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PILOT STUDY OF THE POTENTIAL OF THE REPELLENT CINNAMAMIDE TO REDUCE WOODPIGEON DAMAGE TO OILSEED RAPE

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PILOT STUDY OF THE POTENTIAL OF THE REPELLENT CINNAMAMIDE TO REDUCE WOODPIGEON DAMAGE TO OILSEED RAPE

by

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Abstract

Woodpigeons (*Columba palumbus*) cause significant damage to oilseed rape, especially between January and March. No effective means of controlling this damage currently exists. The use of a chemical repellent, such as cinnamamide, which makes the crop temporarily unpalatable may offer a viable solution. The potential of cinnamamide to protect growing oilseed rape from woodpigeon damage was assessed by comparing damage to the crop in untreated and cinnamamide-treated 20 x 20m plots laid out on a 9 ha field that was regularly used by a flock of over 500 woodpigeons. Damage to the rape was assessed before cinnamamide was applied and twice weekly thereafter. Damage to the new inner leaves was considered separately to the older, outer leaves. Loading and persistence of cinnamamide on the leaves was monitored at application and then twice weekly from samples collected during damage assessments. Despite a low initial loading of cinnamamide and low persistence of the compound after spraying, damage to the inner leaves of treated plants after application was significantly less than damage to the inner leaves of untreated plants ($p<0.05$) and this was reflected later in the trial in a decline in damage to the outer leaves of treated plants ($p<0.05$). No signs of phytotoxicity were seen on treated leaves during the trial. However, cinnamamide did not completely protect the rape and in some plots treated rape received considerable damage. This was probably because these plots were damaged before the repellent was applied, and were therefore accessible to the birds, and also because of the low persistence of the compound on the leaf due to harsh weather conditions with substantial precipitation.

Objective

To carry out a pilot field study to assess the potential of cinnamamide, a compound shown to be repellent to birds, to reduce damage to oilseed rape (*Brassica napus*) by woodpigeons (*Columba palumbus*).

Introduction

The woodpigeon is the most significant bird pest in Britain. It feeds on a wide range of arable crops, and causes significant damage to oilseed rape (Murton & Jones, 1973; Inglis *et al.*, 1989), driving many farmers out of production (Lane, 1984). Most woodpigeon damage to autumn sown oilseed rape occurs between January and March, when the young rape provides an abundant source of green winter food at a time when alternatives are scarce (e.g. Murton, 1965; Murton *et al.*, 1966). Although scaring by visual stimuli, such as kites and scarecrows, and by auditory stimuli, such as butane gas guns, can bring about some reduction in damage, woodpigeons frequently become habituated to these stimuli and in some cases may even learn to associate the stimuli with a good food source (Inglis, unpublished data). An alternative means of reducing woodpigeon damage is urgently needed.

Non-lethal chemical repellents designed to render a crop unpalatable during its vulnerable stage may provide an effective, environmentally sensitive means of preventing damage. One such compound is cinnamamide, a synthetic derivative of the naturally occurring plant secondary compound cinnamic acid. Cinnamamide has been shown to be effective against a wide range of birds, including feral pigeon (*Columba livia*), quail (*Coturnix coturnix*), rook (*Corvus frugilegus*), chaffinch (*Fringilla colebs*), greenfinch (*Carduela chloris*), blue tit (*Parus caeruleus*), great tit (*Parus major*), great-spotted woodpecker (*Dendrocopus major*) and chestnut-capped blackbird (*Agelaius ruficapillus*) (Crocker & Perry, 1990; Crocker & Reid, 1993; Crocker *et al.*, 1993; Gill *et al.*, 1994; Watkins *et al.*, in press; Gill *et al.*, unpublished data). A dose response curve determined for cinnamamide against the feral pigeon showed that under laboratory conditions food consumption is depressed by at least 50% at an application rate of 0.26% w/w and by over 80% at 0.5% application (Watkins *et al.*, in press). A weather-resistant formulation for field trial use has been developed which maintained levels of cinnamamide on peanuts contained in wire mesh peanut feeders sufficient to prevent any consumption of peanuts for at least 7 days (Gill *et al.*, unpublished data). This pilot field study assesses the potential of cinnamamide to reduce damage by woodpigeons to autumn sown rape plants in February and March.

