REDUCED HERBICIDE INPUTS IN CEREALS

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Teagasc acknowledges with gratitude the support of Cereals Levy Farmer Funds and European Union Structural Funds (EAGGF) in the financing of this research project.

ISBN 1 901138 68 2

September 1998

teagasc
The Science of Farming and Food

EUROPEAN UNION
European Agricultural Guidance and Guarantee Fund

Teagasc, 19 Sandymount Avenue, Dublin 4

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SUMMARY

The objective of this project was to examine if herbicides used in cereals at rates lower than recommended by the manufacturer (reduced rates) would give acceptable weed control resulting in lower crop production costs. Field trials with a number of herbicides at full and reduced rates were carried out in winter barley, winter wheat and spring barley in 1994-1996. Herbicides used at recommended rates gave the highest and most consistent levels of weed control. Herbicides used at 50% of the recommended rates gave slightly lower levels of weed control than the recommended rates but did not result in lower yields. While rates lower than 50% gave about 70% control of weeds, grain yield was reduced in some trials. Reduced rates gave higher weed control in barley than in wheat. The level of weed control was influenced by weed species and the growth stages of the weeds at the time of herbicide spraying. Thus selection of herbicides and their rates of application should be field specific. The findings show that it is possible to reduce the amount of herbicides used in cereals with considerable cost savings and reduced risk of herbicide residues in grain, soil and water.

INTRODUCTION

The primary objective of herbicide use is to maintain weed free crops resulting in profitable yields and trouble free harvesting (Elliott, 1978). Decreasing cereal prices, increasing costs and growing concern about excessive use of chemicals has heightened interest in minimising the use of chemicals in crop production. However, any reduction of inputs must be achieved without lowering gross margins as influenced by yield and quality.

Several factors combine to determine how effectively a cereal crop can compete with weeds. Crop variety, sowing date and general growth conditions are important. In addition weed type, size and vigour in relation to the host crop play a major part in determining yield response to weed pressures. Increased yield as a result of herbicide use has not always been significant. However, other factors such as ease of harvest and general seed quality are often as important as yield in determining margins (Sheppard, 1989; Davies, 1993).

In the early nineties trials in the UK and elsewhere with reduced herbicide dose rates have indicated that cost effective weed control can be achieved without loss of yield or quality. The objective of this series of trials was to determine yield responses of winter barley, winter wheat and spring barley to lower than recommended herbicide dose rates with a view to reducing production costs.

METHODS

Winter barley

Investigations in winter barley were carried out in 1994, 1995 and 1996. The following spray programmes were compared:-

(i) ***Autumn treatment only****: the herbicide Cougar applied at full and reduced rates in the autumn after crop and weed establishment with no subsequent herbicides in the following spring.*

(ii) ***Spring treatment only****: no herbicide applied in the autumn with various doses of a mixture of the herbicides Ally and Duplosan or Cameo and Duplosan applied in spring.*

(iii) ***Autumn and spring treatments****: various doses of the herbicide Cougar applied in the autumn followed with mixtures of herbicides in the spring.*

The Cougar was applied in the autumn when the crop had 3-5 leaves (growth stage 25) and weeds are 5.0-7.0 cm high. Spring herbicides were applied when the crop was at growth stage 31-32 and the weeds 6.0 to 10.0 cm high, usually in early to mid April.

Winter wheat

Investigations on winter wheat were carried out in 1995 and 1996. Spring applications of full and reduced rates of herbicides were compared in winter wheat sown in late October-November. Herbicides were applied singly and in mixtures in the spring crop growth stage 30-31 when the majority of weeds were 10 cm high.

Spring barley

Investigations in spring barley were carried out in 1995 and 1996. The herbicides Bandit, Cameo plus Duplosan and Cameo plus the wetter Agral were evaluated at full and reduced rates.

RESULTS AND DISCUSSION

Winter barley

Effect on weeds: The main weeds in the sites were common poppy, field speedwell, field pansy, chickweed, fumitory, red deadnettle, cleavers, and low levels of fathen.

The mean weed control values obtained at three sites in 1994 and 1995 are shown in Table 1. Highest levels of control were obtained with the full rate herbicides. Reducing rates by 50 per cent had only a small negative effect on weed control. Compared with the untreated controls weeds which survived the reduced rates were not competitive with the crop and this was reflected in the grain yield data. Similar results were obtained in 1996 (Table 2).

In general the standard rate of the herbicide Cougar (1.5 l/ha) which is widely used in winter barley in the autumn gave the highest level of weed control. Reducing the rate of application to 50 per cent standard had only a small effect

on the level of control. While still high relative to the untreated the 25 per cent gave the lowest control.

