tillage Management in a Stubble Mulch Fallow-Winter Wheat Rotation with Herbicides." Agronomy Journal, Vol. 63, 1971, pp. 19-20.

Tweeten, Luther. "An Economic Investigation Into Inflation Pass-through to the Farm Sector." Western Journal of Agricultural Economics, June, 1980, pp. 86-106.

Tweeten, Luther. Foundations of Farm Policy. 2nd ed. Lincoln and London: University of Nebraska Press, 1979.

Tweeten, Luther and Steve Griffin. "General Inflation and the Farming Economy." Research Report P-732. Stillwater, Oklahoma: Agricultural Experiment Station, 1976.

U.S. Department of Agriculture. Soil Survey of Garfield County, Oklahoma. Washington, D.C.: U.S. Government Printing Office, 1967.

Wiese, A. F., J. J. Bond, and T. J. Army. "Chemical Fallow in the Southern Great Plains." Weeds, Vol. 8, 1960, pp. 284-290.

APPENDIXES

APPENDIX A

OPERATING INPUTS AND TRACTOR-IMPLEMENT COMBINATIONS FOR TWENTY-TWO WHEAT PRODUCTION SYSTEMS

Table 16. System 1 - Conventional Tillage (Plow)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	263.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
37 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	50.	4.	-1.
38 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	7.	50.	4.	0.
39 M.B. PLOW 316	0.0	0.0	0.0	0.0	0.0	0.0	0.29	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.	31.	4.	0.
40 M.B. PLOW 618	0.0	0.0	0.0	0.0	0.0	0.0	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	36.	4.	0.
41 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	3.	84.	4.	0.
42 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	2.	95.	4.	0.
43 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.48	0.0	0.0	0.0	0.0	0.0	2.	75.	4.	0.
44 DRILL W/O FERT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	94.	4.	0.
45 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.	98.	4.	0.
46 M.B. PLOW 414	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.	32.	4.	0.
47 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.52	0.0	0.0	0.0	0.0	0.0	3.	76.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 81	2.	81.0	23401.	0.0	0.88	1.20	0.000631	1.60	445.	10.0	0.680	0.920	21061.	3.	12000.	81.
TRACTOR 91	3.	91.0	33382.	0.0	0.88	1.20	0.000631	1.60	489.	10.0	0.680	0.920	30043.	3.	12000.	91.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	469.	10.0	0.680	0.920	49106.	3.	12000.	180.
M.B. PLOW 316	31.	4.0	1876.	5.0	0.75	2.00	0.000251	1.30	197.	10.0	0.600	0.885	1688.	0.	2000.	0.
M.B. PLOW 414	32.	4.7	2475.	5.0	0.75	2.00	0.000251	1.30	223.	10.0	0.600	0.885	2228.	0.	2000.	0.
M.B. PLOW 618	36.	9.0	5194.	5.0	0.75	2.00	0.000251	1.30	100.	10.0	0.600	0.885	4675.	0.	2000.	0.
OFF-SET DISK	50.	20.3	12094.	5.5	0.75	0.65	0.000251	1.80	245.	10.0	0.600	0.885	10885.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	96.	10.0	0.600	0.885	1800.	0.	2000.	0.
FIELD CULTIVATOR	76.	13.5	2170.	5.5	0.75	1.00	0.000251	1.80	96.	10.0	0.600	0.885	1953.	0.	2000.	0.
ANHYDROUS APPLIE	84.	22.0	4092.	5.5	0.67	1.00	0.000631	1.60	126.	10.0	0.600	0.885	3683.	0.	1000.	0.
DRILL W/O FERT.	94.	40.0	14372.	4.5	0.70	0.65	0.000251	1.80	81.	10.0	0.600	0.885	12935.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	48.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	66.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 17. System 2 - Conventional Tillage (Chisel)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
37 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	98.	4.	0.
38 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	48.	4.	-1.
39 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	0.34	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	41.	4.	0.
40 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	1.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	43.	4.	0.
41 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	5.	85.	4.	0.
42 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	5.	95.	4.	0.
43 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	1.00	0.0	0.0	0.0	0.0	0.0	7.	80.	4.	0.
44 DRILL W/O FERT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	5.	94.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR 131	5.	131.0	41256.	0.0	0.88	1.25	0.000631	1.60	624.	10.0	0.680	0.920	37130.	3.	12000.	131.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	542.	10.0	0.680	0.920	49106.	3.	12000.	180.
CHISEL PLOW	41.	12.0	2609.	4.5	0.75	1.20	0.000251	1.80	89.	10.0	0.600	0.885	2348.	0.	2000.	0.
CHISEL PLOW	43.	16.0	3194.	4.5	0.75	1.20	0.000251	1.80	312.	10.0	0.600	0.885	2874.	0.	2000.	0.
OFF-SET DISK	48.	13.5	8460.	5.5	0.75	0.65	0.000251	1.80	184.	10.0	0.600	0.885	7614.	0.	2000.	0.
FIELD CULTIVATOR	80.	27.5	9208.	5.5	0.75	1.00	0.000251	1.80	180.	10.0	0.600	0.885	8287.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	99.	10.0	0.600	0.885	4272.	0.	1000.	0.
DRILL W/O FERT.	94.	40.0	14372.	4.5	0.70	0.65	0.000251	1.80	81.	10.0	0.600	0.885	12935.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	48.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	66.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — 05/28/81 — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 12/17/81 — 0100000000 — PRICE VECTOR 2