Methods & Materials

Study site

The study was carried out in February and March 1995 at a farm in Surrey where approximately 28 ha of oilseed rape are grown (Apex double low variety, drilled in late August 1994). The trial plots were set out in the middle of a 9 ha, predominantly flat, field bounded on three sides by mature trees and on the fourth by a railway line. Rape was also grown on two adjacent fields to the south/south-west and north-west. The farm has traditionally suffered significant damage to the rape crop from woodpigeons; gas bangers are not used, although there is occasional shooting, but for the duration of the trial there was no shooting in the vicinity of the experimental field. The nearest alternative oilseed rape crop was about 3½ miles away on a farm where bangers and scarers are used intensively. Prior to the experiment, a flock of at least 500 birds was seen feeding in the selected field.

The study field was set-aside (1 year mustard) in 1994, and a 0.25 ha (approx.) strip remained as set-aside in 1995 at the south-eastern end. The field is accessed by a track from the farm but there are no farm buildings visible from the field. A public footpath crosses the north-west corner of the field and over the railway line; the experimental plots were situated out of sight of the path which provided access to an observation point on the railway embankment. Rabbits were seen on the edge of the field but no sign of any was recorded in the experimental area. Roe deer are present in the area and their droppings were occasionally found in some of the plots.

Treatments

Experimental plots (20 x 20 m) received one of three treatments: they remained untreated, were treated with cinnamamide at an application rate of 2 kg/ha, or contained three 2 x 2 m netted 'sub-plots'. There were six replicates per treatment which were arranged in a randomised plot design. All plots were marked by 0.6 m long white 'flexicanes' (Frontline Extrusions Ltd., Grimsby) positioned at each corner. The canes were erected at the beginning of February in order to allow the birds to become habituated to their presence in the field. A 5m margin was allowed around all treated plots to protect adjacent plots from spray drift.

The treated plots were sprayed with cinnamamide in a suspension concentrate formulation consisting of finely ground cinnamamide powder, Xanthan gum, Atlox (a surfactant) and Acronal 4D (a sticker), and diluted with tap water. The compound was applied from a 2 m wide 4 jet ground driven boom sprayer pulled by a Kubota 7100 16hp tractor. Previous trials with cinnamamide in this formulation have shown that the amount of cinnamamide will decline by 35 - 50% over 7 days and cannot be detected after 3 - 4 weeks. It was therefore necessary to make two applications, two weeks apart: the first on 24 February 1995 and the second on 10 March.

The netted sub-plots consisted of 5 x 5 cm nylon net (Meshtech Ltd., Liskeard) stretched across four 0.6 m flexicanes. The net was held in position by a cross cut in the top of each cane, and secured to the ground by nylon net pegs (Netlon, Blackburn). The nets were put on 3 days before spraying.

Damage Assessment

The field had suffered damage from woodpigeons before the start of the experiment. In order to account for this, four assessments of woodpigeon damage to the plants in the untreated and treated plots were made in the two weeks before spraying and one assessment was made for each of the netted sub-plots on the day of netting. After spraying, assessments were made in the treated and untreated plots twice a week: 3, 6, 10 and 13 days after each application. A second assessment was made in the netted sub-plots on the final day of the experiment when the nets were removed. Assessments were made between 1000 h and 1300 h in order to avoid disturbing the pigeons' early morning and late afternoon peak feeding times.

Damage was assessed by recording the presence or absence of damage to the inner, new leaves and by classifying damage to the older, outer leaves as either 'negligible' (a few pecks from the outer lamina), 'moderate' (up to 50% of leaf area taken) or 'severe' (more than 50% of leaf area taken), after Inglis *et al.* (1989). All plants within 20 randomly positioned 40 x 40 cm quadrats in each treated and untreated plot, and within one 40 x 40 cm quadrat in each netted sub-plot, were assessed in this way. Damage to the netted sub-plots was assessed a second time on removal of the nets at the end of the experiment.

Within each plot, the proportion of plants that had damaged inner leaves was calculated, together with the proportions of plants that had negligible, moderate or severe damage to their outer leaves. In order to simplify the outer leaf damage, an outer damage 'score' was calculated for each plot in which the proportion of plants with negligible damage was added to the proportion of plants with moderate damage multiplied by 2 and the proportion of plants with severe damage multiplied by 3. Means of inner and outer leaf damage were calculated for the 6 plots in each treatment, and damage was compared between treatments by paired t-test (data were normalised by arcsine transformation).

