PART THREE

Adoption of Conservation Farming

Chapter 16

EFFECTS OF TILLAGE SYSTEMS ON FARM MANAGEMENT AND PROFITABILITY

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Profitability is vital to farmers in determining their tillage and other farm-management practices. Farmers will adopt a new method of farming only if they are convinced that it will increase profitability or help in the management of the farm.

The increasing dependence on herbicides instead of cultivation for weed control in Australia since the early 1970s has been described in Chapters 2 and 3. This adoption did not occur because of any sudden change in the attitude of farmers to conservation farming practices. Rather, it occurred because short-term economic pressures forced farmers to rationalise their tillage operations. Farmers found it in their economic interests to adopt reduced cultivation, which had been made possible by technological developments. Farmers have also adopted residue retention increasingly since the early 1970s, in this case specifically to reduce soil erosion. Once again, however, economic forces have influenced the rate of adoption.

This chapter examines the economic pressures for and consequences of substituting herbicide for cultivation, and then explores the economic advantages of integrating soil-conserving techniques such as reduced cultivation and residue retention into the management of the whole farm. The integrated system is referred to in this chapter as conservation farming.

ECONOMIC PRESSURES TO REDUCE CULTIVATION

All modern farming methods have several variable inputs, such as labour, fuel, machinery, fertiliser and chemicals. The mix of these inputs will vary with farm location, the type of crop produced, the scale of operations, soil type, the weather and a number of other factors. The traditional system has relied heavily on mechanical weed control, and there has been little reliance on chemicals for weed control.

While prices for both inputs and outputs have been increasing, the prices paid for inputs have risen faster than the prices received by farmers for their output (Figure 16.1). This cost-price squeeze is not new. Data from the Bureau of Agricultural Economics indicate that, on average, the ratio of prices received to prices paid has declined by 2.3% per year since 1960.

However, the prices of all inputs have not risen at the same rate (Figure 16.2). It is evident that prices of some inputs such as fuel, labour and machinery have risen considerably faster than prices of chemicals since the early 1970s, and faster than the price received for wheat.

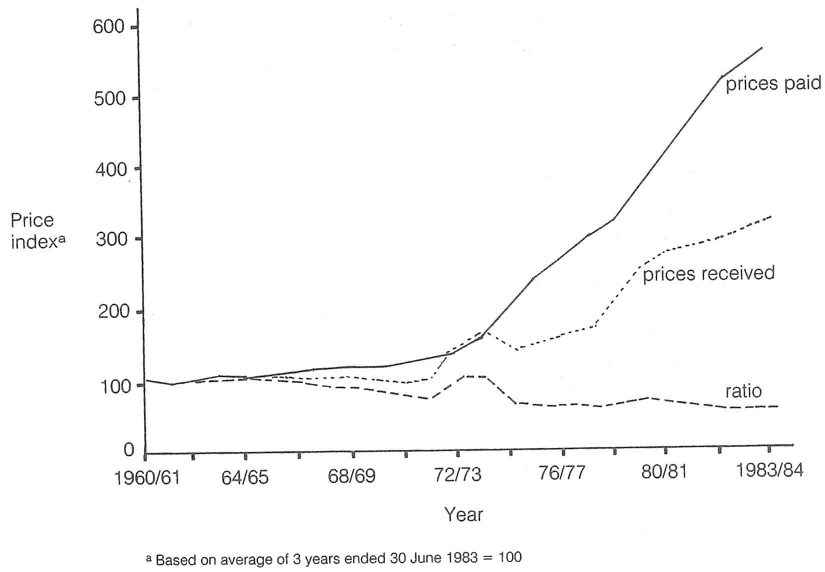

Figure 16.1 Prices paid and received by Australian farmers 1960/61–1983/84 (Bureau of Agricultural Economics)

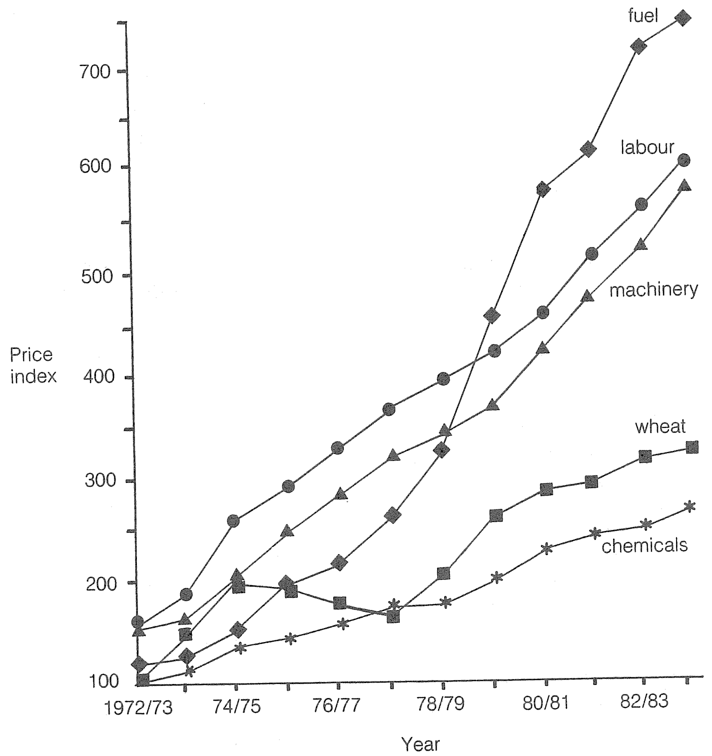

Figure 16.2 Indexes of wheat price and prices of inputs (Bureau of Agricultural Economics)

This has led to a decline in the purchasing power of each unit of the farmer's output. The amounts of different inputs that could be purchased with one tonne of wheat in 1973-74 and 1982-83 are shown in Table 16.1.

