J. Aquat. Plant Manage. 18: 6-9

Effects of Low Concentrations of Terbutryn on *Myriophyllum* and *Cabomba*[1]

DONALD N. RIEMER

Associate Professor and Chairman
Department of Soils and Crops
New Jersey Agricultural Experiment Station
New Brunswick, NJ 08903

and

J. RICHARD TROUT

Associate Professor and Chairman
Department of Statistics and Computer Sciences
New Jersey Agricultural Experiment Station
New Brunswick, NJ 08903

ABSTRACT

In experiments performed in the field in large tanks and in the laboratory, 2-(tert-butylamino)-4-(ethylamino)-6-(methyl-thio)-*s*-triazine (terbutryn) concentrations between 0.05 and 0.20 ppmw reduced growth and vigor of broadleaf watermilfoil (*Myriophyllum heterophyllum* Michx.) and cabomba (*Cabomba caroliniana* Gray). In almost every case, however, the lowest concentration used (0.05 ppmw) produced greater effects than the next two higher concentrations (0.10 and 0.15 ppmw).

INTRODUCTION

Symmetrical triazines have long been known to be effective aquatic herbicides. One of them, 2-chloro-4,6-bis (ethylamino)-*s*-triazine (simazine), is registered for aquatic use in the United States. Recently there has been some interest in the development of terbutryn as an aquatic herbicide. Preliminary experiments by the senior author (unpublished), showed that terbutryn is herbicidally active at much lower rates of application than simazine. The same experiments indicated that the response of test plants was not proportional to dosage at the lower rates of application.

Two experiments were conducted to verify these observations. One was conducted in the field in 765 l stock-watering tanks. The objectives of this experiment were (1) to determine the effects of low concentrations of terbutryn on broadleaf watermilfoil and cabomba, (2) to determine the relationship between rate of application and plant response, and (3) to determine the relationship between exposure time of plant to herbicide and plant response.

The second experiment was conducted in the laboratory to further verify the relationship of plant response to dosage rate.

[1]Paper of the Journal Series, New Jersey Agricultural Experiment Station, Cook College, Rutgers—The State University of New Jersey. This work was performed as part of NJAES Project No. 144 with Hatch funding.

METHODS AND MATERIALS

In the field study, apical cuttings of cabomba and broadleaf watermilfoil (10 cm long) were planted in 5 cm diameter pots and placed in 765 l stock-watering tanks filled with pond water and located under a shade house (40% shade). Twenty-five cuttings of each species were placed in each of five tanks. After 24 days, during which the cuttings became well rooted, four of the tanks were treated with terbutryn at rates of 0.05, 0.10, 0.15 and 0.20 ppmw of active ingredient. The fifth tank served as a control.

After exposure times of 2, 6, 10, and 14 days, five plants of each species were removed from each of the treated tanks and placed in tanks of fresh, untreated pond water. This resulted in a 2 x 4 x 4 factorial design with 2 species of plants, 4 concentrations of terbutryn and 4 exposure times. There were five replications.

Thirty-one days after treatment, all plants were measured to ascertain their growth. Fifty-three days after treatment, all plants were visually rated as to their general vigor. A rating scale of 0 to 10 was used where 0 represented no herbicide effect (plants as vigorous as controls), and 10 represented death of the plant.

In the laboratory study, apical cuttings of broadleaf watermilfoil and cabomba were placed in 3 l of water in wide-mouth 3.8 l jars on a laboratory bench. Light was supplied by equal numbers of GRO-LUX® and daylight fluorescent tubes suspended 30 cm above the tops of the jars. The photoperiod was 10 hours of light and 14 hours of darkness.

Seven days after the cuttings were placed in the jars, terbutryn was added at concentrations of 0.05, 0.10, and 0.15 ppmw. There were 4 replications of each treatment and 4 untreated controls. Plants were measured at 3 day intervals through the 21st day after treatment. Unlike the field experiment, plants were not removed to fresh, untreated water, but remained in the treated water for the course of the experiment.

Data from both studies were subjected to standard statistical analyses.

RESULTS AND DISCUSSION

Field Study

A standard analysis of variance of data revealed that the effects of herbicide concentration, exposure time, and the interaction between these two factors were all significant at the 0.01 level of significance for each of the two species.

Table 1 presents the mean length of the five replicates for each experimental treatment 31 days after the terbutryn was applied. With cabomba, all treatments reduced growth below that of the controls. It is notable, however, that the lowest concentration of herbicide produced a greater effect in general, than the two intermediate concentrations.

