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RESPONSE OF ANNUAL WEED SPECIES TO ATRAZINE-BASED HERBICIDES IN MAIZE

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ABSTRACT.

The response of weed species to preemergence applications of five rates (0.54, 0.81, 1.08, 1.34, and 1.61 kg/ha) of atrazine plus isoxaflutole (Atoll®) mixture was investigated during 2000 and 2001 cropping seasons. Primextra applied at 2.5 kg a.i./ha and atrazine plus Stomp applied at 1.25 + 0.83 kg a.i./ha were the checks in 2000 while 2.5 kg a.i./ha Atrazine SC (Soluble Concentrate) and 2.0 kg a.i./ha Atrazine WP (Wettable Powder) were also included as checks in 2001. Treatments were replicated four times in a randomized complete block design. Adequate level of weed control was exhibited in the weed densities of Atoll® treatments in all locations although these were comparable to weed densities in atrazine and its mixtures. Exceptions were found in Ilorin site in 2000. Weed biomass of herbicide treatments were similar in their respective sites. Most annual grasses and broadleaves encountered at the three sites were controlled except itchgrass in Ilorin. *Bracharia deflexa* population was reduced by 86 – 93% with Atoll treatments in 2000 at Ilorin. Atoll® treated plots reduced *Euphorbia heterophylla* population by 30 – 78% in Orin-Ekiti in 2000. While *E. heterophylla* declined in abundance by 56 – 92% in 0.54 and 0.81 kg a.i./ha, it was totally eliminated in 1.08 to 1.61 kg a.i./ha Atoll treatments in 2001.

KEYWORDS: Atoll, atrazine, isoxaflutole, maize, weed control, *Euphorbia heterophylla*

INTRODUCTION

Weed infestation is a major crop production constraint in southwestern Nigeria (Ayeni, 1991). The most important weeds of maize production are annual weeds and these often emerge with the crop. Weeds emerging with the crop are more competitive than those emerging later in the season (Bensch *et al.*, 2003). Therefore, their timely control is very essential in preventing early weed-crop competition, which often results in yield loss. Weed competition may cause reductions of 40 to 60% in maize grain yield (Lagoke *et al.*, 1981). The use of s-triazine herbicides, most especially atrazine and its formulated mixtures for weed control has been known for a few decades in maize production (Akobundu, 1987; Davelouis-McEnvoy and Valdez Marin, 1972; NACWC, 1994). Atrazine controls seedling grasses and broadleaves. However, environmental restriction on atrazine in several developed countries has led to increasing interest in isoxaflutole herbicide for weed control in maize.

Isoxaflutole {5-cyclopropyl-4-isoxazolyl [2-(methylsulfonyl)-4-(tifluoromethyl)-phenyl] methanone} is a systemic preemergence herbicide for broad-spectrum weed control in maize. It is a new herbicide of the isoxazole family. It is attractive because of its low use rates (Luscombe *et al.*, 1994; Vrabel *et al.*, 1995) and has the potential for usage in no-tillage corn to control weeds prior to planting and provide residual control of future emerging weeds (Vrabel *et al.*, 1996). Atoll® is a proprietary formulation of Rhône-Poulenc Agriculture Limited containing atrazine plus isoxaflutole. The objective of this research is to determine the response of annual weed species to atrazine plus isoxaflutole herbicide mixture in the forest (Orin-Ekiti), southern Guinea savanna (Ilorin) and derived savanna (Ibadan) ecologies of southwestern Nigeria.

