Chapter 4. CHEMICAL INTERACTION BETWEEN FENOXAPROP AND FLUAZIFOP

Abstract: A high level of specificity must be exhibited by a herbicide in order to achieve selective control of bermudagrass in desirable turfgrass. Research has elucidated the superior effectiveness of a premix containing fenoxaprop plus fluazifop compared to the two herbicides applied individually in suppression of bermudagrass. However, little research has been conducted to determine the reasons for this response. The purpose of these experiments was to determine the interaction, if any, which occurs between fenoxaprop and fluazifop when applied in combination. Propagules of 'Midiron' and ''Tifgreen' bermudagrass obtained from mature stands located at the Virginia Tech Turfgrass Research Center (VTTRC) were placed in a greenhouse and maintained for eight weeks prior to treatment. Two tests for each cultivar were conducted to evaluate chemical activity. Herbicides were applied with a belt-sprayer at a delivery volume of 280 L/ha. Each of the cultivars were treated with two applications of fenoxaprop at 0.05, 0.10 and 0.20 kg ai/ha and fluazifop at 0.075, 0.15 and 0.30 kg ai/ha respectively. Studies were rated for bermudagrass control and percent cover on a biweekly basis until ten weeks after the second application (10 WAT). A combination or tank mix treatment of fenoxaprop (R+) and fluazifop was used at a 1:3 ratio (0.05 +0.15 and 0.10+0.30 kg ai/ha). Tifgreen percent green cover at 0.20 kg ai/ha was observed at 13% four weeks after the initial treatment with an expected value of 68% using Colby's method of analysis. Midiron percent cover was 1% with an expected value of 11%. A significant synergistic response was demonstrated at the 0.20 kg ai/ha rate of the mixture, where control at the 0.40 kg ai/ha rate of the mixture was so high that no significant differences could be observed. Tifgreen percent cover at the 0.20 kg rate four weeks after the second application was 4% with an expected value of 85%. Observations from these studies concluded that a synergistic relationship between fenoxaprop and fluazifop exists in control of both Tifgreen and Midiron bermudagrass cultivars.

Nomenclature: Bermudagrass (*Cynodon dactylon* 'Tifgreen I' and 'Midiron' (L.) Pers)*;* fenoxaprop [2-[4-(6-chloro-2-benzoxazobyl] oxy]phenoxy]propanoate]; fluazifop [2-[4-(5 trifluromethyl-2-pyridinyl)oxy] phenoxy]propionate]; chlorthalonil [tetrachloroisophthalonitrile]; brown patch (*Rhizoctonia solani* Kuhn); dollar spot *(Sclerotinia homeocarpa* F.T. Bennet); 2,4-D [(2,4-dichlorophenoxy) acetic acid]; and dicamba [3,6-dichloro-2-methoxybenzoic acid;. isoxaben N-[3-(1-ethyl-1-methylpropyl)-5-isoxazoyl]-2,6-dimethoxybenzamide.

4.1. INTRODUCTION

A high degree of chemical specificity is required to achieve selective control of bermudagrass in turf using postemergence applications (6, 7). In turf management, chemical specificity when using sequential applications is more relevant in minimizing non-target injury rather than in achieving higher levels of control (10). The premix formulation used in these studies contained fenoxaprop [2-[4-(6-chloro-2-benzoxazobyl]oxy]phenoxy]propanoate] plus fluazifop [2-[4-(5 trifluromethyl-2-pyridinyl)oxy] phenoxy]propionate]. An abundant amount of research has been conducted regarding both chemicals individually, but only minimal research regarding their joint application has been conducted. Research has elucidated that a synergistic response occurs when these two compounds are jointly applied (2, 3, 4, 5, 7).

