CALCULATING THE ECONOMICS OF WEED CONTROL

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SUMMARY

A simple method of calculating the "breakeven yield loss" for weed control in an annual crop is developed, and illustrated by means of a worked example. A farmer "breaks even" from weed control when the gross monetary return from the extra yield minus any marginal costs associated with the extra yield equals the cost of weed control minus any cost savings associated with weed removal.

INTRODUCTION

Economic decisions about weed control measures can be made at various levels. Decisions can be made concerning individual fields, whole farms or regions. These decisions can be short term, relating to just a single crop in a single year, or long term, considering future crops, as discussed in Auld *et al* (1987). In this paper we consider the simplest case, that of a short term decision concerning the profitability of weed control in an annual crop in a single field.

The crucial component of any economic analysis of weed control is the relationship between the weeds in a crop and the resultant yield loss. Yield loss due to weeds has most often been related to the population density of the weed (Cousens 1985). The yield loss — weed density function is sensitive to various factors, including time of weed emergence (Zimdahl 1988), time of sowing, crop density and environmental factors (Auld *et al* 1987). This sensitivity has made the creation of reliable models of crop yield loss complicated. As a result, yield losses due to weeds remain unpredictable for most crop-weed combinations.

Nevertheless, it is still possible to undertake a useful economic analysis of weed control in a particular crop, based on concepts discussed by Bourdot and Saville (1988). This involves estimating a "breakeven yield-loss %" using the cost-price structure for the crop-weed-herbicide scenario of interest, plus an informed guess regarding the yield loss in the absence of weed control.

METHOD

It will be profitable to apply a herbicide to control a weed infestation in a particular field when the cost of doing so is less than the value of the increased production (Auld *et al* 1987). A farmer can be said to "breakeven" from treating a weed infestation when

$$\text{Treatment cost} = \frac{\text{Crop value} \times \text{Preventable yield loss \%}}{100} \quad (1)$$

Here the treatment cost is defined as the cost of the appropriate herbicide plus application, minus any cost savings associated with removal of the weeds. Examples of cost savings are crop desiccation prior to harvest and drying of grain after harvest when these are necessitated by the presence of weeds in the mature crop. Weeds in the mature crop may also make harvesting more difficult and costly. These costs may depend on the species of weed and on the weather conditions during the ripening and harvesting of the crop, and in the latter case may not be incurred every year. For a cost that is not incurred every year, a long term average cost should be used. For example, if the crop requires desiccation in 1 out of 5 years, the cost of desiccation should be divided by five.

Crop value in Equation (1) is defined as the expected gross monetary return from the crop if it were weed-free, minus any costs that increase in direct proportion to crop yield ("marginal" costs). Common marginal costs for cereal production are those of harvesting, transport of grain and drying of grain.

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Preventable yield loss % in Equation (1) is the portion of the yield loss caused by weeds that can be prevented by treatment, expressed as a percentage of the yield that would be obtained in the absence of weeds. The loss that can be prevented will depend upon the efficacy of the treatment which will be a function of the rate of herbicide used and the susceptibility of the weeds.

Any reduction in crop yield due to toxicity of the herbicide reduces the percentage increase in yield which can be achieved by treatment. This effect should therefore be subtracted from the preventable yield loss %. Crop toxicity effects are usually unknown, and often presumed to be insignificant in comparison to the losses prevented by controlling the weeds.

Equation (1) can be rearranged so that the breakeven yield loss % is expressed in terms of the treatment cost and crop value.

$$\text{Breakeven yield loss \%} = \frac{\text{Treatment cost} \times 100}{\text{Crop value}} \quad (2)$$

For any combination of treatment cost and crop value, the breakeven yield loss % can be easily calculated from Equation (2). Alternatively the breakeven yield loss % can be obtained conveniently from Fig. 1 which has been derived from Equation (2).

Fig. 1: The Ready Reckoner Graph. The “breakeven” yield loss percentage is graphed against crop value for a range of weed control treatment costs. The curves are derived from Equation (2).

EXAMPLE

The method is now illustrated by way of a numerical example. In the example, the profitability of weed control in a wheat crop in the 1989 season is investigated. The input data for this example is in Table 1.

We suppose that the expected loss in yield if the weeds are not controlled is 10%, and that the herbicide will completely prevent this loss with no toxic effect on the crop, and ask: Is usage of the herbicide profitable?

