Potential economic benefit from research into alternative forms of wild oat (*Avena* spp.) control

Sushil Pandey[1], R.W. Medd[2] and R.K. Lindner[3]
[1]Department of Agricultural Economics, University of New England, Armidale, NSW 2351, [2]Agricultural Research and Veterinary Centre, Orange, NSW 2800 and [3]School of Agriculture, University of Western Australia, Nedlands, WA 6009 Australia

Summary.
An economic model for estimating benefits from alternative research tactics for weed control is developed and applied to wild oats. Research benefit is measured as the shift in steady-state profit resulting from population changes induced by regulating demographic parameters. The results indicate that relatively unexplored research tactics, especially that of reducing fecundity, offer economically attractive alternatives to the traditional approach of reducing seedling survival through improved herbicide efficacy.

Introduction

The population growth of wild oats is the product of the probability of seedling emergence (recruitment), the probability of seedling survival, the probability of survival of seeds in the soil, and the number of seeds produced per adult (fecundity), minus losses. Any one of these parameters may be regulated to alter population size. Historically, weed research has concentrated on controlling weeds by maximising seedling mortality, primarily through the application of herbicides. Little research has been directed to developing more competitive crops or techniques which alter the survival of seeds in the soil, the recruitment of seedlings or plant fecundity in order to conceive better integrated weed management systems.

In this paper, an economic model is developed to evaluate the relative magnitude of potential research benefits of tactically altering demographic parameters to regulate population growth of wild oats in the context of the Australian wheat industry.

An economic framework

Research-induced demographic changes result in a new steady-state weed density. This may result in an increase in yield and/or a reduction in production costs. The difference in the profit between the pre-innovation, and the post-innovation steady-state is a measure of research benefit; herein calculated using an optimal control framework.

The increase in wild oat density from one year to the next was specified by a logistic growth curve which captured the density-dependent effects on seedling survival and fecundity. A linear yield loss function modelled the competition from wild oats and an exponential function governed seedling mortality resulting from the post emergence application of diclofop-methyl. Full details of the model are described in Pandey *et al.* (1).

To accommodate its plasticity, wild oats were classified into eight demographic types based on seed mortality, fecundity and recruitment characteristics. A high and a low value was considered for each parameter. The parameters altered by research were the mortality of seeds in the soil, fecundity, recruitment, weed competitiveness, and seedling survivorship. Research benefits came from the savings in the cost of herbicide and increased crop yield.

Results and Discussion

Research benefit for one-at-a-time change by 50% of the initial values of parameters shows that the research activity which generates the highest benefit is strongly influenced by the demographic type (Table 1). However, research into decreasing seedling survival and research into reducing fecundity are the most profitable across all demographic types.

Table 1. Research benefit for a 50% change in demographic parameters.

Demographic Characteristics*	Type	50% Increase in Seed mortality	50% Increase in Seedling recruitment	50% Reduction in Seedling survival	50% Reduction in Potential fecundity	50% Reduction in Seedling recruitment	50% Reduction in Weed competitiveness
		($ ha^{-1})	($ ha^{-1})	($ ha^{-1})	($ ha^{-1})	($ ha^{-1})	($ ha^{-1})
$m_1g_1f_1$	A	1.78	-1.92	5.57	5.90	4.07	0.78
$m_1g_1f_2$	B	1.31	-2.39	7.42	4.59	4.78	2.72
$m_1g_2f_1$	C	0.39	-0.66	6.70	6.20	1.74	0.31
$m_1g_2f_2$	D	0.35	-1.00	9.10	5.62	2.47	1.32
$m_2g_1f_1$	E	3.05	-3.30	3.92	6.20	5.86	0.24
$m_2g_1f_2$	F	2.72	-3.35	6.31	5.61	5.93	1.28
$m_2g_2f_1$	G	1.38	-2.34	6.19	6.24	4.72	0.22
$m_2g_2f_2$	H	1.26	-2.46	8.69	5.80	4.89	1.03

*m, g and f denote seed mortality, recruitment and potential fecundity, respectively. The initial values assumed were $m_1 = 0.1$, $g_1 = 0.1$, $f_1 = 20$, $m_2 = 0.5$, $g_2 = 0.5$ and $f_2 = 100$.

Changes in each of the demographic parameters by 10 to 70% of the original values, for each demographic type, revealed some complex interactions (Figure 1). Thus, whether or not one tactic is superior to the other depends on both the demographic type and the magnitude of the research-induced change. In some cases, the tactic of reducing seedling survival ranked first, and that of reducing fecundity returned either the highest or the second highest benefit.