Table 16.1 Inputs purchased by 1 tonne of wheat (I. Crook, personal communication)

Item	Year of purchase	
	1973–74	1982–83
Net wheat price per tonne ($)[a]	96.67	119.37
Inputs purchased:		
Tractor kW[b]	0.94	0.29
Superphosphate (tonnes)[c]	4.92	1.16
Urea (tonnes)[c]	1.11	0.50
Fuel (litres, wholesale)	2644	368

[a] On farm, Western Australia.
[b] Using prices of 75 kW Chamberlain tractor in Perth, WA.
[c] Using prices paid ex works, Kwinana, WA.

Until recently, this growing disparity between input costs and prices received has been met in the traditional system by varying the mix of the traditional tillage-system inputs such as labour, fuel and machinery. So, historically, farmers have coped with the situation by substituting machinery for labour and improving fuel and operating efficiencies.

The development of new technology has made it technically feasible for farmers to adopt an alternative strategy using chemical weed control to replace cultivations. The fact that this new technology has been accompanied by a reduction in the prices of chemicals relative to other inputs has made it economically more attractive. The prices paid for chemicals have not risen as rapidly as those for the other major inputs (Figure 16.2) and, in real terms, the retail prices of many agricultural chemicals have fallen in the past decade. The buying power of wheat in terms of selected herbicides commonly used for seedbed preparation and in-crop weed control generally has increased between 1978-79 and 1982-83 (Table 16.2).

Table 16.2 Selected herbicides purchased with 1 tonne of wheat (I. Crook, personal communication)

Item	Year of purchase	
	1978–79	1982–83
Net wheat price per tonne ($)[a]	103.84	119.37
Herbicides purchased (litres):		
Hoegrass	6.21	7.42
Spray.Seed	17.54	18.36
Roundup	6.23	6.83
2, 4-D Amine 50	49.45	45.91

[a] On farm, Western Australia.

The direction of the movement of the costs of the variable inputs appears unlikely to change dramatically in the future. It is expected that the relative costs of chemical weed control will continue to fall in the long term, in view of the competition in the chemical industry and the likely improvements in application technology.

These changes in relative prices have convinced many farmers that reducing cultivation is in their short-term economic interests. However, earlier chapters in this monograph have shown that conservation farming entails more than the substitution of herbicides for cultivation. Therefore, the economics of conservation farming are more complex than changes in the relative costs of the variable inputs in farming.

Many other conservation farming practices, such as erosion banks, have not been widely adopted in Australia because of the long-term nature of the investment involved, and the negative short-term effects on a farmer's financial position.

ECONOMIC CONSEQUENCES OF CONSERVATION FARMING

Whatever reason for adopting conservation farming methods initially, farmers will be vitally interested in the economic effects of such changes. There are a number of consequences for farm management and profitability of a change from conventional cultivation to reduced cultivation. The direct impact can be considered by comparing the changes in the mix of inputs and in the cost of variable inputs under each system. This approach highlights the immediate changes in farm management as well as the relative costs of replacing cultivations with herbicide applications.

However, there are many longer-term effects, which do not enter such a comparison, such as machinery overhead costs and livestock management strategies. In addition, the integration of soil-conserving management practices into the whole farm system has opened up new cropping possibilities, with increased cropping intensities now possible (Chapters 2 and 3), and by extending the area where crops of different types can be grown. These further effects can only be taken into account in a whole-farm analysis that considers the dynamic effects of changes in technology.

A third, and related, approach to the effect of the change to conservation farming is to consider the economic gains from the increased soil conservation. A value can be placed on the soil conserved under a conservative cropping programme.

Each of these three approaches is considered in turn.

DIRECT ECONOMIC CONSEQUENCES FOR MANAGEMENT

The advantages and disadvantages of reduced cultivation and residue retention are discussed in Chapters 2 and 3. Those of particular concern to the economic analysis of the effects on farm management and profitability are: direct variable costs, labour requirements, timeliness, machinery overhead costs, rotations and cropping intensity, and livestock enterprises. These are discussed below.

Comparisons of variable costs

A number of comparisons have been made between the variable costs of conventional cultivation and reduced-cultivation systems (for example Malcolm, 1971; Richardson, 1977; Roy, 1977; Patterson, 1980; Crook, 1981; Pike and Ashman, 1981; Farquharson, Ockwell and Johnston, 1983; Ward, 1983; and Godyn and Brennan, 1984).

While the comparisons vary from region to region, the general conclusion is that **cash** costs increase with the replacement of cultivations with herbicide applications. (Implications for cash flow are considered later). The tractor and implement running expenses of one cultivation are lower than those of one herbicide application plus herbicide cost. Although the relative costs vary with the size of the implements and the operating conditions, Godyn and Brennan (1984) found that a scarifying operation had running costs of approximately $4 per hectare. Thus any herbicide costing more than about $3 per hectare will mean higher cash costs.

Therefore a herbicide application must generally replace more than one (often more than three or four) cultivations for it to result in a reduction in cash costs.