Interaction of agrochemicals with one another can be beneficial and can include increased weed control, decreased usage rates, and diminished toxicity on non-target plant (13, 18, 19). The three relative terms used to discuss effects of herbicide combinations versus individual applications are synergism, additivity and antagonism (1 ,13, 16, 19). Since 1964, when P.M. Tammes (19) first defined synergy as “The cooperative action of two components of a mixture such that the total effect is greater or more prolonged than the sum of the effects of the two taken individually,” a significant debate has ensued between plant scientists over the interpretation of the true properties of chemical interaction (11, 13, 15, 16). Conclusions about the existence or absence of interaction's between two agrochemicals must be based on an appropriately devised reference model (11, 18).

4.2. MATERIALS AND METHODS

In 1994 and 1995 greenhouse studies were conducted to determine the degree, if any, of interaction between fenoxaprop and fluazifop when applied jointly for control of bermudagrass. Experiments were performed on *Cynodon dactylon* (L.) Pers. 'Midiron' and 'Tifgreen I' Both of the turfgrasses were harvested from a well established stand of bermudagrass at the Virginia Tech Turfgrass Research Center (VTTRC). A standard 10 cm cup cutter was used to obtain the bermudagrass plugs, which were cut at a depth of 15 cm. The plugs were then placed in 15cm plastic pots to be propagated in the greenhouse. The soil in the plugs was a Groseclose-Poplimento-Duffield with a pH of 7.1 and an organic matter content of 4.0%. Medium containing a 50/50 mixture of Pro-mix[1] and sterilized soil were used to fill the remaining space in the pots.

The bermudagrass plugs were irrigated daily . A 20-20-20 liquid fertilizer[2] at .10 kg N/1000 ft^2 was applied on a biweekly basis. 2,4-D [(2,4-dichlorophenoxy) acetic acid] at 0.6 kg ai/ha, dicamba[3,6-dichloro-2-methoxybenzoic acid] at 0.3 kg ai/ha and isoxaben [N-[3-(1-ethyl-1-methylpropyl)-5-isoxazoyl]-2,6-dimethoxybenzamide], at 0.84 kg ai/ha were used to control broadleaf weeds in each experiment six weeks prior to the first treatment. Chlorthalonil [tetrachloroisophthalonitrile] at 6.72 kg ai/ha was used on an as needed basis to control brown patch (*Rhizoctonia solani* Kuhn) and dollar spot *(Sclerotinia homeocarpa* F.T. Bennet). Pesticides and fertilizers used for routine turf maintenance were applied to the pots using a CO_2 back pack sprayer with a pressure of 210kPa, using 8004 flat fan nozzle tips[3] to apply 280 L/ha. Plants were grown under high intensity sodium lights to maintain constant day length interval of 16 daylight hours throughout the study period.

Tests were arranged in a randomized complete block design with four replications and repeated. The chemical treatments of fenoxaprop and fluazifop were applied using a belt sprayer set at 280 L/ha using 80015E tips. Herbicide rates were selected by calculating the individual rates present in the 0.10, 0.20, 0.40 kg ai/ha rates of the pre-mix formulation. Fenoxaprop at 0.05, 0.10, and 0.20 kg ai/ha and fluazifop at 0.075, 0.15, and 0.30kg ai/ha were applied individually and in combination (2, 9). The fenoxaprop active ingredient used in these experiments was the isolated single (R+) isomer. Other formulations contain multiple isomers of fenoxaprop. Research has elucidated this single isomer form to be equally effective at half the chemical rate of the multiple isomer formulations (12, 14). All chemical treatments were applied with 0.25% v/v nonionic surfactant[4].

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[2] E. C. Geiger, Inc., PO Box 285, Harleysville, PA 19438

[3] Spraying Systems Inc., North Ave., Wheaton, IL 60197-7900

[4] Kinetic, Helena Chemical Co., 6075 Poplar Avenue, Memphis, TN

Visual estimations of bermudagrass control, injury, and percent cover were taken on biweekly intervals until eight weeks after the second herbicide treatment was applied. Each pot was rated as a direct comparison to the control pot in the same replication.

