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ECONOMIC THRESHOLDS OF *AVENA* SPP., AND *ALOPECURUS MYOSUROIDES* IN WINTER WHEAT FIELDS

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Abstract

Avena spp. and *Alopecurus myosuroides* are noxious weeds in many cereal-growing regions of Turkey. The aim of the study was to estimate economic thresholds of wild oat and black grass in terms of costs and returns in different wheat fields. The trials were conducted in 2000-2002 in two different wheat fields, which were selected to be a representative for Samsun province. In these fields, the plots each 2 m^2 in size had different weed densities of 1, 5, 10, 20 and 40 plant m^2 maintained after wheat emergence. In addition, weed-free control plots were set up in the same fields. After harvest, the effect of different densities was calculated as % yield losses compared to control plots. The % yield losses were correlated to the weed density using a linear regression model for both weed species. The economic thresholds of wild oat and black grass were determined in terms of the herbicides registered against them. Economic threshold for wild oat was between 11.77-14.70 plants/m^2 and for black grass 15.70-32.56 plants/m^2.

Introduction

Some species of annual grass weeds are problems in the arable fields of many countries (Caussanel & Kafiz 1986; Roebuck, 1987; Schroeder *et al*., 1993; Uygur *et al*., 1996). *Avena* spp., (Wild oat) and *Alopecurus myosuroides* (Black grass) are noxious weed species of many cereal-growing regions of Turkey due to poor control (Mennan & Uygur, 1994; Kadıoğlu *et al*., 1998). The number of resistant populations of wild oat is increasing and control is becoming more difficult (Uludağ *et al*., 2001).

In recent years, agricultural policy has changed depending on the technological improvement and reduction of production costs is a primary concern of farmers. There is also increasing pressure on the farmer to reduce herbicide use for both economic and environmental reasons (Brain *et al*., 1999). The use of herbicides have to be minimised since widespread and excessive use of them cause environmental side-effects, increasing resistant weed populations and residue in foods. This can be provided by using herbicides according to the economical thresholds of weed species.

The effect of weed competition on crop yield has been investigated and explained by empirical models. Numerous empirical threshold models have been developed relating crop losses to weed density, leaf area index, relative time of emergence or biomass (Cousens, 1985; Streibig, 1989; Heitefuss *et al*., 1987; Kropff & Spitters, 1991; Debaeke *et al*., 1997). Generally, the models of crop losses that related to weed density are preferred. The thresholds of weeds are affected by many factors such as the type of crop, weed densities, climatic conditions and soil type. Also it is strongly affected by the efficiency of control treatment, application costs, crop yield and the price of grain.

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There have been many economic threshold studies conducted on winter wheat in different countries. In earlier studies, the economic threshold of wild oat was stated by Carslon & Bagholt (1981) in USA (6 plants/m^2), by Rolston (1982) in New Zealand (10 plants/m^2) and Caussanel & Kafiz (1986) in France (16-29 plants/m^2). The results of other work on the economic threshold of blackgrass were 30-50 plants/m^2 as indicated by Cousens *et al*., (1985) in England and 20-42 plants/m^2 by Zanin *et al*., (1993) in Italy.

The objectives of this study were to estimate the competitive effects of wild oat and black grass on wheat in a field experiment, and to determine the economic thresholds of wild oat and black grass in wheat.

Material and Methods

Wild oat and blackgrass seed were collected from wheat fields in Samsun province, Turkey in the first week of July 2000. The inflorescences of mature plants were hand harvested, cleaned, stored at room temperature until at the beginning of trials. The wheat-wild oat-black grass field competition experiment was conducted at Black sea Agriculture Research Institute experiment station and Havza district of Samsun. Average annual precipitation in the experiment area is about 700 mm. Soil composition of experimental site is 13.53% sand, 45.40% silt, 41.20% clay, 1.86% organic matter, 4.94% lime and pH 7.89.

Field Experiment

The trials were carried out to determine the damage levels of wild oat and black grass and to assess their economic thresholds in terms of costs and returns in two different wheat fields between 2000-2002. Seeds of the two weeds and winter wheat were sown (220 kg ha^{-1}) in plots during autumn. In these fields, the plots each 2 m^2 in size and five different weed densities of 1, 5, 10, 20 and 40 plant/m^2 were established after wheat emergence. The weeds were thinned manually in order to reach the required density. All weeds were marked and all other species that emerged later in the season were removed at biweekly intervals by hand. The experiment was a randomised plot with four replication in each different field. Fertilizer was applied at normal levels with application periods of the farmers of the region.

