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Effects of Simazine Treatment on Channel Catfish Production and Water Quality in Ponds[1,2]

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ABSTRACT

Channel catfish (*Ictalurus punctatus*) ponds infested with *Chara vulgaris* were treated with 1.3 mg/l simazine. Water quality changes following treatment included decreased dissolved oxygen concentrations, increased total ammonia-nitrogen, nitrite-nitrogen, and carbon dioxide concentrations. The magnitude of the effects were greatest in the 2 week period immediately following treatment. Although these variables did not reach lethal levels, fish production was reduced 20% compared to untreated control ponds.

INTRODUCTION

Tucker and Boyd (7) found a 20% reduction in channel catfish [*Ictalurus punctatus* (Rafinesque)] production in ponds treated three times with 2-chloro-4,6-bis (ethylamino)-*s*-triazine (simazine) for season-long control of phytoplankton abundance. However, simazine is seldom used for this purpose because of reduced fish yields and the difficulty in achieving precise control of phytoplankton abundance. The most frequent use of herbicides in commercial catfish culture is to remove noxious growths of aquatic macrophytes to facilitate fish harvest. The effects of this usage are not known but could potentially reduce fish production as indicated in the previous study (7).

In the present study, we evaluate the effects of a single application of simazine on fish production and water quality. The application was made late in the growing season to rid ponds of *Chara vulgaris* (L.) prior to fish harvest.

METHODS AND MATERIALS

In June 1981, channel catfish (55 g average weight) were stocked into twenty 0.06 ha earthen ponds at 12,350 fish/ha for a catfish nutrition study. The ponds were filled with ground water from a well with water added periodically to replace evaporation and seepage losses. During the study total alkalinity in the pond waters ranged from 200-250 mg/l as $CaCO_3$, total hardness from 200-250 mg/l as $CaCO_3$, calcium hardness from 140 to 185 mg/l as $CaCO_3$ and total dissolved solids from 250 to 350 mg/l. Fish were fed one of four experimental rations 7 days a week with daily feed allotments adjusted periodically for fish growth and feeding response. Fish were harvested and weighed in November 1981.

During this nutrition study, several of the ponds became infested with *Chara*. Four heavily infested ponds, ultimately treated with simazine, and 4 ponds containing little or no *Chara* were monitored for changes in water quality before and after herbicide treatment. In late August, weed coverage was estimated by dividing each pond into quadrants, wading through each quadrant, and subjectively evaluating the extent of infestation. On September 7, 1.3 mg ai/l simazine was applied to the four infested ponds.

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[2] An abstract of this paper was previously published in the proceedings of the 35th Annual Southern Weed Science Society meeting (1982).

Dissolved oxygen (DO) concentrations were measured daily at dawn and dusk with a polarographic oxygen meter. Concentrations of DO were also determined at intervals each night. If DO levels decreased to 2.5 mg/l, emergency aeration was initiated in that pond and continued until an hour after daylight using 1/3 hp surface spray-type agitators. Surface water samples were collected at dusk and dawn at frequent intervals between August 10 and October 29 for pH determination by glass electrode. At least once every 2 weeks surface water samples were collected for the measurement of total ammonia-nitrogen (phenate method), nitrite-nitrogen (diazotization method), chlorophyll *a* (acetone extraction and spectroscopy), carbon dioxide (nomograph) and phytoplankton enumeration (sand filtration and microscopy). Analytical methods used are presented in Standard Methods (1). Un-ionized ammonia-nitrogen concentrations were calculated using tables in Boyd (2) from total ammonia-nitrogen concentrations and pH and water temperature data collected at dusk.

RESULTS AND DISCUSSION

Before treatment, control ponds contained from 0-25% coverages of *Chara* with the larger infestations generally consisting of dead or apparently dying stands. The *Chara* was dying probably as the result of decreased light penetration due to the development of moderately dense phytoplankton communities in these ponds. Treated ponds contained 65-85% coverages of healthy stands of *Chara* that often filled the entire water column. The simazine treatment completely eliminated infestations within 2-3 weeks after treatment. As simazine concentrations decreased with time, phytoplankton communities became established.