Turf injury was rated on a 0 to 10 scale. The numeric values indicate the following:

0	no apparent injury to turfgrass
1 to 3	slight injury, acceptable color, very little discoloration
4 to 6	definite turfgrass injury, noticeable discoloration and/or phytotoxicity
7 to 9	unacceptable injury to serious injury
10	dead and brown turfgrass

Bermudagrass control was rated on a 0 to 100 scale. The numeric values indicate the following:

0	no apparent response
10 to 30	slight control or injury, light green to discoloration
40 to 60	poor to fair control, minimal suppression, green shoot number reduced
70 to 80	fair to good control, moderate suppression in green shoot size and number
80 to 90	good weed control, severe green shoot suppression and phytotoxicity or necrosis
90 to 99	excellent weed control, few remaining green shoots
100	complete control of targeted weed

Bermudagrass percent cover is rated as a percentage of green bermudagrass in the plot being observed. Percent cover was used as an indicator of rhizome regrowth which would correlate with rhizome control. Shoot emergence over time to increase percent cover would occur from rhizomes therefore percent groundcover can be used as a visual representation of rhizome suppression and/or control.

Both tests of each bermudagrass cultivar were combined after a homogeneity test was performed which indicated an acceptable variance. Data were treated as one randomized complete block and analyzed. Data were subjected by analysis of variance and means were separated using Fisher's protected least significance difference with a 0.05 significance level. The method described by Colby (1967) (8) was used to calculate interactions of herbicide tank mixtures. Synergistic or antagonistic interactions were determined when the observed response to the herbicide combination was significantly different from the expected response according to Fisher's protected least significant difference test at a 0.05 significance level. When the expected and observed value were not significantly different, the herbicide combination was declared additive (8).

4.3. RESULTS AND DISCUSSION

The rating system used was based on visual injury and percent green bermudagrass on the surface of the plugs. Bermudagrass cover was used to compare the treatments using Colby's method. Two applications of the mixture at a 1:3 ratio of fenoxaprop to fluazifop (0.05+ 0.15 and 0.10+0.30 kg ai/ha) at 0.20 kg ai/ha or 0.40 kg ai/ha were needed to prevent any regrowth from occurring prior to or at the 70 DAT evaluation. Bermudagrass green cover at two weeks after the initial application displayed 40-60 % lower green cover than the expected results calculated using Colby's method (Table 41. and 4.2). Shoot control levels of Tifgreen and Midiron were high at two weeks after the second application with 9% Tifgreen and 10% Midiron at the 0.20 kg ai/ha rate of the herbicide treatment with an expected value of 26% and 13% respectively (Table 4.5 & 4.6). The substantial differences between the expected results and the observed results in percent cover of both bermudagrasses four weeks after the first and second applications demonstrates the significant interaction which occurred between fenoxaprop and fluazifop.

Tifgreen percent cover at 0.20 kg ai/ha was 13% four weeks after treatment with an excepted percent cover of 68%. Midiron percent cover was 14% with an expected value of 36% (Tables 4.3 & 4.4). Tifgreen percent cover four weeks after the second application was 4% with an expected value of 85% while Midiron percent cover was 1% with an expected value of 11% respectively (Table 4.7 & 4.8). After determining the expected values of bermudagrass cover from the individual treatments in the joint application and comparing them to the actual observed effects a positive or synergistic chemical interaction was apparent. Fenoxaprop and fluazifop seem to act together in some manner to increase efficacy in terms of bermudagrass control. The actual levels of bermudagrass cover are much lower than the calculated expected levels from the individual treatments (Table 4.1-4.8). The higher rates of the mixture (i.e. 0.20 & 0.40 kg ai/ha) do not display a significant difference in control due to the high level of control with fluazifop; however, regrowth occurred much quicker in the individual treatments than in the combination treatment.

Table 4.1.

