Turkish Journal of Agriculture and Forestry

Volume 25 | Number 1 Article 5

1-1-2001

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Turk J Agric For
25 (2001) 31-36

Changes in weed response to 2,4-D application with 5 repeated applications in spring wheat

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Received: 26.01.2000

Abstract : 2,4-D amine and 2,4-D isooctylester were sprayed repeatedly in the spring of 5 consecutive years on spring wheat *(Triticum aestivum L.* cv. Kırik) in Erzurum during the years 1990-1994. The herbicide efficacy against all broad-leaved weeds and against the most common weed species was determined by comparing the number of weeds in untreated and treated plots. The most abundant weed species were *Polygonum aviculare, Amaranthus retroflexus* and *Chenopodium album* in spring wheat.

The effect of 2,4-D amine decreased after 3 or 4 years in *A. retroflexus, C. album, Convolvulus arvensis, Acroptilon repens, Lactuca serriola, P. aviculare, Cirsium arvense* and other broad-leaved weeds. Effects against *Sinapis arvensis* and *Sisymbrium altissimum* remained unchanged.

The reduction in the effectiveness of Isooctylester on *A. retroflexus, C. album, C. arvensis, C. arvense, A. repens, L. serriola, P. aviculare* and other broad-leaved weeds was statistically significant, but the rate of decrease was not statistically significant for *S. arvensis* and *S. altissimum.* The resistance of *A. retroflexus* against isooctylester increased in the 4th year. The results indicate that the effects against some weeds of herbicides were reduced especially from fourth year. Therefore, the herbicides using against weeds should be changed periodically.

Key Words: 2,4-D, changes in effect of herbicides on weeds, spring wheat

Yazlık Buğdayda 5 Yıl Tekrarlı 2,4-D Uygulamasına Karşı Yabancı Otların Tepkisindeki Değişmeler

Özet : Erzurum'da, 1990-1994 yıllarında, yazlık buğdaydaki *(Triticum aestivum L.* cv. Kırik) yabancı otlara karşı çıkış sonrası 5 yıl süreyle üst üste 2,4-D amin ve 2,4-D isooctylester kullanılmıştır. Önemli geniş yapraklı yabancı ot türlerine karşı herbisitlerin etkinliğini belirlemek amacı ile uygulama görmemiş ve uygulama görmüş parsellerdeki yabancı ot sayıları karşılaştırılmıştır. Yazlık buğdayda en yoğun yabancı ot türleri *Polygonum aviculare, Amaranthus retroflexus* ve *Chenopodium album* olarak belirlenmiştir.

Amaranthus retroflexus, C. album, Convolvulus arvensis, Acroptilon repens, Lactuca serriola, P. aviculare, Cirsium arvense ve diğer geniş yapraklılara karşı 2,4-D amin'in etkililiği 3. veya 4. yıllardan itibaren azalmıştır.

Amaranthus retroflexus, C. album, C. arvensis, C. arvense, A. repens, L. serriola, P. aviculare ve diğer geniş yapraklı yabancı otlara karşı Isooctylester'in etkililiğindeki azalmanın istatistiki olarak önemli olduğu saptanmıştır. Isooctylester'in *A. retroflexus*'a karşı olan etkililiğinin 4. yılda oldukça azaldığı tespit edilmiştir.

Bunun yanında, her iki ilacın *Sinapis arvensis* ve *Sisymbrium altissimum*'a karşı olan etkililiğinde yıllara göre değişmenin olmadığı belirlenmiştir. Bu çalışma sonucu, özellikle 4. yıldan itibaren bazı yabancı otlara karşı herbisitlerin etkilerinin azaldığı belirlenmiştir. Bu nedenle belirli aralıklarla yabancı otlara karşı kullanılan herbisitlerin değiştirilmesi gerekir.