Monitoring of pigeon presence

Estimates of the number of woodpigeons in the area were made at dawn once a week for 5 consecutive weeks, commencing the week before spraying. Counts were made from a vantage point, where the footpath crossed the railway line, which could be accessed without going near to the plots. The number of birds flying into the area and the size of feeding flocks were estimated during the first 2 hours after dawn, together with the length and location of any feeding bouts observed.

Complementary to these observations, small areas of the plots were sampled for fresh woodpigeon droppings during each damage assessment. A stick was placed in the centre of the first 5 quadrats sampled and fresh droppings were counted within a 1 m radius, defined by walking round the stick at the end of a 1 m piece of string attached to it.

Persistence of cinnamamide on the rape leaf - residue analysis.

Samples of leaves (5 randomly selected pairs) were taken from each treated plot 1 - 2 hours after spraying (depending on drying conditions) and during each subsequent damage assessment. Samples were kept frozen until analysis.

For analysis, leaves were removed frozen from the bag. The compound was removed from the leaves by sonicating (subjecting to ultrasonic waves) weighed quantities of leaves twice for 10 minutes in methanol/water (80:20). The liquid was then filtered twice to remove chlorophyll. The filtrate was injected into a High Pressure Liquid Chromatography column which isolated cinnamamide from coloured contaminants, and the amount of cinnamamide was quantified against a standard curve.

Estimation of biomass

At the end of the experiment, in each plot (including netted) all plants contained in 6 randomly positioned 40 x 40 cm quadrats were cut to ground level. The number of plants in each quadrat were counted and their wet and dry weights determined.

Results

Presence of woodpigeons

There were 500-800 woodpigeons in the study area throughout the trial. The birds did not roost overnight in the trees immediately around the field but flew in from all directions to form post-roost assemblages in these trees about 30 minutes after dawn. The first feeding bout occurred 45 - 60 minutes after dawn. Feeding bouts were 3 - 10 minutes long at this time of day.

Fresh droppings (maximum 20 per plot) were found in most plots on all assessment days. The mean number found in treated and untreated plots on each assessment day was calculated and compared by paired t-test (Fig. 1). The presence of fresh droppings varied considerably within and between plots, and between assessment days, although significantly more ($p<0.05$) droppings were found in the untreated plots on day 10 after the first application of cinnamamide and on day 3 after the second application.

Damage to rape

Before cinnamamide was applied, many of the plots had been damaged by woodpigeons but this damage did not differ between allocated treatments ($p>0.05$) (Figs. 2 & 3). Damage to outer leaves on the first day of assessment (13 February) was omitted from the analyses as on this day these data were not collected in a standard manner. After spraying, damage to both inner and outer leaves was greater in the untreated plots than in the treated. This effect was observed in inner leaves immediately after spraying (Fig. 2) and later for the outer leaves (Fig 3): inner leaf damage was significantly greater ($p<0.05$) in the untreated plots 3, 6 and 13 days after the first application and 3 and 10 days after the second application (Fig. 2), and outer leaf damage was significantly greater ($p<0.05$) 13 days after the first application and 3 and 10 days after the second (Fig. 3). Examination of the outer leaf damage categories (negligible, moderate and severe) reveals that these significant differences are due to an increased proportion of rape plants with severe damage to their outer leaves in untreated plots (Fig. 4). The apparent delay in protection for treated outer leaves relative to inner leaves is likely to be because most damage to outer leaves was probably done when they were inner leaves; consequently differences in damage to outer leaves would not become apparent until the inner leaves had grown out. Damage to plants in the netted plots was similar to that in the untreated and treated plots at netting (mean % netted plants with inner leaf damage = 35.3, s.e. 9.73; mean outer leaf damage score (multiplied up from 3 to 20 sample quadrats per plot to achieve a comparable figure) = 19.7, s.e. 2.48) but declined to a negligible amount when the damaged leaves had grown out and died back 5 weeks later when the nets were removed (mean inner leaf damage = 0; mean outer damage score = 0.42, s.e. 0.17). No signs of phytotoxicity were seen on treated leaves during the trial.

Persistence of cinnamamide on rape leaves

The measured application rate of cinnamamide on the leaves was quite low (maximum of approx. 450g cinnamamide/ha) and declined to 29 - 6 % of the measured level 3 days after spraying and to 5 - 0.4% after 10 days (Table 1). It was undetectable after 13 days.

Estimation of biomass

Mean dry weight of plants and dry weight of plants per m^2 were calculated for each treatment (Table 2). Netted plots contained more biomass per m^2 than treated plots (paired t-test; $p<0.05$). There were no significant differences in biomass or plant weight between treated and untreated plots (paired t-test: $p>0.05$).