The entire plots were harvested by hand separately and the yield per plot recorded. The effects of different weed densities were calculated as % yield loss compared to the control plot for each application separately. The % yield losses were correlated to the weed density using a linear regression model for both weed species. In addition to that, theoretical income calculated from the control plots was correlated with application costs of different herbicides registered for wild oat and black grass.

The economic threshold, the weed density at which the cost of treatment equals the economic benefit obtained from that treatment, was calculated according to formula presented below (Uygur & Mennan, 1995).

$$y = \frac{\left(\frac{100}{H.E} \text{ X } H.M.\right) + (U.M.)}{(B.F.) \text{ X } (V.\,Ort.)} \text{ X } 100$$

where;
y is percentage yield losses at a different weed density
H.E. is herbicide efficiency
H.M. is the cost of herbicides applied
U.M. is the cost of herbicide application
B.F. is the price of grain
V. Ort. is the average yield obtained from the weed-free control plots.

The value of the economic threshold can be obtained by calculating y in the equation (above) and then replacing in linear regression model ($y = ax + b$) and solving it.

Herbicide trials

The efficacy of herbicide registered for wild oat and black grass was investigated in the region. For this purpose, the trial was arranged in a randomized complete block design with four replications and each plot was 20 m^2. The rates used are usually field doses for these herbicides in Samsun. Dosage and active ingredients of herbicides used are given in Table 1. Herbicides were applied at the beginning of tillering using a laboratory sprayer equipped with Tee Jet 8004 nozzles calibrated to 300 L ha^{-1}. Trials were evaluated using a 1-9 scale.

Table 1. Dosage and active ingredients of herbicides registered for wild oat and black grass control in Turkey.

Herbicides (Active ingredients %)	Application rate (a. i. g ha^{-1})	Weed species Controlled
Clodinafop-propargyl 24 % EC	48	wild oat, black grass
Diclofop-methyl 28 % EC	568	wild oat
Fenoxaprop-p-ethyl 7.5 % EC	45	wild oat, black grass
Imazamethabenz-methyl 25 % SC	562.5	wild oat
Tralkoxydim % 25 SC	250	wild oat

Statistical analysis

The data of yield losses and density of wild oat and black grass were evaluated by analysis of variance (ANOVA). Variance stabilizing transformation was applied to yield losses ($\sqrt{x}$). Follow-up of ANOVA included Duncan's multiple range test.

Results and Discussion

Wild oat and black grass are the most widespread annual grass weeds of winter wheat and black grass prefers heavier soils with high moisture (Mennan & Uygur, 1994). Competitive effects of wild oat and black grass were found to be greatly different. However, both species caused significant decrease in wheat yield with increasing density. These species caused significant yield losses even at low density as also observed by Roebuck (1987). While 10 wild oat/m^2 reduced the yield by 8.69%, yield losses of 4.87% were observed at the same densities of black grass. Taking these yield losses into consideration, the competitive ability of wild oat was nearly two fold higher than that of black grass. The differences between yield losses and different densities of wild oat and

black grass are given Table 2. The differences between groups were found significantly different (P<0.001).

Table 2. The ANOVA of differences between yield losses and different densities of wild oat and black grass.

	Df	MS	F	P
Wild oat between groups 2000-2001	4	812.82	55.45	0.001
2001-2002	4	1449.20	47.84	0.001
Black grass between groups 2000-2001	4	256.88	29.93	0.001
2001-2002	4	417.80	32.48	0.001

The linear regression analysis revealed that there was a close correlation between weed density and yield losses for both species (Figs. 1&2). The value of economic thresholds were calculated for wild oat and black grass using the data of yield losses obtained in regression analysis.

The mean yield of crops in the control plots were determined as 3805 kg ha^{-1}. The costs of herbicides application and grain price were 13.5∈ ha^{-1} and 153 ∈ t^{-1}, respectively. The costs of herbicides were estimated using the prices of herbicides registered in Turkey and considering their efficiency and application dosage.