Since there are no reasons for assuming changes in seed, fertiliser, or other variable costs with reduced cultivation, the total variable cash costs generally increase with a change to reduced cultivation methods. The exceptions are where no herbicide is needed or where a single herbicide application can replace several cultivations. Such is generally the case in Western Australia and occurred across areas of southern Australia in 1980, 1981 and 1982, possibly accounting for much of the adoption of direct drilling in those years (Chapter 2).

Many costs are not direct cash costs. These include unpaid labour and machinery depreciation. Where these costs are included in the comparison, reduced cultivation is often shown to have lower total costs. The comparisons depend on the value placed on labour and the relationship between depreciation and machinery use. Nevertheless, the large savings in machinery and labour time for seedbed preparation with reduced cultivation means that it has considerable economic benefits for management, often outweighing the extra cash costs of the herbicide.

Effect on labour requirements

The labour time required for the establishment of a crop is clearly lower with reduced cultivation than with conventional cultivation. This is seen as one of the most advantageous aspects of reduced cultivation from the point of view of the farmer. Long hours on the tractor during cultivations are avoided. For example, estimates of the savings in labour time with direct drilling vary, but generally around 60% of time spent in seedbed preparation can be saved by farmers. This either frees the farmer's own labour for other jobs or saves on hired labour costs and gives the farmer extra flexibility in operations. The labour saved can be used for other enterprises, farm maintenance or for increasing the area of crop.

However, the need for a herbicide application shortly before sowing, and a possibly slower sowing speed, can mean that the demands on labour are greater during the sowing period itself with the direct drilling system, depending on the amount of cultivation that the farmer undertakes close to sowing under conventional cultivation (Godyn and Brennan, 1984).

Effect on yields

In comparisons of conventional cultivation and reduced cultivation, crop yields for each system vary from crop to crop and from environment to environment, so it is difficult to generalise. However, in south-eastern and south-western Australia, most yield comparisons show comparable yields for the two cropping systems for the winter cereals (Chapter 2).

In northern Australia, grain yields of winter cereals appear to have shown a similar pattern (Ward, 1984), with systems based on herbicides for weed control having yields similar to those of the conventional systems (Chapter 3). The data for summer crops are less extensive. However, in northern New South Wales, grain sorghum has shown a consistent yield response to no-till fallow (Holland and Felton, 1983).

Effect on timeliness

Timeliness of sowing

Direct drilling can increase the timeliness of sowing (Brennan and Godyn, 1982), in some areas by allowing sowing to take place immediately after the autumn break, and in others by reducing bogging in wet conditions.

In Western Australia, a daily grain yield loss of 9 kg ha^{-1} can be expected, for every day sowing extends beyond the optimum date. In the eastern wheat belt of Western Australia, the optimum sowing date may well be the date of the opening rain.

In New South Wales, Kohn and Storrier (1970) and Doyle and Marcellos (1974) have both shown that yields decline with delays in sowing past the optimum sowing date. In southern New South Wales, Kohn and Storrier found an approximate 4% decline in yields for each week's delay, while in the north-west slopes, Doyle and Marcellos found a decline of 5-7% for each week's delay.

Trials in Queensland have shown an average decline in grain yields varying from 0.7-1.3% per day as anthesis occurred after the last frost at a given location. The actual yield loss in a given year will be influenced by the timing of the last frost, choice of variety, and the rainfall pattern experienced at a given location (Woodruff and Tonks, 1983).

Furrow planters, fitted press wheels and narrow ground tools allow sowing up to 89 days after the last significant rainfall, permitting crop establishment at an optimum time if sowing rains fail. With chemical fallowing, the number of sowing opportunities has been shown to increase, due to the greater usefulness of small rainfalls (less than 12 mm), due to the improved moisture retention (Ward, 1983).

Overall, the loss of grain yield from delays in sowing appear to be in the range of 5-10 kg ha^{-1} day^{-1}. If the wheat is valued at \$110 t^{-1} on farm, this is a daily loss of \$0.55-\$1.10 ha^{-1}. Clearly a farmer's time is better spent sowing instead of cultivating once the optimum sowing date has passed.

Timeliness of spraying

Spraying weeds at the right size and at the appropriate stage of growth permits lower rates of herbicide to be used on fallows. In Queensland, timely spraying of summer fallow can save up to \$12 ha^{-1} in direct chemical costs. It may also mean the difference between success and failure. Advanced weeds draw heavily on stored moisture, and may reduce the potential crop yield or cause sowing delays due to lack of moisture. Cultivated fallows sometimes cannot be worked at all because of wet conditions.

Similarly, timely spraying of in-crop weeds can enhance crop yield by improving weed kill and reducing competition (Table 16.3). Delays in spraying, which may arise because the farmer is engaged in tillage, can cost more than \$3.50 ha^{-1} day^{-1}, with a wheat price of \$110 t^{-1} on farm. The improved trafficability of soils when crops are sown directly into uncultivated soil can also result in more timely spraying of weeds in wet years.

Table 16.3 Crop yields obtained when annual ryegrass (at 276 plants m^{-2}) is killed at different growth stages (I. Crook, personal communication)

Growth stage of ryegrass at spraying	Crop yield (kg ha^{-1}) (Katanning)
1–2 leaves	1235
3–5 leaves	1058
5–6 leaves	414
Tillering	243
Nil	248

Comparisons of gross margins

Gross margins, which equal gross income less variable cash costs, are often used to compare cropping methods. Where yields are the same under each system, the gross income will be unchanged. The generally higher cash costs of systems using herbicides therefore mean that gross margins are often lower with reduced cultivation than with conventional cultivation methods. Many costs are not included in such gross margin analyses. When the further costs such as labour and machinery ownership are taken into account, comparisons generally show that soil-conserving methods are more profitable (for example, see Figure 16.3). This is also demonstrated in Appendix 16.1.

