POSTER SESSION 6C
POST-GRADUATE STUDENT RESEARCH

Session Organiser — Mr J Smith
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Poster Papers — 6C-1 to 6C-16

Rapid determination of herbicide resistance pattern in blackgrass

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ABSTRACT

A rapid reliable seedling test was developed to determine the resistance pattern of *Alopecurus myosuroides* populations through a set of 13 herbicides. It is based on coleoptile length of seedlings exposed to the commercial herbicide formulation for six days. For each herbicide, the lowest concentration that strongly inhibits the coleoptile growth of a suceptible population was selected using the inhibition curve. Resistant populations were used to check the accuracy of these concentrations for a reliable screening of resistance.

INTRODUCTION

In France, more than 200 populations of blackgrass (*A. myosuroides*) were reported to be especially hard to control in winter cereal crops. Hence, testing resistance is becoming vital for the rational implementation of integrated control strategies.

The aim of this paper is to propose a modified and extented version of our seedling test already developed (Letouzé & Gasquez, 1999) for screening resistance, using the commercial form of the herbicide. According to the effective herbicides on *A. myosuroides* and the resistances already known, thirteen herbicides were selected. Such a bioassay has been developed in order to achieve a standardised and common resistance screening test for all the French institutes involved in herbicide control.

METHODS AND MATERIALS

Three *A. myosuroides* populations from Dijon (France) were used in this study : a herbicide susceptible (S) population, a resistant (R1) population to aryloxyphenoxypropionates (APPs), cyclohexanediones (CHDs) and sulfonylureas, and a resistant (R2) population to ureas. One hundred pre-germinated seeds of each population were transferred onto a blotting paper within closed boxes filled with herbicide solutions. Boxes were placed in a controlled environment room (18-h, 22°C light / 6-h, 20 °C dark) for 6 days. After incubation, the herbicide effect was assessed by measuring coleoptile length.

The herbicides used were : fenoxaprop-P ethyl as 'Puma S' 69 g a.i./l, haloxyfop as 'Eloge' 104 g a.i./l, clodinafop propargyl as 'Celio' 100 g a.i./l, cycloxydim as 'Stratos' 100 g a.i./l, tralkoxydim as 'Grasp' 60 g a.i./l, flupyrsulfuron as 'Lexus' 33.3%, trifluralin as 'Callifort' 480 g a.i./l, pendimethalin as 'Prowl' 400 g a.i./l i, alachlor as 'Lasso' 480 g a.i./l, propyzamide as 'Kerb' 400 g a.i./l, triallate as 'Avadex' 300 g a.i./l, isoproturon as 'IPU' 500 g a.i./l, chlorotoluron as 'Dicuran 500 g a.i./l.

For each herbicide, the inhibition curve was used to determine the 100% lethal dose (LD 100). Then, to validate the test, the R1 and R2 populations were tested to each LD 100 selected for APPs, CHDs and sulfonylureas and ureas, respectively.

RESULTS

For all the herbicides tested (except ureas), the coleoptile growth of the susceptible population (S) was affected by increasing concentrations. Therefore, it was possible to select the lowest concentration that strongly inhibits the S coleoptile growth. As ureas inhibit photosynthesis, it was not possible to use coleoptile length as a discriminant parameter for assessing resistance. Thus, for this herbicide group, the test is based on the complete bleaching of the coleoptile within 2 weeks. The selected concentrations for all the herbicides are shown in Table 1.

Table 1. Coleoptile lengths (% of control) and percent of bleached coleoptiles of a susceptible population (S) and resistant populations (R1 and R2) exposed to the selected concentrations.

Herbicide	Concentration (mg/l)	S coleoptile lenght	R1 coleoptile length	R2 coleoptile length
fenoxaprop-P ethyl	10	3.2	93.7	3.1
haloxyfop	2.5	1.25	73.8	2.8
clodinafop propargyl	5	2.5	78.2	1.5
cycloxydim	0.625	3.1	89.6	1.1
tralkoxydim	2.5	2.9	90.7	2.3
flupyrsulfron	320	4.8	50	5.1
trifluralin	40	4.7	4.1	5.2
pendimethalin	40	4.5	3.9	4.6
alachlor	40	4.1	5.9	5.6
propyzamide	5	2.5	5.4	4.2
triallate	20	4.1	4.3	4.3
		% of bleached coleoptiles		
isoproturon	100	100	100	0
chlorotoluron	100	100	100	0

CONCLUSION

The seedling test developed in this study allows the quick determination of the resistance pattern of a seed sample through a set of commercial herbicide formulations effective on *A. myosuroides*. This test may be useful for Institutes involved in herbicide control and even for farmers.

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Potential use of oxadiargyl / propanil mixture for control of propanil resistant *Echinochloa crus-galli* in rice

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ABSTRACT

Oxadiargyl / propanil mixture was evaluated for the post-emergence control of susceptible and propanil-resistant *Echinochloa crus-galli.* The mixture controlled both biotypes at the highest dose, indicating an alternative for the control of propanil resistant biotype. Oxadiargyl and propanil showed a synergistic action in mixture.

INTRODUCTION

Propanil, a highly effective amide herbicide with its mode of action on PS-II has been extensively used against broadleaf and grass-weeds in rice. The repeated and extensive use over the past 35 years has led to the development of propanil-resistance in *E. crus-galli*, by elevating aryl amidase activity levels (Norsworthy *et al*, 1998). Oxadiargyl, a new herbicide with mode of action on protoporphyrinogen oxidase has been mainly developed for the control of *E. crus-galli* (Dickmann *et al*, 1997). Although, marketed for pre-emergence application, it can also be applied post-emergence in mixture with propanil (Dickmann *et al*, 1997). The aim of this experiment was to evaluate the efficacy of this mixture on susceptible and propanil resistant biotypes of *E. crus-galli.*

METHODS AND MATERIALS

A pot experiment was conducted under glasshouse conditions to evaluate the efficacy of oxadiargyl plus propanil in mixture for the control of susceptible and propanil resistant *E. crus-galli* biotypes. The night temperature of the glasshouse was approximately 20°C and the daily average was 27±3°C. The photoperiod was more than 16 h. Six *E. crus-galli* seeds per pot were sown to a depth of 1cm in sandy-loam soil. Five days after emergence the plants were thinned leaving three plants per pot. At the two-leaf growth stage, four doses of oxadiargyl (6.25, 12.5, 25, 50 g a.i./ha, SC 400 g a.i./l), propanil (125, 250, 500, 1000g a.i./ha, EC 360 g a.i./l) and oxadiargyl (SC) plus propanil (EC) (6.25+125, 12.5+250, 25+500, 50+1000 g a.i./ha, respectively) were applied (Table 1). Herbicide applications were performed using a CO_2 hand-held Oxford precision micro-sprayer calibrated at 2.7 bar pressure, to deliver 300l/ha sprayer volume. The plants were watered forty-eight hours after treatment. Two weeks after treatment plant fresh weight was recorded. The experimental design was a randomised complete block design with herbicides and doses as main factors.

There were four replications per treatment. The responses of *E. crus-galli* to combinations of the mixture were statistically analysed according to Colby's 'expected response' method: "*E=XY/100*" (Colby, 1967).

RESULTS AND DISCUSSION

Propanil controlled the S- biotype perfectly but not the R- biotype, whereas oxadiargyl caused slight effects on both biotypes. The highest dose of the mixture (50+1000g a.i./ha) reduced fresh weight of both R- and S- biotypes by more than 80% (Table 1). The results indicated that oxadiargyl / propanil mixture offers an alternative control for propanil-resistant *E. crus-galli* (Figure 1). The response was always synergistic for both biotypes (Table 1).