Table 18. System 3 - Two Tillage (Bladex + Sweep, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
18 BLADEX	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
19 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.
20 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	7.	98.	4.	0.
39 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	7.	65.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.
41 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	65.	4.	-1.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	416.	10.0	0.680	0.920	49106.	3.	12000.	180.
SWEEP & SF	65.	30.0	20437.	5.5	0.55	0.65	0.000251	1.80	191.	10.0	0.600	0.885	18393.	0.	2000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	99.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 02/09/82 — PRICE VECTOR 2

Table 19. System 4 - One Tillage (Bladex + Paraquat, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
18 BLADEX	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
19 PARAQUAT	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
20 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	4.	68.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
41 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.
42 SPRAYER	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	-1.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	269.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	312.	10.0	0.680	0.920	33300.	3.	12000.	111.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	191.	10.0	0.600	0.885	6844.	0.	2000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	80.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	93.	10.0	0.600	0.885	23542.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	164.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 01/29/82 — PRICE VECTOR 2

Table 20. System 5 - One Tillage (Surflan + MCPA, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS					RATE/UNIT								PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.83	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 SURFLAN	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
18 MCPA	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
19 2-4-D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 AERIAL HERB. APP	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 AERIAL INSECT.AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	93.	4.	0.
39 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	4.	68.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
41 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	124.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	312.	10.0	0.680	0.920	33300.	3.	12000.	111.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	191.	10.0	0.600	0.885	6844.	0.	2000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	80.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/·	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	93.	10.0	0.600	0.885	23542.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	33.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR EPPLIN MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS, AERIAL SURFLAN & MCPA APPLICATION, EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING 01/29/82 PRICE VECTOR 2

Table 21. System 6 - One Tillage (Bladex + NH_3 + Sweep, Paraquat)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS					RATE/UNIT								PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	-1.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 BLADEX	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
18 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
19 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	263.	3.	0.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.50	1.00	0.0	0.0	0.0	0.0	0.0	3.	98.	4.	0.
40 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.	62.	4.	-1.
41 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.78	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	64.	4.	-1.
42 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR 91	3.	91.0	33382.	0.0	0.88	1.20	0.000631	1.60	237.	10.0	0.680	0.920	30043.	3.	12000.	91.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	213.	10.0	0.680	0.920	49106.	3.	12000.	180.
SWEEP & SF	62.	15.0	9494.	5.5	0.55	0.65	0.000251	1.80	50.	10.0	0.600	0.885	8545.	0.	2000.	0.
SWEEP & SF	64.	25.0	16528.	5.5	0.55	0.65	0.000251	1.80	105.	10.0	0.600	0.885	14875.	0.	2000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	88.	10.0	0.600	0.885	35520.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	165.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES-YEAR
80% TIMELINESS 10 HOUR DAYS
CUSTOM COMBINE & TRUCKING

12/14/81

EPPLIN

MACHINERY COMPLEMENT 14
EQUIPMENT COMPLEMENT 14
PRICE VECTOR 2

Table 22. System 7 - No Tillage (Bladex + Paraquat, Paraquat)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 NITROGEN (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.01	0.0	0.0	0.0	0.0	6.750	0.0	16.	211.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 BLADEX	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 PARAQUAT	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
20 LIQUID FERT SPRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.01	0.0	0.0	0.0	0.0	0.300	0.0	16.	362.	3.	0.
21 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
22 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
23 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.50	1.00	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 LQD FRT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	1.	96.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.
41 SPRAYER	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	-1.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	333.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	98.	10.0	0.680	0.920	49106.	3.	12000.	180.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	72.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	231.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 12/14/81 — PRICE VECTOR 2

Table 23. System 8 - No Tillage (Surflan + MCPA, Paraquat)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.83	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 NITROGEN (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.01	0.0	0.0	0.0	0.0	6.750	0.0	16.	211.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 SURFLAN	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
18 2-4-D	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 MCPA	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
20 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
21 LIQUID FERT SPRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.01	0.0	0.0	0.0	0.0	0.300	0.0	16.	362.	3.	0.
22 AERIAL HERB APP	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	-1.
23 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
24 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	1.00	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 LQD FRT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	1.	96.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	188.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	98.	10.0	0.680	0.920	49106.	3.	12000.	180.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	72.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	99.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
AERIAL APPLICATION OF SURFLAN + MCPA IN APRIL — 12/14/81 — PRICE VECTOR 2

Table 24. System 9-- 50% System 1 - Conventional Tillage (Plow)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
20 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	263.	3.	0.

MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
36 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	-1.
37 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.	98.	4.	-1.
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	10.	98.	4.	0.
39 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	0.
40 M.B. PLOW 314	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	30.	4.	0.
41 M.B. PLOW 416	0.0	0.0	0.0	0.0	0.0	0.0	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	33.	4.	0.
42 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	10.	95.	4.	0.
43 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	85.	4.	0.
44 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	68.	4.	0.
45 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	1.	74.	4.	0.
46 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	0.0	0.0	0.0	0.0	0.0	10.	73.	4.	0.
47 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	10.	86.	4.	0.
48 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	332.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	623.	10.0	0.680	0.920	33300.	3.	12000.	111.
TRACTOR NC 70	10.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	258.	10.0	0.680	0.920	17761.	3.	12000.	70.
M.B. PLOW 314	30.	3.5	1845.	5.0	0.75	2.00	0.000251	1.30	202.	10.0	0.600	0.885	1660.	0.	2000.	0.
M.B. PLOW 416	33.	5.3	2526.	5.0	0.75	2.00	0.000251	1.30	123.	10.0	0.600	0.885	2273.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	198.	10.0	0.600	0.885	6955.	0.	2000.	0.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	95.	10.0	0.600	0.885	6844.	0.	2000.	0.
FIELD CULTIVATOR	73.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	31.	10.0	0.600	0.885	1432.	0.	2000.	0.
FIELD CULTIVATOR	74.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	100.	10.0	0.600	0.885	1432.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	50.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	65.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	100.	10.0	0.600	0.885	23542.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	115.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 25. System 10-- 50% System 1 - Conventional Tillage (Plow)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

