J. Aquat. Plant Manage. 18: 3-6

Tolerance of Two Grass Species to Copper-Treated Irrigation Water[1]

D. N. RIEMER AND H. L. MOTTO

Associate Research Professors
Department of Soils and Crops
New Jersey Agricultural Experiment Station
Rutgers—The State University
New Brunswick, NJ 08903

ABSTRACT

Copper algaecides are frequently used in irrigation-water supplies, particularly on golf courses. A field study and a greenhouse study were conducted to determine whether the copper content of treated water is likely to be toxic to irrigated grasses on greens and fairways. The studies showed an adequate safety margin between the copper levels to which grasses might be exposed and the toxic level. Grasses were more tolerant of copper in the soil at pH 6.5 than at pH 4.8.

INTRODUCTION

Until recently, copper-containing compounds such as copper sulfate and various chelated copper compounds have been the only type of algaecides in widespread use in the United States. They are still the only algaecides in widespread use in water which is to be used for irrigation. In New Jersey, golf course superintendents have used water from copper-treated ponds for many years to irrigate greens and fairways with no reported injury to the grass. Occasionally, however, the question arises of how tolerant grasses are to copper which is applied in irrigation water. There is concern over direct toxicity from foliar-applied, foliar-absorbed copper as well as concern over chronic toxicity due to copper accumulations in the soil. This paper presents the results of a field study and a greenhouse study designed to determine the safety of this irrigation practice.

METHODS AND MATERIALS

The field study was conducted primarily to determine the tolerance of two species of grass to foliar-applied copper. The duration of the study was too short to cause a significant accumulation of copper in the soil.

Circular experimental plots 28.6 cm in diameter were established in three different areas at New Brunswick, New Jersey. Area A was an established bentgrass (*Agrostis palustris* Huds.) turf mowed at a height of 0.635 cm and maintained as a typical golf course green. Optimum moisture and fertilizer were supplied throughout the course of the experiment.

Area B was in a grassy strip between two experimental fields. It was mowed regularly throughout the course of the experiment but was not irrigated or fertilized. The primary grass present was annual bluegrass (*Poa annua* L.).

Area C was an established bentgrass turf similar to Area A except that it was not fertilized or irrigated. The grass in Areas B and C were under considerable moisture stress all summer, while the grass in Area A was never under moisture stress.

Applications of irrigation water containing varying amounts of copper were made weekly to all plots beginning 30 June 1976. On each treatment date 0.635 cm of water was applied uniformly over each plot. The water contained 0, 5, 25, 50, or 100 mg/l $CuSO_4 \cdot 5H_2O$. These values are far in excess of those normally recommended of algae control (usually 0.5 to 10.0 ppmw of the pentahydrated salt).

Each treatment was replicated three times in each of the three experimental areas for a total of 45 plots. Treatments in Areas B and C were terminated as soon as the grass became dry and brown from lack of moisture. Treatments in Area A continued each week through 7 September 1976. A summary of the treatment schedule with amounts of copper actually applied appears in Table 1.

Soil samples (0 to 2.54 cm and 2.54 to 5.08 cm deep)

TABLE 1. SUMMARY OF COPPER SULFATE TREATMENTS ON GRASS PLOTS IN THE FIELD.

Area	Number of Applications	Treatment (mg/l)	Total Cu Applied (kg/ha)
A	10	0	.00
		5	.80
		25	3.99
		50	7.98
		100	15.97
B	7	0	.00
		5	.56
		25	2.79
		50	5.61
		100	11.19
C	9	0	.00
		5	.72
		25	3.60
		50	7.19
		100	14.38

[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.

were taken from the plots in Area B after treatments were discontinued and analyses for extractable copper in the soil were made.

The greenhouse study was designed to determine the tolerance of the same two species of grass to above-normal levels of copper in the soil. In this study, bentgrass (var. Emerald) and annual bluegrass were established from seed in two groups of 15 cm diameter pots in a Freehold sandy loam soil to which N, P, and K were added. In one group the existing pH of 4.8 was left unchanged. In the other group the soil was limed to a pH of 6.5. Three different copper concentrations were then established at each of the pH levels by adding dry $CuSO_4 \cdot 5H_2O$ to the soil and mixing thoroughly. The amounts of actual copper added were 0, 200, and 400 mg/kg. All lime and $CuSO_4 \cdot 5H_2O$ additions were made before placing the soil in the pots and seeding the grass.

Growth of the grass was measured by periodically clipping off the topgrowth to a height level with the rim of the pot and determining the oven-dry weight of the clippings. After weighing, the clippings were digested in nitric and perchloric acids and their copper contents determined by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

Field Studies

Visual ratings of all field plots were made each week throughout the summer by two observers, each rating the plots independently. No differences were detected in color, density, or general vigor of the plants. The grass in all of the treated plots was indistinguishable from the grass in the control plots and the grass in the untreated areas between plots.