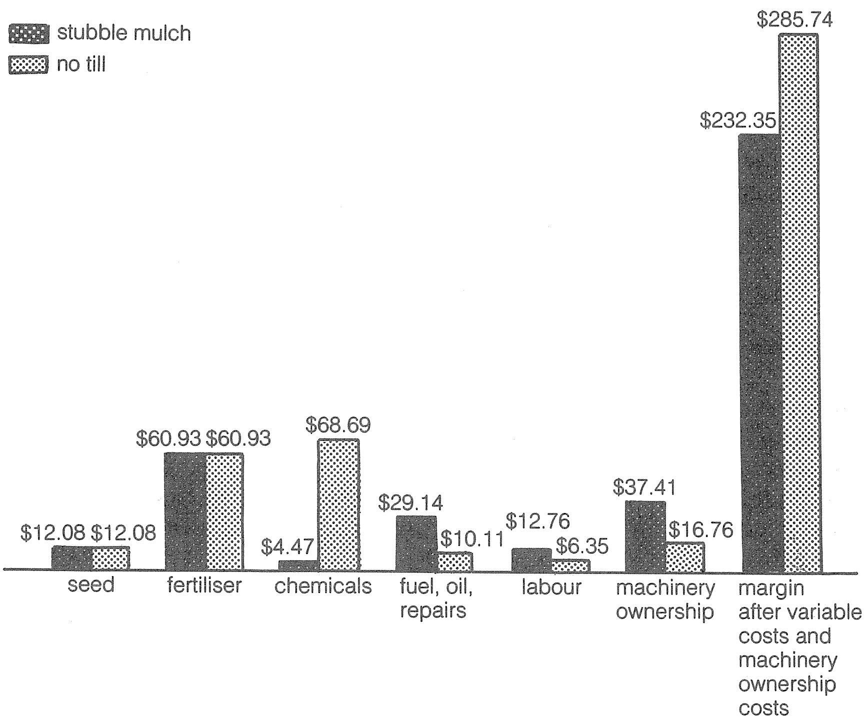

Figure 16.3 Costs and returns ($ ha^{-1}) of land-preparation methods in Queensland

Gross margins may even be higher where yield increases are found with soil-conserving crop establishment methods, as found in sorghum in northern New South Wales, or through improved timeliness of operations in southern Australia. Where a crop can be grown successfully with direct drilling without herbicides, the gross margin will be higher than with the conventional system.

WHOLE-FARM CONSEQUENCES FOR MANAGEMENT

Whole-farm comparisons

Reduced cultivation provides better use of labour, machinery, fuel and other inputs. Other factors of production are substituted, at least in part, for labour, machinery and fuel.

For inputs to change markedly, either in quantity or in type, there must be a major management change. Managers will have to acquire new skills to match changed inputs. They must acquire a more complete understanding of:

* herbicides and their application and timing;
* weeds and their response to different tillage methods;
* soil and environmental effects;
* new planting technologies;
* crop physiology;
* the impact of seasonal conditions.

This knowledge can improve the results of even the traditional methods, as has occurred in many areas since about 1969, but is even more necessary if herbicide substitution is to work.

In addition to new skills, the farmer will need to change the management of his entire farm if he is to get the maximum benefit out of the new conservation farming methods. Changes will have to be made in machinery ownership, cropping rotations and livestock practices.

These changes cannot be considered by comparing variable costs or gross margins in a simple partial-budgeting analysis. Whole-farm analyses are needed to take account of the dynamics of farm operations and resources management (Ronan, 1981). The advantages of integrating reduced cultivation and stubble retention into a whole-farm situation are difficult to assess because of problems in finding a 'control'. Some data from two comparative farms in the south-west Darling Downs in Queensland are given in Appendix 16.1. The advantages shown in this comparison could be even greater if rotations and cropping intensity were also changed, as demonstrated in Chapter 3.

Because of the difficulty of finding comparative situations, some analyses based on simulating typical farms have been undertaken (Farquharson, Ockwell and Johnston, 1983; Clark, Johnston and Matuska, 1984; Farquharson, Ockwell and Davenport, 1984; and Godyn and Brennan, 1984). These have enabled the whole-farm implications of some of the changes associated with conservation farming to be examined in detail.

For example, in a simplified model for southern New South Wales, Godyn and Brennan (1984) examined the consequences of direct drilling (wheat) on both the crop and livestock components of the farm system. They found that total gross margins were higher with direct drilling, since the decrease in cropping gross margin was more than offset by the increase in livestock incomes in an average year. Overhead costs were also lower with direct drilling, so that total net incomes were higher with direct drilling than with conventional cultivation. Where no value was attributed to the labour saved, Godyn and Brennan found the differences between the two systems to be relatively small. Where labour was valued, the advantage for direct drilling became significant. It is important to note that for direct drilling to be economically attractive it is necessary to increase livestock numbers to take advantage of the extra grazing available. Alternatively, the study showed that direct drilling could allow an increase in cropping intensity, with no change in livestock numbers, and this too gave a farm system based on direct drilling an economic advantage.

In more sophisticated simulation models, the other three studies all found similar results for the short term, but found considerable gains in the long run as machinery investment, rotations and livestock enterprises were adjusted to the new system.

