EFFECT OF CROP ROTATION, TILLAGE PRACTICE AND HERBICIDE USE ON THE POPULATION DYNAMICS OF WILD OATS

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Summary. The effects of crop rotation, tillage practice and herbicide use on the population dynamics of wild oats were studied in a field experiment in northern New South Wales. Fallow tillage did not improve control of wild oats compared with the no-tillage treatment and there were no consistent tillage effects on grain yield, wheat and wild oat plant density, wild oat seed production or carry-over of wild oat seed in the soil. Rotation of wheat with sorghum was the most effective means of reducing the wild oat seed reservoir. Annual use of either tri-allate or flamprop-methyl did not prevent a massive build-up of the wild oat seed reservoir after four successive wheat crops.

INTRODUCTION

In northern N.S.W., wild oat (*Avena* spp.) seed populations can be dramatically reduced by winter fallowing in association with a rotation of wheat and sorghum (8). This is also the most popular cultural control measure with farmers for wild oats (3). The selective herbicides tri-allate, diclofop-methyl and flamprop-methyl are also commonly used. Although tri-allate was the most popular selective herbicide for wild oat control it was ranked by farmers as being the least effective (3).

Because of the risk of soil erosion in the region there have been changes in tillage practices towards increased use of tyned implements and to the retention of stubble residues. This study was done to determine the effect of stubble-retained tillage practices and both pre- and post-emergence herbicide use on the survival of wild oat seeds in the soil.

METHODS

The experiment, on a black self mulching cracking clay, at the Agricultural Research Centre, Tamworth New South Wales was commenced in 1983. The experimental design was a split-plot randomized complete block with four replicates. Main plots, each 31.5 x 20 m, were sub-divided into three sub-plots, each 10.5 x 20 m. and sub-plots were further sub-divided into three sub-sub-plots, each 3.5 x 20 m consisting of 13 rows of wheat spaced 0.25 m apart. The two main-plot treatments were four years of mono-cropped wheat and a rotation of wheat-fallow-sorghum-fallow-wheat. Fallow management treatments on sub-plots were; (a) no-tillage, where crop residues were not disturbed and all weed growth was controlled using herbicides, (b) cultivated fallow, where weeds were controlled using a chisel plough, and (c) no-tillage burnt, where crop residues were burnt at commencement of the fallow and weeds controlled using herbicide. Sub-sub-plots consisted of wild oat herbicide applications; nil, tri-allate at 0.84 kg/ha, and flamprop-methyl at 0.5 kg/ha. Tri-allate was incorporated by the sowing implement (IBS). Tillage operations and herbicide applications were carried out when necessary during the fallow to prevent weed growth and to maximise storage of fallow rainfall in the soil.

Wild oat seeds were sown prior to the first wheat crop in 1983 to give 150 viable, non-dormant seeds per m^2. Soil samples were taken at harvest and sowing time each year from single 1.0 x 0.1 m quadrats to a depth of 10 cm in each plot. Measurements of wild oat density and the grain yield of wheat were also made.

RESULTS AND DISCUSSION

Fallow tillage did not improve control of wild oats compared with the no-tillage treatment. There were no consistent tillage effects on grain yield, wheat and wild oat plant density, wild oat seed production or carry-over of wild oat seed in the soil. The hygroscopic action of awns on wild oat seeds resulted in rapid burial in the self-mulching clay soil after seed shedding regardless of tillage practice.

With continuous wheat the four year total grain yields were 4971, 9845 and 9786 kg/ha for the untreated control, triallate and flamprop-methyl treatments respectively (Table 1). In agreement with Martin *et al.* (4) the performance of IBS tri-allate was better than expected from farmer's assessment. The 1986 data demonstrate the influence of the longer fallow in the sorghum to wheat rotation with wheat grain yields being increased by 2920, 1672 and 1934 kg/ha for the nil, triallate and flamprop-methyl treatments respectively compared with the same treatments in the continuous wheat system.

The grain sorghum crop in 1984/85 was a failure because of the hybrid selected. A new midge resistant hybrid was used which matured too late for the dry conditions in 1985. A grain yield of 2000 to 2500 kg/ha would have been obtained with a faster maturing hybrid.

Table 1.Effect of crop rotation and herbicide use over four years on wild oat plant density, viable seed production, viable seeds in soil and wheat grain yield.

Rotation Year	Herbicide	Wild oat density (plants/m^2)	Viable seeds produced (per m^2)	(per plant)	Viable seeds in soil (seeds/m^2)	Wheat yield (kg/ha)
Wheat/wheat/wheat/wheat						
1983	nil	24	4971	(207)	2030	1703
	tri-allate	5	862	(172)	510	3620
	flamprop-methyl	3	307	(102)	570	3806
1984	nil	135	3454	(26)	4480	950
	tri-allate	10	562	(56)	540	1693
	flamprop-methyl	32	859	(27)	690	1443
1985	nil	93	8072	(87)	13270	1296
	tri-allate	25	3518	(141)	3990	2403
	flamprop-methyl	38	3226	(85)	5060	2536
1986	nil	758	5843	(8)	14770	1022
	tri-allate	232	2398	(10)	6560	2129
	flamprop-methyl	173	1174	(7)	4120	2001
Wheat/sorghum/wheat						
1983	nil	26	5528	(213)	1950	2053
	tri-allate	2	237	(119)	260	3402
	flamprop-methyl	3	335	(112)	830	3148
1986	nil	24	168	(7)	250	3942
	tri-allate	1	5	(5)	90	3801
	flamprop-methyl	2	10	(5)	50	3935

Rotation of wheat with sorghum was the most effective means of controlling wild oats (Table 1). Annual use of either tri-allate or flamprop-methyl did not prevent a massive build-up of the wild oat seed reservoir after four successive wheat crops.