Anahtar Sözcükler: 2,4-D, herbisitlerin yabancı otlara etkisindeki değişme, yazlık buğday

Introduction

Herbicide resistance is defined as the decreased response of a population of a species to a herbicide as a result of the herbicide's application, and a resistant plant is one that survives and grows normally at the usually effective dose of a herbicide (1). The distribution and the number of herbicide resistant weeds have increased rapidly in recent years. In the last decade, certain weed species have been found to display herbicide resistance. Resistance is thought to develop as a result of repeated application of herbicide over an extended period of time with little or no rotation (1, 2). There are now over 50 weeds resistant to triazines (3) and a total of 107 resistant biotypes that have evolved around the world (4). There have been local and rather isolated occurrences of resistance or increased tolerance in various weed species to several other types of herbicides, including phenoxy (e.g., 2,4-D), trifluralin, paraquat, and ureas (e.g., diuron) (1).

This study was undertaken to determine if weed species in wheat fields increase or decrease their tolerance against 2,4-D as a result of repeated application.

Material and methods

Field trials

Field experiments were carried out at the Research Station of the Faculty of Agriculture, Atatürk University Erzurum. Spring wheat (c.v. Kırik) was sown at a rate of 180 kg ha^{-1} in May in each year. The experiment was carried out with a randomized block design, with three replications of permanent plots for the herbicides and a non-treated control. Each plot was 5 m x 11 m with a 2 m margin between adjacent plots.

Herbicide application

The weed control treatments consisted of an unweeded control, 2,4-D (2,4-D [(2,4-dichlorophenoxy) acetic acid]) isooctylester (800 g a.i. ha^{-1}) and amine (1000 g a.i. ha^{-1}). The herbicides were applied with a portable knapsack sprayer at 400 l ha^{-1}. The treatment period was during the 3- to 4-leaf stage of the wheat when the weed seedlings were between the cotyledon and the four-leaf stages (Table 1) in 1990-1994. The weather was sunny and clear with no wind when the herbicides were applied. The foliage was dry and no rain fell within 24 h. All other cultivations, fertilizer usage, etc., were identical in all the plots.

Weed assessments

The number of weed seedlings that emerged from the natural seed bank of the field was determined before spraying. Furthermore, weed infestation was assessed 4 weeks after spraying and at harvest by determining the seedling numbers of weeds in two 1 m^2 circles per plot. The herbicide efficacy against all broad-leaved weeds and against the most common weed species was determined by comparing the number of weeds in untreated and treated plots.

Statistical analysis

The relative efficacy values were transformed with arcsin (√y) before the data were subjected to an analysis of variance. Statistical analyses were performed with MSTAT 1.4 (provided by the Knowledge Dynamics Corporation). Duncan's test was used to analyze mean differences between years.

Results and Discussion

Occurrence of weeds

At the time of treatment, the density of weeds in the untreated plots was 110.50 weeds per m^2 in 1990, 227.38 weeds per m^2 in 1991, 276.58 weeds per m^2 in 1992, 276.75 weeds per m^2 in 1993 and 241.06 weeds per m^2 in 1994. The most abundant weed species were *Polygonum aviculare*, *Amaranthus retroflexus and Chenopodium album* in the spring wheat.

Table 1. Application data from field trials with spring wheat in 1990-1994

	1990	1991	1992	1993	1994
Application date	25 JUN	18 JUN	25 JUN	15 JUN	22 JUN
Temperature (C°)	18.6	18.8	14.8	15.6	17.4
Relative humidity (%)	53	58.3	66.3	57.0	41.7
Days between					
Sowing/spraying	46	39	36	40	40
Spraying/assessment	31	29	30	35	32
	71	69	70	75	72
Precipitation (mm) between					
Sowing/spraying	60.99	59.89	88.43	96.32	66.37
Spraying/assessment	32.66	27.84	16.82	36.18	20.45
	36.46	42.44	31.32	49.78	34.35

Herbicide efficacy

It was determined that there were significant effects of the herbicide application against the weed population. The results of ANOVA are given in Table 2.

The effect of 2,4-D amine decreased in consecutive years (Tables 2 and 3) in *A. retroflexus, C. album, C. arvensis, A. repens, L. serriola, P. aviculare, C. arvense* and other broad-leaved weeds. There was an unchanged response with time in *S. arvensis* and *S. altissimum* (Table 3 and Fig. 1). There was a lower kill percentage in these weed species in the 3rd and 4th years of the experiment.