The same pattern is evident for the broadleaf watermilfoil. With short exposure time, in particular, the intermediate concentrations produced less herbicidal effect than the lowest concentration. With increasing exposure time this effect did not manifest itself. With an exposure time of 14 days there was virtually no difference between the 0.05 ppmw concentration and the 0.15 ppmw concentration.

TABLE 1. MEAN LENGTH OF PLANTS (CM), 31 DAYS AFTER TREATMENT WITH TERBUTRYN.

Terbutryn conc. (ppm)	Exposure Time (days) 0	2	6	10	14
	cabomba ($LSD_{.05}$ = 10.6)				
0	44.5	—	—	—	—
.05	—	17.2	27.7	0.0	0.0
.10	—	21.5	36.3	15.2	3.6
.15	—	21.5	21.5	9.9	8.9
.20	—	16.5	11.4	0.0	0.0
	broadleaf watermilfoil ($LSD_{.05}$ = 5.8)				
0	47.8	—	—	—	—
.05	—	20.6	21.3	24.6	22.9
.10	—	50.3	46.7	30.5	0.0
.15	—	33.3	28.2	27.7	22.6
.20	—	0.0	30.0	0.0	0.0

Table 2 indicates the mean rating of the five replicates for each experimental treatment 53 days after the terbutryn was applied. In the case of cabomba, the 0.10 ppmw concentration was less effective than the 0.05 ppmw concentration when exposure times were 6 days or 10 days. The 0.15 ppmw concentration behaved in an erratic manner with respect to exposure time.

TABLE 2. MEAN VIGOR RATINGS OF PLANTS 53 DAYS AFTER TREATMENT WITH TERBUTRYN. (RATING SCALE IS 0 TO 10, WHERE 0 = NO REDUCTION IN VIGOR AND 10 = DEATH OF THE PLANT.)

Terbutryn conc. (ppm)	Exposure Time (days) 0	2	6	10	14
	cabomba ($LSD_{.05}$ = 1.25)				
0	0.00	—	—	—	—
.05	—	5.60	6.50	10.00	9.60
.10	—	5.00	2.40	6.00	9.80
.15	—	6.33	7.25	6.67	7.00
.20	—	7.33	8.00	9.80	9.80
	broadleaf watermilfoil ($LSD_{.05}$ = 1.41)				
0	0.00	—			—
.05	—	4.50	6.33	5.40	7.80
.10	—	0.00	2.00	7.00	10.00
.15	—	2.00	2.40	5.00	5.80
.20	—	5.25	6.00	9.00	10.00

In the case of broadleaf watermilfoil the overall pattern is more regular. With short exposure times, the intermediate concentrations are not very effective. At longer exposure times, the effect of the 0.10 ppmw concentration catches up to, and surpasses, the effect of the 0.05 ppmw concentration.

A mathematical model (full second order regression equation) was used to predict lengths of both species 31 days after treatment and vigor ratings 53 days after treatment. The results are presented in Figures 1 through 4. In every case it can be seen that the predicted herbicidal effect of the lowest concentration (0.05 ppmw), is greater than the herbicidal effect of the two intermediate concentrations (0.10 and 0.15 ppmw). The coefficient of determination (R^2) is presented in the caption for each of these figures. The R^2 values represent the percentage of variability in the mean observed responses which is accounted for in the regression model.

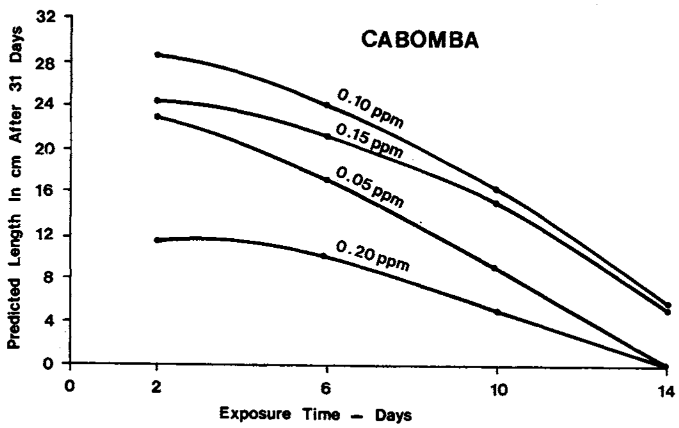

Figure 1. Predicted lengths of cabomba plants after 31 days. based on second order regression model. $R^2 = 72\%$.