The effects of herbicides on wild oat and black grass are shown in Fig. 3. At the end of trials, there were no conspicuous differences among the effects of herbicides on weeds. The efficiencies of Fenoxaprop-p-ethyl, Diclofop-methyl, Clodinafop-propargyl, Tralkoxydim and Imazamethabenz-methyl on wild oat were 93, 84.25, 83.5, 79.5 and 79%, respectively. There were no differences among herbicides in the (P<0.05) confidence intervals, except Fenoxaprop-p-ethyl. Only Clodinafop-propargyl and Fenoxaprop-p-ethyl are registered against black grass in Turkey. Fenoxaprop-p-ethyl showed good efficiency (88.75%) against black grass but Clodinafop-propargyl didn't completely control it. The efficiency of herbicides were found to be significantly different (P< 0.05).

Depending on the herbicide used, the economic threshold of wild oat ranged between 8.82 and 14.70 plants/m^2. For black grass economic thresholds were calculated as 15.70 plants/m^2 for Fenoxaprop-p-ethyl and 32.56 plants/m^2 for Clodinafop-propargyl (Table 2).

Table 2. Economic thresholds of the wild oat and black grass in terms of different herbicides in winter wheat.

Herbicides (Active ingredients %)	Application rate (a. i. gr ha^{-1})	Application cost* ∈ ha^{-1}	Economic threshold (plants/m^2)	
			wild oat	black grass
Clodinafop-propargyl 24 % EC	48.0	62.25	13.93	32.56
Diclofop-methyl 28 % EC	568.0	53.25	11.77	--
Fenoxaprop-p-ethyl 7.5 % EC	45.0	41.80	8.82	15.70
Imazamethabenz-methyl 25 % SC	562.5	62.20	14.13	--
Tralkoxydim % 25 SC	250.0	63.05	14.70	--