Table 1. Fresh weight (% of control)[a] of R- and S- biotypes treated with doses (g a.i./ha) of oxadiargyl, propanil and oxadiargyl / propanil mixture

Resistant biotype						Susceptible biotype					
Oxadiargyl		Propanil		Oxadiargyl / Propanil		Oxadiargyl		Propanil		Oxadiargyl / Propanil	
6.25	91	125	98	6.25+125	70 (89)[+bc]	6.25	100	125	71	6.25+125	35 (71)[+]
12.5	80	250	89	12.5+250	49 (71)[+]	12.5	87	250	33	12.5+250	25 (29)[+]
25	74	500	82	25+500	36 (61)[+]	25	64	500	17	25+500	10 (11)[+]
50	57	1000	64	50+1000	14 (36)[+]	50	59	1000	8	50+1000	4 (5)[+]

[a]Means of four replications, [b]Values in parenthesis are the calculated expected responses, according to the 'expected response' method of Colby: *E= XY/100*, where *E* is the expected response and *X*, *Y* are the % of control of the two herbicides, [c]Synergism=+

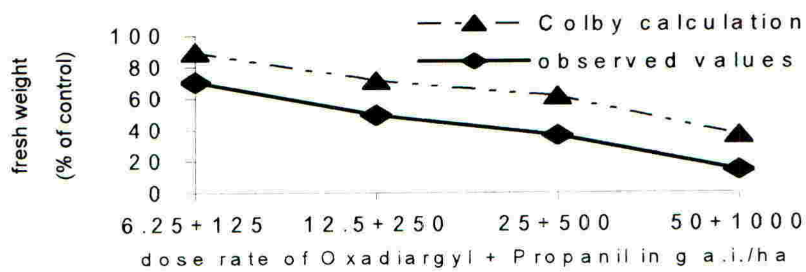

Figure 1. Synergy of Oxadiargyl + Propanil for the control of propanil -resistant *Echinochloa crus-galli*

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An investigation of the detoxification of active oxygen species in black-grass (*Alopecurus myosuroides*) plants susceptible and resistant to herbicides

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ABSTRACT

Elevated glutathione *S*-transferase activity in the herbicide-resistant black-grass biotype Peldon has been previously reported in this lab. This investigation focuses on activities of other enzymes involved in the detoxification of active oxygen species (AOS). Study of four such enzymes revealed no difference in activities in susceptible and resistant biotypes, suggesting that increased herbicide tolerance in the Peldon biotype is not a result of greater general protection against AOS.

INTRODUCTION

Black-grass (*Alopecurus myosuroides*) is a weed associated with the growth of winter cereals in the UK and Europe, and is controlled by a combination of cultural and chemical means. However, herbicide resistance is becoming an increasing problem and satisfactory weed control is not always achieved. The herbicide-resistant biotype Peldon has been demonstrated to possess approximately double the activity of the enzyme glutathione *S*-transferase (GST) compared to susceptible biotypes (Sharples *et al*., 1995). It has been postulated that GSTs are involved in the metabolism of certain herbicides and that increased activities of these enzymes may confer resistance to the plant. However, GSTs are also involved in the metabolism of glutathione, a tripeptide that is important in the detoxification of active oxygen species (AOS), including superoxide and H_2O_2. As certain herbicides give rise to AOS, it is possible that increased GST activities may play a role in resistance by detoxifying them. This investigation has examined whether susceptible and resistant biotypes differ in respect to the activities of a variety of other enzymes involved in the detoxification of active oxygen species, namely ascorbate peroxidase, glutathione reductase, monodehydroascorbate reductase and superoxide dismutase.

MATERIALS AND METHODS

Susceptible (Herbiseed Ltd., UK) and resistant (Peldon, UK) black-grass plants were grown under glasshouse conditions and harvested at the three leaf stage. Proteins were extracted, GST activities and total protein concentration determined as described in Reade *et al,* (1997). Other enzymes involved in AOS detoxification were assayed using adaptations of the methods described in Jahnke *et al*, (1991). Ascorbate peroxidase (APX) activity was determined by measuring ascorbate loss at 290nm, glutathione reductase (GR) and monodehydroascorbate reductase (MDHAR) activities by measuring oxidation of NAD(P)H at 340nm. Superoxide dismutase (SOD) activity was determined using the nitroblue tetrazolium competition assay (Beyer & Fridovich, 1987).

RESULTS AND CONCLUSIONS

The results in Table 1 show that, with the exception of glutathione *S*-transferase, enzymatic activities do not differ between the two biotypes examined.

Table 1. Comparison of five enzyme activities between Herbiseed (susceptible) and Peldon (resistant). All activities are expressed as µmoles substrate min^{-1} mg^{-1} total protein, except SOD which is expressed as units SOD activity min^{-1} mg^{-1} total protein. Values are expressed as means, where n=6, ± SE; n.s = not significant.

	Enzyme				
	GST	APX	GR	MDHAR	SOD
Herbiseed	0.069 ± 0.010	0.609 ± 0.057	0.117 ± 0.012	0.106 ± 0.008	3.204 ± 0.583
Peldon	0.104 ± 0.014	0.529 ± 0.075	0.133 ± 0.017	0.103 ± 0.010	3.139 ± 0.373
Ratio	1.51	0.87	1.14	0.98	0.98
P	0.05	n.s	n.s	n.s	n.s

These data suggest that although GST activities were higher in resistant plants, activities of other enzymes involved in AOS detoxification were similar between the two biotypes. Hence, it appears that resistant and susceptible biotypes may not differ in their capacity to deal with AOS. It further suggests that the role of GSTs in herbicide resistance in black-grass is unlikely to be purely as a protectant from AOS.

ACKNOWLEDGEMENTS

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Extent of resistance of ACCase inhibiting herbicides in UK populations of wild oat (*Avena sp.*) and Italian ryegrass (*Lolium multiflorum*)

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ABSTRACT

Several populations of *Avena fatua*, *Avena sterilis ssp ludoviciana* and *Lolium multiflorum* were screened in dose response trials using diclofop-methyl, fenoxaprop-p-ethyl and tralkoxydim. Each population was found to exhibit resistance to different herbicides and at different rates.

INTRODUCTION

Wild oat *(Avena sp.)* and Italian ryegrass (*L. multiflorum*) are pernicious grass weeds, which can cause significant reductions in crop yields. Control was a particular problem in cereal crops such as wheat, owing to the lack of selective herbicides available. However, the introduction of two classes of herbicide, the aryloxyphenoxypropionates ('fops') and cyclohexanediones ('dims') improved selective weed control. Both classes of herbicide inhibit the enzyme acetyl coenzyme-A carboxylase (ACCase).

The widespread use of these herbicides in cereal and dicot crops has resulted in the selection of resistant biotypes in a number of species. In some cases cross resistance has evolved, where resistance to one chemical confers resistance to another. Resistance was first detected in UK wild oat and ryegrass populations in the early 1990s (Heap, 1997). This study investigates the extent of resistance to ACCase inhibitors in several of these populations.

METHOD AND MATERIALS

Seed collections were taken from 3 putative resistant *A. fatua* populations and one resistant *A. sterilis ssp. ludoviciana* population, spread across southern England. Susceptible standards for each species were obtained from IACR Long Ashton. Resistant and susceptible *L. multiflorum* populations were obtained from IACR Rothamsted.

Each population was screened with diclofop-methyl, fenoxaprop-p-ethyl and tralkoxydim. Plants were sown in 4-inch pots (4 plants per pot), with 6 replicates of each arranged in randomised blocks. Plants were grown in a glasshouse to the 2-3 leaf stage prior to spraying. Nine herbicide rates were applied, up to twenty times recommended field rates. Control plants were sprayed with water. Plants were harvested 3 weeks after spraying, dried for 5 days at 60°C and dry weights recorded. Regression analysis was used to calculate the GR_{50} (herbicide concentration which reduced dry weight to 50% of the untreated control) of each population. These values were used to calculate the ratio of resistant GR_{50} : susceptible GR_{50}, giving a relative resistance for each population.

RESULTS AND DISCUSSION

The relative herbicide resistance of each population are shown in Table 1.

Table 1. Resistance:susceptiblity ratios of *A. fatua*, *A. sterilis ssp. ludoviciana* and *L. multiflorum* populations treated with ACCase inhibiting herbicides

Species	Population	R GR_{50}/S GR_{50}		
		Fenoxaprop-p-ethyl	Diclofop-methyl	Tralkoxydim
A. fatua	Barn Field	3.3 ± 1.5	2.1 ± 0.8	3.7 ± 0.6
	Milden	32.1 ± 5.4	4.8 ± 1.6	2.2 ± 0.3
	Oxon	3.2 ± 0.9	14.6 ± 4.6	10.4 ± 2.9
A. sterilis	T41	>55.5	>57.3	1.2 ± 0.2
Lolium	Oxford 1A	3.1 ± 1.7	6 ± 2.5	1.1 ± 0.3
multiflorum	Essex 1A	>37.9	>75.7	9.6 ± 4.1
	Lincs 1A	>75.8	>151.5	15.7 ± 4.9

In *A. fatua*, Barn Field was susceptible to all herbicides at the field rate. By contrast, Milden showed high levels of resistance to fenoxaprop only. Oxon was the only population to show moderate resistance to both tralkoxydim and diclofop, but was susceptible to fenoxaprop. High levels of resistance to fenoxaprop and diclofop were exhibited by the *A. sterilis* population T41. In *L. multiflorum*, Oxford 1A exhibited low resistance to diclofop, but was otherwise susceptible. However, Essex 1A and Lincs 1A were both resistant to all chemicals, and survived treatment with the highest chemical rates of fenoxaprop and diclofop. Both these populations constitute a serious control problem, as does population T41 in its current cropping situation (winter wheat). While further characterisation at the biochemical and molecular level is necessary to develop an effective management strategy for these populations, it is clear that ACCase inhibitor resistance is an increasing problem, and that prevention of evolution to resistance is the best way to ameliorate the problem in the future.