Machinery investment

Machinery overhead costs dominate crop-production costs, particularly in times of high interest rates. Where there are lower machinery requirements with conservation farming, as in the case of direct drilling, farmers are able to reduce their total machinery investment. This releases capital, which consequently becomes available for reinvestment, or which reduces the borrowings of the farmer.

A Queensland survey (Blomfield, 1979) showed that, on average, land-preparation machinery (including the tractor) comprises 43% of the total machinery investment (Table 16.4). Systems involving herbicide substitution for tillage offer scope to reduce land-preparation overheads.

Table 16.4 Percentage of farm machinery investment—Queensland (Bloomfield, 1979)

Machinery item	Percentage of total
Tractors	29
Planters	5
Tillage	9
Sub-total	(43)
Headers	20
Drying	1
Transport	11
Storage and handling	8
Machinery sheds	12
Miscellaneous	5
	100

A case study in Queensland (Appendix 16.1), comparing the stubble mulch and the no-till fallow systems, indicated that there are significant savings in land-preparation costs attributed to machinery ownership - \$37 ha^{-1} for stubble mulching and \$17 ha^{-1} for no-till fallow (Table 16.5). In fact, the investment in land-preparation equipment reduced from \$148 000 to \$76 000 for an equivalent farm area (Appendix 16.1).

These savings in machinery investment will be fully available to a new farmer. However, Farquharson, Ockwell and Davenport (1984) pointed out that some questions remain for farmers who

Table 16.5 Costs of land preparation inputs—Queensland[a]

Inputs	Cost of inputs ($ ha⁻¹)	
	Stubble mulching	No-till fallow
Chemicals	4.47	68.69
Fuel, oil, repairs	29.14	10.11
Labour	12.76	6.35
Machinery ownership	37.41	16.76
Land preparation	83.78	101.91

[a] See Appendix 16.1.

already own land preparation machinery as to the relative worth of selling it, possibly only at salvage value, rather than retaining it for possible future use. Farmers will be loath to dispose of cultivating machinery altogether. For example, the wet summer of 1983-84 in south-eastern Australia saw the re-emergence of the disc plough in many areas. Godyn and May (1981) found that the move to direct drilling in Western Australia generally was not accompanied by a reduction in machinery investment. Nevertheless, farmers have the option to do so with conservation farming, and would certainly be able to delay replacement of machinery.

Where conservation farming systems require additional or new specialised equipment, capital requirements can increase. The potential savings in machinery investment can be lost if such specialised equipment needs to be purchased with adoption of conservation farming. This is most likely to arise where special equipment is needed for sowing into stubble (Chapter 7).

Rotations and cropping intensity

Reducing cultivation can mean that more skilled management is needed to prevent the development of problem weeds, soil- and stubble-borne diseases, and soil compaction by heavy grazing. Some of these difficulties can be overcome by the strategic use of alternative crops in the rotation (Colton, 1980), by strategic stubble burning, or by the methods such as spray-topping or hay-cutting to prevent weeds from setting seed prior to the cropping phase.

The use of reduced cultivation can also lead to a reconsideration of the type of pastures used in mixed farming rotations. Where there is annual pasture, the difficulties of obtaining a suitable seedbed from reduced cultivation are less than occurs with a perennial, deep-rooted pasture such as lucerne (Brennan and Godyn, 1982).

Nevertheless, under a system of reduced cultivation, the farmer will have more flexibility to alter his rotation, because of the reduced demands on labour and machinery, and the ability of specialised sowing equipment to prepare a seedbed of tilth suitable for crop establishment at sowing (Ward and Norris, 1982).

The use of reduced cultivation methods can allow the farmer to use the extra labour and machinery time to increase the area of crop sown each year, that is, the cropping intensity (Richardson, 1977; Roy, 1977; 1979; Scarsbrick, 1979; Hart, 1980). However, this will be possible only in the following circumstances (Brennan and Godyn, 1982):

* where the effect of reduced cultivation on the soil structure and the level of soil nutrients allows the farmer to extend the cropping phase of the rotation;

* where there is extra land available, which, although suitable for cropping in terms of the rotation, cannot be planted under conventional cultivation methods because the limited time available for pre-sowing cultivation prevents seedbed cultivation - such areas are more likely to be common on larger farms in the Western Australian cereal belt where all pre-sowing cultivation is done immediately prior to sowing, than in the established cropping areas of southern and eastern Australia;

* where there is land that cannot be conventionally cultivated because of the proneness to erosion, for instance, but on which a crop could be established using direct drilling - this is likely to be especially important on the slopes and tablelands;

* where the farmer decides to ignore the long-term rotation for perhaps one year, such as following a drought or on newly purchased land - reduced cultivation in this situation could enable the farmer to plant a considerably larger area than he could if he used conventional cultivation;

* where a sharefarmer could expand the area of crop he could establish if his time controlling weeds were reduced;

* where the possibility exists for opportunity or double cropping in seasons that are particularly suitable, epecially in the northern Australian cereal belt - this aspect is discussed in more detail in Chapter 3.

Whole-farm analyses have consistently found that if the adoption of the reduced-cultivation system allowed farmers to increase their cropping area, significant economic benefits could be realised. This is mainly because extending the area sown means that overhead costs are spread over a larger area, and the marginal costs of the extra cropped area are much lower than the marginal returns from the crop (provided it can be undertaken with the same machinery and without too great a penalty due to the loss of timeliness associated with the increased area of crop). However, in order to obtain the full benefits from this increase in cropping intensity, changes would be required in the whole farming system, not merely in the method of crop establishment. These changes could include such diverse components as changes in the crops in the rotation, changes in the livestock enterprise, changes in pasture types, and changes in machinery investment. Nevertheless, such whole-farm changes could lead to substantial benefits for the farmers. Where the dynamics of this change were examined in detail (for example Farquharson, Ockwell and Davenport, 1984), farmers were found to move towards increased cropping intensity as quickly as possible.