The effect of 2,4-D isooctylester decreased in consecutive years (Tables 2 and 4) in *A. retroflexus, C. album, C. arvensis, C. arvense, A. repens, L. serriola, P. aviculare* and other broad-leaved weeds, but the time response was not the same in *S. arvensis* and *S. altissimum* (Table 4 and Fig. 2). The resistance of *A. retroflexus* against 2,4-D isooctylester increased in the 4th year, and it increased in the last year for *C. album* (4th year), *C. arvensis* (3rd year), *C. arvense* (4th year), *L. serriola* (5th year), *P. aviculare* (4th year) and other broad-leaved weeds.

Schroeder *et al.* (5) reported that weeds such as *A. retroflexus, C. album, C. arvense, A. repens, C. arvense* and *P. aviculare* gain resistance against herbicides and, of these, *Cirsium arvense, P. aviculare* and *C. arvensis* are resistant against 2,4-D. There is also a danger of cross-resistance, which has been documented for several weed species, e.g. *Amaranthus retroflexus and Chenopodium album* (6).

Morphologically different varieties of *Cirsium arvense* have also been reported. In two studies, carried out in Montana (7) and Ontario (8), these different *C. arvense* varieties exhibited markedly different sensitivities to 2,4-D. Similarly, Whitworth (9) also documented intraspecific variations in sensitivity to 2,4-D in morphologically different strains of *Convolvulus arvensis* collected in Washington State. Beauge (10) reported a population of *C. album* that was resistant to 2,4-D.

The development of new herbicides is considerably hampered by high levels of investment and increasing safety demands, which may prevent the development of effective herbicides for minor crops. Finally, there is increasing public pressure to reduce the application of pesticides, because of health and ecological concerns.

Table 2. Repeated measurements and analysis of variance (ANOVA) of weed kill, Arcsin ($\sqrt{y}$), in sprayed plots in spring wheat. Trials were repeated over five years

Weed species	2,4-D Amine				2,4-D Isooctylester			
	Year		Block		Year		Block	
	F	P	F	P	F	P	F	P
Amaranthus retroflexus	194.52	0.000	2.38	0.155	26.70	0.000	3.23	0.094
Chenopodium album	234.37	0.000	0.33	0.731	12.16	0.002	0.24	0.793
Convolvulus arvensis	4.25	0.039	1.30	0.324	11.01	0.002	2.38	0.155
Cirsium arvense	2.54	0.122	0.55	0.596	10.46	0.003	0.41	0.679
Acroptilon repens	25.19	0.000	0.16	0.856	29.03	0.000	0.95	0.426
Sisymbrium altissimum	-		-		-		-	
Lactuca serriola	15.38	0.001	0.43	0.666	25.93	0.000	1.00	0.410
Sinapis arvensis	-		-		-		-	
Polgonum aviculare	3.11	0.081	0.47	0.641	19.34	0.000	0.69	0.529
Other broad-leaved weeds	8.69	0.005	1.74	0.236	16.57	0.001	0.74	0.507

Table 3. Effect of 2.4-D amine on broad-leaved weeds in spring wheat ower 5 years (1990-1994) (kill %)

Weed species	Years					SE**	LSD
	1990	1991	1992	1993	1994		
Amaranthus retroflexus	89.24 (70.89)*	77.82 (61.94)	73.70 (59.35)	29.30 (32.78)	28.64 (32.35)	1.27	6.05
Chenopodium album	100.0 (90.04)	99.25 (86.08)	99.45 (87.58)	34.01 (35.67)	30.23 (33.31)	1.91	9.08
Convolvulus arvensis	73.33 (63.87)	56.74 (48.89)	44.37 (41.78)	35.22 (36.42)	32.41 (34.70)	5.74	27.25
Cirsium arvense	66.67 (55.02)	67.06 (55.09)	63.65 (52.94)	60.03 (50.81)	49.44 (44.70)	2.70	12.79
Acroptilon repens	96.82 (84.04)	91.26 (72.84)	85.70 (67.96)	56.11 (48.57)	44.67 (41.95)	3.47	16.48
Sisymbrium altissimum	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)		
Lactuca serriola	99.00 (86.71)	99.00 (86.71)	91.00 (72.86)	77.30 (62.06)	58.33 (50.02)	4.06	19.27
Sinapis arvensis	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)		
Polgonum aviculare	80.32 (69.19)	69.40 (56.49)	63.55 (52.95)	55.87 (48.41)	35.27 (36.15)	6.82	32.37
Other broad-leaved weeds	96.97 (84.19)	93.94 (78.34)	83.33 (70.03)	64.58 (53.59)	50.37 (45.23)	5.58	26.50

LSD (P=0.01) values.