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Resistance to imazapyr in *Conyza albida* in Spain

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ABSTRACT

A biotype resistant to imazapyr of *Conyza albida* has been detected in a road in Sevilla (Southern Spain) continuously treated with this herbicide. In order to characterize this resistant biotype, growth assays, penetration and translocation assays, metabolism studies as well as ALS assays were performed with imazapyr. Growth assays revealed a marked difference between resistant (R) and susceptible (S) biotypes (ED_{50} R/ ED_{50} S value of 300). There were no differences in the penetration and translocation between either biotype and their metabolism pattern was similar. The effect of imazapyr on ALS activity measured in leaf extracts from both biotypes was investigated, the I_{50} value being approximately 4 fold greater for the resistant biotype. These data suggest that the resistance to imazapyr found in the resistant biotype of *C. albida* is primarily due to an altered target site.

INTRODUCTION

A biotype of *Conyza albida* coming from a road continuously treated with imazapyr was found in Sevilla (Southern Spain). That biotype survived greater imazapyr rates than those used by farmers. The objective of this research was to determine the mechanism of resistance of this imazapyr-resistant biotype.

MATERIALS AND METHODS

Seeds of both resistant and susceptible *Conyza albida* were placed in a pot (4 plants each) in a peat/soil mixture (1/2, v/v). Plants were grown in a chamber, 25/28 °C day/night temperature, with a 16-h photoperiod of 350 $\mu mol/m^2s$ PPDF, and 80% relative humidity. At the two- to three- leaf stage, the R and S biotypes were sprayed with commercial formulation of imazapyr at several concentrations using a laboratory track sprayer delivering 200 litres/ha at 200 kPa. Treatments were replicated five times and shoot fresh weight was evaluated after 21 days. Herbicide concentrations required to inhibit shoot growth by 50% (ED_{50} values) were obtained as described in Menendez and De Prado (1996). Penetration and translocation studies were performed according to Menendez and De Prado (1996). Metabolism assays were based on that described by Nissen *et al.* (1995). ALS activity was determined according to Saari *et al.* (1992). The effect of imazapyr on ALS activity was expressed as herbicide concentrations which inhibited ALS activity by 50% (I_{50}).

RESULTS AND DISCUSSION

In growth assays with imazapyr the ED_{50} value for the resistant biotype was 300 times greater than for the susceptible biotype (Table 1).

Table 1. ED_{50} and I_{50} values of imazapyr-resistant and -susceptible biotypes of *Conyza albida*.

Biotype	ED_{50} (g a.i. / ha)	Resistance factor (ED_{50} R/ ED_{50} S)	I_{50} (μM)	Resistance factor (I_{50} R/ I_{50} S)
R	3000	300	15.3	4
S	10		3.8	

There were no differences in the penetration of ^{14}C-imazapyr into R and S biotypes. After 48 hours of treatment, 15.66% had penetrated into the resistant biotype, while 13.32% had penetrated into the susceptible biotype. Imazapyr translocation was also similar for both biotypes as shown in Figure 1. Qualitative and quantitatively, imazapyr metabolism pattern was similar in the resistant and susceptible biotypes. Metabolism studies revealed that both biotypes were able to form the same polar metabolite, with a retention time of 3.2.

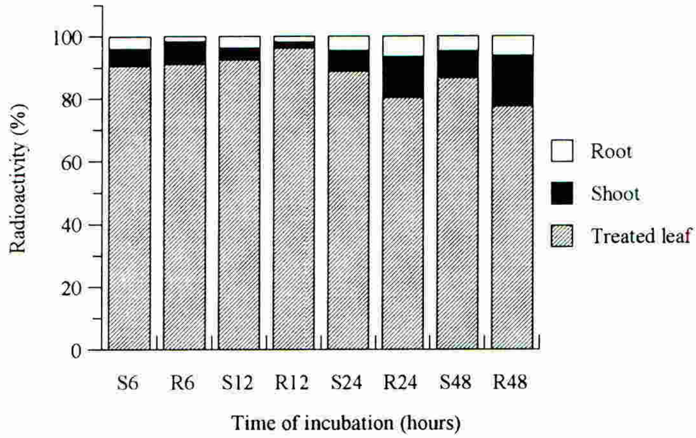

Figure 1. Translocation of [^{14}C] imazapyr in susceptible and resistant bioypes of *Conyza albida*.

The resistant biotype also showed a higher level of resistance to imazapyr at the ALS enzyme level than the susceptible biotype (Table 1). The I_{50} of the resistant biotype was approximately 4 fold greater that the corresponding susceptible biotype. The results suggest that resistance to imazapyr found in the resistant biotype is primarily due to the presence of a mutant form of ALS, which render the enzyme less sensitive to this herbicide.

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An application of diversity indices to soil weed seedbank data from a long-term rotational ploughing experiment

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ABSTRACT

A rotational ploughing experiment at ADAS Boxworth, UK has been conducted in its present form since 1994. Treatments consist of two drilling dates and a range of ploughing frequencies in a split plot design. In this paper, seedbank data (species composition and frequency) from soil cores taken in autumn 1998 are used to calculate Simpson's diversity indices and statistically analysed. Results indicate that there was a significant interaction between drilling date and ploughing frequency on the diversity of the seedbank in the upper (0-10 cm) layer of the soil. These results are discussed in relation to agricultural practice.

INTRODUCTION

Recent declines in farm income, due to rising costs and falling prices, have forced farmers to attempt to reduce inputs and costs whilst maintaining profitability. Low input farming systems adopt an holistic approach to the control of pest, weed and disease problems using a range of techniques including choice of crop, cultivar, cultivation system, drilling date and agrochemical inputs. Weed problems in such systems have occurred due to a reduction in herbicide use and reliance on cultural methods that have failed to prevent seed return and increased the soil weed seedbank, aggravated by non-inversion cultivation techniques. Thomas & Frick (1993) have demonstrated that the interaction of cultivation type and depth with crop, year and timing has important effects on both the weed community and the seedbank. This rotational ploughing experiment was designed to investigate the impact of drilling date in conjunction with ploughing frequency on the incidence of pernicious grass weeds and to consider the implications for seedbank dynamics in low input farming systems.

MATERIALS AND METHODS

The rotational ploughing experiment is a long-term trial carried out at two sites including ADAS Boxworth, near Cambridge, UK; this is a heavy clay site with natural infestations of a range of pernicious grass weeds (*Alopecurus myosuroides, Anisantha sterilis, Bromus commutatus*) and broad leaved species such as *Galium aparine* and *Veronica* species. The trial is a split plot design with three replicates. Treatments include two drilling dates of the winter wheat crop ('normal' and 'late') and six cultivation treatments (continuous plough; continuous tine; ploughed 1994 & 97; ploughed 1995 & 98; ploughed 1996 and ploughed 1994, 96 & 98). Soil cores (75 x 2.5 cm diameter per sub plot) were taken in December

1998, split into 0-10 cm and 10-20 cm samples and frozen until required for processing. Seeds were extracted from 30% of the sample using a wet sieving/flotation technique (Roberts & Ricketts, 1979) and seeds resistant to gentle pressure with forceps were assumed to be viable (Ball & Miller, 1989). Counts of viable seeds were then used to calculate Simpson's diversity index (D) for each plot and analysis of variance carried out. Higher values of D reflect greater diversity.

RESULTS AND DISCUSSION

Analysis of Variance shows that the only significant effect (p=0.039, standard error of the difference of the means = 0.404) on diversity was the interaction of drilling date with ploughing frequency for the seedbank in the upper layer of the soil (0-10 cm). Mean values of D are given in Table 1.

Table 1. Mean values of Simpson's diversity index for seedbank (0-10 cm).

Driling date	Cont plough	Cont tine	Plough 94 & 97	Plough 95 & 98	Plough 96	Plough 94, 96 & 98
Early	2.133	1.811	1.501	1.989	1.949	1.789
Late	1.380	2.611	1.853	2.341	1.686	2.904

Treatments which were late drilled and ploughed in 1994, 96 & 98 were the most diverse, as defined by this index. Mean species number was 4.33 in this treatment, whereas greatest species richness was recorded in the late drilled, continuous tine plots (6.33). These samples were collected shortly after plots in this treatment had been ploughed. Ploughing inverts the soil, thus affecting the size and composition of the seedbank in the upper layers of the soil. Simpson's diversity index gives greater weight to common species and relatively few grass weed seeds were present in these plots, but a range of other dicot species were found (data not presented here). The three highest values of D occurred in late drilled treatments. It is suggested that higher values of D occur in late drilled plots because delayed drilling destroys seedlings of early germinated grass weeds such as *A. myosuroides* and *A. sterilis*, thus benefiting a range of less competitive and later germinating species which subsequently set seed. Cardina *et al.* (1991) found that as soil disturbance increased, species number decreased and this is supported by these findings; the lowest value of D was recorded under late drilled, continuous plough conditions and the lowest mean number of species (3) was found in the earlier drilled, continuous plough plots.