The results show that the 50 per cent rate of Cougar applied as an early post emergence spray can give acceptable control of a wide range of weeds. In situations where weeds survive the autumn treatment crops should be monitored in the spring and if required a reduced rate of an appropriate herbicide or herbicide mixture can be used to attain optimum grain yield and quality. A spring herbicide will be necessary most likely following an autumn spraying of the herbicides Cougar or IPU which are only moderately effective on cleavers. Work by Proven and Davies (1993) also showed that when cleavers are a problem in winter wheat a spring herbicide as a follow-up to low rate of autumn applied herbicide was necessary to achieve effective weed control.

Table 1: Effect of herbicides on weeds, grain yield, hectolitre wt. and screenings %, winter barley, 1994-1995

Product [Autumn, GS25]	Rate l/ha	Product [Spring, GS31]	Rate g/ha l/ha	Weed score (0-10)	Yield t/ha (15% mc)	Hecto. wt. kg/hl	Screen.% < 2.2 mm
Cougar	1.50	Ally + Duplosan	0.0+0.0	10.0	8.1	66.3	2.1
Cougar	0.75	Ally + Duplosan	0.0+0.0	9.5	7.9	67.3	1.9
Cougar	0.375	Ally + Duplosan	0.0+0.0	8.5	7.9	66.7	2.0
Cougar	1.50	Ally + Duplosan	30.0+1.0	10.0	8.0	67.3	1.6
Cougar	0.75	Ally + Duplosan	30.0+1.0	10.0	8.0	67.2	2.1
Cougar	0.375	Ally + Duplosan	30.0+1.0	9.5	7.9	66.9	1.8
Cougar	1.50	Ally + Duplosan	15.0+0.5	10.0	8.2	67.3	1.7
Cougar	0.75	Ally + Duplosan	15.0+0.5	9.5	8.0	67.1	1.8
Cougar	0.375	Ally + Duplosan	15.0+0.5	9.0	8.1	66.8	2.0
Cougar	1.50	Ally + Duplosan	7.50+0.25	9.0	8.0	66.9	1.8
Cougar	0.75	Ally + Duplosan	7.50+0.25	9.0	7.9	67.3	1.8
Cougar	0.375	Ally + Duplosan	7.50+0.25	8.5	7.5	66.7	2.1
Untreated				0.0	6.4	66.3	2.3

Table 2: Effect of herbicides on weeds, grain yield, hectolitre wt. and screenings %, winter barley, 1996

Product [Autumn, GS25]	Rate l/ha	Product [Spring, GS31]	Rate g/ha l/ha	Weed score (0-10)	Yield t/ha (15%mc)	Hecto. wt. kg/hl	Screen.% < 2.2 mm
Cougar	1.50	Cameo + Duplosan	0.0+0.0	9.0	7.7	64.7	3.8
Cougar	0.75	Cameo + Duplosan	0.0+0.0	8.5	7.4	63.0	4.9
Cougar	0.375	Cameo + Duplosan	0.0+0.0	8.0	7.3	63.1	3.6
Cougar	1.50	Cameo + Duplosan	25.0+2.0	10.0	7.8	64.7	2.8
Cougar	0.75	Cameo + Duplosan	25.0+2.0	9.5	7.7	65.0	3.9
Cougar	0.375	Cameo + Duplosan	25.0+2.0	9.5	7.8	65.0	3.9
Cougar	1.50	Cameo + Duplosan	12.5+1.0	9.5	7.7	64.5	4.5
Cougar	0.75	Cameo + Duplosan	12.5+1.0	9.5	7.7	63.5	4.7
Cougar	0.375	Cameo + Duplosan	12.5+1.0	9.5	7.6	64.0	4.6
Cougar	1.50	Cameo + Duplosan	6.25+0.5	9.5	7.8	64.5	4.8
Cougar	0.75	Cameo + Duplosan	6.25+0.5	9.5	8.0	65.2	3.8
Cougar	0.375	Cameo + Duplosan	6.25+0.5	9.0	7.6	64.9	4.3
SED						0.70	0.9
Untreated						59.0	8.6

The effectiveness of the herbicides Duplosan and Starane applied with and without the wetter Agral is shown by the data in Table 3. Despite an autumn treatment of a mixture of the herbicides Cougar and IPU high numbers, approximately 40 plants m^2 of cleavers were present in spring. Low levels of red deadnettle and field pansy were also present.