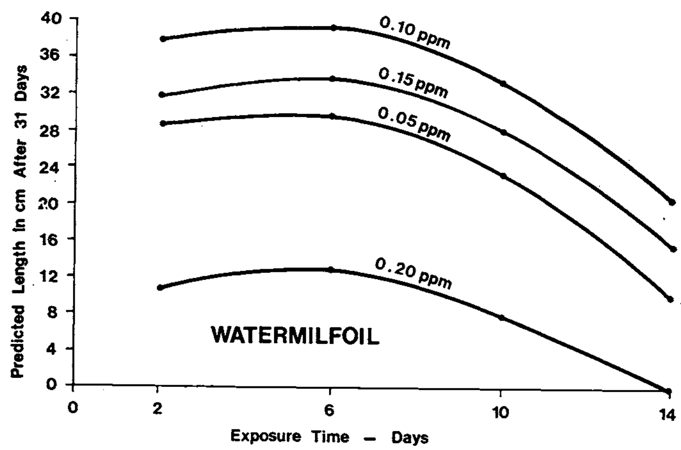

Figure 2. Predicted lengths of broadleaf watermilfoil plants after 31 days, based on second order regression model. $R^2 = 61\%$.

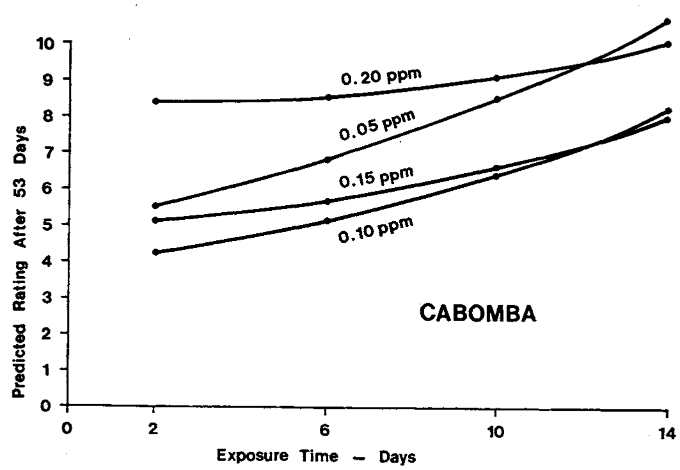

Figure 3. Predicted ratings of cabomba plants after 53 days, based on second order regression model. Rating system is 0 to 10 where 0 = no herbicidal effect and 10 = death of plant. $R^2 = 70\%$.

Laboratory Study

The laboratory study was conducted to confirm the findings of the preliminary unpublished studies and the field study which showed that the responses of cabomba and broadleaf watermilfoil are not proportional to dosage rate when low concentrations of terbutryn are applied. Unlike the field experiment, various exposure times were not used. The plants were all treated at the same time and remained in the treated water throughout the experiment.

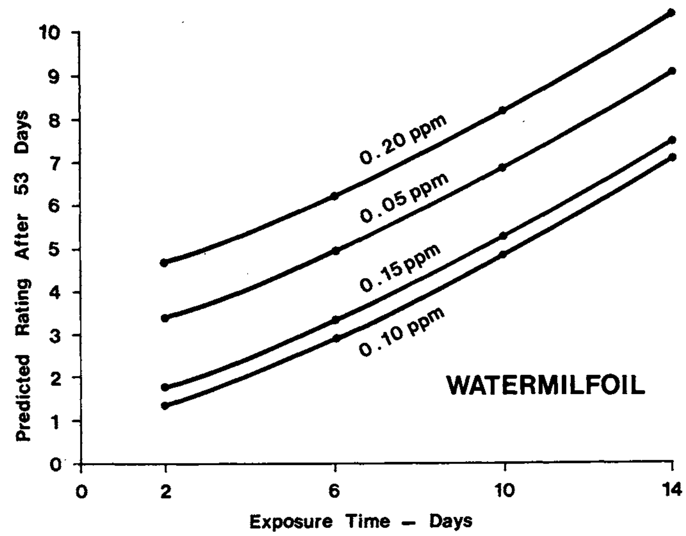

Figure 4. Predicted ratings of broadleaf watermilfoil plants after 53 days, based on second order regression model. Rating system is 0 to 10 where 0 = no herbicidal effect and 10 = death of plant. $R^2 = 79\%$.