The rotation with sorghum, which allowed two winters for control of wild oats by either cultivation or with glyphosate, resulted in an exponential decline in wild oat seed numbers in the soil (Fig. 1).

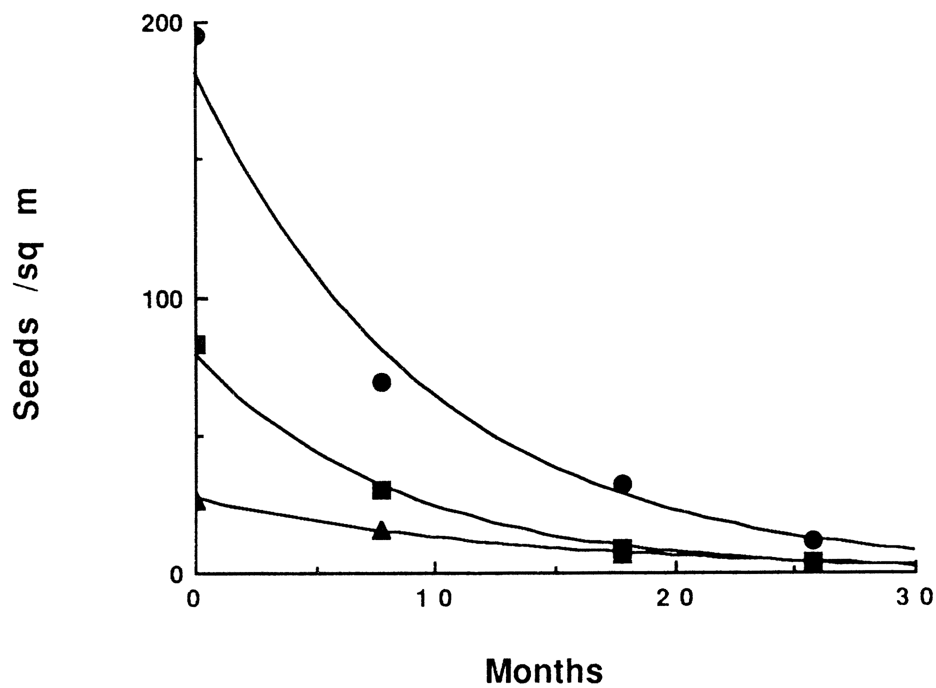

Figure 1. The exponential decline in wild oat seed numbers for three herbicide treatments in soil during the sorghum cropping phase of a wheat/sorghum/wheat rotation between January 1984 and January 1986;

nil herbicide (●), Y = 181 * 10(-.0452X) r^2 = .989,

tri-allate (■), Y = 27 * 10(-.0322X) r^2 = .998,

flamprop-methyl (▲), Y = 79 * 10(-.0513X) r^2 = .998.

The exponential rate of disappearance of seeds in the soil during the 2 year sorghum fallow was the same for both the no-tillage and the cultivated stubble retention treatments. During this period the soil seed population was reduced by 95%. Cheam (1) obtained similar results for brome grass where storage conditions under stubble or on bare soil had no effect on final germination but shallow burial promoted breakdown of dormancy.

Our results are similar to those obtained for black-grass (*Alopecurus myosuroides*) by Moss (6, 7) where the effects of tyne cultivation and direct drilling on seed and plant populations were either similar or showed no consistent trends. Inversion of soil can prolong the life of weed seeds (10) and insulate seed populations from seasonal fluctuations (6). However, tillage implements, such as disc and mouldboard ploughs which invert soil, are unlikely to be used extensively in Australia because of their damaging effects on soil structure and stability.

These results provide data which can replace assumptions used in economic models of long-term wild oat control such as that of Fisher and Lee (2). They used the dynamic programming approach to the economic control of wild oats and crown rot (*Fusarium graminearum*) in relation to crop rotation options in northern N.S.W. Dynamic programming requires the problem to be divided into stages and in this case the year was divided into two (summer and winter) cropping periods. There were three state variables in the program; moisture status in the soil, level of crown rot infestation and population of wild oats.

Assumptions regarding wild oat seed production did not take into account the density dependence of seed production and the variability in seed production which occurs from year to year. It was also assumed that pre-emergence herbicide was always applied and controlled 95% of expected wild oat seedlings. A post-emergence herbicide option was included which was assumed to give 99.5% control. The sensitivity of dynamic programming models to variations in the yield loss function and assumptions about wild oat fecundity need to be tested.

Medd and Ridings (5) concluded that killing seeds, produced from wild oat plants that matured in the crop, in association with the use of herbicides for plant kill was a biologically feasible tactic for reducing wild oat populations. Pandey and Medd (8) evaluated the economic feasibility of seed kill for controlling wild oats in a wheat mono-culture using a dynamic programming model linked to a bio-economic simulation model. Seed kill was shown to be an economically viable tactic in a wheat mono-culture but its efficacy requires validation under crop rotation sequences where seed reserves of short cycle weeds decline naturally at a rapid rate.

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