Table 1.

Measured application rate of cinnamamide and its persistence on rape leaves

Date	Mean (s.e.) measured application (g/ha) per plot (n=6)	Maximum (g/ha)	Minimum (g/ha)	Mean % (s.e.) remaining after spraying	Maximum %	Minimum %
24/2 (Spray)	190.4 (24.7)	285.3	115.78	-	-	-
27/2	30.9 (4.9)	41.2	11.3	17.9 (3.8)	28.5	5.6
6/3	3.9 (0.7)	5.9	1.47	2.7 (0.6)	5.1	0.9
10/3 (Spray)	255.4 (49.7)	450.9	143.5	-	-	-
13/3	36.0 (10.5)	67.5	9.5	14.4 (2.8)	22.3	6.6
20/3	2.4 (1.2)	3.8	1.1	1.1 (0.3)	2.5	0.4

Table 2.

Biomass in netted, untreated and treated plots (n=6) at the end of the trial

	Mean dry weight(g)/m^2 (s.e)	Mean dry weight(g)/plant (s.e)
Netted	203.3 (8.51)	2.4 (0.09)
Untreated	152.9 (15.94)	2.3 (0.28)
Treated	144.6 (12.69)	2.0 (0.12)

Discussion

The damage assessment data suggest that cinnamamide in the formulation and at the application rate used in this trial reduced damage to young oilseed rape plants by woodpigeons. However, cinnamamide did not prevent damage to the rape altogether, and some of the treated plots sustained considerable damage during the experimental period.

There are two principal factors that may account for this: the timing of the application of cinnamamide and the loading and persistence of the compound. The crop was not treated until late February, by which time parts of the experimental field had already sustained damage, as shown by the damage assessments carried out prior to spraying. Once an area has been damaged it becomes more accessible to the birds and so more susceptible to further damage. Damage to autumn sown oilseed rape begins in December and increases significantly during January (Inglis *et al.*, 1989). Protecting the crop from woodpigeon damage with cinnamamide earlier in the growing season, possibly from late December and throughout January, would allow more rapid and uniform growth, thereby enabling plants to protect themselves from further damage by developing a dense and uniform leaf cover which is less vulnerable to attack from woodpigeons. The low application rate of cinnamamide may be due to uneven spray cover on overlapping leaves, and harsh weather conditions with substantial precipitation are likely to have been a major cause of the low persistence of the compound. However, that such low levels of cinnamamide on the leaves could still significantly reduce damage, highlights the potential of this compound to protect the growing crop. Owing to the small size of the plots and the uneven growth of the crop the effect of cinnamamide on final yield was not assessed. Estimates of biomass 4 weeks after the first application of cinnamamide showed that there was no difference between treated and untreated plots and that growth was highest in the netted plots. For future trials in which larger areas are involved it will be necessary to consider the impact of cinnamamide use on final yield.

This pilot trial has confirmed the potential of cinnamamide to protect growing oilseed rape from damage by woodpigeons. However, any formulation applied to the leaf surface of growing rape has a limited life because of the growth of the leaves; the application rate of the compound on the leaf surface is diluted as the leaf grows and the compound is lost when the leaf dies back. Nevertheless, if, as noted above, the crop could be protected during its early stages of growth until it had reached the stage of dense and uniform leaf cover when it can protect itself from woodpigeon damage, a cost-effective means of protection could be provided by cinnamamide. In order to pursue this further, research is needed to develop a more persistent and weatherproof formulation. Laboratory studies have shown that at low levels of application, feral pigeons reject cinnamamide because of primary effects of bad taste or smell and/or an irritation of the buccal cavity (Watkins *et al.*, in press and unpublished data). An effective formulation of cinnamamide must protect the compound from the elements whilst allowing its detection by woodpigeons. Possible alternatives to the suspension concentrate formulation used in this pilot trial include: increasing the amount of sticker added to the suspension concentrate formulation, using an oil-based formulation that would be less easily washed off the leaf surface, encapsulating cinnamamide in slow-release 'leaky' microcapsules that would adhere to the leaf and release the repellent over a period of time, or a combination of the latter with the suspension concentrate formulation. Prior to field application, candidate formulations would have to be rigorously tested for persistence and efficacy of the active ingredient and phytotoxicity.