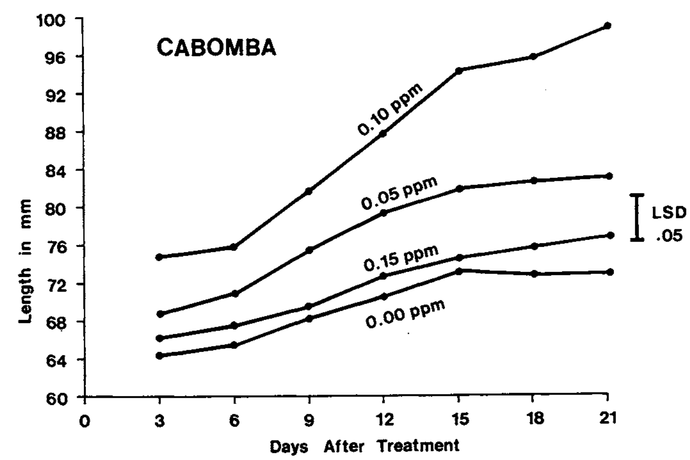

Figure 5. Length of cabomba plants at indicated time intervals following treatment with terbutryn.

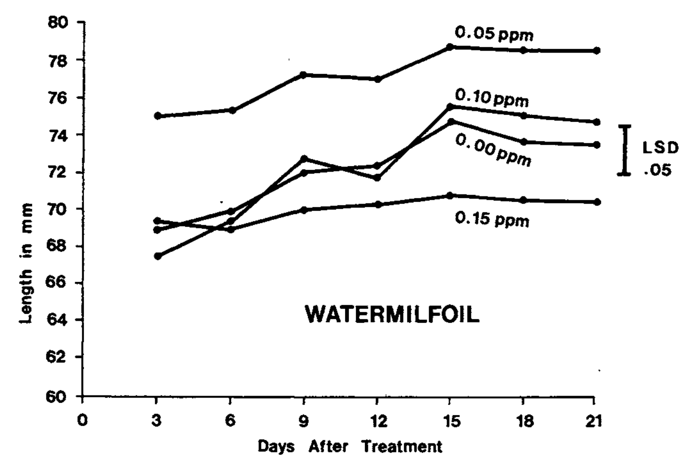

Figure 6. Length of broadleaf watermilfoil plants at indicated time intervals following treatment with terbutryn.

The average lengths of the plants at 3-day intervals are presented in Figures 5 and 6. Figure 5 clearly indicates that terbutryn has a stimulatory effect on cabomba at concentrations of 0.05 ppmw and 0.10 ppmw. Even at 0.15 ppmw there was no inhibitory effect. Plants treated with this concentration averaged slightly larger than the controls, but the difference was not significant.

Figure 6 shows a somewhat similar pattern but indicates that broadleaf watermilfoil is more sensitive to terbutryn than cabomba. With broadleaf watermilfoil, 0.05 ppmw terbutryn is stimulatory but plants treated with 0.10 ppmw do not differ from the untreated plants. A concentration of 0.15 ppmw exerts an herbicidal effect after approximately one week.

It is obvious from the data of both experiments that at very low concentrations, terbutryn does not exert an herbicidal effect in proportion to the dosage applied. There are two possible explanations for this seemingly strange phenomenon.

First, it is possible that terbutryn has a direct effect on the plants which stimulates their growth. If this is true, (and such an effect is not unknown among the symmetrical triazines), it is logical to assume that the stimulatory effect could be manifested at low concentrations but hidden or overcome at higher concentrations where herbicidal effects become dominant to the stimulatory effects. In the case of the field data presented here, for example, the 0.05 ppmw rate might not be enough to stimulate growth. The 0.10 and 0.15 ppmw rates could have been stimulatory, and at the 0.20 ppmw rate the herbicidal effect was sufficient to overcome or mask the stimulatory effect.

The second possible explanation is related to the fact that symmetrical triazines are excellent algaecides. It is conceivable that in the field experiment, for example, the 0.05 ppmw rate was not sufficient to control algae and vascular plant growth was suppressed by algal competition. At the 0.10 and 0.15 ppmw rates the algae may have been controlled, thus releasing the milfoil and cabomba from this source of competition. At the 0.20 ppmw rate, according to this theory, the algae are still controlled but the terbutryn exerts an herbicidal effect which limits vascular plant growth.

During the experiments reported on this paper, quantitative measurements of algae were not made but visual inspection did not indicate dense populations. Therefore, the first explanation, (a direct physiological stimulation by the terbutryn), appears to be the more probable one.