Levels of extractable copper in the soils showed no significant increase with increasing amounts of copper applied.

Dry-weight yields for each harvest in the greenhouse are presented in Figures 1 through 5. These data clearly show that soil-copper toxicity in bentgrass and annual bluegrass is a function of soil pH. For the first three harvests there was a dramatic decrease in growth with increasing copper concentrations in the unlimed (pH 4.8) soil for both species of grass. In the limed soil (pH 6.5), there were no differences

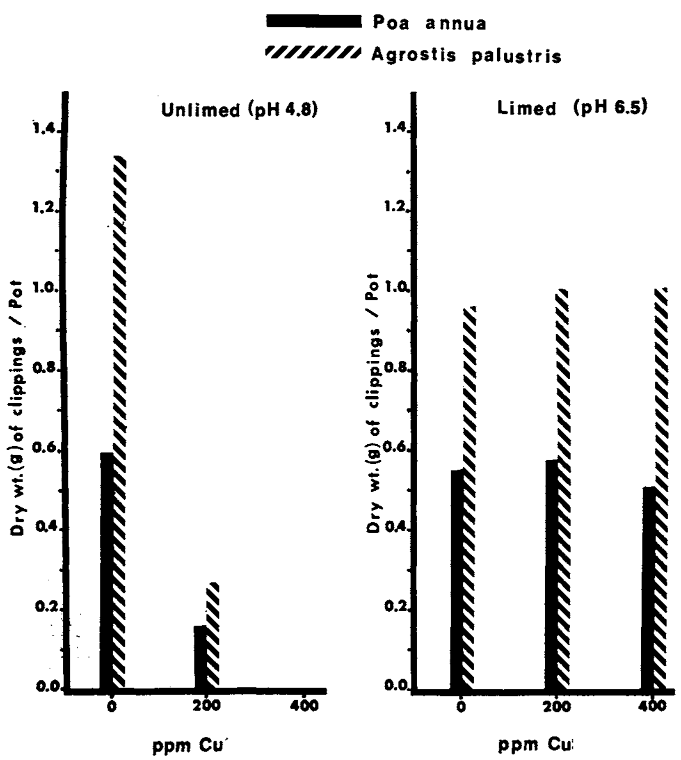

Figure 1. Yield (first harvest), of two grass species grown on soils of varying pH and copper content.

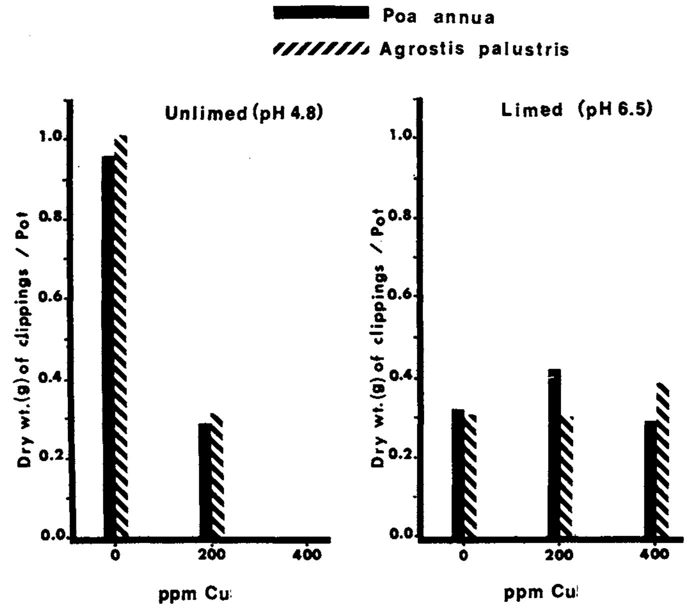

Figure 2. Yield (second harvest), of two grass species grown on soils of varying pH and copper content.