Acknowledgements

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Fig. 1

Presence of droppings in treated and untreated plots

The mean number of fresh droppings found in samples taken from treated and untreated plots on each assessment day from 13 February to 27 March was calculated and compared between treatments by paired t-test. Error bars are 1 standard error.

* p = 0.05-0.01

** p = 0.01-0.001

Fig. 2

The effect of cinnamamide on damage to inner rape leaves.

The proportion of plants sampled with damaged inner leaves was determined for each plot and means calculated for each treatment from 13 February to 27 March. Means of treated and untreated plots were compared by paired t-test on each day of assessment. Error bars are 1 standard error.

* p = 0.05-0.01

** p = 0.01-0.001

Fig. 3

The effect of cinnamamide on damage to outer rape leaves.

Damage to outer leaves was classified as either 'negligible' (a few pecks from the outer lamina), 'moderate' (up to 50% of leaf area taken) or 'severe' (more than 50% of leaf area taken). Within each plot, the proportions of plants that had negligible, moderate or severe damage to their outer leaves was determined. In order to simplify the outer leaf damage, an outer damage 'score' was calculated for each plot in which the proportion of plants with negligible damage was added to the proportion of plants with moderate damage multiplied by 2 and the proportion of plants with severe damage multiplied by 3. Mean scores were calculated for treated and untreated plots for each assessment day from 16 February to 27 March and compared by paired t-test. Error bars are 1 standard error.

* p = 0.05-0.01

** p = 0.01-0.001

Fig. 4

Effect of cinnamamide on degree of outer leaf damage

The mean number of plants with each category of outer leaf damage was determined for each plot. Means of treated and untreated plots were compared by paired t-test on each day of assessment from 16 February to 27 March. Error bars are 1 standard error.