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Seed bank depletion of wild oat and cleavers in integrated arable farming systems

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ABSTRACT

In a field scale study seeds of *Avena fatua* and *Galium aparine* were introduced into plots and monitored through various phases of a seven-year rotation. Depletion of both species was considerable at over 60% in integrated and conventional wheat after beans. Seed of *G. aparine* declined more than seed of *A. fatua* in both systems.

INTRODUCTION

Weed control in integrated arable farming systems (IAFS) seeks to contain weed populations by use of a combination of cultural, chemical and mechanical techniques. Higher populations of weeds may be tolerated in some phases of the rotation within IAFS on the basis of subsequent 'cleansing' phases. In addition IAFS favour annual weeds such as *Avena fatua and Galium aparine* (Cussans, 1995). Over a whole rotation it is, however, important that there is minimal risk of a build up of the weed burden, which could lead to long-term weed problems (MAFF, 1998).

To assess the risk there is a need to investigate weed seed dynamics in IAFS. Since the soil seed bank is the primary source of most weed infestations, it offers a unique insight into how weed populations may change through rotations.

The aim of this $2^1/_2$ year study was to measure the annual depletion of *A. fatua* and *G. aparine* in an integrated and conventional high input rotation.

MATERIALS AND METHODS

A field scale study was set up in the Focus on Farming Practice experiment at CWS's Stoughton estate in Leicestershire, UK (Leake, 1995). This experiment comprises fourteen fields in a seven-year rotation of two years grass ley followed by wheat, set aside, wheat, beans and finally wheat. Seven fields are managed conventionally, with high inputs of chemical pesticides and fertiliser, and seven are managed according to integrated techniques.

Three plots of 3 by 1.5m were marked out in the first year grass ley, set aside and third wheat phases of the conventional and integrated rotation. In October 1997 seeds of *A. fatua* and *G. aparine* were rained onto each plot at a rate of 2000 and 4000 seed m^2 respectively. Seeds were raked into the soil surface immediately.

Five soil cores of 8cm diameter were taken from each plot in autumn 1997 and thereafter immediately before cultivation and after the following crop had been drilled.

RESULTS

Table 1. The depletion of *G. aparine* and *A. fatua* in an integrated and conventional crop of wheat after beans

	Integrated		Conventional	
	G. aparine	*A. fatua*	*G. aparine*	*A. fatua*
No. seeds m^2 Oct-97	2679	477	2851	716
No. seeds m^2 Aug-98	305	159	637	212
Depletion	2374	318	2214	504
% Depletion	89	67	78	70

Considerable depletion of seeds of both species was observed and it appears that considerable depletion occurred during the period after introduction and before sampling in October 1997.

In both systems *A. fatua* seed declined by around 70% while *G. aparine* declined by a larger amount in the integrated system than in conventional wheat after beans.

ACKNOWLEDGEMENTS

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Laboratory studies of weed seed predation by carabid beetles

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ABSTRACT
Cafeteria style feeding tests were conducted on the following carabid beetles: *Harpalus rufipes, Amara aenea* and *Pterostichus melanarius*. Beetles were offered two diets containing a selection of arable weed seeds, and one diet containing a mixture of food items including seeds, insects and plant material. Results of ANOVA indicate that beetles had particular preferences for certain types of seeds. When given a mixed diet, seeds still accounted for between 30-62%.

INTRODUCTION
Studies of the population dynamics of weeds have identified significant post-shedding and pre-germination losses of seeds, the fate of which is largely unknown. Post-dispersal seed predation occurring on or within the soil is one potentially significant source of seed loss, reducing the seed pool available for germination. Carabid beetles, are already considered to be beneficial predators of agricultural pests. In this study the feeding preferences of some commonly occurring species of carabid beetles for economically important arable weeds were investigated.

METHODS AND MATERIALS

Cafeteria style feeding preference tests were carried out (Jorgensen & Toft 1997) for three species of beetle collected from arable farms during the summer of 1998: *A. aenea*, *H. rufipes* and *P. melanarius*. Each beetle was presented with equal quantities of different food types in a Petri dish, and the number of food items remaining after 48h was counted, each trial being replicated a number of times.

Beetles were given three different combinations of food items. Diet one contained the seeds of *Chenopodium album*, *Poa trivialis*, *Matricaria sp.*, *Stellaria media* and *Viola arvensis*. Diet two consisted of seeds of *Alopecurus myosuroides*, *Avena fatua*, *Bromus sterilis*, *Galium aparine* and *Polygonum persicaria*. Diet three varied for each beetle species but contained the most preferred seeds from diets one and two, cereal aphids, meal worms and germinating wheat seeds. A two-way ANOVA in randomised blocks was carried out on the log number of seeds consumed after 48h for diet one and two ($P \geq 0.01$). Student t-tests were than used to determine statistical significance between means within trials ($P \geq 0.05$).

RESULTS

Table 1. Mean number of seeds from diet one consumed by carabids over 48h*

	C.album	*S.media*	*V.arvensis*	*P.trivialis*	*M. sp.*
A.aenea	1.00(0.21)^{ab}	4.65(0.43)^{c}	0.43(0.10)^{a}	5.57(0.76)^{d}	1.83(0.33)^{bc}
H.rufipes	13.05(1.37)^{c}	6.05(0.79)^{a}	38.45(2.36)^{d}	7.45(1.12)^{b}	11.05(1.03)^{b}
P.melanarius	0.80(0.02)^{a}	3.00(0.57)^{c}	5.34(0.85)^{d}	2.44(0.58)^{c}	1.07(0.25)^{b}

* Log transformed data shown in brackets, different letters indicate statistically significant differences where $P \geq 0.05$.

Table 2. Mean number of seeds from diet two consumed by carabids over 48h

	A.fatua	*A.myosuroides*	*B.sterilis*	*P.persicaria*	*G.aparine*
A.aenea	0.16(0.05)^{b}	0.06(0.02)^{ab}	0.09(0.02)^{ab}	0(0)^{a}	0.09(0.02)^{ab}
H.rufipes	0.66(0.04)^{b}	0.72(0.04)^{b}	0.09(0.02)^{a}	0.22(0.03)^{a}	0(0)^{a}
P.melanarius	1.36(0.05)^{a}	0.53(0.04)^{a}	0.33(0.03)^{a}	0.20(0.03)^{a}	0.20(0.03)^{a}

Results of the ANOVA showed significant differences in the number of seeds of each weed species consumed by all three species of carabid for diet one. However, there was only a significant difference in weed species eaten by *H.rufipes* and *P.melanarius* for diet two. Although seed preference was specific to carabid species, *Galium aparine* was particularly unpopular perhaps because of its hard seed coat. When fed a mixed diet, diet three, the proportion of food items eaten which were seeds was 39%, 62% and 31% for *A. aenea*, *H. rufipes* and *P. melanarius* respectively, albeit this proportion is based on numbers of food items eaten and not biomass of food consumed.

CONCLUSIONS

The feeding studies have demonstrated that some carabid beetles have specific preferences for certain types of weed seeds and that seeds are still important as part of a mixed diet. This differential feeding behaviour may have an important effect on weed seed bank dynamics.

ACKNOWLEDGEMENTS

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Implications of seed dormancy for control of *Striga hermonthica* in Ghana

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ABSTRACT

Freshly collected seeds of *Striga hermonthica* were conditioned (in darkness) at various constant temperatures (20 - 35°C) and water potentials (0 to -2MPa) for periods up to 35 d to observe the effects of temperature and water potential on germination. In general germination increased as the water potential during conditioning increased from -2 to 0 MPa irrespective of temperature. Maximum germination occurred at 25°C and 0 MPa after 10-14 days conditioning. Restricted seed germination was also observed after conditioning at low to medium water potentials over the entire temperature range. The optimum conditioning temperature and period appeared to remain the same (i.e. 25°C) with decrease in water potential. Results are discussed in terms of predicting the optimum planting dates of susceptible crops as a function of period from onset of seasonal rains. Field trials in Northern Ghana to validate these predictions will also be described.