OPERATING INPUTS	RATE/UNIT												PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 2-4-D	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 MCPA	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
20 SURFLAN	0.0	0.0	0.0	0.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 AERIAL HERB APP	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	-1.
23 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.

MACHINERY REQUIREMENTS	TIMES OVER												XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
37 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	-1.
38 SPRAYER	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	10.	98.	4.	0.
39 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	0.
40 M.B. PLOW 314	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	30.	4.	0.
41 M.B. PLOW 416	0.0	0.0	0.0	0.0	0.0	0.0	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	33.	4.	0.
42 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	10.	95.	4.	0.
43 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	85.	4.	0.
44 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	68.	4.	0.
45 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	1.	74.	4.	0.
46 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	10.	86.	4.	0.
47 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.
48 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	0.0	0.0	0.0	0.0	0.0	10.	73.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	332.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	623.	10.0	0.680	0.920	33300.	3.	12000.	111.
TRACTOR NC 70	10.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	186.	10.0	0.680	0.920	17761.	3.	12000.	70.
M.B. PLOW 314	30.	3.5	1845.	5.0	0.75	2.00	0.000251	1.30	202.	10.0	0.600	0.885	1660.	0.	2000.	0.
M.B. PLOW 416	33.	5.3	2526.	5.0	0.75	2.00	0.000251	1.30	124.	10.0	0.600	0.885	2273.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	199.	10.0	0.600	0.885	6955.	0.	2000.	0.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	96.	10.0	0.600	0.885	6844.	0.	2000.	0.
FIELD CULTIVATOR	73.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	31.	10.0	0.600	0.885	1432.	0.	2000.	0.
FIELD CULTIVATOR	74.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	100.	10.0	0.600	0.885	1432.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	50.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	65.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	100.	10.0	0.600	0.885	23542.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	50.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 26. System 11-- 50% System 1 - Conventional Tillage (Plow)
50% System 7 - No Tillage (Bladex + Paraquat, Paraquat)

OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 NITROGEN (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	6.750	0.0	12.	211.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
19 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
21 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
22 LIQUID FERT SPRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	0.300	0.0	16.	362.	3.	0.
23 AERIAL SPRAY A?P	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	263.	3.	0.
24 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
25 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.

MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
36 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	-1.
37 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	-1.
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.25	0.50	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	0.
40 M.B. PLOW 316	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.	31.	4.	0.
41 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	95.	4.	0.
42 LQD FRT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	96.	4.	0.
43 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	85.	4.	0.
44 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	2.	75.	4.	0.
45 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
46 M.B. PLOW 416	0.0	0.0	0.0	0.0	0.0	0.0	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	33.	4.	0.
47 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	300.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR NC 81	2.	81.0	23401.	0.0	0.88	1.20	0.000631	1.60	304.	10.0	0.680	0.920	21061.	3.	12000.	81.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	518.	10.0	0.680	0.920	33300.	3.	12000.	111.
M.B. PLOW 316	31.	4.0	1876.	5.0	0.75	2.00	0.000251	1.30	177.	10.0	0.600	0.885	1688.	0.	2000.	0.
M.B. PLOW 416	33.	5.3	2526.	5.0	0.75	2.00	0.000251	1.30	123.	10.0	0.600	0.885	2273.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	198.	10.0	0.600	0.885	6955.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	99.	10.0	0.600	0.885	1800.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	50.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	65.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	100.	10.0	0.600	0.885	23542.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	36.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	150.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 27. System 12-- 50% System 1 - Conventional Tillage (Plow)
50% System 8 - No Tillage (Surflan + MCPA, Paraquat)

OPERATING INPUTS	RATE/UNIT												PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 NITROGEN (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	6.750	0.0	16.	211.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
19 2-4-D	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 MCPA	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
21 SURFLAN	0.0	0.0	0.0	0.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
22 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
23 LIQUID FERT SPRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	0.300	0.0	16.	362.	3.	0.
24 AERIAL HERB APP	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	-1.
25 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
26 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.