Relative prices can change between cropping and livestock, so that it is possible that at other times there may be no such gains from increasing cropping at the expense of the livestock enterprises.

Effect on livestock

One of the important advantages of direct drilling in southern Australia, where livestock form an integral part of the mixed farming systems, can be the extra grazing that it allows. Close grazing can help in weed control, and the extra feed can be very valuable, but a farmer may have to change his livestock enterprises to include sheep rather than cattle, and wethers rather than ewes to maximise the use of the extra grazing available (Brennan and Godyn, 1982).

Where this extra grazing allows farmers to increase overall stocking rates, extra demands may be placed on labour and finance throughout the year, so that other adjustments may be needed to integrate the enterprises on the farm. Of course, higher stocking rates lead to greater livestock profitability.

The value of the extra grazing will vary with the season, location and the livestock enterprise. In southern New South Wales, Godyn and Brennan (1984) estimated that it would be worth $9-$10 ha^{-1} in an average season, but would vary from nil to approximately double that amount, depending on the season.

These benefits through the livestock enterprise are only available on those farms in southern Australia where livestock form an integral part of the mixed farming system. However, it has already been demonstrated that livestock and, in particular, sheep, can be used for fallow weed control in Queensland. The opportunity to do this will vary with the season and the enterprise. Large integrated mixed farming enterprises may be the most suitable because stock on hand can be diverted or used as the season and conditions determine. Smaller producers could be forced into buying and selling situations that are not economically rewarding due to seasonal stock-price fluctuations.

ECONOMIC BENEFITS FROM EROSION CONTROL

Systems involving no or reduced tillage and appropriate crop-residue management are soil conservative and, under certain conditions, they can considerably improve fallow efficiency. It has also been found that no-till fallow allows sorghum in marginal areas to increase water-use efficiency. So it can be said that conservation farming systems provide additional benefits for little or no extra cost.

On Queensland's Darling Downs, five tillage options were evaluated on a 'typical' 200 ha farm of 5% slope and a soil depth of 75 cm (Ward, 1982). The options were:

1 conventional cultivation (crop residue is burnt, contour banks are not used);

2 conventional cultivation (conventional cultivation, contour banks and waterways);

3 contour banks and stubble mulching;

4 opportunity cropping with stubble mulching and contour banks;

5 no-till fallow (herbicide substitution for mechanical weed control, stubble retained, with contour banks).

The study showed that the soil conservation options (3-5) substantially reduced gullying (Table 16.6). In 20 years, these treatments produced much higher gross margins than the conventional tillage systems. The data showed that options 4 and 5 were clearly more profitable than the options based on conventional cultivation systems (Table 16.7). The benefits in this study were derived from an initial increase in productivity, reduced productivity decline over time, and lower land losses to gullies. As well, there were savings associated with some of the reduced-tillage options with respect to machinery costs.

In a simulation-model study in north-central, Victoria, Arch and Dumsday (1981) found that the potential reduction in soil loss from conservation rather than exploitative farming systems was very large (19 t ha^{-1} rather than 660 t ha^{-1} over 20 years). There was a high return to a

Table 16.6 Agricultural production in year 20 of a long-term tillage-option programme (Ward, 1982)

Option[a]	Total area lost to gullies (%)	Annual soil loss (t ha^{-1})	Average crop yield (total area) (t ha^{-1})	Average crop yield cultivated (t ha^{-1})	Initial yield (t ha^{-1})	Gross margin (total area) ($ ha^{-1})
1. Conventional, no banks	10.0	98	2.05	2.28	2.70	116
2. Conventional plus banks	5.8	53	2.41	2.56	2.80	156
3. Banks plus stubble mulch	2.0	6	2.91	2.97	3.00	231
4. Banks plus opportunity cropping	0	4	4.64	4.64	4.67	335
5. Banks plus no-till fallow	0	1	2.99	2.99	3.00	241

The difference in average gross margin per year between the 'accepted' farmer practice (No. 1) and the most favourable option (No. 4) is $219 per hectare after 20 years.

[a] See text for full description of options.

Table 16.7 Variation of net present value with period of analysis and discount rate (Ward, 1982)

Option[a]	Evaluation period	Net present value (1982 dollars)			
		@−1.8%	@ 0%	@ 4.545%	@ 18.18%
2. Conventional plus banks	10	−117	−115	−112	−112
	20	86	43	−26	−96
	50	2365	1191	215	−89
3. Banks plus stubble mulch	10	567	502	318	152
	20	1805	1436	848	232
	50	10274	7369	1674	257
4. Banks plus opportunity cropping	10	1685	1510	1167	601
	20	4295	3475	2165	768
	50	19038	10883	3791	813
5. Banks plus no-till fallow	10	735	644	469	190
	20	2103	1667	980	273
	50	11766	6540	2010	300

[a] See text for full description of options.

conservative system compared with the exploitative system. These reductions in soil loss cost the farmer very little, although the economic benefits were only evident in the longer term (at least 5 years, with more than 20 years before the full benefits were realised). The benefit in increased revenue came from increased livestock production rather than cropping, as yields were virtually equal under either system. However, the revenue from cropping would almost certainly change over a longer period of time. Overall, the use of conservative farming practices yielded a higher return for the farmer.