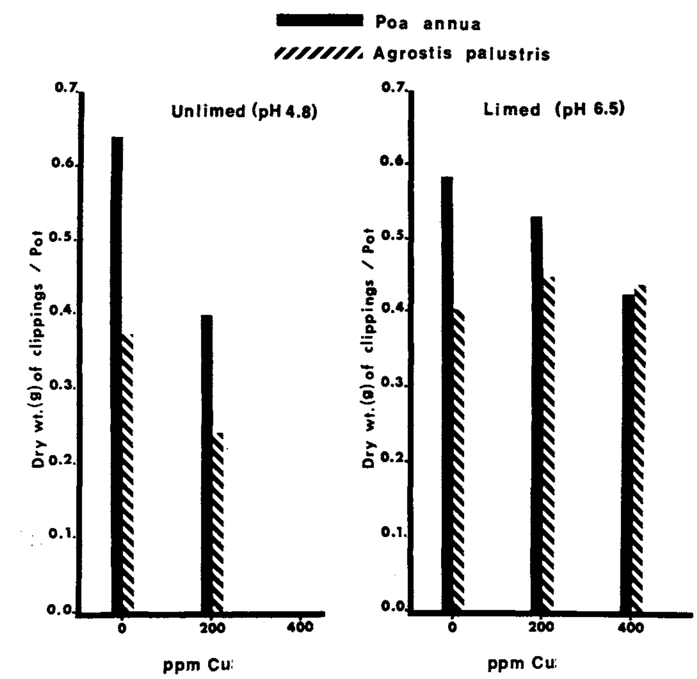

Figure 3. Yield (third harvest), of two grass species grown on soils of varying pH and copper content.

in grass growth among the three copper concentrations. This is assumed to be due to the fact that the copper was less soluble and therefore unavailable to the plants at the higher pH.

On the fourth harvest only, there was an unexplained tendency for annual bluegrass growth to decrease with increasing amounts of copper in the soil. At the fifth and final harvest, this tendency did not appear and the situation reverted to what it had been at the first three harvests. Bentgrass behaved the same at all five harvests.

Figure 6 shows the yields of the five harvests combined. It points out the marked effect of copper on grass in the

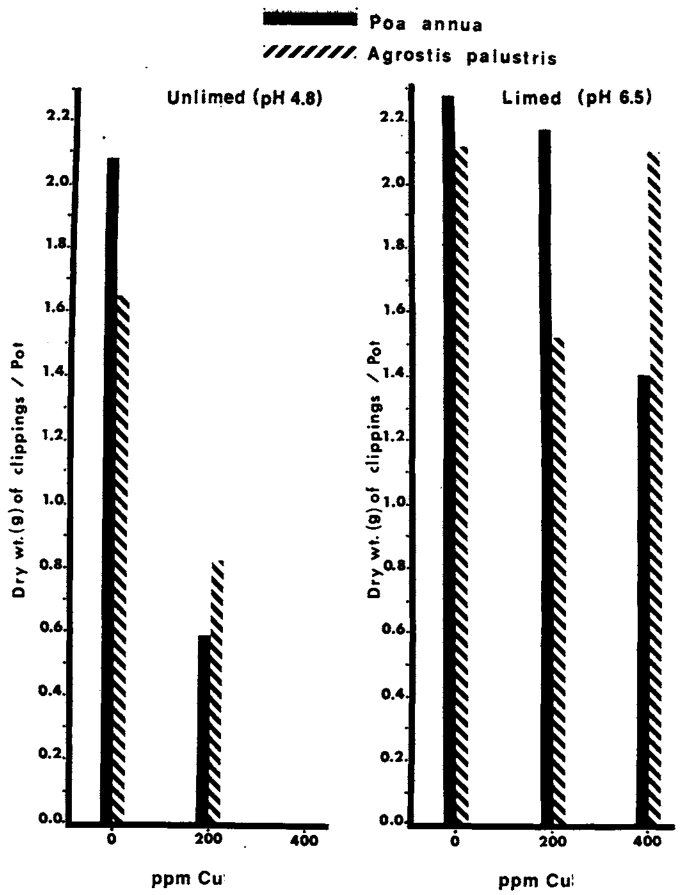

Figure 4. Yield (fourth harvest), of two grass species grown on soils of varying pH and copper content.

TABLE 2. COOPER CONTENT (MG/KG DRY WT.) OF GRASS CLIPPINGS GROWN IN SOILS OF VARYING pH AND COPPER CONTENT.

Treatment		Harvest				
pH	Cu added (mg/kg)	1	2	3	4	5
		Annual Bluegrass				
4.8	0	13.8	15.4	12.5	17.0	11.0
4.8	200	35.1	30.4	32.6	43.2	37.4
4.8	400	plants dead—no clippings available				
6.5	0	19.3	26.5	17.8	15.4	10.4
6.5	200	19.4	32.4	20.7	18.7	14.8
6.5	400	25.0	30.6	23.2	21.3	17.8
		Bentgrass				
4.8	0	16.7	25.9	20.2	19.8	12.6
4.8	200	59.2	61.2	44.1	36.8	29.6
4.8	400	plants dead—no clippings available				
6.5	0	18.7	25.6	16.0	18.4	9.6
6.5	200	15.9	34.0	27.0	24.0	14.0
6.5	400	32.2	38.0	34.8	27.3	18.8