INTRODUCTION

Striga hermonthica (Del.) Benth (*Scrophulariaceae*) is an obligate parasitic annual weed on staple cereal crops such as maize, millet and sorghum in many semi-arid zones of sub-Saharan Africa. Seeds of *S. hermonthica* are stimulated to germinate by a chemical exuded by the host's roots. Seeds must be sensitized to this stimulant by imbibing for a period but prolonged conditioning leads to an induction of secondary dormancy. The role of temperature in the breaking of seed dormancy, germination and induction of secondary dormancy has been well documented (Kebreab & Murdoch, 1999). Large variations occur in soil moisture potential on *Striga* infested fields and indeed soil moisture availability could have an over-riding influence on timing and duration of seed germination. Information on the relationships of soil water potential and temperature on *Striga* seed germination patterns appears to be limited. This paper reports the effects of temperature and water stress during preconditioning on subsequent germination.

MATERIALS AND METHODS

S. hermonthica seeds were collected from plants parasitising sorghum at Walewale in northern Ghana in November 1998. The seeds were stored in black plastic containers and immediately dispatched to Reading where they were stored in the dark at 18 ± 2°C for three weeks and incubated at 40°C for 14 days before use. Water was deionised and then autoclaved before use. Filter papers and seeds were sterilised as described in Kebreab and Murdoch (1999). Aqueous solutions of polyethylene glycol (PEG 6000, Merck) were used to prepare non-toxic solutions at three osmotic potentials (Michel & Kaufmann, 1973; Emmerich & Hardegree, 1990).

Seeds were conditioned as follows. About 25 seeds were placed on 9 mm glass fibre filter discs (Whatman GF/A). Several discs were placed in 9 cm Petri dishes on two layers of filter paper (Whatman No. 1) which were moistened with 5ml of PEG solutions of the required concentration in order to condition the seeds for periods of 0 to 35 days at 20, 25, 30 and 35°C. The discs containing the seeds were then placed on a non-sterile filter paper to remove excess moisture. For germination tests, the discs containing the seeds were then placed in fresh Petri dishes containing two layers of 9 cm filter papers. These dishes were moistened with 5 ml of 3 ppm GR24, an artificial germination stimulant, and then incubated for 8 days in the dark at 35°C. GR24 was handled as described by Kebreab & Murdoch (1999).

RESULTS AND DISCUSSION

Seed germination of *S. hermonthica* was affected by temperature and water stress during conditioning. Conditioning in water (0 MPa) at 25 to 35°C gave the highest germination. Germination declined from 77 to 8 % with a decrease in the conditioning water potential from 0 to -2MPa at 25°C. The optimum conditioning temperature at each water potential was 25°C while the lowest germination was obtained for seeds conditioned at 35°C and -2mpa. Water stress during conditioning therefore reduced the seed germination percentage. Germination was however, not sensitive to temperature at medium to high water stresses. Kebreab & Murdoch (1999) noted water stress reduced the germination percentage of *Orobanche aegyptiaca* seeds and restricted the temperature range (20-26°C) over which highest germination occurred. The optimum temperature of 25°C observed for *S. hermonthica* conditioning in water reported here lies within the optimum range for *O. aegyptiaca*, but slightly higher than *O. crenata*. This could probably be due to the tropical ecological preference of *Striga*.

Prediction of *S. hermonthica* seed germination following conditioning in the soil as influenced by environmental factors such as temperature and water potential could be a useful agronomic tool for optimising planting dates of host and trap crops as part of an integrated management of the parasite in smallholder farming systems.

ACKNOWLEDGEMENTS

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Integration of socio-economically appropriate management strategies for *Striga hermonthica* in The Gambia

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ABSTRACT

Striga hermonthica is a major constraint to coarse grain production in The Gambia. Integrated trials were carried out in 1997 and 1998 in two contrasting sites to assess the effectiveness of various cultural control methods for reducing infestations and improving crop yields. Long-term effectiveness was an especial concern as reflected in the ability of different strategies to deplete the soil seed bank. Fertility improvement by tethering livestock proved particularly effective in both depleting the soil seed bank and improving crop yield. Cotton trap crops were less so. Results are discussed in terms of a co-ordinated approach, including various cultural methods (rotation with leguminous non-host trap crops, tethering of livestock to improve fertility), with an annual *Striga* campaign to prevent seed shedding.

INTRODUCTION

Surveys carried out in 1984 under the FAO Weed Management Project showed that 75% of all cereal fields in The Gambia were infested with *Striga* at an average rate of 1.35 shoots / m^2. Crop losses caused by *Striga* were estimated to range from 20-30 %, an annual loss of 10,000 metric tonnes of cereal grains valued at US $900,000 (Carson, 1988). Further spread and higher infestations of *Striga hermonthica* in The Gambia are likely to result from declining soil fertility, arising from a decline in bush fallowing and an increase in the continuous cropping of land without return of removed nutrients and generally a poor standard of crop and soil management. Since input acquisition is the main constraint facing farmers (Carson, 1988) the focus on *Striga* control should be on viable, low cost, yet effective technologies. These may include the identification of economically attractive trap crops, the role of green manure, and legume or attrition crop rotations within known *Striga* infested farmlands.

MATERIALS AND METHODS

A survey was carried out between mid-September and the first week of October 1998 to gather information on farm size and *Striga* as well as information on intensity and spread of *Striga* within Eastern (Upper River Division, URD) and Western (Lower River Division, LRD) Gambia. Discussions were held with 47 farmers in URD and 39 in LRD on *Striga* control methods from a holistic perspective using a standardised questionnaire and Participatory Rural Appraisal tools. Field trials were carried out in Mankamangkunda where trap and host crops were grown under different soil fertility enhancement practices involving tethering of livestock at night for 21 days, inorganic fertiliser (30 KgN ha^{-1}) in main plots whilst different crop species were assigned to sub plots. Initial and final *Striga* seed loads were determined from soil cores. *Striga* seed separation was done by using a flotation technique.

RESULTS AND DISCUSSION

On average, a farmer has 1.6 farms and 2.4 fields in URD and the average field size is 0.5ha. The low average field and total farm size in URD is an indication that in this area, land pressure is high. *Striga* seed depletion in Mankamangkunda was higher with cotton trap crops in the first season (Figure 1). It was highest when a cotton trap crop was planted in environments in which both organic and inorganic fertilisers were applied independently. Where these fertiliser sources were combined, the percent *Striga* seed depletion dropped by an average of 13% and twice that much under zero fertiliser environments (Figure 1a). Fertility improvement increased the rate of depletion in both host and trap crops and hence tethering livestock at night and close to homesteads is highly beneficial. Use of tethering as a component of integrated *Striga* management in The Gambia also substantially influences crop yield (data not shown). In Eastern Gambia where the Fulani tribe are the primary livestock owners and herders, tethering livestock for a short period on arable fields during the dry season is technically feasible and beneficial and could be included as a socio-economically appropriate component of *Striga* management.

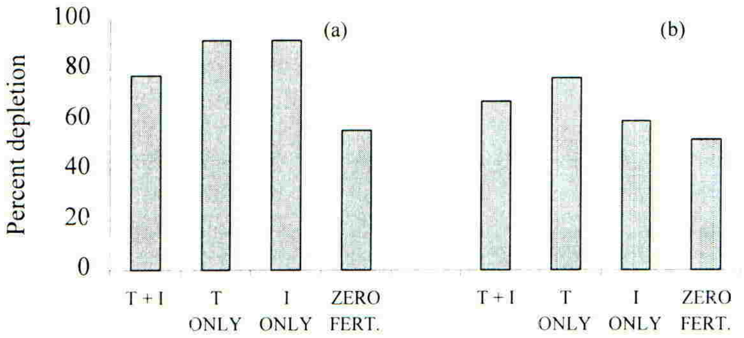

Figure 1. Overall *Striga* seed depletion at Mankamangkunda as influenced by (a) cotton trap crop in 1997, followed by sorghum in 1998 and (b) sorghum host cropping in both years. Depletion of soil seed bank was assessed over two wet seasons (June 1997 to August 1998). Inorganic fertilizer (I) and/or tethering livestock (T) enhanced soil fertility.

ACKNOWLEDGEMENTS

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Integration of reduced dose rates of fluazifop-butyl or sethoxydim with hand-hoe weeding for the control of *Digitaria abyssinica* and other weed species.

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ABSTRACT

Field experiments were conducted in 1995/96 cotton season at Namulonge and Bukalasa in Uganda. The study was conducted to evaluate the efficacy of reduced dose rates of the grass selective herbicides fluazifop-butyl and sethoxydim on *D. abyssinica* and other grass weed species. Treatments used were; fluazifop-butyl applied at 137.5, 162.5 and 187.5g a.i/ha sethoxydim at 405.3, 501.8 and 579g a.i/ha integrated with 2 hand-hoe weedings, hand-hoe weeding alone and control. These herbicides similarly gave good grass weed control while the broad leaf weeds were suppressed by the hand-hoe weedings. Overall grass weed reductions of 78-93% were obtained after the application of herbicides. Detailed data will be reported on percentage weed control of the grasses, and fresh weight of *D. abyssinica*.