The phytoplankton communities in control ponds were dominated throughout the study by genera of blue-green algae and represented at least 50% and usually 80% or more of the total community. Commonly encountered blue-green genera in control ponds were (in order of decreasing abundance): *Oscillatoria, Microcystis, Anabaena, Gomphosphaeria, Spirulina,* and *Merismopedia.* Prior to treatment, the sparse phytoplankton community in the *Chara* infested ponds also consisted predominantly of blue-green algae, primarily *Microcystis* and *Anabaena.* For 2 weeks after the simazine treatment the only phytoplankton found in treated ponds were diatoms (primarily *Gomphonema, Frustulia,* and a very small, unidentified pennate genus) and unicellular, motile chlorophytes (primarily *Chlamydomonas*). After 2 weeks, community diversity increased, but blue-green algae were never identified from any simazine-treated pond. On the last sampling date (October 29), predominant genera in treated ponds were (in order of decreasing abundance): *Chlamydomonas, Oocystis, Cryptomonas, Gomphonema, Frustulia, Stauroneis,* and *Euglena.* The relative sensitivity of the blue-green algae to simazine is in accord with findings in previous studies (7).

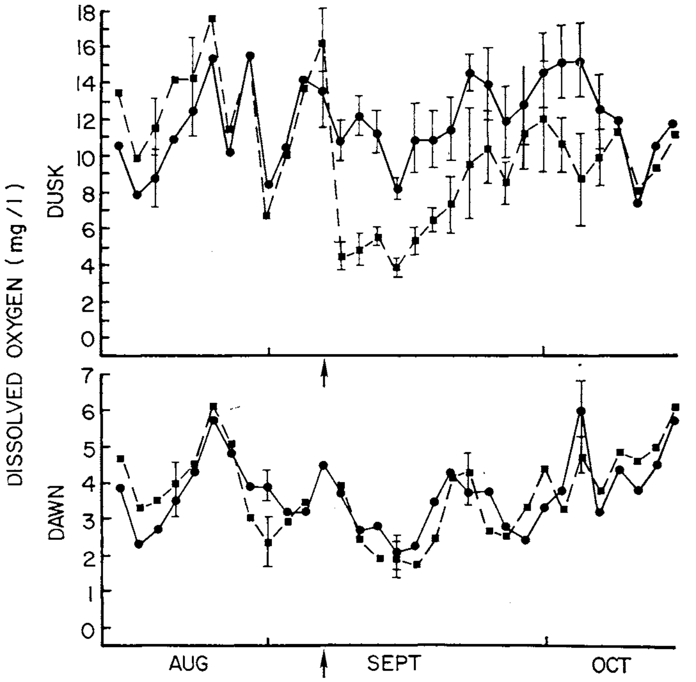

Figure 1. Dissolved oxygen concentrations (mean ± SE for selected dates) in control ponds (solid line) and ponds treated with 1.3 mg/l simazine (dashed line). Dissolved oxygen was measured at dawn and dusk. Four ponds were used per treatment. Date of herbicide application is indicated by an arrow.

There was an immediate effect on net oxygen production following application of simazine (Figure 1). In the one month period prior to treatment, average dusk DO concentrations varied from 6.7 to 17.8 mg/l (83 to 225% saturation). The day after treatment average dusk DO concentration was 4.3 mg/l (54% saturation). Dusk DO concentrations did not increase to levels comparable to control ponds until about two weeks after application. Because ponds were aerated when DO concentration fell to 2.5 mg/l, there was no obvious effect of treatment on dawn DO levels in treated ponds (Figure 1).

The overall effect on the dissolved oxygen status of treated ponds is clearly seen in the total hours of emergency aeration used in the ponds (Figure 2). Before herbicide application, total hours of aeration were similar for treatment and control ponds. In the two week period following treatment, the 4 treated ponds were aerated for a total of 337 hours, approximately 3.5 times the total for control ponds. Although treated and control ponds had comparable DO concentrations at dawn, treated ponds reached critical DO levels earlier in the night and fish were exposed to low DO levels for a longer period of time.

Increased carbon dioxide (CO_2) concentrations resulting from plant decomposition caused a decrease in average dusk and dawn pH in treated ponds (Figure 3). Average dusk pH values were lower in treated ponds for a month following treatment. Except for the week immediately following treatment, average dawn pH and CO_2 concentrations were comparable in treated and control ponds. As with DO concentrations, differences in dawn CO_2 and pH probably would have been greater if emergency aeration were not used. Considerable CO_2 was undoubtedly volatilized during periods of aeration thus moderating both CO_2 concentrations and pH values measured at dawn in treated ponds.