MATERIALS AND METHODS

This study was conducted in the year 2000 and 2001 at Ilorin, Ibadan and Orin-Ekiti stations of the Institute of Agricultural Research and Training, Moor-Plantation. Land preparation entailed a disc plough and harrow. Formulated mixture of atrazine plus isoxaflutole (Atoll) was applied pre-emergence at five rates (0.54, 0.81, 1.08, 1.34, and 1.61 kg/ha). Atrazine plus metolachlor (Primextra) at 2.5 kg a.i./ha, and atrazine plus Stomp (pendimethalin) at 1.25+0.83 kg a.i./ha were included as checks. Atrazine SC (Soluble Concentrate) at 2.5 kg a.i./ha, Atrazine WP (Wettable Powder) at 2.0 kg a.i./ha were included only in 2001. There were eleven treatments with handweeded {at 3 and 6 weeks after sowing (WAS)} and weedy controls inclusive. Treatments were replicated four times in a randomized complete block design. Maize (variety, DMR-ESR-Y), was sown in 6 m x 5 m plots at a spacing of 90 cm x 40 cm. Seeds were sown on August 10 at Ilorin, September 25 at Ibadan, August 15 at Orin-Ekiti in 2000; and June 12 at Ilorin, July 16 at Ibadan, May 31 at Orin-Ekiti in 2001. Herbicides were applied with a CP 15 knap-sack sprayer calibrated to deliver 200 l/ha spray solution the same day seeds were sown.

Weed control treatments were assessed by weed density and weed biomass. Weeds were sampled in each plot at 6 WAS using a 50 cm x 50 cm quadrat. Weeds were identified by species for each treatment, counted, harvested and oven-dried at 80°C until a constant weight is obtained. Annual weed species collected were grouped into broadleaves and grasses and the percentages were calculated relative to the weedy check. The General Linear Model (GLM) procedure of Statistical Analysis System (SAS Institute, 1989) was used to conduct the Analysis of Variance (ANOVA) for the data. Duncan Multiple Range Test was used to separate differences between treatment means where ANOVA indicated the presence of such difference at 5% level of significance.

RESULTS AND DISCUSSION

Weed density and biomass were affected by herbicide treatments and year. The prevalent weeds at the three experimental sites are shown in Table 1. *Bracharia deflexa, Digitaria horizontalis, Commelina benghalensis, and Cyperus* spp. were common to all locations. Weed infestation varied considerably between years and locations. Weed densities of herbicide treatments were not significant at Ilorin site in 2000 (Table 2). Also, in 2001, weed densities of Atoll treatments at Ilorin site were not better than other herbicide treatments. Atoll treatments applied at 1.08 to 1.61 kg a.i./ha had comparable weed densities to handweeding at Ibadan site in 2000 (Table 2), while a better level of weed control was recorded in 0.81 to 1.61 kg a.i./ha Atoll treatments than the weedy check in 2001. Weed infestation at Orin-Ekiti site was significantly reduced ($p=0.05$) in 1.08 to 1.61 kg a.i./ha Atoll treatments when compared to 1.25 + 0.83 kg a.i./ha atrazine plus Stomp, 2.5 kg a.i./ha Primextra and the weedy check in 2000. Weed densities of all herbicide treatments were not

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different in 2001 because the weed pressure was considerably reduced. Atrazine SC applied at 2.5 kg a.i./ha gave the lowest weed density in Orin-Ekiti and this was significantly different (p=0.05) from handweeding and weedy check.

There was no significant difference among the weed biomass of various herbicide treatments at Ilorin in 2000 (Table 3). Also in 2001, all Atoll treatments, atrazine plus Stomp and Primextra had no significant effect on total weed biomass in Ilorin. This is because while the population of annual broadleaves and grasses were reduced by the treatments, the perennial weeds encountered in this location remained uncontrolled. In Ibadan, 0.81 to 1.61 kg a.i./ha Atoll treatments had significantly lower (p=0.05) weed biomass than Primextra in 2000 (Table 3). All herbicide treatments and handweeding had significantly lower (p=0.05) weed biomass than the weedy check in Ibadan in 2001. At Orin-Ekiti, weed biomass of the herbicide treatments were not significantly different in 2000. Weed biomass of Atoll treatments were significantly lower than those of the weedy check while atrazine and its mixtures were not in 2001.