INTRODUCTION

Grasses are important weeds in cotton production. These include *Digitaria abyssinica, Panicum maximum, Cynodon dactylon*. They are not easily controlled by hand-hoe weeding alone especially the rhizomatous *D. abyssinica*. Since cotton is very susceptible to weed competition during the first 4-5 weeks after emergence early weeding is important. Removal of weeds during this period greatly improves cotton yields. Recommendation that weeds should be controlled in the early growth stages of cotton might be difficult to follow due to labour constraints at farm level. Thus post emergence herbicides such as sethoxydim and fluazifop-butyl are used to suppress the early and fast emerging grass weeds since the initial growth rate of cotton is quite slow. The two hand-hoe weeding supplements are used to suppress the broad leaf weeds, which are not controlled by the herbicides. As part of integration of weed management in cotton the grass weed component was investigated. The objective of the study therefore was to evaluate the efficacy of reduced dose rates of these herbicides for the control of *D. abyssinica* and other grasses.

METHODS AND MATERIALS

The experiment was laid out in a randomised complete block design in four replications at Namulonge Research Institute and Bukalasa Technology Verification Centre. Cotton variety BPA 95 was used in this study. It was planted in 5mx10m plots at a spacing of 70cmx50cm. Land preparation involved ploughing twice and disc harrowing once. The treatments were fluazifop-butyl (Fusilade) at 137.5, 162.5, 187.5 g a.i/ha, sethoxydim (Checkmate) at 405.3, 501.8, 579g a.i/ha (each of these dosages was supplemented with 2 hand-hoe weedings), 5 hand-hoe weedings and unweeded. The highest rate for each herbicide is the commercial recommended rate. The herbicides were applied in 10 litres/ha of water in a CP15 Sprayer, 14 days after the emergence of cotton and weeds. At the assessment times a quadrat of 0.3mx0.3m was randomly thrown four times in each plot and the grass weed shoots were counted. Weed counts were done 21 days after herbicide application, before hand-hoe weeding. The fresh shoots of *D. abyssinica* were collected from the quadrats and determined the fresh weights.

RESULTS AND DISCUSSION

D.abyssinica, *C dactylon* and *P maximum* were found across both sites. Results indicated that both herbicides gave good control (79-95%) of all the grasses in both locations (Figure 1). Similar results were reported elsewhere (Panwar *et al,* 1988). The activity of these reduced dose rates on the grasses was as good as the recommended rates.

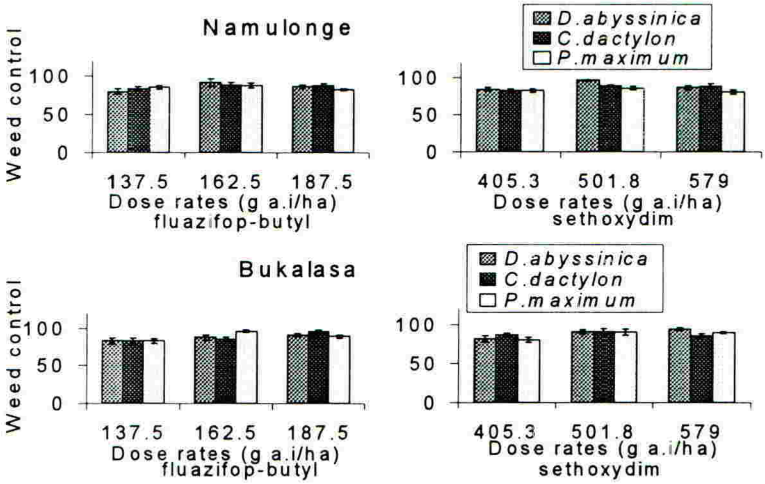

Figure 1.Effect of herbicide dose rates on the control of grass weed species.

On average, fresh weight of *D. abyssinica* was reduced by 17-24.5% after the application of herbicides. Herbicide dose rates did not significantly ($P \leq 0.05$) differ amongst each other in fresh weight reduction as they significantly differed from the control. Assessment of fresh weight and weed counts of *D. abyssinica* after the application of herbicides indicated significant reduction of the weed. The reduction of fresh weight was directly associated with the weed counts.

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Studies on the allelopathic potential of various cereal cultivars on selected test species

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ABSTRACT

The allelopathic potential of several cultivars of four winter cereal crops (wheat, barley, oat and rye) were studied in germination and radicle elongation bioassays. Exudates of barley cv. Thermi had an inhibitory effect on germination percentage of white mustard, used as indicator species. Exudates of the other cereals either increased or did not affect germination percentage of white mustard. Effects were significant three days after sowing but were not apparent in subsequent assessments. Barley cv. Thermi caused a 40% reduction in mustard radicle length, six days after sowing.

INTRODUCTION

Allelopathy involves detrimental or beneficial effects when chemical compounds are added from the plants to the environment (Rice, 1984). There is convincing evidence that allelopathic interactions between plants play an important role in manipulated ecosystems, such as those employed in agriculture (Rizvi *et al.*, 1992). Crops like barley and rye have been reported as 'smother crops' where mechanisms other than physical competition were suspected (Overland, 1966). The aim of the present work was to evaluate the allelopathic potential of various cultivars of cereal crops, during early stages of establishment.

MATERIALS AND METHODS

Exudates from cereal cvs. were collected under glasshouse conditions using double-pots. These consisted of a plastic pot (90 mm diameter) filled with sand and inserted in a polysterene cup, which served as a container. The cultivars employed were, for wheat: Cadenza (CD) and Equinox (EQ), rye: Merkator (MR) and Motto (MT), oat: Craig (CR) and Aintree (AI) and barley: Intro (IN), Fighter (FG) and Thermi (T). Each cultivar was sown in monoculture or in mixture with white mustard, also sown in monoculture. One pot per block (total of three) contained sand only. Pots were watered with deionised water as required. Two weeks after sowing, a germination test was established in Petri dishes lined with two layers of filter paper and sown with white mustard (25 seeds) as indicator species. Petri dishes were watered with 5 ml of the exudates collected and placed in an incubator at an alternating diurnal temperature of 15°C for 8 hrs and 25°C for 16 hrs, in the dark. Germination percentage was assessed for five consecutive days, starting three days after sowing (DAS).

Radicle elongation bioassays were conducted in an incubator at 16°C in the dark, using a siphoning apparatus (Liu and Lovett, 1993) that eliminates competition for water. Twenty-five mustard seeds were sown alone or with ten barley seeds (cv. Thermi) in Petri dishes placed on stands on top of a container filled with deionised water (three replicates). Petri dishes were lined with a rectangular glassfibre filter paper, the ends of which were suspended in the water container. Mustard radicle length was recorded for four consecutive days, starting three days after sowing.

RESULTS AND DISCUSSION

Germination percentage of white mustard (assessed 3 DAS) was significantly reduced when treated with exudates of barley cv. Thermi, while it was increased when treated with exudates of wheat cv. Cadenza, rye cv. Merkator and oat cvs (Table 1). However, the effects in germination were not significant at subsequent assessments (data not shown). The presence of mustard in the double pots did not affect the cereal's exudates activity.

Table 1. Effect of cereal cultivars on germination percentage of white mustard seeds 3 DAS

	Rye		Wheat		Oat			Barley		Control	s.e.d.
	MT	MR	CD	EQ	AI	CR	FG	IN	T	M/S[a]	38 d.f.
mc[b]	49.3	48.0	54.7	50.7	54.7	48.0	44.0	45.3	36.0	38.7	
+M[c]	48.0	54.7	50.7	40.0	48.0	53.3	50.7	48.0	38.7	46.7	
mean	48.7	51.3	52.7	45.3	51.3	50.7	47.3	46.7	37.3	42.7	4.6

[a] M/S: exudates from mustard in monoculture or sand only, [b] mc: exudates from cereals in monoculture
[c] +M: exudates from cereals in mixture with mustard

Table 2. Effect of barley on mustard radicle elongation (data square root transformed)

	Days after sowing			
	3	4	5	6
Control	3.16	4.08	5.84	7.44
With barley	3.69	3.88	5.77	5.72
s.e.d. (15 d.f.)		0.56		

Mustard radicle length (6 DAS) was significantly reduced (40% of the control) in the presence of barley (Table 2). The siphoning bioassay apparatus enabled separation of competition for water from allelopathic interference. Results suggest that there is evidence of inhibitory or stimulatory allelopathic activity of cereal plants, during their early stages of establishment. However, the effects can be transitory and possibly concentration dependent.