*Arcsin-transformed data in parentheses.

**SE= Standard Error

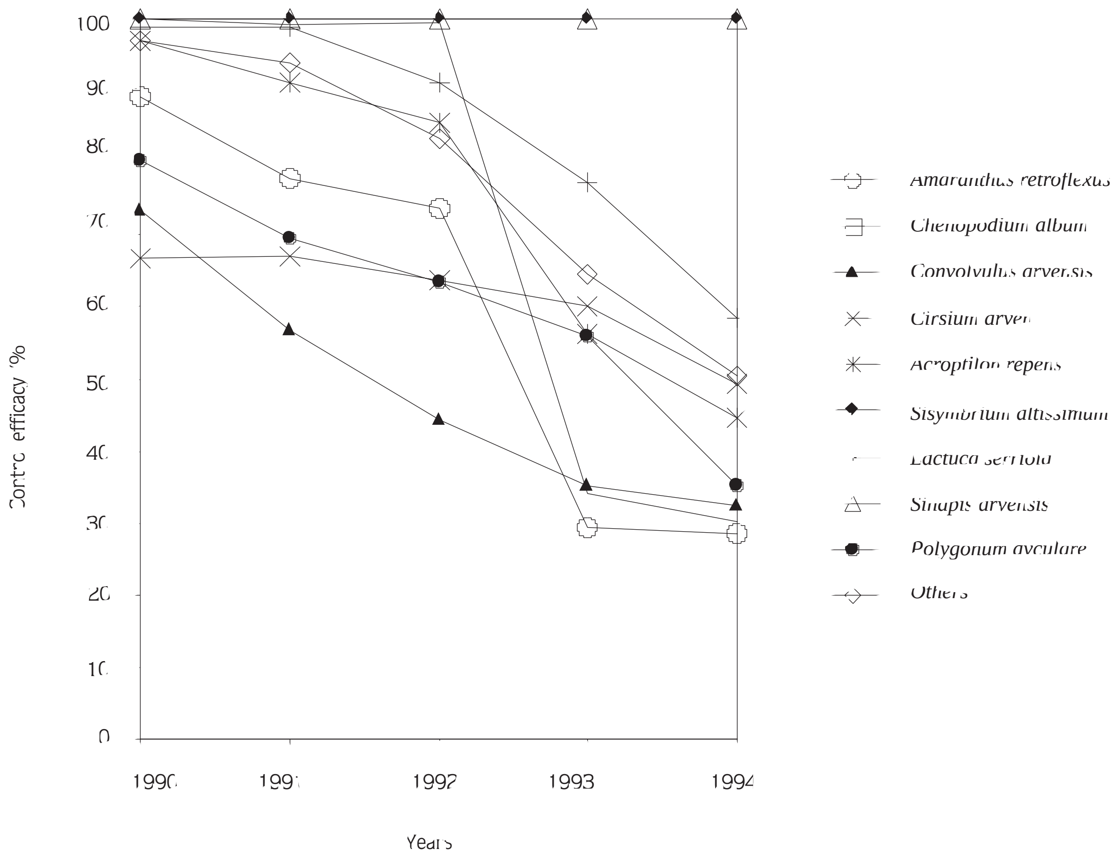

Figure 1. Effect of 2.4-D amine on broad-leaved weeds in spring wheat over 5 years (1990-1994) (kill %).