Control of broadleaf and grass species found in association with maize cultivation at the three sites were presented in Tables 4 to 6. Weed species at the three sites were mostly annuals. The Ilorin site, in 2000, had a total of 16 broadleaves and 9 grass species which were reduced by the herbicide treatments to 5 broadleaves and 5 grass species in 2001. The most prominent of the grass weeds were *Bracharia deflexa, Digitaria horizontalis and Rottboellia cochinchinensis* (itchgrass). These grasses except itchgrass were adequately controlled by the herbicides. Stomp contains pendimethalin which is a grass killer known to suppress itchgrass. This explains why in 2000 its mixture with atrazine gave an excellent weed control of 91%, a value that is much better than other herbicide treatments (Table 4). Most annual weeds that occurred in 2000 were controlled, hence, itchgrass increased in importance. This resulted in very poor control of grass weeds in 2001 with exceptions in atrazine plus pendimethalin mixture where weed control was 89% (Table 4).

Adequate weed control was achieved in Ibadan site in 2000 through 2001 where broadleaf and grass weed control were ≥72% and 62% respectively (Table 5). Sedge was not controlled in both years. The occurrence of *Oldenlanuia corymbosa* and *Bracharia deflexa* was restricted to the weedy checks in the two seasons. With the exception of the sedges, *Cyperus* spp. and *Panicum maximum* no other weed resisted control in this site. Concentrations of Atoll were as good as the herbicide formulations already in use in maize cultivation.

Total broadleaf control in 2000 was between 55 to 85% in Atoll treatments while no control was recorded in atrazine plus Stomp and Primextra in Orin-Ekiti site (Table 6). There was an improved broadleaf weed control which ranged from 58 to 93% in 2001. Contrary to the results obtained in 2000, atrazine alone or its tank mixes had 60 to 69% broadleaf weed control. Lingenfelter et al. (2002) have shown that isoxaflutole provided effective control of many common annual broadleaves such as pigweed species (*Amaranthus hybridus* and *A. retroflexus*), and common ragweed (*Ambrosia artemisifolia*). The control of these weed species improved at the higher use rate compared to the lower rates. Generally, poor control of grass weeds was observed in the Orin-Ekiti site. The control of broadleaf weeds increased as the concentration of Atoll increased. The high grass weed control, 82% in 2000 and 100% in 2001, observed in atrazine plus Stomp treatment in Orin-Ekiti resulted from the grass killer in the mixture. *Pennisetum purpureum* (elephant grass) was largely responsible for the very poor grass control in Primextra treatment. The herbicides applied could not control perennial weeds hence the poor performance where they occurred. *Euphorbia heterophylla* (milkweed) was the most abundant broadleaf in Orin-Ekiti. Earlier researches reported its resistance to the preemergence s-triazines and urea derivatives (Vidal *et al*, 1997; Garson and Vicente Lazo, 1996; Akinyemiju, 1992; Akobundu, 1987; Davelouis-McEnvoy and Valdez Marin, 1972) used for broadleaf weed control in maize production. In this study, *E. heterophylla* population was reduced by 30 – 78 % in Atoll treated plots in 2000. During 2001, the population was further reduced by 56 – 92% in 0.54 to 0.81 kg a.i./ha while it was eliminated from 1.08 to 1.61 kg a.i./ha Atoll treatments. *Ageratum conyzoides* constituted no menace in maize as all the herbicides used gave excellent control when compared to the density of 35 plants/ m^2 obtained in the weedy check.

Table 1: Predominant weed species of the experiment sites.