With and without wetter, Starane gave a higher level of weed control than Duplosan at full and reduced rates. The wetter Agral enhanced the weed control efficacy of both herbicides at all rate of application. The full rate of Duplosan gave about 10 and 15 per cent better weed control than the 50 per cent and the 25 per cent rates respectively. However, the full rate of Starane was only marginally better than the 50 per cent rate and about 14 per cent better than the 25 per cent rate.

Table 3: Effect of Duplosan and Starane rates applied in the spring following autumn applied Cougar on weeds, grain yield, hectolitre wt., screenings %, winter barley, 1995

Product [Spring, GS31]	Rate l/ha	Weed score (0-10)	Yield (t/ha 15% mc)	Hecto. wt. kg/hl	% Screenings
Duplosan	2.50	9.5	8.0	69.9	3.1
Duplosan	1.25	8.5	8.2	69.8	2.7
Duplosan	0.625	7.5	7.2	67.0	3.4
Duplosan + Wetter	2.50 + 0.1%	10.0	8.2	68.8	3.2
Duplosan + Wetter	1.25 + 0.1%	9.0	8.0	69.1	2.8
Duplosan + Wetter	0.625 + 0.1%	8.5	8.0	67.9	3.1
Starane	1.00	10.0	8.0	69.6	2.0
Starane	0.50	10.0	8.1	69.3	2.0
Starane	0.25	9.0	7.9	69.2	2.6
Starane + Wetter	1.0 + 0.1%	10.0	8.0	68.8	2.4
Starane + Wetter	0.5 + 0.1%	10.0	7.8	69.2	2.6
Starane + Wetter	0.25 + 0.1%	9.5	8.0	69.2	2.4
SED			± 0.38	± 0.70	± 0.40
Untreated			6.5	65.2	4.2

In all the winter-sown barley trials response to low dose herbicides treatments was good ranging from 70 to 100 per cent. This agrees with experiences in Scotland (Fisher and Davies, 1993). Generally the 50 per cent rate treatment was equal to the full recommended dose but the quarter dose rate gave 10 to 30 per cent lower control. In all cases the 25 per cent rate weed control efficacy was increased substantially when a subsequent low dose spring herbicide treatment was included.

Effect on yield: The yields in all the herbicide treatments were significantly greater than the untreated controls. The yield response to full rate herbicides treatment was approximately 25 per cent. This is much greater than that reported elsewhere and probably reflects the high numbers of weeds in the untreated control. While yields were not significantly affected by herbicide rate there was a trend for lower yields at the 25 per cent rates. This evidence suggests that using 25 per cent rates may result in below optimum grain yield.

Effect on quality: Hectolitre weights and screenings per cent of the grain were not affected by herbicide rate.

Winter wheat

In 1995 and 1996 herbicides applied in the spring were evaluated in winter wheat crops sown in late October and mid-November respectively. No pre emergence or early post emergence herbicides were used. The spring herbicides were sprayed at crop growth stage 31 when the majority of weeds were 12.0 cm high.

Effect on weeds: In 1995 the main weeds in order of density were field pansy, cleavers, fathen and chickweed. In 1996 the weeds were chickweed, charlock, field pansy, cleavers and low numbers of annual meadow grass.

In 1995 high levels of weed control were obtained with spray mixtures of the herbicides Ally and Starane at full (30.0 g/ha + 1.0 litre/ha) and reduced rates with the exception of the mixture containing 25 per cent rates of either herbicide alone or in mixtures (Table 4).

Table 4: Effect of rates of Ally plus Starane applied in the spring on weeds, grain yield, hectolitre wt., screenings %, winter wheat, 1995

Herbicide [Spring, GS 31]	Rate g/ha l/ha	Weed score (0-10)	Yield (t/ha, 15% mc)	Hecto. wt. kg/hl	% Screenings
Ally + Starane	30.0+1.0	10.0	13.4	79.6	2.7
Ally + Starane	15.0+1.0	10.0	13.2	79.1	2.7
Ally + Starane	07.5+1.0	8.0	12.1	78.7	3.1
Ally + Starane	30.0+0.5	9.5	13.1	68.8	2.6
Ally + Starane	15.0+0.5	9.0	12.8	69.1	2.5
Ally + Starane	07.5+0.5	7.0	12.2	67.9	2.6
Ally + Starane	30.0+0.25	9.0	12.7	69.6	2.7
Ally + Starane	15.0+0.25	9.0	12.6	69.3	2.9
Ally + Starane	07.5+0.25	7.0	12.1	69.2	3.5
SED			± 0.43	± 0.78	± 1.3
Untreated			6.5	65.2	3.8

In 1996 Starane at 50 per cent rate (0.5 litre/ha) alone and in mixtures with reduced rates of the herbicide Cameo gave excellent weed control (Table 5). Applied as single treatments Duplosan gave lower levels of control than Starane. However the effectiveness of Duplosan was improved considerably when applied in mixtures with Cameo.