ACKNOWLEDGMENTS

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Comparative phytotoxicity of pyrenophorin and pyrenophorol isolated from a *Drechslera avenae* pathotype

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ABSTRACT

The macrodiolides pyrenophorin and pyrenophorol were isolated from a *Drechslera avenae* pathotype with host-specificity for *Avena sterilis*. Pyrenophorin at $7{\cdot}10^{-5}$ M caused root inhibition and chlorophyll retention on all gramineous plants tested. On the other hand, pyrenophorol at $64{\cdot}10^{-5}$ M was less potent but more selective towards wild-oats, causing leaf necrosis and chlorophyll retention but not root inhibition.

INTRODUCTION

The macrodiolide pyrenophorol (Figure 1, a), isolated from cultures of a *Drechslera avenae* pathotype with host specificity for *Avena sterilis*, exhibits a rather selective phytotoxicity towards *A. sterilis* and *Avena fatua* (Kastanias & Chrysayi-Tokousbalides, 1999). Pyrenophorol can be oxidized to pyrenophorin (Figure 1, b), which has been characterized as a phytotoxin (Lerario & Graniti, 1985). The aim of this work was to examine whether pyrenophorin is also produced by the above mentioned fungal pathotype and to evaluate its phytotoxic potential in comparison with that of pyrenophorol.

a b

Figure 1. Chemical structures of pyrenophorol (a) and pyrenophorin (b).

MATERIALS AND METHODS

The fungus, a *Drechslera avenae* pathotype isolated from naturally infected plants of *A. sterilis*, was grown on oatmeal agar at 20°C, in the dark. Pyrenophorin and pyrenophorol were extracted with appropriate organic solvents, purified through sequential thin layer chromatography and characterized by spectrometry analysis. The compounds were bioassayed on germinating seeds, seedling cuttings, excised leaves and 25 mm^2 leaf sections of wild-oats (*A. sterilis* and *A. fatua*), oats (*Avena sativa*), wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*). All plants were grown in a growth chamber at 20°C and 12-hour photoperiod.

RESULTS AND DISCUSSION

In addition to pyrenophorol, pyrenophorin can be detected in cultures of the isolated *D. avenae* pathotype, reaching a maximal yield 10 days after inoculation. The results of the bioassays showed that pyrenophorin at $7{\cdot}10^{-5}$ M inhibits root growth and interferes with chlorophyll retention on all gramineous plants tested, indicating a rather broad spectrum of activity. On the other hand, pyrenophorol can be characterized as a less potent but rather selective phytotoxin, since at $64{\cdot}10^{-5}$ M it causes leaf necrosis and chlorophyll retention on wild-oats only. The phytotoxicity pattern of these macrodiolides differs not only in respect to plant specificity, but also in the type of symptoms produced: pyrenophorin does not cause any leaf necrosis on seedling cuttings and pyrenophorol does not inhibit root growth on any of the plants tested (Table 1).

The observed variation in the expression of phytotoxicity may be related to the structural difference between the two compounds which lies at C-5 and C-13 positions. Ongoing research aims at the elucidation of this structure-activity relationship.

Table 1. Phytotoxicity symptoms of pyrenophorin ($7{\cdot}10^{-5}$ M) and pyrenophorol ($64{\cdot}10^{-5}$ M) bioassayed on gramineous plants.

Treatment		Phytotoxicity symptoms *		
		Root inhibition [a]	Leaf necrosis [b]	Chlorophyll retention [c,d,e]
pyrenophorin	*A. sterilis*	+	–	+ [d,e]
	A. fatua	+	–	+ [d,e]
	A. sativa	+	–	+ [d,e]
	T. aestivum	+	–	+ [d,e]
	H. vulgare	+	–	+ [d,e]
pyrenophorol	*A. sterilis*	–	+	+ [c,d,e]
	A. fatua	–	+	+ [d,e]
	A. sativa	–	–	–
	T. aestivum	–	–	–
	H. vulgare	–	–	–

* observed 48 hours after treatment of germinating seeds (a), seedling cuttings (b), intact leaves (c), punctured leaves(d) and leaf sections (e).

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Effects of cultivar and crop density on herbicide sensitivity of winter wheat

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ABSTRACT

The sensitivity of ten winter wheat cultivars at three plant densities to four herbicides was evaluated in two glasshouse experiments. Crop phytotoxicity to diclofop-methyl and fluroxypyr was insignificant but isoproturon and chlorotoluron caused differential damage between cultivars, with isoproturon causing most severe effects. Evidence of reduced herbicide damage with increased plant density is suggested.

INTRODUCTION

Recommended herbicides for selective weed control have been developed to exploit differences in phytotoxicity between species adequate to kill competing weeds without significantly damaging crop plants and hence reducing crop yield. On the other hand relationships between crop density and herbicide efficacy have to be established for better justification of the herbicidal effects on crop and weed plants. The aim of this study was to evaluate the effects of intra-specific competition of various winter wheat cvs at a range of plant densities subject to herbicide application.

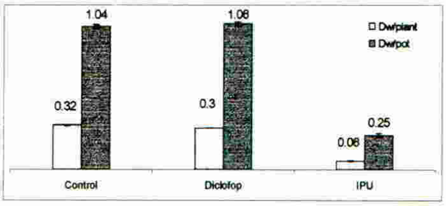
METHODS AND MATERIALS

Ten winter wheat cvs (Buster, Cadenza, Flame, Fresco, Hussar, Maris Huntsman, Maris Widgeon, Mercia, Rialto and Riband) were sown in 10×10×10 plastic pots containing a standard mixture of soil (JIP-1 potting compost) and kept under glasshouse conditions until the final harvest (approximately 50 days after sowing for both experiments). The plant densities used were one, four and eight plants/pot. In the first experiment isoproturon (IPU) and diclofop-methyl were applied at 2.5 kg a.i./ha and 567 g a.i./ha respectively and in the second chlorotoluron (CTU) diclofop-methyl and fluroxypyr at 1.75 kg a.i./ha, 283.5 g a.i./ha and 100 g a.i./ha respectively. Herbicides were applied at GS 13-14 using an Oxford Precision Sprayer. Mean temperatures for the first and second experiment respectively were 19.7 and 24.9 ^{0}C. Effects of intra-specific competition, cultivar sensitivity and effect of plant density on herbicide efficacy were evaluated by measurement of plant height, tiller number and dry weight.

RESULTS AND DISCUSSION

Intra-specific competition significantly affected ($P<0.001$) height and tiller number in both experiments such that height was disproportional to plant density and tiller number/plant decreased as plant density increased (results not shown). Biomass production on a per plant basis was significantly greater ($P<0.001$) at lower plant density. On a per pot basis the reverse was observed. This indicates that at low plant density plants show an inability to produce enough biomass to compensate fully for lower plant numbers at the time of harvesting.

Significant differences (P<0.001) were observed for height and tiller number (results not shown) as well as biomass production (Figure 1) resulting from herbicide application where phenylurea herbicides, especially IPU, exhibited more severe damage relative to the untreated controls and diclofop-methyl and fluroxypyr treated plants.



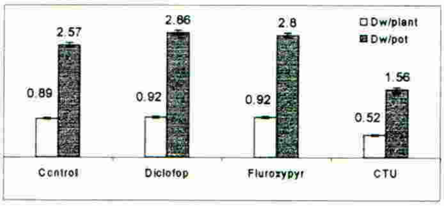


Figure 1. Effects of herbicides on dry weight 50 DAS (mean of 10 cvs and 3 plant densities for the first (left) and second (right) experiment respectively). Vertical bars represent LSD values at 0.1% significance level.

IPU damage to dry weight of treated plants ranged from 70 to 84% in contrast to CTU in which sensitivity was clear cut where Riband, Maris Huntsman, Hussar and Cadenza were the most severely affected (70 to 90% of the controls). The remaining cvs were affected between 0-25%. Krahmer and Russel (1994) found that IPU and CTU exhibited phytotoxic effects on winter wheat cv. Kolibri ranged from 25 to 89% of the controls under glasshouse conditions with IPU showing the greater severity. Diclofop-methyl and fluroxypyr caused insignificant reduction (no more than 10%) in all the parameters measured and sometimes acted as growth promoters in agreement with Brar and Singh (1997).

Table 1. Effects of plant density and herbicide on reduction of dry weight/pot expressed as % of the untreated control (mean of 10 cvs). (-) indicates growth promotion.

	Experiment 1		Experiment 2		
Herbicide	Diclofop	IPU	Diclofop	Fluroxypyr	CTU
Plant density					
1 plant/pot	9.04	83.9	0.5	1.6	40.1
4 plants/pot	1.28	76.6	-12.8	-5.0	42.7
8 plants/pot	-10.37	69.6	-19.7	-21.2	31.2
LSD	6.3			8.6	
Significance level (F test)	5%			5%	

Increased plant density caused reductions in herbicide phytotoxicity (Table 1). Dry weight of diclofop-methyl and fluroxypyr treated plants increased with increasing plant density. Courtney (1994) stated that the effects of increased plant density on foliar applied herbicide might affect interception of herbicide.