* p = 0.05-0.01

**p = 0.01-0.001

Fig. 1

Presence of droppings in treated and untreated plots

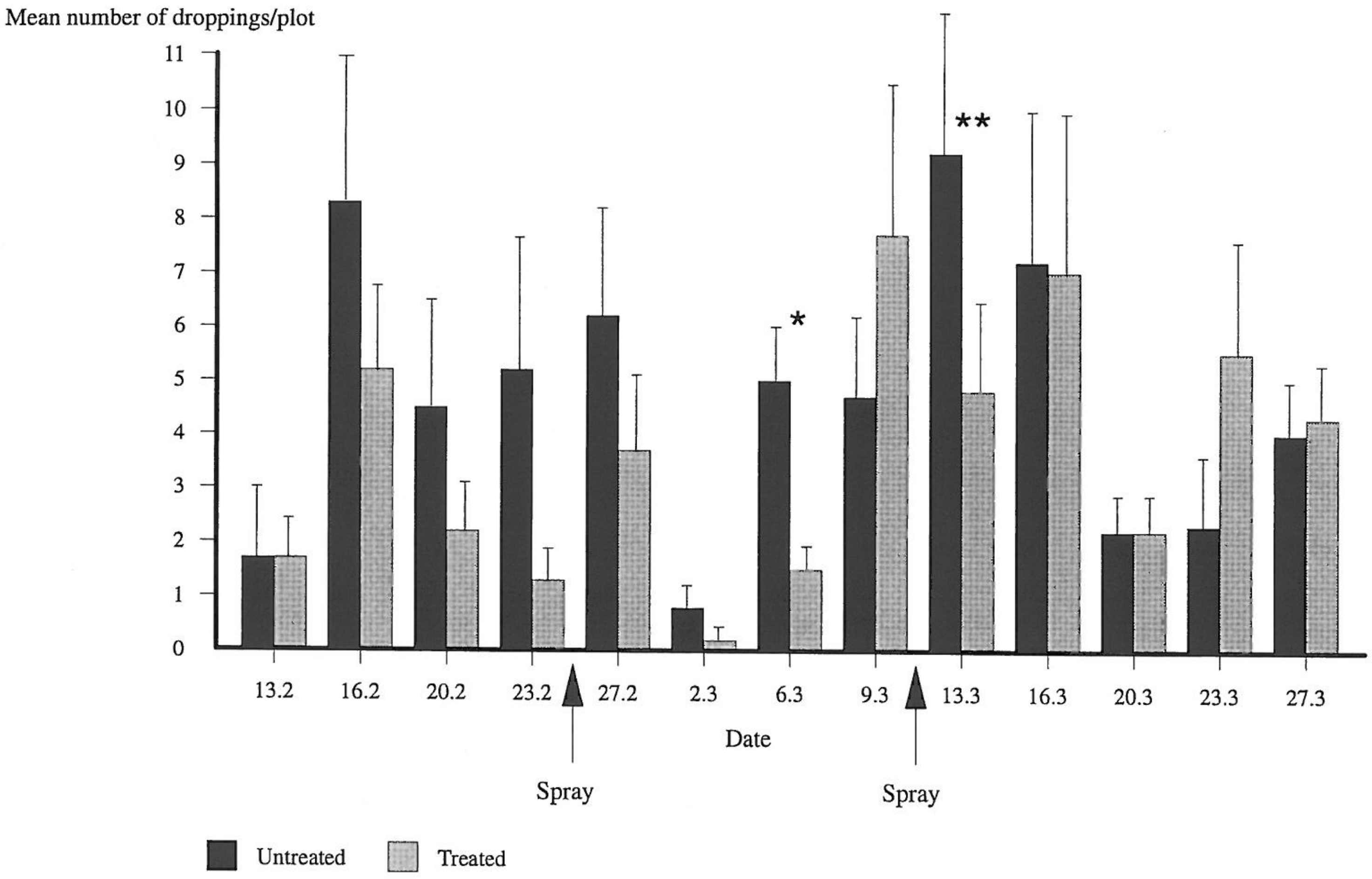


Fig. 2