Effect on yield: In 1995 crop yield ranged from 13.4 t/ha where the Ally/Starane combination was applied at normal rate to 12.1 t/ha where the quarter rate was applied (Table 5). As in previous trials yield response was related to herbicide rate used. There were no significant differences in crop yield where the full and half rate herbicide combinations were used but there were some significant differences (5% level), in the quarter rate treatments when compared to the full and half rate combinations.

In 1996 yield difference between herbicide treatments were not significant (Table 6). This reflects the low competitiveness of stunted weeds which survived in some of the herbicide treatments.

Effect on quality: There was no significant differences in grain hectolitre weight and screenings % between herbicide treatments in 1995 and 1996 (Table 5 and Table 6).

Spring barley

Full, 50 per cent and 25 per cent herbicide rates were evaluated in spring barley in 1995. The effect of weed growth stage at the time of spraying on herbicide efficacy was examined in 1996.

Table 5: Effect of rates of Duplosan, Starane, Cameo plus Duplosan and Cameo plus Starane applied in the spring on weeds, grain yield, hectolitre wt., screenings %, winter wheat 1996

Product (Spring, GS31)	Rate g/ha l/ha	Weed score (0-10)	Yield t/ha (15% m.c.)	Hecto. wt. kg/hl	% Screen.
Duplosan	0.0+1.0	80	12.8	73.9	1.4
Duplosan	0.0+0.5	70	12.4	71.3	1.6
Starane	0.0+0.5	100	13.0	73.9	1.7
Starane	0.0+0.25	80	12.7	72.7	1.6
Cameo/Duplosan	12.5+1.0	100	12.7	74.1	1.4
Cameo/Duplosan	12.5+0.5	100	12.8	74.4	1.6
Cameo/Duplosan	6.25+1.0	80	12.7	72.8	1.7
Cameo/Duplosan	6.25+0.5	90	12.0	74.0	1.6
Cameo/Starane	12.5+0.5	100	12.0	74.2	1.6
Cameo/Starane	12.5+0.25	100	12.1	74.0	1.7
Cameo/Starane	6.25+0.5	90	12.3	73.5	1.5
Cameo/Starane	6.25+0.25	85	12.3	73.6	1.7
SED			±0.52	±0.81	2.2
Untreated	-	-	9.5	71.4	

In 1995 trials were carried out at two sites, A and B, in Oak Park. Site A the crop, var. Cooper, was sown on the 22nd March and at site B, var. Cork, the crop was sown on 14th April 1995. Weed density at both sites was medium with 50 plants per square metre.

The weeds in order of density were knotgrass, bindweed, red dead nettle, and fathen. Both trials were sprayed at crop growth stage 30/31. At this time the majority of the weeds were 5.0 to 7.0 cms high.

Cameo applied at 25.0, 12.5 and 6.25 g/ha in combination with 0.5 l/ha Duplosan gave between 90 to 100 per cent weed control at both sites. Bandit, a dicamba/CMPP/MCPA formulation, applied at 5.0, 2.5 and 1.25 l/ha gave weed control ranging from 88 to 100 per cent. Where the 25 per cent rates were used in both trials some weeds, particularly the knotgrass and bindweed were present in the plots but were only a quarter normal unsprayed size and therefore non competitive.

Table 6: Effect of rates of Cameo plus Duplosan and Bandit on weeds, grain yield, hectolitre wt, spring barley 1995

Product	Rate g/ha l/ha	Weed score (0-10) (A)	Yield t/ha (A)	Hecto wt. (A)	Weed score (0-10) (B)	Yield t/ha (B)	Hecto wt. (B)
Cameo + Duplosan	25.0+0.5	10.0	8.1	67.1	9.5	4.2	66.3
Cameo + Duplosan	12.5+0.5	10.0	8.7	66.5	9.5	4.4	66.5
Cameo + Duplosan	6.25+0.5	9.0	8.2	66.3	10.0	4.0	66.4
Bandit	0.0+5.0	10.0	8.2	67.3	10.0	4.8	65.9
Bandit	0.0+2.5	10.0	8.5	67.5	10.0	4.5	66.3
Bandit	0.0+1.25	9.0	8.4	66.9	9.5	4.4	65.7
SED			± 0.71	± 0.47		± 0.41	± 0.56
Untreated		0.0	5.0	67.1	0.0	3.5	64.3

A = Site No. 1; B = Site No. 2.