Weed species	Life cycle	Morpho-logical group	Family	Occurrence		
				Ilorin	Ibadan	Orin Ekiti
Ageratum conyzoides L.	A	B	Asteraceae	No	Yes	Yes
Bracharia deflexa (Schumach.) C. E. Hubbard	A	G	Poaceae	Yes	Yes	Yes
Cleome viscosa L.	A	B	Cleomaceae	Yes	No	No
Commelina benghalensis L.	A	-	Commelinaceae	Yes	Yes	Yes
Cyperus esculentus L.	P	S	Cyperaceae	No	Yes	Yes
Cyperus rotundus L.	P	S	Cyperaceae	Yes	Yes	No
Digitaria horizontalis Willd	A	G	Poaceae	Yes	Yes	Yes
Euphorbia heterophylla L.	A	B	Euphorbiaceae	No	No	Yes
Lactuca teraxacifolia (Willd.) Schum.	A	B	Asteraceae	No	No	Yes
Mariscus umbellatus Vahl.	P	S	Cyperaceae	No	No	Yes
Panicum maximum Jacq.	P	G	Poaceae	No	Yes	No
Pennisetum purpureum Schum.	P	G	Poaceae	No	Yes	Yes
Rottboellia cochinchinensis (Lour) Clayton	A	G	Poaceae	Yes	No	No

A= Annual P= Perennial B= Broadleaf G= Grass S= Sedge

Table 2. Effect of herbicide treatments on weed density 6 WAS.

Treatment (kg/ha)[a]	Ilorin		Ibadan		Orin-Ekiti	
	2000	2001	2000	2001	2000	2001
			no/m^2			
0.54 Atoll	19.8 b	8.8 bcd	27.8 ab	44.0 bc	28.0 ab	18.5 bc
0.81 Atoll	20.3 b	10.3 bcd	25.3 ab	8.0 bc	29.8 ab	14.3 bc
1.08 Atoll	16.8 b	16.3 ab	24.8 bc	5.0 c	18.8 b	12.3 bc
1.34 Atoll	14.3 b	13.8 abc	18.8 bc	11.0 c	13.8 b	10.5 bc
1.61 Atoll	13.5 b	7.3 cd	25.2 bc	8.0 c	22.5 b	11.0 bc
2.5 Atrazine SC	-	6.0 cd	-	18.0 bc	-	3.8 c
2.0 Atrazine WP	-	8.8 bcd	-	13.0 bc	-	10.3 bc
1.25+0.83 atrazine + Stomp	16.0 b	5.3 cd	22.5 bc	63.0 b	56.5 a	16.8 bc
2.5 Primextra	19.5 b	3.3 d	13.0 bc	18.0 bc	60.8 a	18.0 bc
Handweeded check	21.3 b	6.5 cd	11.8 c	12.0 bc	35.5 ab	24.8 ab
Weedy check	54.3 a	22.0 a	41.0 a	197.0 a	60.0 a	36.3 a

Means followed by the same letter within a column are not significantly different at 5% level using DMRT.
a – Atoll is a proprietary formulation of Rhône-Poulenc containing 37.5 g/l isoxaflutole and 500 g/l atrazine

Table 3. Effect of herbicide treatments on weed biomass 6 WAS.

Treatment (kg/ha)[a]	Ilorin		Ibadan		Orin-Ekiti	
	2000	2001	2000	2001	2000	2001
				no/m^2		
0.54 Atoll	40.25 ab	19.64	35.86 ab	8.78 b	71.90 a	4.86 c
0.81 Atoll	71.47 a	28.11	26.60 bc	4.11 b	17.97 bc	11.48 bc
1.08 Atoll	69.81 a	23.82	27.01 bc	1.96 b	57.87 ab	10.02 bc
1.34 Atoll	28.15 ab	10.58	28.50 bc	1.61 b	12.76 bc	11.00 bc
1.61 Atoll	60.27 a	11.20	28.01 bc	0.42 b	71.95 ab	7.64 bc
2.5 Atrazine SC	-	22.72	-	3.14 b	-	12.17 abc
2.0 Atrazine WP	-	20.58	-	3.49 b	-	17.30 abc
1.25+0.83 atrazine + Stomp	39.85 ab	12.08	31.01 bc	11.56 b	41.95 ab	12.58 abc
2.5 Primextra	76.31 a	26.34	70.12 a	2.36 b	63.94 ab	18.49 ab
Handweeded check	17.80 b	15.67	6.32 c	2.24 b	12.30 c	8.15 bc
Weedy check	63.04 a	24.28	52.93 ab	90.13 a	76.63 a	21.41 a
		NS				

Means followed by the same letter within a column are not significantly different at 5% level using DMRT.
NS = not significant
a – Atoll is a proprietary formulation of Rhône-Poulenc containing 37.5 g/l isoxaflutole and 500 g/l atrazine

Table 4: Effect of herbicide treatments on weed species 6 WAS in Ilorin.