MACHINERY REQUIREMENTS	TIMES OVER												XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.25	0.50	0.0	0.0	0.0	0.0	0.0	1.	93.	4.	0.
39 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	0.
40 M.B. PLOW 316	0.0	0.0	0.0	0.0	0.0	0.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.	31.	4.	0.
41 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	95.	4.	0.
42 LQD FRT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	96.	4.	0.
43 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	85.	4.	0.
44 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	2.	75.	4.	0.
45 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
46 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.
47 M.B. PLOW 416	0.0	0.0	0.0	0.0	0.0	0.0	0.24	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	33.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	223.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR NC 81	2.	81.0	23401.	0.0	0.88	1.20	0.000631	1.60	304.	10.0	0.680	0.920	21061.	3.	12000.	81.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	518.	10.0	0.680	0.920	33300.	3.	12000.	111.
M.B. PLOW 316	31.	4.0	1876.	5.0	0.75	2.00	0.000251	1.30	177.	10.0	0.600	0.885	1688.	0.	2000.	0.
M.B. PLOW 416	33.	5.3	2526.	5.0	0.75	2.00	0.000251	1.30	123.	10.0	0.600	0.885	2273.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	193.	10.0	0.600	0.885	6955.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	99.	10.0	0.600	0.885	1800.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	50.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	65.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	100.	10.0	0.600	0.885	23542.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	36.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	83.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 28. System 13-- 50% System 2 - Conventional Tillage (Chisel)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
18 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
19 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
20 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
37 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.	98.	4.	-1.
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	2.	98.	4.	0.
39 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	7.	68.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.
41 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	49.	4.	-1.
42 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	43.	4.	0.
43 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	2.	95.	4.	0.
44 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	2.	83.	4.	0.
45 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.50	0.0	0.0	0.0	0.0	0.0	2.	75.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 81	2.	81.0	23401.	0.0	0.88	1.20	0.000631	1.60	474.	10.0	0.680	0.920	21061.	3.	12000.	81.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	492.	10.0	0.680	0.920	49106.	3.	12000.	180.
CHISEL PLOW	43.	16.0	3194.	4.5	0.75	1.20	0.000251	1.80	190.	10.0	0.600	0.885	2874.	0.	2000.	0.
OFF-SET DISK	49.	16.8	9936.	5.5	0.75	0.65	0.000251	1.80	74.	10.0	0.600	0.885	8943.	0.	2000.	0.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	96.	10.0	0.600	0.885	6844.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	199.	10.0	0.600	0.885	1800.	0.	2000.	0.
ANHYDROUS APPLIE	83.	15.0	3072.	5.5	0.67	1.00	0.000631	1.60	93.	10.0	0.600	0.885	2765.	0.	1000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	116.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 29. System 14-- 50% System 2 - Conventional Tillage (Chisel)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 SURFLAN	0.0	0.0	0.0	0.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
18 MCPA	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
19 2-4-D	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 AERIAL HERB APP	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
23 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	2.	93.	4.	0.
39 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	7.	63.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.
41 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	49.	4.	-1.
42 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	43.	4.	0.
43 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	2.	83.	4.	0.
44 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	2.	95.	4.	0.
45 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.50	0.0	0.0	0.0	0.0	0.0	2.	75.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 81	2.	81.0	23401.	0.0	0.88	1.20	0.000631	1.60	400.	10.0	0.680	0.920	21061.	3.	12000.	81.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	493.	10.0	0.680	0.920	49106.	3.	12000.	180.
CHISEL PLOW	43.	16.0	3194.	4.5	0.75	1.20	0.000251	1.80	190.	10.0	0.600	0.885	2874.	0.	2000.	0.
OFF-SET DISK	49.	16.8	9936.	5.5	0.75	0.65	0.000251	1.80	74.	10.0	0.600	0.885	8943.	0.	2000.	0.
SWEEP & F	58.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	96.	10.0	0.600	0.885	6844.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	199.	10.0	0.600	0.885	1800.	0.	2000.	0.
ANHYDROUS APPLIE	33.	15.0	3072.	5.5	0.67	1.00	0.000631	1.60	93.	10.0	0.600	0.385	2765.	0.	1000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	50.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 30. System 15-- 50% System 2 - Conventional Tillage (Chisel)
50% System 7 - No Tillage (Bladex + Paraquat, Paraquat)

OPERATING INPUTS	RATE/UNIT												PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 NITROGEN (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	6.750	0.0	16.	211.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
20 LIQUID FERT SPRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	0.300	0.0	16.	362.	3.	0.
21 AERIAL HERB APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
22 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
23 RENT FERT SPRDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
24 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
25 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.

MACHINERY REQUIREMENTS	TIMES OVER												XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
37 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	-1.
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.25	0.50	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 LQD FRT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	96.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.28	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
42 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.72	0.0	0.0	0.0	0.0	0.0	5.	87.	4.	0.
43 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	48.	4.	-1.
44 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	41.	4.	0.
45 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	95.	4.	0.
46 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	83.	4.	0.
47 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.50	0.0	0.0	0.0	0.0	0.0	2.	75.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	402.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR NC 81	2.	81.0	23401.	0.0	0.88	1.20	0.000631	1.60	218.	10.0	0.680	0.920	21061.	3.	12000.	81.
TRACTOR 131	5.	131.0	41256.	0.0	0.88	1.25	0.000631	1.60	489.	10.0	0.680	0.920	37130.	3.	12000.	131.
CHISEL PLOW	41.	12.0	2609.	4.5	0.75	1.20	0.000251	1.80	253.	10.0	0.600	0.885	2348.	0.	2000.	0.
OFF-SET DISK	48.	13.5	8460.	5.5	0.75	0.65	0.000251	1.80	92.	10.0	0.600	0.885	7614.	0.	2000.	0.
FIELD CULTIVATOR	75.	12.5	2000.	5.5	0.75	1.00	0.000251	1.80	198.	10.0	0.600	0.885	1800.	0.	2000.	0.
ANHYDROUS APPLIE	83.	15.0	3072.	5.5	0.67	1.00	0.000631	1.60	93.	10.0	0.600	0.885	2765.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	65.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	100.	10.0	0.600	0.885	23542.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	36.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	149.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 31. System 16-- 50% System 2 - Conventional Tillage (Chisel)
50% System 8 - No Tillage (Surflan + MCPA, Paraquat)

OPERATING INPUTS	RATE/UNIT												PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 NITROGEN (N)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	6.750	0.0	16.	211.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 SURFLAN	0.0	0.0	0.0	0.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
18 2-4-D	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 MCPA	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
20 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
21 LIQUID FERT SPRD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	0.300	0.0	16.	362.	3.	0.
22 AERIAL HERB APP	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	263.	3.	-1.
23 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
24 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
25 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
26 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.