Effect on weeds: In 1996 the herbicide Cameo with and without the wetter Agral was applied at 26.0, 13.0 and 6.5 g/ha at growth stages 15,, 30 and 40 the respective weed size being 3.0 to 5.0 cms, 10.0 to 15.0 cms and 20.0 to 30.0 cms. Weed density was medium at 100 plants/m^2.

The main weeds were bindweed and speedwell, 50 per cent ground cover, oil seed rape, 20 per cent with field pansy, groundsel and red dead nettle, the remaining 30 per cent.

When applied at growth stage 15 all the Cameo treatments gave good weed control of 85 per cent or better (Table 7). Applied at growth stage 30 the weed control ranged from 80 to 90 per cent. When applied at growth stage 40 the three Cameo rates gave a respective weed control of 70, 50 and 40 per cent.

The grain yield level was considerably lower in site B than in site A (Table 6). This is attributed to later sowing and a severe soil moisture deficit during the growing season. Yield differences between herbicide treatments are not significant.

Effect on yield: Crop yield ranged from 7.6 to 8.1 t/ha. when Cameo was applied growth stages 15 and 30 and there were no significant differences between the treatment rates or time of application (Table 7). Where Cameo was applied at growth stage 40 the crop yield ranged from 6.9 t/ha for the full dose to 6.2 and 6.0 t/ha for the half and quarter dose respectively and were significantly lower than the earlier applied treatments.

Effect on quality*:* Compared with the full rate herbicide doses reduced rates did not significantly affect grain hectolitre weight and screenings per cent. This agrees with the findings in winter barley and winter wheat.

Table 7: Effect of herbicide rates applied at three different crop growth stages on weeds and grain, spring barley 1996

Herbicide (Rate of product/ha)	Crop growth stage at spraying					
	G.S. 15		G.S. 30		G.S. 40	
	Weed score (0-10)	Yield t/ha	Weed score (0-10)	Yield t/ha	Weed score (0-10)	Yield t/ha
Cameo+Agral 26.0 g+0.1%	9.5	8.1	9.0	8.1	7.0	6.9
Cameo+Agral 13.0 g+0.1%	9.0	8.0	8.5	7.6	5.0	6.2
Cameo+Agral 6.5 g+0.1%	8.5	8.0	8.0	7.7	4.0	6.0

CONCLUSIONS

- Herbicides used at full rates give the highest and most consistent levels of weed control in winter barley, spring barley and winter wheat.

- Herbicides used at 50 per cent of the recommended rates give slightly lower levels of weed control than full rates but do not lower grain yield.

- Herbicides used at 25 per cent of the recommended rates give moderate levels of weed control but tend to give lower grain yield.

- The levels of weed control obtained with reduced rates of herbicides varies with weed species and the growth stage of weeds at the time of spraying.

- Because of higher crop competition reduced herbicide rates gave more consistent results in winter barley and spring barley than in winter wheat.

- Selection of herbicides and rates of herbicides should be field specific.

- In early sown winter barley and winter wheat a 50 per cent rate of a suitable herbicide applied pre emergence or early post emergence can give optimum results in a high proportion of crops.

- Where inadequate control weed control is obtained in winter cereals with a reduced rate autumn herbicide follow-up spray of reduced rate herbicide in the spring is necessary.

- In late sown winter wheat spring applied herbicides can give acceptable weed control especially where weed grasses are not a problem.

- In spring cereal a single spray of 50 per cent rate herbicide or herbicide mixture can give acceptable weed control.

REFERENCES

Davies, D.H.K., Proven, M.J., Courtney, A.D., Lawson, H.M. 1993. Comparison of the use of weed thresholds and routine herbicide use at reduced rate on the economics of cereal production in the rotation. Proceedings, 8th Symposium of the European Weed Research Society, 2, 747-754.

Elliott, J.G. 1978. The economic objective of weed control in cereals. Proceedings of the 1978 British Crop Protection Conference - Weeds, 1, 829-841.

Fisher, N.M., Davies, D.H.K., Whytock, G.P. 1993. Reliability of broad-leaved weed control in cereals using low doses of herbicide. Brighton Crop Protection Conference - Weeds, 1993, 3, 1223-1228.

Proven, M.J., Davies, D.H.K., Courtney, A.D. 1993. An approach to developing appropriate herbicide options for winter wheat where cleavers are a problem. Brighton Crop Protection Conference - Weeds, 1993, 3, 1221-1216.

Sheppard, B.W., Davies, D.H.K., Richards, M.C. and Whiting, A.J. 1989. Effects of weeds on cereal harvesting efficiency and grain quality, and the economic consequences of reduced weed control. Brighton Crop Protection Conference - Weeds, 1989, 2, 961-967.