Effect of cinnamamide on damage to inner rape leaves

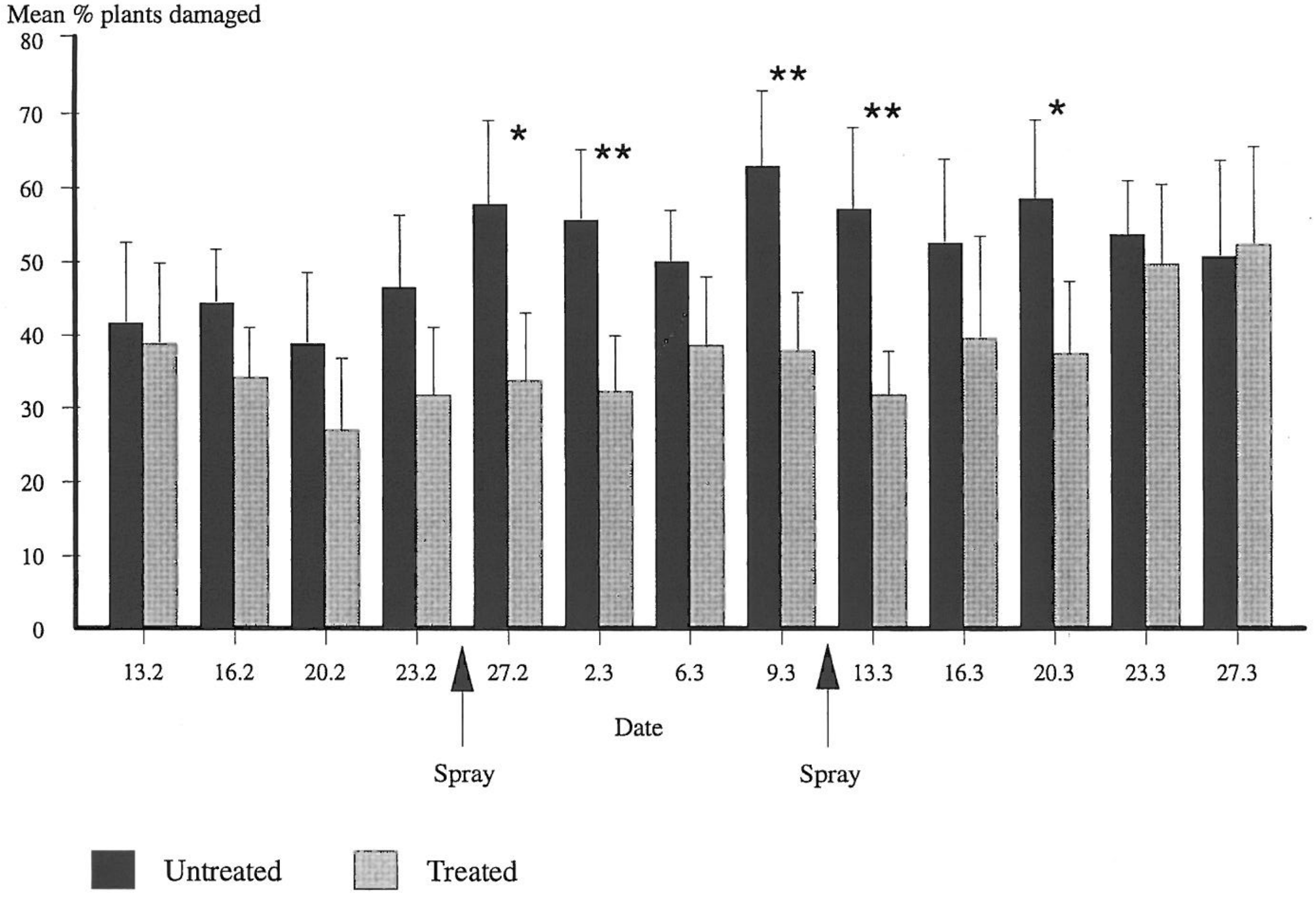


Fig. 3

Effect of cinnamamide on damage to outer rape leaves

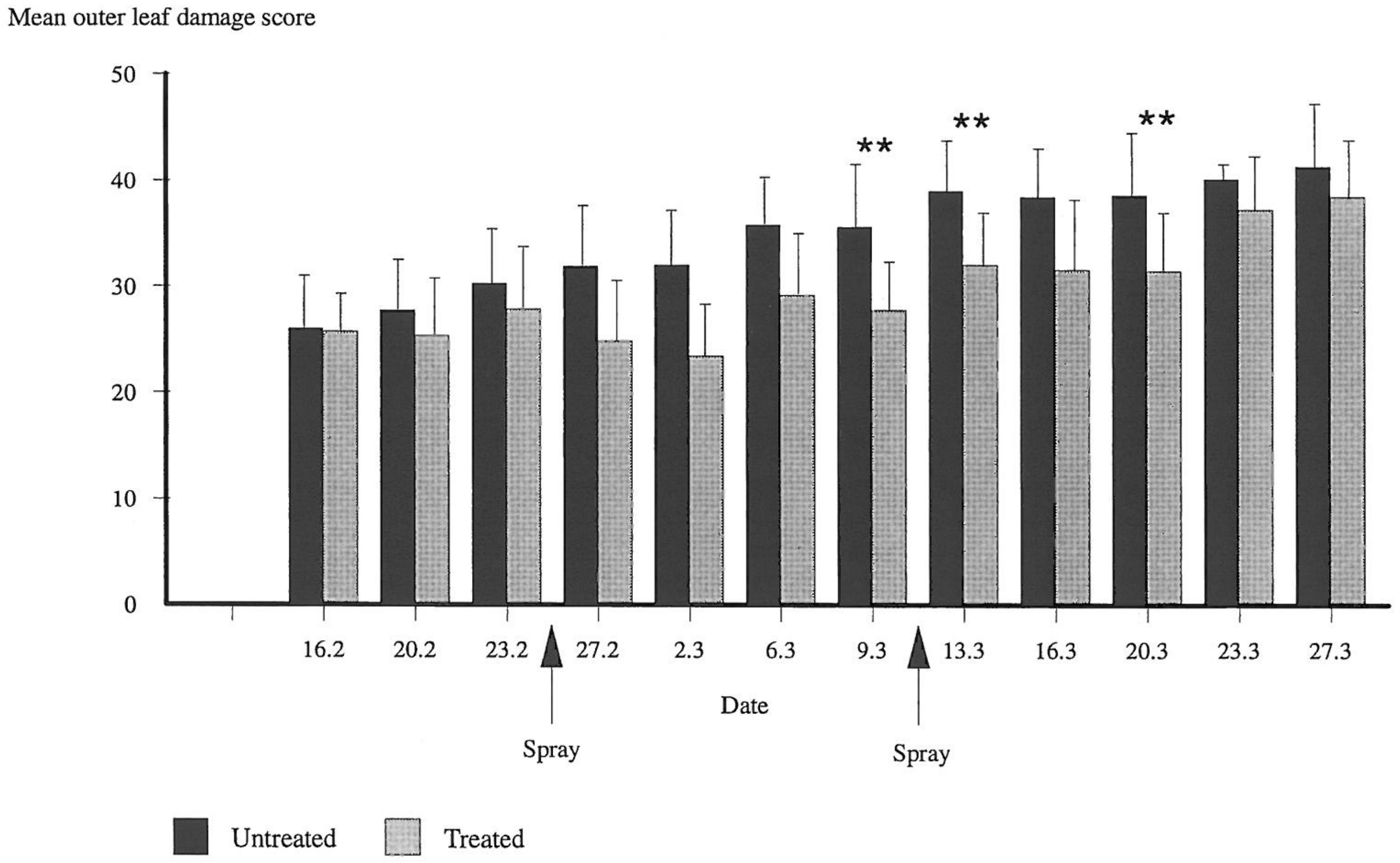