Average total ammonia-nitrogen (TA-N) concentrations were as much as 6.7 times higher in treated ponds

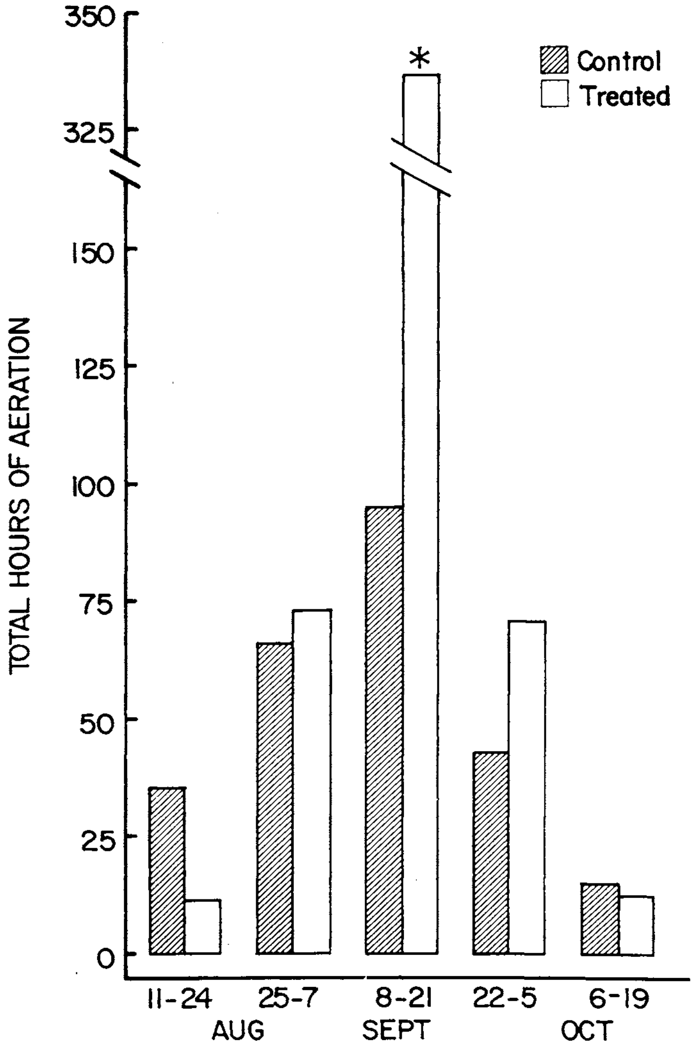

Figure 2. Total hours of emergency aeration in two week periods in control ponds (shaded bars) and ponds treated with 1.3 mg/l simazine (white bars). Each bar is the sum for four ponds. Total hours of aeration for bar marked with an asterisk (*) differs from that for control ponds in the same period at the 0.05 level of probability. Herbicide was applied September 7.

than the control ponds (Figure 4). Concentrations of TA-N were higher relative to control ponds for about 3 weeks after treatment. The highest TA-N concentration recorded for a single pond was 2.22 mg/l on September 17, ten days after herbicide application. There are two major sources for increased TA-N in treated ponds. As plants decompose, protein-nitrogen is mineralized to ammonia-nitrogen and enters the water (2). Ammonia is also the principal nitrogenous waste product of channel catfish and in the absence of assimilation by plants it may accumulate in the water.

Decreased pH in treated ponds compensated for the increased TA-N concentrations thus un-ionized ammonia-nitrogen (UA-N) concentrations remained at moderate levels (Figure 4). This is of considerable practical importance as un-ionized ammonia is considered the principal, if not only, species of ammonia toxic to catfish (3). However, it is difficult to evaluate the effect of exposure of fish to un-ionized ammonia. The toxic level of UA-N for short-term exposure of fish is considered to be between 0.6 and