OTHER MANAGEMENT CONSIDERATIONS

Changes in seasonal cash flows

A change in the farming system will alter the cash flow throughout the year (Scarsbrick, 1979), because of differences in both cropping and livestock operations. In the short run, the adoption of systems involving herbicide substitution for tillage as alternatives to conventional operations means an exchange of fuel, repairs and labour for herbicides. In an examination of the quarterly cash flows in southern New South Wales, Godyn and Brennan (1984) found total payments were higher in autumn, winter and spring with direct drilling. As a consequence, there was a higher net cash demand for direct drilling than for conventional cultivation in the autumn. These higher payments were subsequently more than offset by sheep and wool sales in spring, but there was a higher peak debt in the meantime.

Nevertheless, the cash flow may be improved during late summer and early autumn under direct drilling. With conventional tillage, there can be a substantial demand during late summer and early autumn for cash for cultivations or fallowing. Often this demand occurs at a time when cash reserves are at their lowest, that is, after harvest and before returns from the crop are received. Under direct drilling, the peak demand for cash occurs after the receipt of payments for the previous year's crop, so the cash flow is likely to be improved, and hence the need to borrow for preparing and sowing the current year's crop is reduced.

Where cropping operations were extended through direct drilling, Godyn and Brennan (1984) found that, although at the end of the year direct drilling had a markedly higher income, cash demands were higher for most of the year. Consequently interest charges were higher during the adoption phase; costs had increased but the full increase in returns had not yet been realised. Such considerations could influence decisions to restructure other farm activities to provide extra income during autumn or winter in order to alleviate any cash-flow difficulties.

Although increases in debt and the resultant additional interest charges associated with direct drilling are likely to be small compared with the annual economic gains that can be achieved, these issues could be important to individual farmers.

Changes in annual cash flows

The farmer adopting reduced-cultivation methods may have to buy a boom spray or use a spraying contractor at the outset. In the long term, less machinery is needed to grow the same tonnage of crop, and machinery replacement will have less budgetary significance for the farmer.

Using the partial budgeting approach, ICI (1980, *The Making of Spray.Seed Sam*) showed how a farmer could reduce peak borrowing requirements when facing the purchase of additional land. In this case, the adoption of direct drilling allowed more crop to be grown using only the equipment owned before expansion of farm area. By putting the newly purchased land into crop, the farmer was able to reduce his investment of working capital on new land. The cost of inputs for crop growing such as fertilisers, herbicides, seed and fuel were less than the investment in sheep.

Changes in taxation

Taxation can have an important impact on the decisions affecting the adoption of conservation farming technology. The investment allowance and accelerated rates of depreciation can influence the level of investment in machinery and equipment on farms. Similarly, the tax deductibility of operating expenses may have an effect on the combination of tillage methods that maximises profits, since the operating expenses per hectare vary between different methods.

The model of Farquharson, Ockwell and Davenport (1984) allowed for taxation effects. Although the results showed no significant differences from those of other studies that did not take account of taxation, the inclusion of taxation highlighted the opportunity cost associated with high levels of investment in machinery. A tentative conclusion is that the results of other analyses would be little changed by the impact of taxation on farmers' decisions, although it is likely that in particular cases taxation effects could be critical to the farmers' decisions.

Impact of uncertainty

Farquharson, Ockwell and Johnston (1983) examined the effect of uncertainty and the reaction of farmers to risk on the adoption of reduced-cultivation technology. They found that the results of the analysis were sensitive to the level of risk associated with the new technology. Thus, where reduced cultivation was seen as increasing fluctuations in yield and hence income, its rate of adoption was much lower. This could help to explain regional differences in the adoption of reduced cultivation, if farmers have the perception that it is risky for them in their environment.

CONCLUSIONS

To maintain or improve profitability, Australian farmers need to achieve economic efficiency in the use of resources in producing their crops. This will require them to change the mix of inputs used in land preparation in response to changes in the relative prices of those inputs. Chemicals are likely to continue to be increasingly substituted for machinery, to offset the declining terms of trade for farmers, and the declining productivity experienced with the traditional mechanical tillage method of land preparation. Farmers can gain other benefits from substituting herbicides for cultivation including lower labour and machinery requirements, more timely operations, ability to handle increased cropping areas with the same machinery investment, reduced soil erosion, and higher yields with some crops.

However, this is likely to lead to a reduction in cultivation only when economic circumstances permit, through lower variable costs. Such an *ad hoc* approach will not lead to a permanent, universal adoption of reduced tillage or other conservation farming technology. For this to occur, new systems of management are needed for all agricultural areas and we believe that economic, soil-conserving systems can be developed for each area.

Farmers need to be aware that a change in the tillage method may need to be accompanied by changes in crop rotations, pasture and livestock management, machinery requirements and many other facets of farm operation. In short, the farmer must recognise the need for changes in his management of the farming system as a whole, not just his tillage methods alone, if he is to obtain the maximum gains from the new tillage methods.

However, some of these strategies may need costly adjustment phases or some long-term investment in conservation measures, and farmers may face a long period before the full benefits are realised. The long-term benefits will make this investment worthwhile, but farmers will need to be convinced that money spent on these conservation measures is a sound investment for the future profitability and management of the farm, even if total returns from the investment are not felt until the next generation.