* herbicides + application costs
-- not registered in Turkey

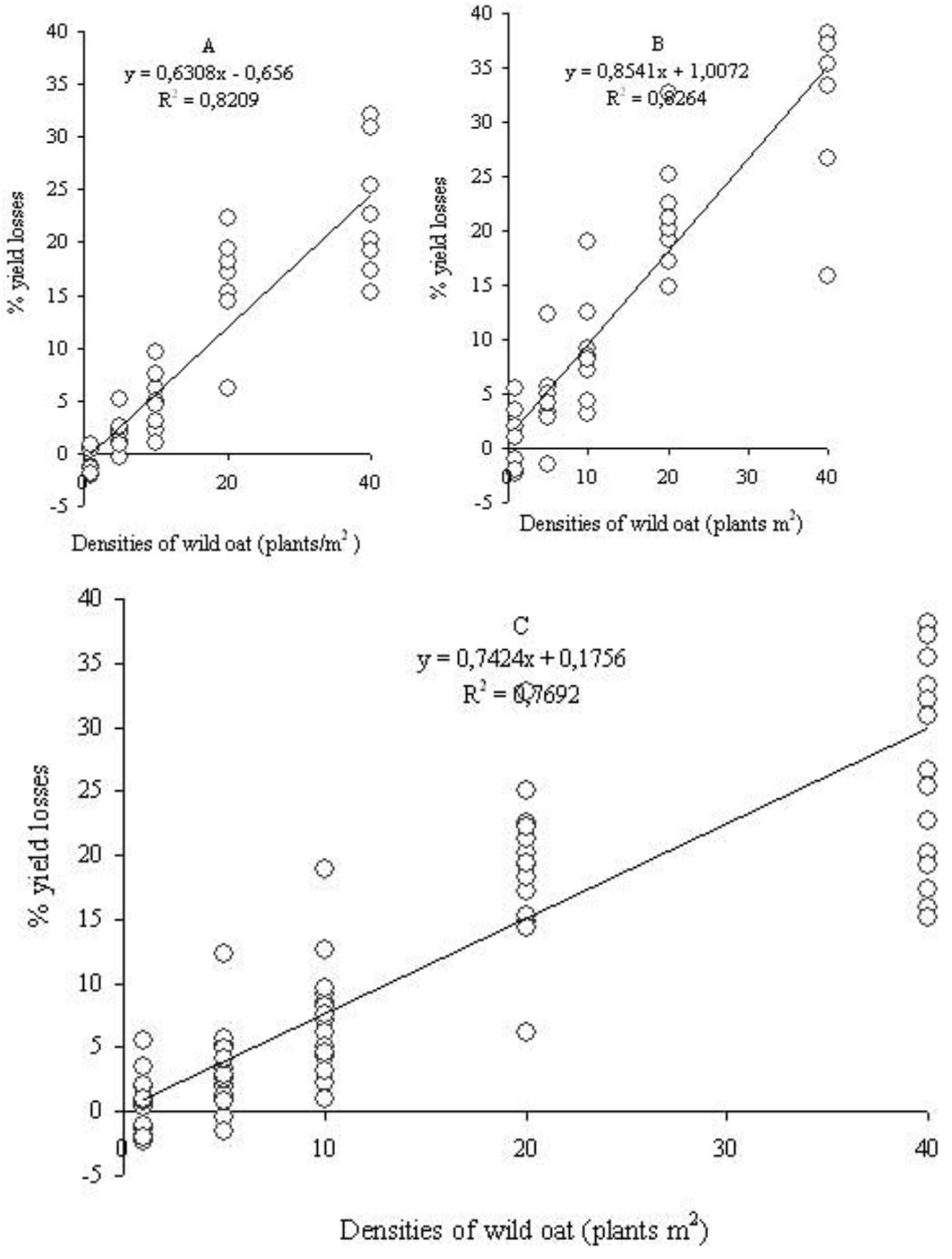

Fig. 1. Trend of percentage yield losses caused by the different densities of wild oat (A: regression analysis of 2000-2001 field experiment. B: regression analysis of 2001-2002 field experiment. C: regression analysis of two years field experiment).