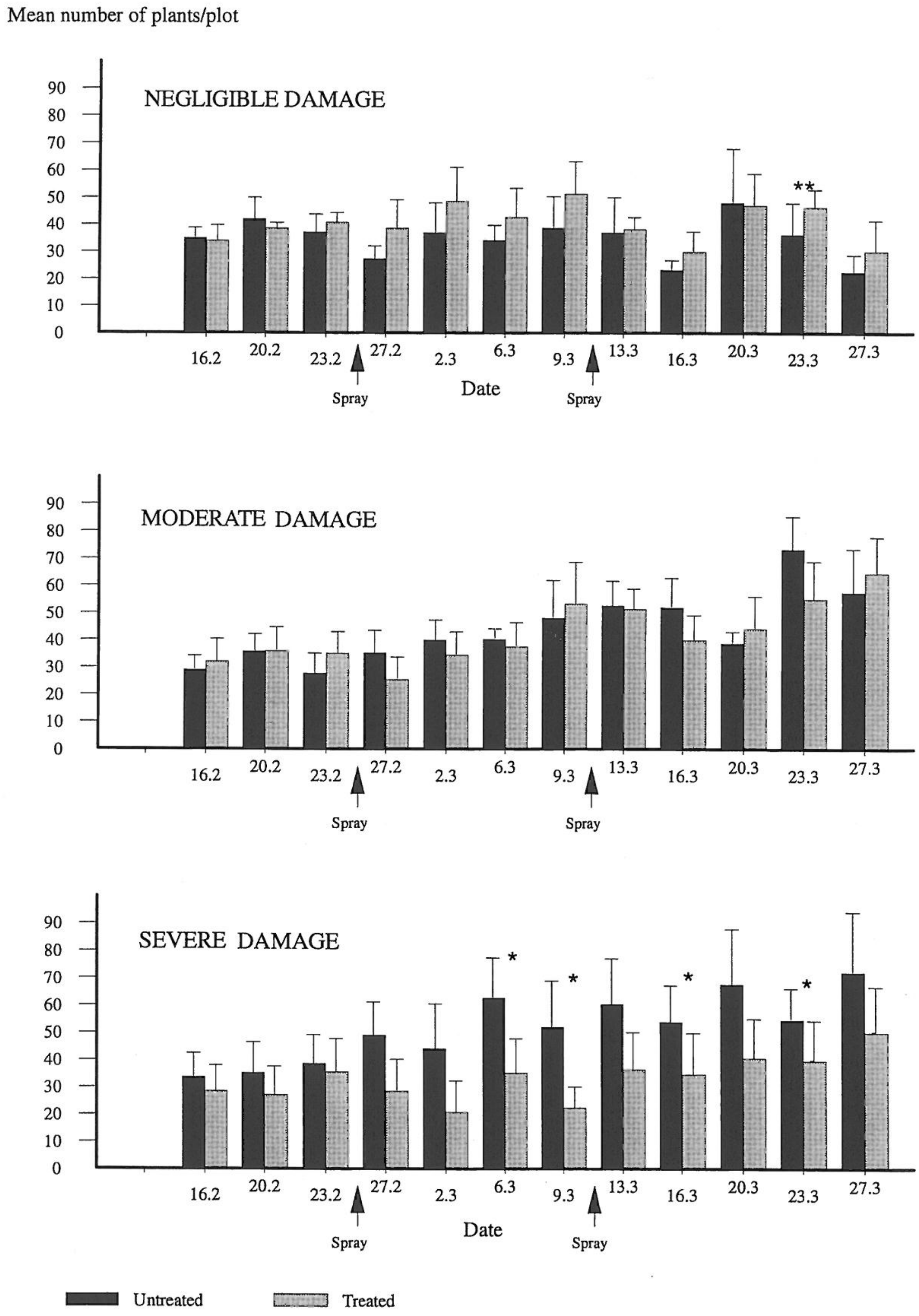


Fig. 4

Effect of cinnamamide on degree of outer leaf damage



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