A reduction in seedling survivorship might be achieved for instance, through an improvement in herbicide efficiency. However, achieving such an improvement may be very expensive given the current high efficiency of herbicides. Moreover, the likelihood of achieving an improvement in herbicide efficiency is probably small, considering the already substantial investment into such research.

On the other hand, investing in research into reducing fecundity is attractive since it consistently gave high benefits across the various demographic types and there is more scope for progress since the tactic is relatively unexplored. As Medd and Ridings (2) illustrated, it makes biological sense in trying to contain wild oats by reducing seed production. Such an endeavour might, for example, explore the prevention of floral development or of pollination. Spray-topping with selective herbicides is one promising method which, in preliminary tests, reduced seed production by up to 96% (3).

References

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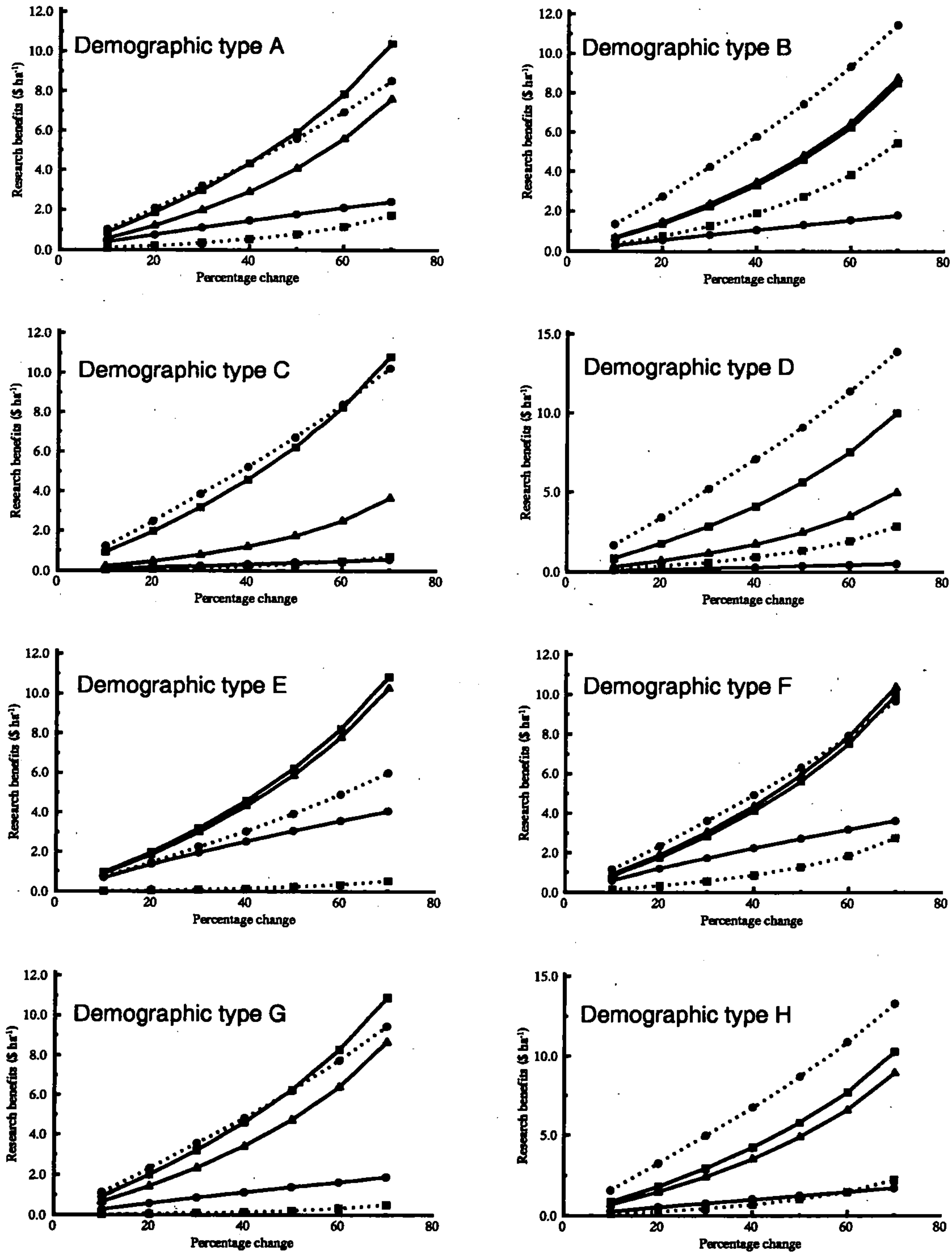

Figure 1. Research benefits for changes in demographic parameters of seedling survival ··●··, fecundity –■–, seed mortality –●–, recruitment –▲–, and weed competitiveness ··■·· for eight demographic types (A to H).