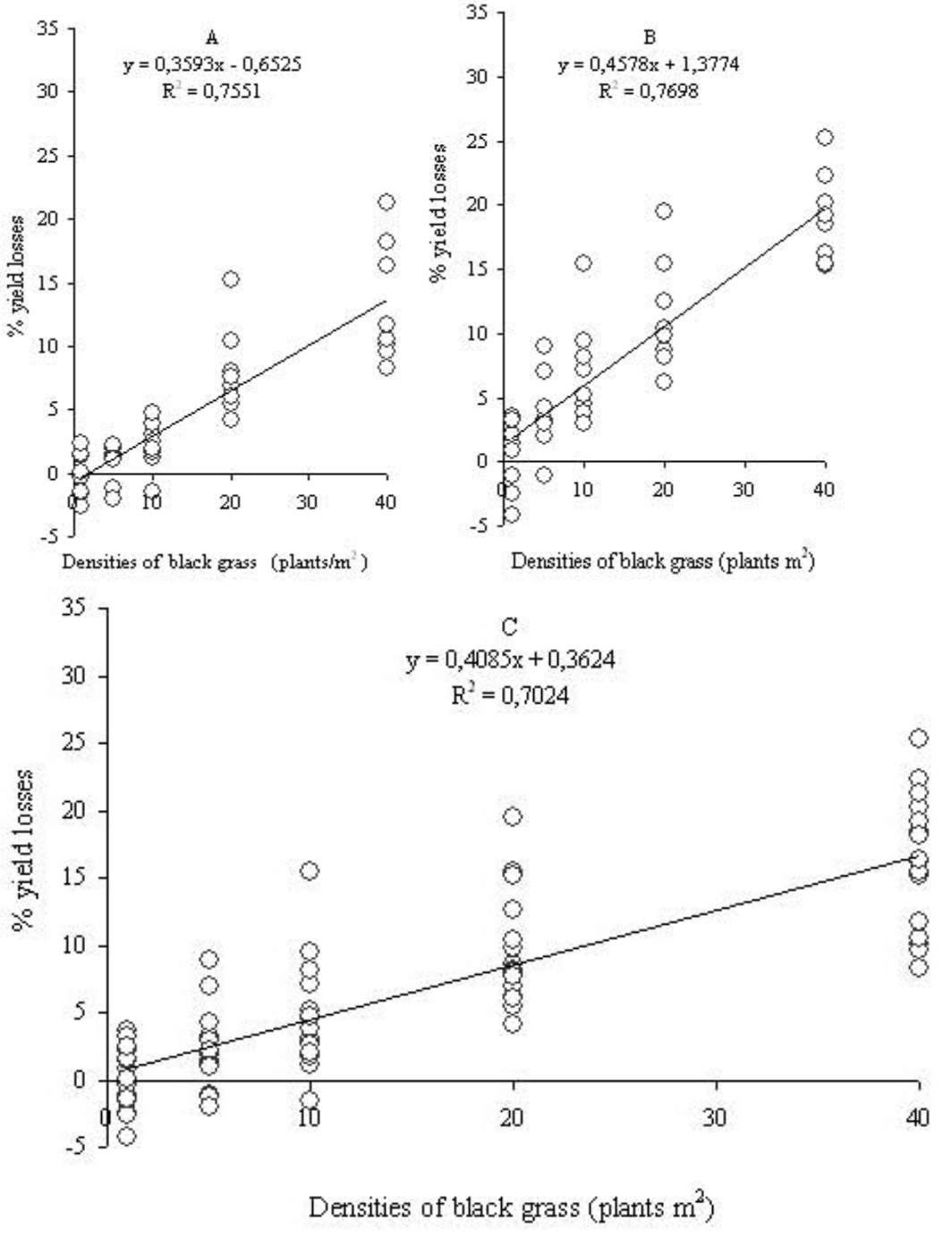

Fig. 2. Trend of percentage yield losses caused by the different densities of black grass (A: regression analysis of 2000-2001 field experiment. B: regression analysis of 2001-2002 field experiment. C: regression analysis of two years field experiment).

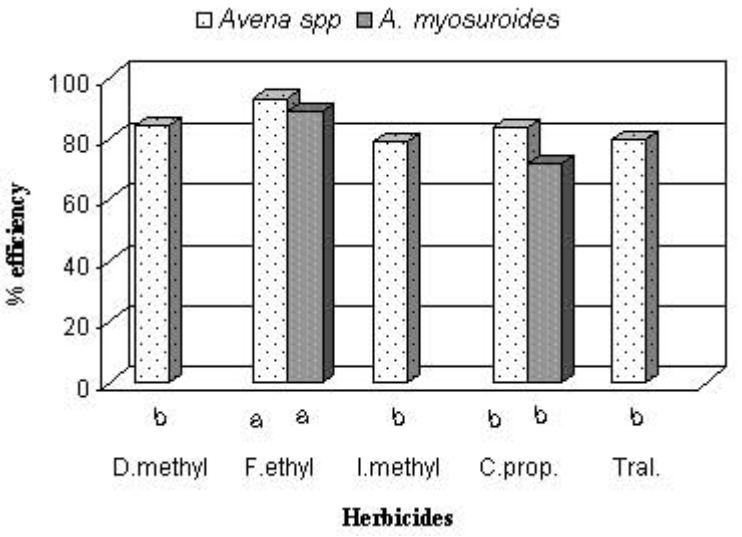

Fig. 3. The efficiency of herbicides that are registered against wild oat and black grass in Turkey (The identical letters treatment in which there were no statistically significantly differences at ($P < 0.05$) according to Duncan's multiple range test).

Our economic threshold results match well with other studies. The economic threshold of wild oat was calculated as 8-12 plants/m^2 in England by Cousens *et al*., (1985). In other previous experiments, comparable results for economic threshold of wild oat were stated by Carslon & Bagholt (1981) in USA (6 plants/m^2), by Rolston (1982) in New Zealand (10 plants/m^2) and Cauusanel & Kafiz (1986) in France (16-29 plants/m^2).

In the studies done by different researchers in Germany, the economic threshold of black grass was found to be 27-50 plants/m^2 by Koch & Hess (1980), 20 plants/m^2 by Niemann (1986), 30 plants/m^2 by Wahmhoff (1986) and 30 plants/m^2 by Heitefuss *et al*., (1987). The results of other previous works on the economic thresholds of black grass were 30-50 plants/m^2 as indicated by Cousens *et al*., (1985) in England and 20-42 plants/m^2 by Zanin *et al*., (1993) in Italy. The economic thresholds of both species in Turkey were estimated to be rather low according to other studies. This could be explained by lower herbicide prices and labour costs in Turkey.

Wild oat and blackgrass are able to produce many seeds and dispersed effectively in cereal grain. Also these species have a long period of germination from November to April. So, 95% of these species should be controlled. Because wild oat is the more serious weed, weed control will generally emphasize on this species. Our data indicated that fenoxaprop-p-ethyl seems to be most suitable herbicides in order to keep the weed under control. The studies of the economic threshold give us the opportunity for the practical application against weed species in some crops and also basic concept of the integrated weed management system.

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