Step One

Calculate Treatment cost per ha

$$= \left\{ \begin{array}{c} \text{cost of herbicide/ha} \\ + \\ \text{cost of application/ha} \end{array} \right\} - \left\{ \begin{array}{c} \text{cost of desiccation/ha} \\ + \\ \text{cost of grain drying/ha} \end{array} \right\}$$

TABLE 1: Input data for calculating the economics of weed control in a New Zealand wheat crop in 1989.

Cost of herbicide	= \$60/ha	
Cost of application	= \$15/ha	
Gross return	= \$250/tonne	(Expected weed-free
Harvesting cost	= \$35/tonne	yield is 4.5 tonnes/ha)
Transport cost	= \$45/tonne	

The grain from a weed-free crop needs to be dried 1 year in every 10, at a cost of \$20/tonne.

If herbicide is not applied, there is a one in eight chance that the crop will need to be desiccated, at a cost of \$112/ha. Also, the chance of needing to dry the grain increases from 1/10 to 1/5.

In our example:

Cost of herbicide	= \$60/ha
Cost of application	= \$15/ha
Cost of desiccation	= $\$112 \div 8 = \$14/\text{ha}$
Cost of grain drying	= $\$20/\text{tonne} \times 4.5 \text{ tonnes/ha} \div 10$

(where the cost of grain drying is divided by 10 since treatment reduces the probability of grain drying by 1/10, from a 1 in 5 chance to a 1 in 10 chance)

$$\text{Treatment cost} = (60 + 15) - (14 + 9) = \$52/\text{ha}$$

Step Two

Calculate crop value per tonne

$$= \text{gross return/tonne from weed-free crop} \\ - (\text{cost of harvesting/tonne} + \text{transport cost/tonne} + \text{cost of grain drying/tonne})$$

and multiply by the expected weed-free yield per ha to obtain the crop value per ha.

In our example:

Gross return	= \$250/tonne
Harvesting cost	= \$35/tonne
Transport cost	= \$45/tonne
Grain drying cost	= $\$20 \div 10 = \$2/\text{tonne}$ (for weed-free crop)
Crop value per tonne	= $250 - (35 + 45 + 2) = \$168/\text{tonne}$
Crop value per ha	= $\$168/\text{tonne} \times 4.5 \text{ tonnes} = \$756/\text{ha}$

Step Three

Read the Breakeven yield loss % off the Ready Reckoner graph (Fig. 1). If the expected yield loss through weeds is greater than the breakeven %, apply the herbicide.

In our example:

Treatment cost	= \$52/ha
Crop value	= \$756/ha
From the graph, the Breakeven yield loss %	= 7%
(or from Equation (2), $52 \div 756 \times 100$)	= 6.9%

The conclusion is that it is profitable to apply the herbicide since our expected yield loss (10%) exceeds the calculated breakeven loss (7%).

DISCUSSION

In this paper we have shown how to calculate the crop yield loss that must be prevented in order to breakeven from weed control. We have called this the "breakeven" yield loss. When the expected yield loss is greater than the breakeven loss, it is profitable to control the weed infestation. Functions relating crop yield loss to weed infestations do not exist for New Zealand crops, owing to a lack of research in this area of weed science (Bourdote and Saville 1988). It is therefore not possible to predict yield

losses due to weeds in any New Zealand crops. The general lack of predictive models of this kind is recognised by Auld *et al* (1987) and is the greatest single impediment to the construction of objective decision-making aids for weed control since the greatest effect of weeds is to reduce crop yield (Zimdahl 1980).

It is, nevertheless, useful to calculate the "breakeven" loss as defined in this paper. The calculated "breakeven" loss can be compared with an informed guess about the likely loss that the crop will suffer if the weeds are not controlled. Such a guess could be based on the experience of the farmer. The process of calculating the "breakeven" loss has the additional value of helping the decision-maker focus on the various issues relevant to the weed control decision.

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REFERENCES

- Auld, B.A., Menz, K.M. and Tisdell, C.A., 1987. Weed Control Economics. Academic Press; London, 177 pp.
- Bourdote, G.W. and Saville, D.J., 1988. The economics of herbicide use in cereal crops in New Zealand. *N.Z. J. Exp. Agric.* 16: 201-207.
- Cousens, R., 1985. A simple model relating yield loss to weed density. *Ann. appl. Biol.* 107: 239-252.
- Zimdahl, R.L., 1988. The concept and application of the critical weed-free period. In: (eds.) Miguel, A., Altieri and Matt Liebman. Weed Management in Agroecosystems: Ecological Approaches. CRC Press; Florida, p 145-156.
- Zimdahl, R.L., 1980. Weed-Crop Competition, a Review. Oregon State University; Corvallis USA, 196 pp.