In these new conservation farming systems, the three economically sensitive areas are the yields obtained, changes in the relative prices of inputs, and the capital requirements of the systems. Firstly, it will be important for farmers to be confident that yields will not decline with a change to reduced cultivation, as productivity increases are the major means they have for coping with the continuing decline in terms of trade for farmers. Thus, even if yields will be higher in the long term, there must not be a marked yield reduction during the adoption phase, or farmers will be reluctant to adopt the new methods. Secondly, any marked change from the trend in relative prices of inputs seen in the early 1980s could lead to rapid changes in the rate of adoption of reduced cultivation, as these cost-price pressures will remain important if farmers are to adopt practices that are beneficial to them in the long run. Thirdly, because of the high cost of capital, new technologies will need to have low-to-moderate capital requirements if they are to be widely adopted. New technologies based on very expensive machinery, for instance, are likely to be ignored by the majority of farmers.

All involved with conservation farming need to maintain a clear overview of the implications for farm management of the technical changes being undertaken. There is a need for more integrated biological and economic information, in order to enable whole-farm analyses to be made, and to enable the long-term benefits from conservation farming to be assessed more thoroughly. In particular, further examination is needed of the long-term effects on yields, changes in weed spectrums and general weed levels, changes in machinery, and the implications of changes in rotations on the management and profitability of farms. Also, further examination is needed of the most efficient process by which farmers can adopt the new systems, which require them to change their traditional farming practices (see Chapter 17).

If farmers are to adopt the farming methods that will be most beneficial to them and to their successors, they need to be shown that it is in their own economic interests to make the change to conservation farming methods.

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Appendix 16.1: THE INFLUENCE OF CHEMICAL WEED CONTROL ON MACHINERY INVESTMENT AND FARM RETURNS

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A.1 The systems

In this case study, an examination is made of a father/son property that was split, giving each 500 hectares of similar, totally arable, land on the south-western Darling Downs. Rainfall is about 575 mm per year. The father uses a mechanical system; the son uses a no-till or low-till system.

A.1.1 Capital

The mechanical system had $148 000 worth of tillage equipment at December 1983 values, while the no-tillage system had only $76 000 worth of tillage equipment at 1983 values. The equipment, together with its cost, for each system is as follows:

Equipment used in stubble-mulch system

Item	Cost ($)
Tractor, 120 kW	60 000
Scarifiers, 7.5 m	13 000
One-way disc	15 000
Chisel plough, 6 m	14 000
Combine, 8.5 m	32 000
Boom spray, 21 m	5 000
Harrows, 12 m	1 500
Tractor, 55 kW	7 500
	148 000

Equipment used in no-till system

Item	Cost ($)
Tractor, 88 kW	35 000
Scarifier, 3.75 m	6 500
No-till combine, 6 m	20 000
Boom spray, 22.5 m	7 500
Tractor, 55 kW	7 500
	76 500

A.1.2 Labour

Both systems require a manager plus one working man.

A.1.3 Operations and rotations

Crop yields used represent a mean of those obtained from the 1979 season onwards. A 5-year rotation was used with approximately equal areas being planted to each part of the rotation. Rotation and crop yields (t ha^{-1}) are:

	Yields (mechanical)	Yields (no-till)
Year 1, winter crops	3.08	3.08
Year 2, winter crops	3.08	3.08
Year 3, long-fallow sorghum	4.20	5.56
Year 4, sorghum	4.00	5.00
Year 5, winter crop (barley immediately following sorghum, i.e. double crop)	1.85	2.47
Mean	3.24	3.84

A.2 Discussion

The net returns per hectare for the two systems, excluding harvesting costs, are:

	Stubble mulch ($)	No-till ($)
Year 1, winter crop	199.93	176.54
Year 2, winter crop	199.93	176.54
Year 3, sorghum on fallow	345.26	466.19
Year 4, sorghum	339.34	451.29
Year 5, winter crop (barley double crop)	76.80	162.64
Mean	232.25	286.64

Indications are that yields from winter crops are similar, irrespective of the system. However, the costs of the no-till winter crops are much higher than for mechanical fallow. The higher yields for sorghum and double-crop barley are sufficient to more than offset the cost disadvantages. The cost of fallows, chemicals, seed and fertiliser for the different crop systems is as follows:

	Stubble mulch		No-till	
	A ($)	B ($)	A ($)	B ($)
Barley-barley	114.11	169.67	169.76	193.06
Long-fallow sorghum	103.64	158.24	174.89	201.01
Sorghum-sorghum	95.51	107.45	125.85	131.76
Barley (double crop from sorghum)	104.22	145.20	113.28	133.76

A = Variable costs excluding labour and machinery ownership costs.

B = Variable costs including labour and machinery ownership costs.

Note: No atrazine was used with the sorghum because of the residual problem.

No account is taken of savings effected through reduced soil erosion and its effects on productivity and earth-work maintenance intervals. Savings in this regard can be considerable (Ward, 1982). The systems are looked at as pure systems; no attempt is made to assess costs and returns for growers in the transition stage. However, in the no-till systems, a scarifier is available for 'emergency tillage'.

A.3 Conclusions

The two systems compare as follows:

	Stubble mulch ($)	No-till ($)
Machinery investment	148 000	76 500
Average returns per hectare	232.35	286.64
Average costs per hectare:		
Excluding labour, machinery	106.32	150.71
Including labour, machinery	150.05	170.56
Costs:		
Machinery	High	Low
Chemical	Low	Very high
Labour requirement	High	Low
Yields		(Advantage summer crop)