Treatments kg a.i./ha	2000				2001			
	Broadleaf	Grass	*Bracharia deflexa*	*Digitaria horizontalis*	Broadleaf	Grass	*Bracharia deflexa*	*Digitaria horizontalis*
	% Control		no/m^2		% Control		no/m^2	
0.54 Atoll[a]	94	62	3	4	100	37	0	0
0.81 Atoll	100	69	0	0	100	29	0	0
1.08 Atoll	87	72	3	0	98	0	0	0
1.34 Atoll	95	56	2	0	100	29	0	1
1.16 Atoll	98	75	3	0	100	44	0	0
2.5 Atrazine SC	-	-	-	-	100	15	0	2
2.0 Atrazine WP	-	-	-	-	96	0	3	0
1.25+0.83 Atrazine + Stomp	100	91	0	1	98	89	0	0
2.5 Primextra	94	73	0	0	10	63	0	0
Handweeding	100	100	0	2	100	100	0	0
Weedy check	0	0	23	8	0	0	0	3

a – Atoll is a proprietary formulation of Rhône-Poulenc containing 37.5 g/

Table 5: Effect of herbicide treatments on weed species 6 WAS in Ibadan.

Treatments kg a.i./ha	2000				2001			
	Broadleaf	Grass	*Oldenlandia corymbosa*	*Bracharia deflexa*	Broadleaf	Grass	*Oldenllandia corymbosa*	*Bracharia deflexa*
	% Control		no/m^2		% Control		no/m^2	
0.54 Atoll[a]	97	72	0	0	79	86	0	0
0.81 Atoll	82	96	0	0	100	93	0	0
1.08 Atoll	97	93	0	0	98	100	0	0
1.34 Atoll	100	79	0	0	99	93	0	0
1.16 Atoll	100	93	0	0	99	100	0	0
2.5 Atrazine SC	-	-	-	-	98	86	0	0
2.0 Atrazine WP	-	-	-	-	100	86	0	0
1.25+0.83 Atrazine + Stomp	94	79	0	0	72	100	0	0
2.5 Primextra	100	62	0	0	96	100	0	0
Handweeding	100	100	0	0	100	100	0	0
Weedy check	0	0	6	4	0	0	25	2

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Table 6: Effect of herbicide treatments on weed species 6 WAS in Orin-Ekiti.

Treatments kg a.i./ha	2000				2001			
	Broadleaf	Grass	Milkweed	Goatweed	Broadleaf	Grass	Milkweed	Goatweed
	% Control		no/m^2		% Control		no/m^2	
0.54 Atoll[a]	59	23	40	0	58	33	28	0
0.81 Atoll	55	65	45	1	81	0	5	0
1.08 Atoll	80	47	21	0	92	0	0	0
1.34 Atoll	85	59	14	0	93	17	0	0
1.61 Atoll	72	47	29	0	92	83	0	0
2.5 Atrazine SC	-	-	-	-	69	50	17	0
2.0 Atrazine WP	-	-	-	-	68	17	13	0
1.25+0.83 Atrazine + Stomp	0	82	106	1	66	100	18	0
2.5 Primextra	0	6	104	3	60	0	27	0
Handweeding	100	100	0	0	100	100	0	0
Weedy check	0	0	65	35	0	0	63	27

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CONCLUSION

Atoll is as effective as the conventional herbicides already in use for annual weed control in maize. However, it has a major breakthrough in the control of *E. heterophylla* that has defied all chemical weed control in maize cultivation in southwestern Nigeria.

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