MACHINERY REQUIREMENTS	TIMES OVER												XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.25	0.50	0.0	0.0	0.0	0.0	0.0	4.	98.	4.	0.
39 LQD FRT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	96.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.
41 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	-1.
42 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	43.	4.	0.
43 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	95.	4.	0.
44 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	85.	4.	0.
45 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.50	0.0	0.0	0.0	0.0	0.0	4.	77.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	485.	10.0	0.680	0.920	33300.	3.	12000.	111.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	306.	10.0	0.680	0.920	49106.	3.	12000.	180.
CHISEL PLOW	43.	16.0	3194.	4.5	0.75	1.20	0.000251	1.80	190.	10.0	0.600	0.885	2874.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	100.	10.0	0.600	0.885	6955.	0.	2000.	0.
FIELD CULTIVATOR	77.	16.5	3549.	5.5	0.75	1.00	0.000251	1.80	150.	10.0	0.600	0.885	3194.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	50.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
LQD FRT	96.	40.0	0.	5.5	0.65	0.75	0.000251	1.80	36.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	83.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 32. System 17-- 50% System 3 - Two Tillage (Bladex + Sweep, Sweep)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
18 BLADEX	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
19 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
20 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	4.	62.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
41 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.
42 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	-1.
43 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	62.	4.	-1.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	233.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	417.	10.0	0.680	0.920	33300.	3.	12000.	111.
SWEEP & SF	62.	15.0	9494.	5.5	0.55	0.65	0.000251	1.80	286.	10.0	0.600	0.885	8545.	0.	2000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	80.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	93.	10.0	0.600	0.885	23542.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	132.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 01/29/82 — PRICE VECTOR 2

Table 33. System 18-- 50% System 3 - Two Tillage (Bladex + Sweep, Sweep)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS					RATE/UNIT								PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 SURFLAN	0.0	0.0	0.0	0.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
18 MCPA	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
19 2-4-D	0.0	0.0	0.33	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 AERIAL HERB APP	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	263.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
23 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	269.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	4.	68.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
41 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.
42 SWEEP & F	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	68.	4.	-1.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	161.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	417.	10.0	0.680	0.920	33300.	3.	12000.	111.
SWEEP & F	68.	15.0	7605.	5.5	0.65	0.65	0.000251	1.80	286.	10.0	0.600	0.885	6844.	0.	2000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	80.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	93.	10.0	0.600	0.885	23542.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	66.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS, AERIAL SURFLAN & MCPA APPLICATION, — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 02/09/82 — PRICE VECTOR 2

Table 34. System 19-- 50% System 6 - One Tillage (Bladex + NH_3 + Sweep, Paraquat)
50% System 4 - One Tillage (Bladex + Paraquat, Sweep)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.096	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
18 BLADEX	0.0	0.0	0.0	0.0	0.0	2.50	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
19 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
20 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	-1.
23 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	-1.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	0.
39 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	5.	63.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0	0.0	0.0	0.0	0.0	1.	86.	4.	0.
41 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.70	0.0	0.0	0.0	0.0	0.0	5.	87.	4.	0.
42 SPRAYER	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	98.	4.	-1.
43 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	63.	4.	-1.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	233.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 131	5.	131.0	41256.	0.0	0.88	1.25	0.000631	1.60	288.	10.0	0.680	0.920	37130.	3.	12000.	131.
SWEEP & SF	63.	20.0	14283.	5.5	0.55	0.65	0.000251	1.80	169.	10.0	0.600	0.885	12855.	0.	2000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	80.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	93.	10.0	0.600	0.885	23542.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	132.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 01/29/82 — PRICE VECTOR 2

Table 35. System 20-- 50% System 6 - One Tillage (Bladex + NH_3 + Sweep, Paraquat)
50% System 5 - One Tillage (Surflan + MCPA, Sweep)

LINE PRODUCTION	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.

OPERATING INPUTS	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
					RATE/UNIT													
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 SURFLAN	0.0	0.0	0.0	0.63	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.400	0.0	12.	266.	3.	-1.
18 MCPA	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.090	0.0	13.	267.	3.	0.
19 2-4-D	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
20 AERIAL HERB APP	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
23 PARAQUAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	5.850	0.0	13.	265.	3.	0.
24 AERIAL INSECT AP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	267.	3.	0.
25 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	51.50	0.0	0.0	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	-1.