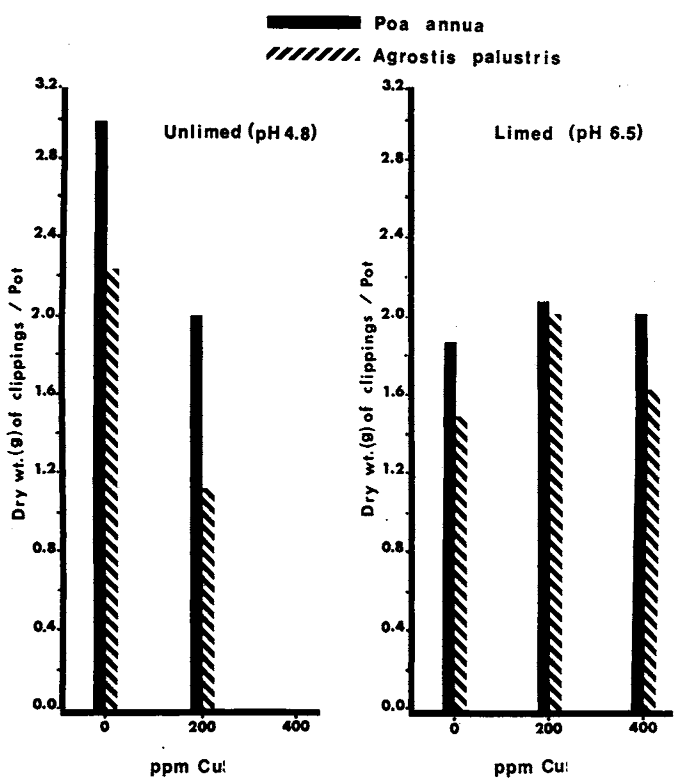

FIGURE 5. Yield (fifth harvest), of two grass species grown on soils of varying pH and copper content.

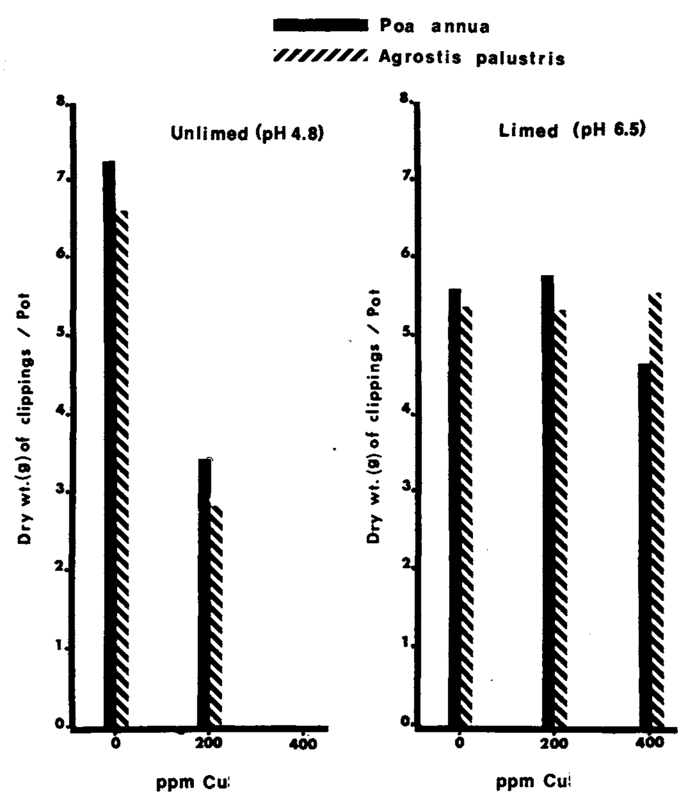

Figure 6. Yield (total of five harvests), of two grass species grown on soils of varying pH and copper content.

unlimed soil and the almost total lack of effect of copper on grass in the limed soil.

The concentrations of copper in the plant tissues at each harvest are shown in Table 2. Plants growing in the limed soil accumulated relatively little additional copper in their tissues with increasing increments of copper in the soil. Plants growing in unlimed soil showed an increase of approximately 100% in the copper content of their leaves when 200 mg/kg copper was added to the soil. Plants did not survive (although some germination occurred) when 400 mg/kg copper was added to the unlimed soil.

CONCLUSIONS

The concentrations of copper used in both the field experiment and the greenhouse experiment were deliberately high in comparison to the concentrations which would normally be encountered where copper-treated water was being used for irrigation of turf. A treated pond would normally have no more than 0.25 mg/l copper in solution. It can therefore be calculated that 10 cm of irrigation water would add copper to the soil in an amount equivalent to .125 mg Cu/kg of soil. It would take many years of irrigation to even get close to the 200 mg/kg or 400 mg/kg concentrations used in this experiment.

The field experiment reported on in this paper demonstrated adequate safety for direct contact of copper containing water with the foliage of grass plants. The greenhouse experiment demonstrated adequate safety for copper concentrations which would be likely to occur in the soil, even after hundreds of years of irrigation.