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Effects of weeds and chemical weed control on yield and breadmaking quality of winter wheat

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ABSTRACT

An experiment was conducted to investigate the effects of weeds and herbicides on yield and breadmaking quality of wheat in 1997/98. Two herbicides, Cheetah (fenoxaprop-p-ethyl) and Starane2 (fluroxypyr) were applied to the crop sown with and without artificially seeded infestations of blackgrass (*Alopecurus myosuroides*) and cleavers (*Galium aparine*) respectively. Protein content and SDS value both increased significantly with increase in herbicide application rate. Herbicide application time, weed species and weed density did not affect these quality characteristics.

INTRODUCTION

Herbicides can directly affect wheat yield and quality. It is, however, unclear whether changes in wheat breadmaking quality are due to (a) a direct herbicide effect, (b) herbicide application time and rate or (c) control of weeds. Recent studies (Martin *et al.*, 1990; Abo-Hameed *et al.*, 1993; Grundy *et al.*, 1996) show that different herbicides when applied at different growth stages and at different dose rates affect the grain yield and quality of the crop. Apart from some studies on grain protein concentration little is known about the effect of weeds and herbicides on the breadmaking quality of wheat as compared to fertilisers and fungicides (Gooding and Davies, 1997). It is emphasised, therefore, that there is a need for optimising the use of herbicides for weed control in relation to wheat crop quality.

MATERIALS AND METHODS

An experiment was sown on 14 Oct. 1997 at Sonning Farm, The University of Reading by using 400 seeds/m^2 of wheat cv. Hereward. Blackgrass and cleavers were also broadcast @ 700 and 1000 seeds/m^2 respectively on the crop sowing date. Herbicides (fenoxaprop-p-ethyl for blackgrass and fluroxypyr for cleavers) were applied using a log sprayer with 2.6 bar pressure and flatfan nozzles, to achieve a dose gradient along the plot length. Herbicides were applied at three application times i.e., 22 April, 12 May and 25 May 1998 between Zadoks GS 30 to GS 39. Sub plots were harvested corresponding to five application rates i.e., 4.24, 2.05, 0.99, 0.47 and 0.0 litres/ha of the commercial products. Quality characteristics i.e. specific weight, 1000-grain weight, Hagberg falling number, SDS (sodium dodecyl sulphate) value and protein content were measured using standard techniques.

RESULTS AND DISCUSSION

Increase in herbicide application rate increased the ground cover of the crop which ultimately increased the grain yield. Similar effects of herbicide application rates were observed on the SDS value (Figure 1a) and protein concentration (Figure 1b), however, no significant effect of weeds and time of application were found on the grain yield, SDS and protein concentration. Specific weight and thousand grain weight were decreased by delaying the herbicide applications but no significant effect of dose rate was found in these characteristics. There were no significant effects of weed species or of the time and rate of herbicide application on the Hagberg falling number. Further experiments are in progress to verify these interesting responses of SDS value and protein content to herbicide application rate.

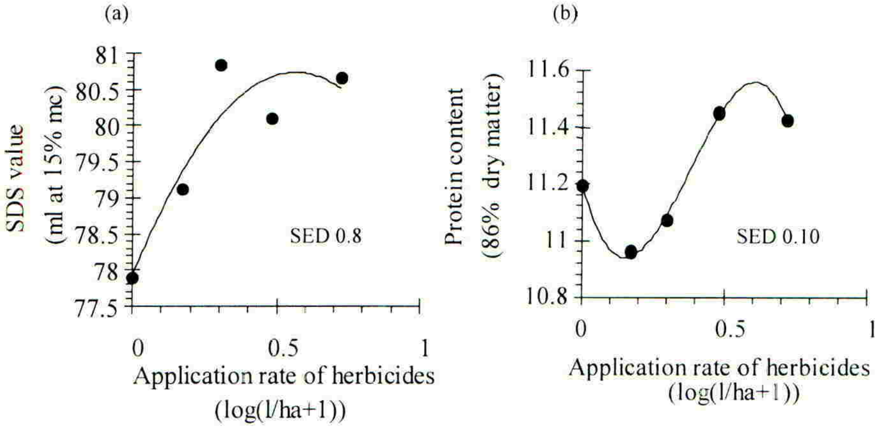

Figure 1. Effect of application rate of herbicides on (a) SDS value and (b) the protein content of wheat. Standard errors of differences (SED) between pairs of means are indicated.

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A new paradigm on weed economic threshold

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ABSTRACT

The usual approach to weed economic threshold (ET) has restricted use due to uncertainties such as crop prices, weed control costs and weed control efficacy. The objectives of this work were to determine the maize yield - weed density relationship over time and to present the weed ET in a format more suited for a changing economy. The weed population assessed at 50 days after crop emergence (DAE) resulted in the best estimate of maize yield. *Brachiaria plantaginea* ET, calculated from the first linear portion of 50 DAE curve, for a range of crop prices and weed control costs, ranged from 2 to 9 plants/m^2. The weed control decision needed to be taken at the onset of the weed interference, at 20 DAE. The results suggest the appropriate decision at 20 DAE was to use residual herbicides with leaf activity to reduce weed infestation ET.

INTRODUCTION

Weed economic thresholds (ET) are based usually on static crop yield - weed density relationship. However, the real world is not static. Weed density, crop prices and weed control costs fluctuate during the crop growing season, complicating the elaboration and the use of the ET to help decisions about weed control.

Brachiaria plantaginea was introduced from Africa into Brazil and has become one of the worst annual grass weeds in southern Brazil (Kissmann, 1997). *B. plantaginea* can reduce maize grain yield by 90% (Merotto Jr *et al.*, 1997). The critical period for *B. plantaginea* control in maize is from 20 to 50 days after crop emergence (Almeida & Oliveira, 1980). The objectives of this work were to determine the maize yield - weed density relationship over time and to present the weed economic threshold in a format more suited for changing economics.

METHODS AND MATERIALS

B. plantaginia density was assessed on 60 plots treated with several pre-emergence herbicides, previously selected to provide weed density diversity. Weed were counted on fixed sites at 10 day intervals, from maize crop emergence up to 50 days after emergence (DAE). After the crop grain harvest, correlations were calculated between maize yield and weed density using the computer program "Origin". The fitted curves were segmented in lines, to obtain the declivity for the linear segment at the lowest weed density. The line declivity (D) was used to estimate the *B. plantaginia* ET according to the equation ET = CC/(D*(CP/1000)), where CC was control cost and CP was crop price.

The novel approach was to determine ET for a range of CP (100 to 200 US$/t) and for a range of CC (20 to 50 US$/ha), which would account for the price fluctuation during the past decade and several post-emergence weed control options.

RESULTS

Exponential decay curves fitted the yield response to weed density assessed 10 and 20 DAE, whereas sigmoidal equations fitted the relationship between maize yield versus weed density from 30 to 50 DAE. The weed population assessed at 50 DAE resulted in the best estimate of maize yield (data not shown). The weed infestation increased with time. The decision for weed control needed to be taken at 20 DAE to avoid crop yield loss.

B. plantaginea counts made at 50 DAE indicated that the ET ranged from 2 to 11 plants/m^2 (Figure 1). The results suggest the appropriate decision at 20 DAT was to use residual herbicides with leaf activity to reduce weed infestation below ET. We speculate that less expensive weed control strategies have the advantage of requiring a lower ET, which would be beneficial because of reduction in the weed seedbank.

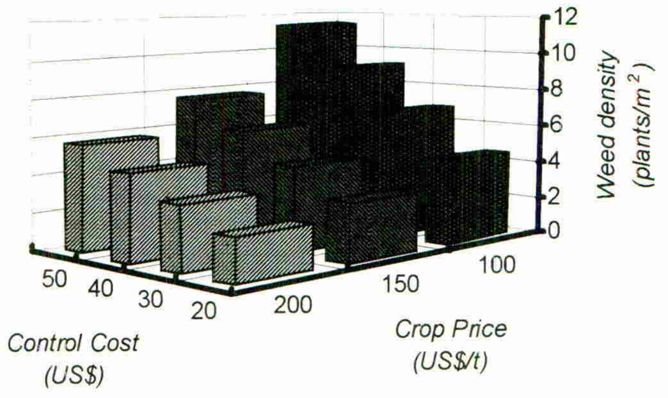

Figure 1. *Brachiaria plantaginea* economic threshold at several maize prices and control costs.

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