MACHINERY REQUIREMENTS	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
					TIMES OVER													
38 SPRAYER	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	7.	98.	4.	0.
39 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	7.	64.	4.	0.
40 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	7.	88.	4.	0.
41 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	64.	4.	-1.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	319.	10.0	0.680	0.920	49106.	3.	12000.	180.
SWEEP & SF	64.	25.0	16528.	5.5	0.55	0.65	0.000251	1.80	135.	10.0	0.600	0.885	14875.	0.	2000.	0.
STUBBLE DRILLW/F	88.	39.6	39467.	4.5	0.65	0.65	0.000251	1.80	89.	10.0	0.600	0.885	35520.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	66.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS, AERIAL SURFLAN & MCPA APPLICATION, — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 02/11/82 — PRICE VECTOR 2

Table 36. System 21-- 50% System 1 - Conventional Tillage (Plow)
50% System 3 - Two Tillage (Bladex + Sweep, Sweep)

OPERATING INPUTS	RATE/UNIT												PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.44	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.086	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.44	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.19	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 BLADEX	0.0	0.0	0.0	0.0	0.0	1.25	0.0	0.0	0.0	0.0	0.0	0.0	3.770	0.0	12.	264.	3.	-1.
21 SEED TREATMENT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.500	0.0	2.	262.	3.	0.
22 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
MACHINERY REQUIREMENTS	TIMES OVER												XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
36 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	62.	4.	-1.
37 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	-1.
38 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	10.	98.	4.	0.
39 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	47.	4.	0.
40 M.B. PLOW 314	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.	30.	4.	0.
41 M.B. PLOW 14	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.	38.	4.	0.
42 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	1.	95.	4.	0.
43 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	85.	4.	0.
44 SWEEP & SF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	4.	62.	4.	0.
45 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.38	0.0	0.0	0.0	0.0	0.0	1.	74.	4.	0.
46 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.12	0.0	0.0	0.0	0.0	0.0	10.	73.	4.	0.
47 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.25	0.0	0.0	0.0	0.0	0.0	10.	86.	4.	0.
48 STUBBLE DRILLW/F	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	4.	87.	4.	0.

COLUMN NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFIC-ENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR NC 70	1.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	351.	10.0	0.680	0.920	17761.	3.	12000.	70.
TRACTOR 111	4.	111.0	37000.	0.0	0.88	1.20	0.000631	1.60	593.	10.0	0.680	0.920	33300.	3.	12000.	111.
TRACTOR NC 70	10.	70.0	19734.	0.0	0.88	1.20	0.000631	1.60	410.	10.0	0.680	0.920	17761.	3.	12000.	70.
M.B. PLOW 314	30.	3.5	1845.	5.0	0.75	2.00	0.000251	1.30	195.	10.0	0.600	0.885	1660.	0.	2000.	0.
M.B. PLOW 14	38.	3.5	1845.	5.0	0.75	2.00	0.000251	1.30	195.	10.0	0.600	0.885	1660.	0.	2000.	0.
OFF-SET DISK	47.	12.5	7727.	5.5	0.75	0.65	0.000251	1.80	193.	10.0	0.600	0.885	6955.	0.	2000.	0.
SWEEP & SF	62.	15.0	9494.	5.5	0.55	0.65	0.000251	1.80	191.	10.0	0.600	0.885	8545.	0.	2000.	0.
FIELD CULTIVATOR	73.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	31.	10.0	0.600	0.885	1432.	0.	2000.	0.
FIELD CULTIVATOR	74.	9.5	1591.	5.5	0.75	1.00	0.000251	1.80	100.	10.0	0.600	0.885	1432.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	50.	10.0	0.600	0.885	4272.	0.	1000.	0.
STUBBLE DRILLW/F	86.	13.2	12845.	4.5	0.65	0.65	0.000251	1.80	65.	10.0	0.600	0.885	11560.	0.	1000.	0.
STUBBLE DRILLW/F	87.	26.4	26158.	4.5	0.65	0.65	0.000251	1.80	100.	10.0	0.600	0.885	23542.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	24.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	82.	10.0	0.600	0.885	3447.	0.	1000.	0.

Table 37. System 22-- 50% System 1 - Conventional Tillage (Plow)
50% System 2 - Conventional Tillage (Chisel)

LINE	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	13 PRICE	14 WEIGHT	15 UNIT CODE	16 ITEM CODE	17 TYPE	18 CONT
PRODUCTION					NUMBER OF UNITS													
1 WHEAT	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	4.450	0.0	2.	76.	2.	0.
2 GRAZING	0.20	0.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.10	0.30	0.0	0.0	10.	89.	2.	0.
OPERATING INPUTS						RATE/UNIT							PRICE	NUMBER UNITS	UNIT CODE	ITEM CODE	TYPE	CONT
11 WHEAT SEED	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	5.000	0.0	2.	176.	3.	0.
12 18-46-0 FERT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	0.0	14.500	0.0	16.	217.	3.	0.
13 ANHYDROUS AMMON	0.0	0.0	0.0	0.0	0.0	0.0	0.0	103.00	0.0	0.0	0.0	0.0	0.150	0.0	12.	210.	3.	0.
14 PARATHION	0.0	10.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.036	0.0	17.	244.	3.	0.
15 CUSTOM COMBINE	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	16.000	0.0	7.	305.	3.	0.
16 CUSTOM HAULING	0.0	0.0	0.0	0.0	0.0	32.00	0.0	0.0	0.0	0.0	0.0	0.0	0.140	0.0	2.	306.	3.	0.
17 RENT FERT SPRDER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.88	0.0	0.0	0.0	0.0	0.125	0.0	16.	361.	3.	0.
18 2-4-D	0.0	0.0	0.75	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.700	0.0	13.	251.	3.	0.
19 AERIAL SPRAY APP	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.000	0.0	7.	268.	3.	0.
MACHINERY REQUIREMENTS						TIMES OVER							XXXXX	XXXXX	POWER UNIT	MACH CODE	TYPE	CONT
37 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	50.	4.	-1.
38 OFF-SET DISK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	7.	50.	4.	0.
39 M.B. PLOW 516	0.0	0.0	0.0	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	34.	4.	0.
41 ANHYDROUS APPLIE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	5.	85.	4.	0.
42 DRY FERT. SPREAD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	5.	95.	4.	0.
43 FIELD CULTIVATOR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.50	1.00	0.0	0.0	0.0	0.0	0.0	7.	80.	4.	0.
44 DRILL W/O FERT.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	5.	94.	4.	0.
45 SPRAYER	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.	98.	4.	0.
46 CHISEL PLOW	0.0	0.0	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.	43.	4.	0.