Midiron bermudagrass percent cover (0-100 %) at two weeks after initial treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	97	90	86
0.075	78	30*b (76)a	24* (72)	24 (24)
0.15	79	16*	10*	26
0.3	30	20 (29)	18 (28)	16 (27)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.2.

Tifgreen I bermudagrass percent cover (0-100 %) at two weeks after initial treatment

	Fenoxaprop ---kg ai/ha---			
	0	0.05	0.1	0.2
Fluazifop --kg ai/ha--				
0	100	97	98	84
0.075	66	19*b (64)a	11* (59)	25 (55)
0.15	42	33* (41)	6* (41)	55* (35)
0.3	16	19 (16)	15 (14)	5 (13)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.3.

Midiron bermudagrass percent cover (0-100 %) at four weeks after initial treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	97	90	86
0.075	31	7*b (31)a	16* (28)	11 (27)
0.15	36	14* (36)	15* (32)	23 (31)
0.3	8	6 (14)	9 (13)	9 (12)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.4.

Tifgreen I bermudagrass percent cover (0-100 %) at four weeks after initial treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	97	98	92
0.075	81	34*b (79)a	7* (79)	11 (75)
0.15	70	13* (68)	3* (69)	15* (64)
0.3	9	8 (9)	10 (9)	1 (8)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.5.

Midiron bermudagrass percent cover (0-100 %) at two weeks after second treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	88	91	63
0.075	34	7*b (30)a	11* (31)	8* (21)
0.15	15	10* (13)	9* (14)	14* (9)
0.3	8	7 (7)	7 (7)	2 (5)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.6.

Tifgreen I bermudagrass percent cover (0-100 %) at two weeks after second treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	85	72	65
0.075	45	18*b (38)a	4* (32)	4* (29)
0.15	31	9* (26)	4* (22)	5* (20)
0.3	11	2 (9)	3 (8)	0 (7)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.7.

Midiron bermudagrass percent cover (0-100 %) at four weeks after second treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	98	100	85
0.075	43	10*b (42)a	3* (43)	0 (37)
0.15	11	1 (11)	2 (11)	0 (9)
0.3	2	4 (2)	3 (2)	0 (2)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

Table 4.8.

Tifgreen I bermudagrass percent cover (0-100 %) at four weeks after second treatment

	Fenoxaprop			
	0	0.05	0.1	0.2
	---kg ai/ha---			
Fluazifop				
--kg ai/ha--				
0	100	100	100	100
0.075	78	62*b (78)a	7* (78)	3* (78)
0.15	85	4* (85)	8* (85)	3* (85)
0.3	3	2 (3)	0 (3)	0 (3)

LSD (0.05)= 24.1

b An asterisk denotes synergism according to Colby 1967.
a Expected percent cover value using Colby's method procedure

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DISCUSSION

Fenoxaprop and fluazifop demonstrated a significant amount of synergism when applied in combination . Reduction in tall fescue injury at equal rates of fluazifop within combination treatments when compared to individual treatments was just as apparent, as were concurrent increases in bermudagrass control with the combination treatments. The combination treatment is ideal in that it seems to produce an antagonistic reaction in tall fescue injury and a synergistic reaction in bermudagrass control, thereby increasing weed control and decreasing crop injury.

VITA

Michael Dale Johnson was born to Linda Jane and Larry Dale Johnson on January 3, 1971 in Lynchburg, Virginia. Growing up in Lynchburg and Smith Mountain Lake he attended Brookville School District in Campbell County. Upon graduating from high school in 1989, he entered VPI &SU, and in 1993 received a B.S. in Crop Soil and Environmental Science. Throughout high school and college breaks he worked for Ralph Firebaugh constructing golf courses in central Virginia. In August of 1993, he began his masters studies in Department of Plant Physiology, Pathology and Weed Science at Virginia Polytechnic Institute and State University under the direction of Dr. S. Wayne Bingham.

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