Table 4. Effect of 2,4-D isooctylester on broad-leaved weeds in spring wheat over 5 years (1990-1994) (kill %)

Weed species	Years					SE**	LSD
	1990	1991	1992	1993	1994		
Amaranthus retroflexus	99.86 (88.81)*	98.48 (83.30)	98.48 (83.30)	81.00 (65.33)	64.16 (53.46)	2.88	13.67
Chenopodium album	100.0 (90.04)	94.08 (76.79)	93.32 (75.97)	85.10 (67.94)	74.45 (59.66)	3.24	15.38
Convolvulus arvensis	78.69 (63.10)	64.76 (53.71)	56.48 (48.77)	52.44 (46.42)	44.41 (41.81)	2.45	11.62
Cirsium arvense	90.99 (75.66)	78.79 (62.80)	69.45 (56.52)	59.03 (50.32)	36.06 (36.88)	4.46	21.14
Acroptilon repens	96.97 (84.18)	89.95 (75.50)	61.11 (51.51)	50.05 (45.05)	43.80 (41.46)	3.55	16.85
Sisymbrium altissimum	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)		
Lactuca serriola	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	54.44 (47.91)	3.70	17.56
Sinapis arvensis	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)	100.0 (90.04)		
Polygonum aviculare	100.0 (90.04)	89.86 (74.73)	76.61 (61.27)	72.47 (58.38)	25.65 (29.45)	5.11	24.24
Other broad-leaved weeds	100.0 (90.04)	100.0 (90.04)	91.53 (76.14)	77.34 (61.71)	64.38 (53.69)	4.04	19.18

LSD (P=0.01) values.

*Arcsin-transformed data in parentheses.

**SE= Standard Error.

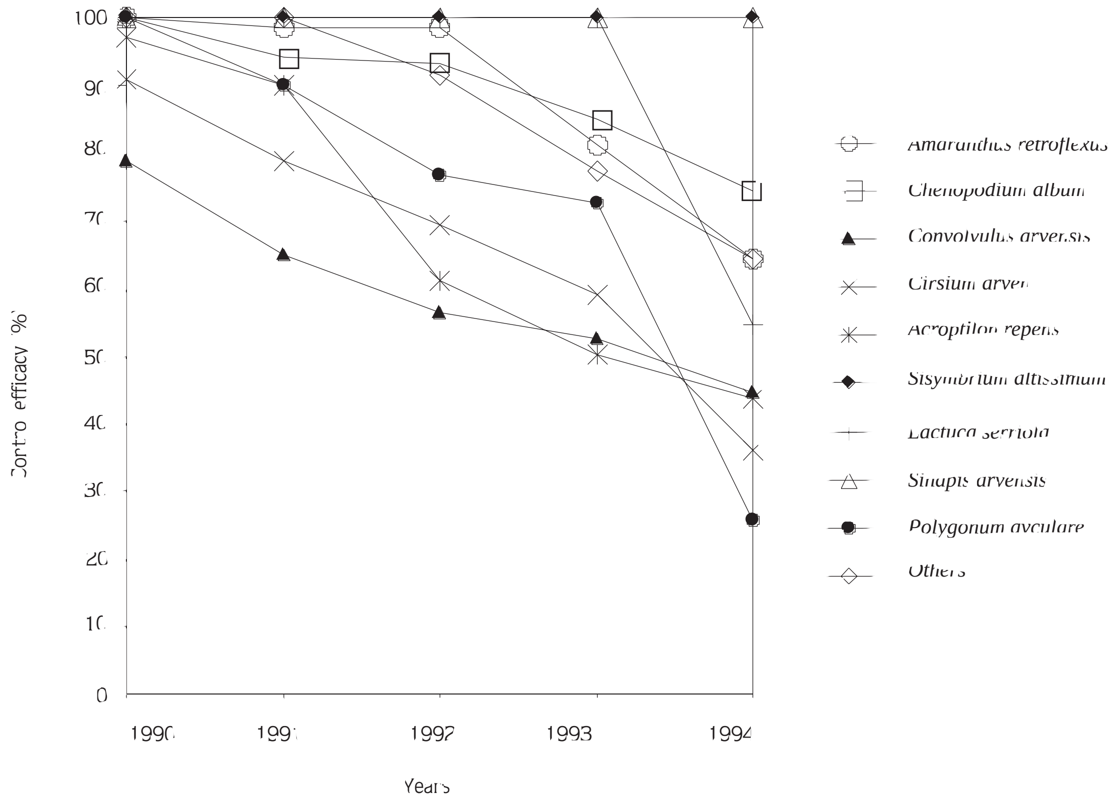

Figure 2. Effect of 2,4-D isooctylester on broad-leaved weeds in spring wheat over 5 years (1990-1994) (kill %).

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