COLUMN / NAME OF MACHINE	1 CODE	2 WIDTH (FEET)	3 INITIAL LIST PRICE	4 SPEED (MPH)	5 FIELD EFFICIENCY	6 RC1	7 RC2	8 RC3	9 HOURS USED ANNUALLY	10 YEARS OWNED	11 RFV1	12 RFV2	13 PURCHASE PRICE	14 FUEL TYPE	15 HOURS OF LIFE	16 HP
TRACTOR 131	5.	131.0	41256.	0.0	0.88	1.25	0.000631	1.60	547.	10.0	0.680	0.920	37130.	3.	12000.	131.
TRACTOR 180	7.	180.0	54563.	0.0	0.88	1.20	0.000631	1.60	559.	10.0	0.680	0.920	49106.	3.	12000.	180.
M.B. PLOW 516	34.	6.7	4150.	5.0	0.75	2.00	0.000251	1.30	204.	10.0	0.600	0.885	3735.	0.	2000.	0.
CHISEL PLOW	43.	16.0	3194.	4.5	0.75	1.20	0.000251	1.80	190.	10.0	0.600	0.885	2874.	0.	2000.	0.
OFF-SET DISK	50.	20.3	12094.	5.5	0.75	0.65	0.000251	1.80	184.	10.0	0.600	0.885	10885.	0.	2000.	0.
FIELD CULTIVATOR	80.	27.5	9208.	5.5	0.75	1.00	0.000251	1.80	135.	10.0	0.600	0.885	8287.	0.	2000.	0.
ANHYDROUS APPLIE	85.	28.0	4747.	5.5	0.67	1.00	0.000631	1.60	99.	10.0	0.600	0.885	4272.	0.	1000.	0.
DRILL W/O FERT.	94.	40.0	14372.	4.5	0.70	0.65	0.000251	1.80	81.	10.0	0.600	0.885	12935.	0.	1000.	0.
DRY FERT. SPREAD	95.	60.0	0.	5.5	0.65	0.75	0.000251	1.80	48.	10.0	0.560	0.885	0.	0.	1000.	0.
SPRAYER	98.	47.0	3830.	5.5	0.60	0.65	0.000251	1.80	66.	10.0	0.600	0.885	3447.	0.	1000.	0.

HOURS USED ANNUALLY BASED ON 1240 ACRES/YEAR — EPPLIN — MACHINERY COMPLEMENT 14
80% TIMELINESS 10 HOUR DAYS — EQUIPMENT COMPLEMENT 14
CUSTOM COMBINE & TRUCKING — 12/14/81 — 05/28/81 — PRICE VECTOR 2

APPENDIX B

TOTAL COSTS PER ACRE RANKED BY SYSTEM WITH VARYING WAGE RATES, DIESEL FUEL PRICES, AND INTEREST RATES

Table 38. Total Costs Per Acre Ranked by System With $4 Per Hour Labor

	Diesel Fuel Prices ($/Gallon)								
	1.20			1.70			2.20		
	Interest Rates								
System	0.12	0.17	0.22	0.12	0.17	0.22	0.12	0.17	0.22
1	100.96	106.71	112.45	105.05	110.96	116.88	109.13	115.22	121.31
2	100.10	105.53	110.91	104.53	110.12	115.72	108.96	114.74	120.52
3	99.83	104.95	110.08	101.83	107.03	112.24	103.83	109.12	114.40
4	101.74	106.62	111.50	103.05	107.98	112.91	104.36	109.34	114.32
5	101.41	106.42	111.44	102.48	107.53	112.59	103.54	108.64	113.74
6	107.66	113.79	119.91	109.14	115.32	121.50	110.61	116.85	123.10
7	114.08	119.64	125.20	115.08	120.67	126.27	116.08	121.71	127.34
8	113.48	119.16	124.84	114.23	119.94	125.65	114.98	120.72	126.46
9	104.11	109.68	115.25	106.84	112.52	118.20	109.57	115.36	121.16
10	104.00	109.64	115.27	106.61	112.35	118.10	109.21	115.07	120.92
11	109.10	114.82	120.53	111.65	117.47	123.29	114.20	120.12	126.05
12	105.97	111.42	116.88	108.09	113.63	119.17	110.21	115.84	121.46
13	104.70	110.36	116.01	107.83	113.62	119.41	110.97	116.89	122.81
14	104.46	110.18	115.90	107.46	113.30	119.15	110.45	116.42	122.39
15	110.06	115.86	121.66	112.77	118.69	124.60	115.49	121.51	127.54
16	110.15	116.24	122.33	112.84	119.04	125.24	115.53	121.84	128.15
17	101.84	106.86	111.88	103.54	108.62	113.71	105.24	110.39	115.55
18	99.56	104.41	109.25	100.98	105.88	110.79	102.40	107.36	112.32
19	102.94	108.11	113.28	104.27	109.49	114.71	105.60	110.87	116.14
20	102.38	107.52	112.67	103.79	108.99	114.19	105.19	110.45	115.71
21	103.32	108.91	114.51	106.37	112.09	117.82	109.42	115.27	121.12
22	99.36	104.84	110.31	103.62	109.28	114.93	107.89	113.72	119.55