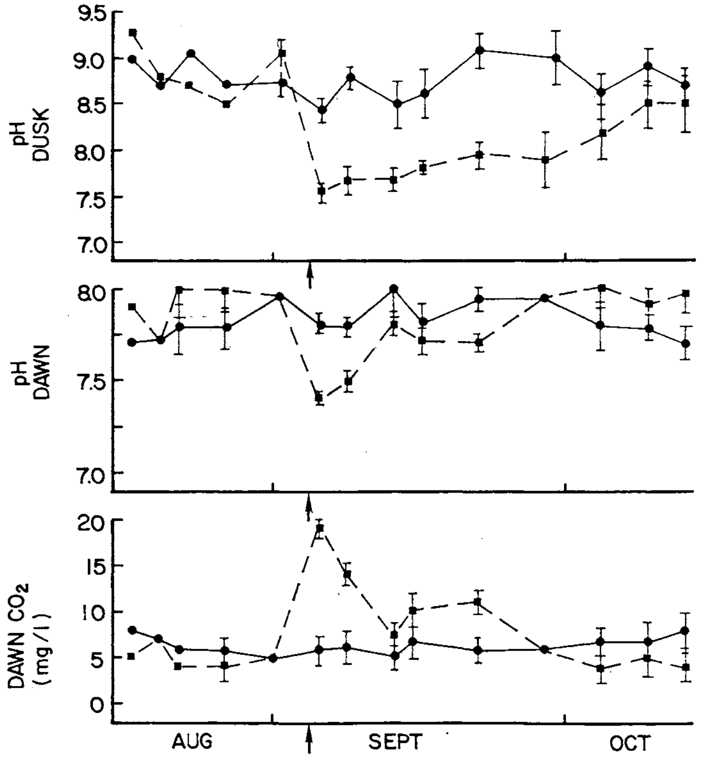

Figure 3. Carbon dioxide (CO_2) concentrations and pH in control ponds (solid line) and ponds treated with 1.3 mg/l simazine (dashed line). Carbon dioxide was determined at dawn, pH at both dawn and dusk. Four ponds were used per treatment and values are means ± SE for selected dates. Date of herbicide application is indicated by arrows.

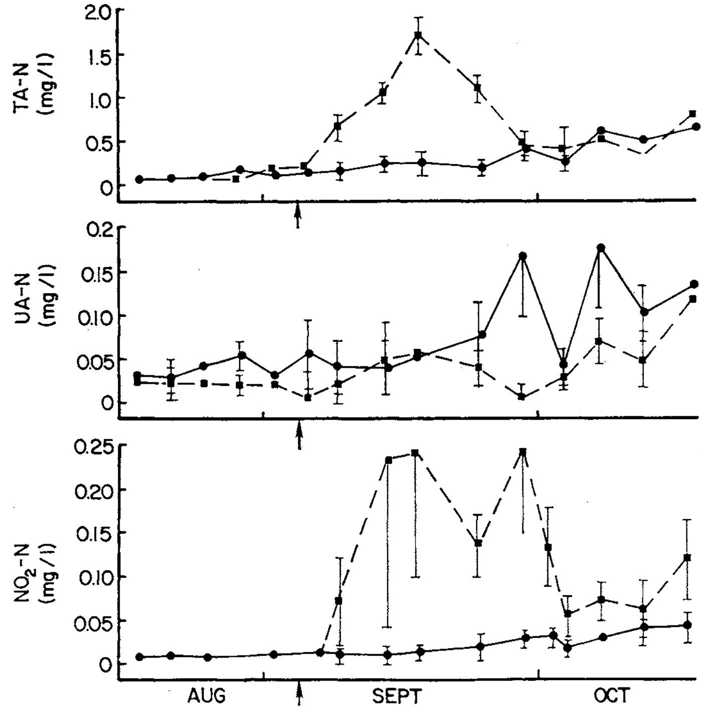

Figure 4. Total ammonia-nitrogen (TA-N), un-ionized ammonia-nitrogen (UA-N), and nitrite nitrogen (NO_2-N) concentrations in control ponds (solid line) and in ponds treated with 1.3 mg/l simazine (dashed line). Un-ionized ammonia-nitrogen values were calculated using pH and temperature values collected at dusk. Values given are means ± SE for selected dates with four ponds per treatment. The date of herbicide application is represented by arrows.

2.0 mg/l (3, 4). Values for the 96 LC_{50} for UA-N range from 0.4 to 3.1 mg/l. However, decreased growth and histological changes have been attributed to exposure to much lower concentrations (3).

Nitrite-nitrogen (NO_2-N) concentrations increased to an average of 0.24 mg/l 10 days after treatment (Figure 4). This was 19 times the average NO_2-N in control ponds at that time. Nitrite levels remained high relative those in control ponds for 4 weeks. Concentrations of nitrite reported to be toxic to fish are quite variable because of interactions with other environmental parameters, most importantly chloride ion concentration and DO levels (6). In the present study, exposure of fish to the highest NO_2-N concentration recorded (0.80 mg/l) resulted in a blood methemoglobin level of about 30%. This is based on an empirical relationship developed at this laboratory for nitrite, chlorides and % methemoglobin. This level of methemoglobin is probably not dangerous unless DO levels decrease to extremely low levels.