Table 39. Total Costs Per Acre Ranked by System With $7 Per Hour Labor

	Diesel Fuel Prices ($/Gallon)								
	1.20			1.70			2.20		
	Interest Rates								
System	0.12	0.17	0.22	0.12	0.17	0.22	0.12	0.17	0.22
1	104.71	110.46	116.20	108.80	114.71	120.63	112.88	118.97	125.06
2	103.19	108.59	114.00	107.62	113.21	118.81	112.05	117.83	123.61
3	101.03	106.15	111.28	103.03	108.23	113.44	105.03	110.32	115.60
4	103.30	108.18	113.06	104.61	109.54	114.47	105.92	110.90	115.88
5	102.58	107.59	112.61	103.65	108.70	113.76	104.71	109.81	114.91
6	108.86	114.99	121.11	110.34	116.52	122.70	111.81	118.05	124.30
7	115.22	120.78	126.34	116.22	121.81	127.41	117.22	122.85	128.48
8	114.23	119.91	125.59	114.98	120.69	126.40	115.73	121.47	127.21
9	107.35	112.92	118.49	110.08	115.76	121.44	112.81	118.60	124.40
10	107.03	112.67	118.30	109.64	115.38	121.13	112.24	118.10	123.95
11	112.10	117.82	123.53	114.65	120.47	126.29	117.20	123.12	129.05
12	108.49	113.94	119.40	110.61	116.15	121.69	112.73	118.36	123.98
13	107.28	112.94	118.59	110.41	116.20	121.99	113.55	119.47	125.39
14	106.83	112.55	118.27	109.83	115.67	121.52	112.82	118.79	124.76
15	113.06	118.86	124.66	115.77	121.69	127.60	118.49	124.51	130.54
16	112.25	118.34	124.43	114.94	121.14	127.34	117.63	123.94	130.25
17	103.73	108.75	113.77	105.43	110.51	115.60	107.13	112.28	117.44
18	101.09	105.94	110.78	102.51	107.41	112.32	103.93	108.89	113.85
19	104.32	109.49	114.66	105.65	110.87	116.09	106.98	112.25	117.52
20	103.22	108.36	113.51	104.63	109.83	115.03	106.03	111.29	116.55
21	107.01	112.60	118.20	110.06	115.78	121.51	113.11	118.96	124.81
22	102.30	107.78	113.25	106.56	112.22	117.87	110.83	116.66	122.49

Table 40. Total Costs Per Acre Ranked by System With $10 Per Hour Labor

	Diesel Fuel Prices ($/Gallon)								
	1.20			1.70			2.20		
	Interest Rates								
System	0.12	0.17	0.22	0.12	0.17	0.22	0.12	0.17	0.22
1	108.46	114.21	119.95	112.55	118.46	124.38	116.63	122.72	128.81
2	106.28	111.68	117.09	110.71	116.30	121.90	115.14	120.92	126.70
3	102.23	107.35	112.48	104.23	109.43	114.64	106.23	111.52	116.80
4	104.35	109.74	114.62	106.17	111.10	116.03	107.48	112.46	117.44
5	103.75	108.76	113.78	104.82	109.87	114.93	105.88	110.98	116.08
6	110.06	116.19	122.31	111.54	117.72	123.90	113.01	119.25	125.50
7	116.36	121.92	127.48	117.36	122.95	128.55	118.36	123.99	129.62
8	114.98	120.66	126.34	115.73	121.44	127.15	116.48	122.22	127.96
9	110.59	116.16	121.73	113.32	119.00	124.68	116.05	121.34	127.64
10	110.06	115.70	121.33	112.67	118.41	124.16	115.27	121.13	126.98
11	115.10	120.82	126.53	117.65	123.47	129.29	120.20	126.12	132.05
12	111.01	116.46	121.92	113.13	118.67	124.21	115.25	120.88	126.50
13	109.86	115.52	121.17	112.99	118.78	124.57	116.13	122.05	127.97
14	109.20	114.92	120.64	112.20	118.04	123.89	115.19	121.16	127.13
15	116.06	121.86	127.66	118.77	124.69	130.60	121.49	127.51	133.54
16	114.35	120.44	126.53	117.04	123.24	129.44	119.73	126.04	132.35
17	105.62	110.64	115.66	107.32	112.40	117.49	109.02	114.17	119.33
18	102.62	107.47	112.31	104.04	108.94	113.85	105.46	110.42	115.38
19	105.70	110.87	116.04	107.03	112.25	117.47	108.36	113.63	118.90
20	104.06	109.20	114.35	105.47	110.67	115.87	106.87	112.13	117.39
21	110.70	116.29	121.89	113.75	119.47	125.20	116.80	122.65	128.50
22	105.24	110.72	116.19	109.50	115.16	120.81	113.77	119.60	125.43

VITA[2]

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