The principal source of nitrite in catfish ponds is unknown. Nitrite is an intermediate in both nitrification and denitrification. Although some workers feel that the major source of nitrite is derived from the nitrification pathway, Hollerman and Boyd (5) demonstrated that considerable nitrite may enter catfish pond waters from denitrification. It is not possible to identify the source of nitrite from data in the present study.

There was considerable pond to pond variation in the effect of simazine treatment on water quality, particularly DO and NO_2-N concentrations. This is indicated by relatively large standard errors associated with mean concentrations (Figure 1 and 4) and by DO and NO_2-N data for two individual ponds (Figure 5). Dusk DO levels reached 100% saturation in one treated pond (Pond 12) 10 days after treatment and at 14 days after treatment the dusk DO concentration was 18.0 mg/l (220% saturation). In another treated pond (Pond 6), dusk DO concentrations remained below 100% saturation for 20 days. The highest NO_2-N concentration recorded in Pond 6 (0.80 mg/l) occurred 8 days after treatment and was the highest recorded for any pond. Nitrite levels decreased fairly rapidly in this pond and reached a concentration of 0.005 mg/l NO_2-N four weeks after treatment. In contrast, the highest concentration recorded in Pond 12 was 0.41 mg/l NO_2-N seven weeks after herbicide application. Frequent measurements of water quality are even more important because of the inconsistent pond to pond effect of simazine treatment on DO and NO_2-N concentrations. At this time, it is not possible to predict the magnitude nor length of time that water quality will be affected.

Temporal changes in DO, CO_2, pH, TA-N, and possibly NO_2-N concentrations in treated ponds, are related to the response of the plant community to simazine. Decreased DO production and increased CO_2 and TA-N are the result of the death and decomposition of the dominant plant species, *Chara vulgaris*. As simazine concentrations decreased with time, certain phytoplankton species became established. The increase in planktonic chlorophyll *a* concentrations at the end of September (Figure 6) was accompanied by increases in average dusk pH and DO con-

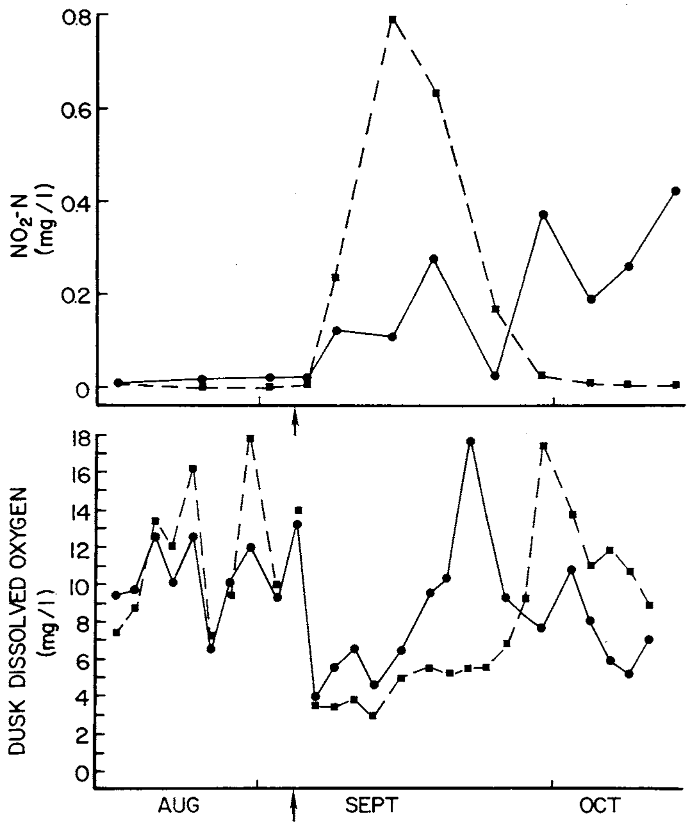

Figure 5. Nitrite-nitrogen (NO_2-N) and dissolved oxygen (measured at dusk) concentrations in two ponds treated with 1.3 mg/l simazine each. Dashed lines are "Pond 6," solid lines are "Pond 12." Date of herbicide application is indicated by arrows.

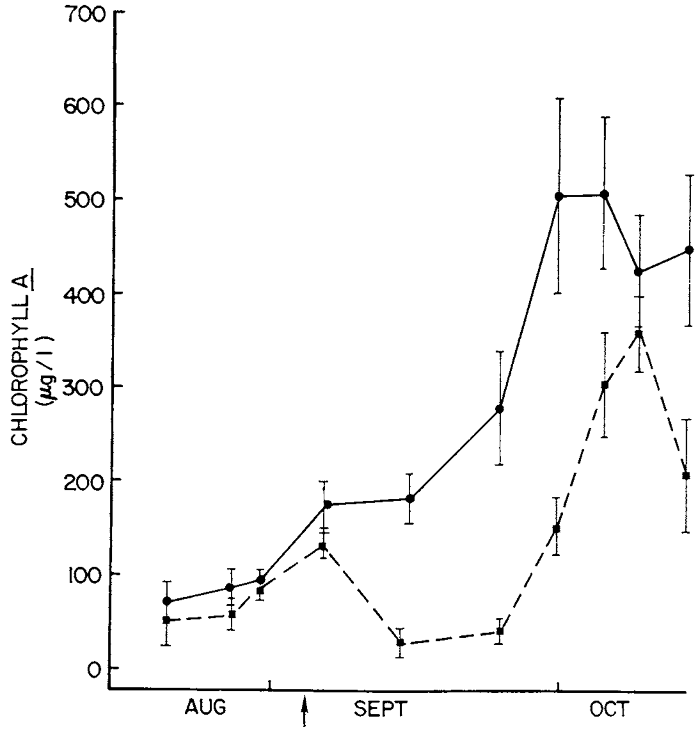

Figure 6. Chlorophyll *a* concentrations (mean ± SE) in control ponds (solid line) and ponds treated with 1.3 mg/l simazine. Four ponds were used per treatment and date of herbicide application is indicated by an arrow.

centrations and decreases in CO_2, TA-N and NO_2-N concentrations. This is the result of photosynthetic oxygen production and CO_2 uptake which moderated these parameters as well as pH. Uptake of inorganic nitrogen by phytoplankton decreased TA-N levels and possibly had an indirect effect on NO_2-N concentrations by decreasing the concentration of substrate for nitrification.

Emergency aeration prevented DO concentrations from decreasing to lethal levels and concentrations of un-ionized ammonia, nitrite and CO_2 never reached concentrations considered acutely toxic. However, the effect of these variables on fish health cannot be evaluated independently. Both nitrite and CO_2 effect respiratory efficiency and the combination of low DO and even moderately high nitrite and CO_2 concentrations will severely compromise fish respiration and cause stress.

Feeding response of fish in treated ponds ceased immediately after simazine application and remained suppressed until harvest. This resulted in a 20% reduction in fish production and poorer feed conversions for treated ponds at harvest (Table 1). While water quality changes after herbicide treatment undoubtedly affected feeding response, the reduced response persisted even after water quality variables in treated ponds returned to control pond levels. This suggests a possible direct effect of the simazine on feeding response.

TABLE 1. FISH PRODUCTION AND FEED CONVERSION IN CONTROL PONDS AND PONDS RECEIVING ONE APPLICATION OF SIMAZINE. EACH VALUE REPRESENTS THE AVERAGE OF THREE PONDS AS ONE REPLICATE OF EACH GROUP WAS DELETED DUE TO THE EFFECTS OF DISEASE OR STOCKING ERROR ON THE PRODUCTION DATA.

	Production (kg/hectare)	Average fish wt. (g)	Feed conversion[b]
Treated	2670	280	1.99
Control	3340[a]	333[a]	1.58

[a]Means differ at the 0.1 level of probability.
[b]Feed allotted/fish weight gain.

Simazine was quite effective as a preharvest treatment for eliminating infestations of *Chara* in channel catfish production ponds. Label instructions for Aquazine, (80 WP formulation of simazine) recommend treatment only when water temperatures are less than 24C as resulting low dissolved oxygen levels may cause fish stress. Although the commercial catfish producer might adequately prevent dissolved oxygen depletions with emergency aeration equipment, he must also recognize potential problems of increased carbon dioxide and nitrite concentrations and an expected reduction in fish growth from even a single simazine application.

ACKNOWLEDGMENTS

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