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Selective Patterns of Herbicide Application for Improved Biological Control of Waterhyacinth

KIM H. HAAG[1], MARGARET S. GLENN[2], AND JACQUELINE C. JORDAN[3]

ABSTRACT

The effects of two different herbicide application patterns on waterhyacinth regrowth and waterhyacinth weevil population dynamics were studied in 7 ponds in Alachua Co. In Treatment 1, after half of the weed mat was sprayed, the waterhyacinths were left with a short boundary area along which daughter plants could form and colonize open water. In these ponds (# 1, 4, 5) a reduced plant expansion rate fostered the success of the biocontrol agents (*Neochetina* sp.) and the resulting heavy insect feeding damage caused a total decline of the weed populations. In Treatment 2, after half of the weed mat was sprayed, the waterhyacinths were left with a long boundary area along which daughter plants could form. In these ponds (# 2, 3, 6, 7) the plant population rapidly expanded to fill available open water. Plant growth rate surpassed the weevil population rate of increase, and insect feeding damage was not sufficient to control the weed mats.

Key words: Eichhornia crassipes, biocontrol, *Neochetina,* integrated pest management.

INTRODUCTION

There is growing evidence that the acreage of waterhyacinth (*Eichhornia crassipes*) [Mart.] Solms) has diminished in Florida and elsewhere as a result of damage by the released biological control agents *Neochetina eichhorniae* Warner and *N. bruchi* Hustache (Center 1982, DeLoach and Cordo 1983, Theriot 1982, Wright 1980). However, waterhyacinth continues to be a problem at some intensively used sites and in these situations herbicides are used to manage the weed. Contact with herbicide does not kill *Neochetina* weevils (Haag 1986a), but rapid loss of habitat following herbicidal control may reduce weevil populations. Previous research efforts have focused on limiting the extent of herbicide application, thereby conserving portions of a waterhyacinth mat as a reservoir for waterhyacinth weevil populations. Results have shown that weevils will disperse from sprayed plants to adjacent unsprayed waterhyacinths if they are available (Haag 1986b). This study was designed to examine the effects of various herbicide spray patterns on waterhyacinth regrowth and subsequent population dynamics of the biological control insects involved.

MATERIALS AND METHODS

Seven ponds on the University of Florida campus were chosen as experimental sites. The shallow, clay-lined ponds (mean depth 1.5 m) are rectangular (30 m x 150 m) and receive pump-circulated water from Bivan's Arm Lake. At the beginning of the study (August 1984) approximately 60% of the water surface in Pond 1 was covered with waterhyacinth. Waterhyacinth weevils were present on these plants at a density of approximately 0.5 weevils per plant. Small populations of waterhyacinth (less than 20% total pond surface area) were present in Ponds 2, 4 and 5. No waterhyacinths were present in Ponds 3, 6 and 7. In March 1985 waterhyacinth plants were collected from southeastern Alachua Co. and transported to the experimental site. A quantity of plants was added to each of ponds 2, 4 and 5 to increase the total plant surface area coverage to approximately 20%. Plants were added to Ponds 3, 6 and 7 to provide approximately 20% total surface area coverage. Waterhyacinth weevils were present on these introduced plants at an average density of 0.5 weevils per plant.

Plants were allowed to colonize the ponds for several months in order to obtain complete surface coverage. Three separate analyses of water quality between August 1984 and April 1985 indicated that nutrient levels were relatively low (total N: $\bar{x} = 1.3$ ppm; total P: $\bar{x} = 0.9$ ppm). Consequently inorganic fertilizer (10N-10P-10K) was added to each pond at a rate of 85.25 kg/ha (75 lb/acre) in late May, 1985. In a further attempt to promote water surface coverage by the plant, foliar fertilizer (Sunniland™,

[1]Postdoctoral research associate, Dept. of Entomology and Nematology, Univ. of Florida, Gainesville, FL 32611.
[2]Biologist, Agronomy Department, University of Florida.
[3]Lab Technician, Department of Entomology and Nematology, Univ. of Florida.

15-7-7) was applied to the plants in August of 1985 at a rate of 16.5 l/ha (1.5 gal/acre). By early April of 1986, from 80 to 100% of the surface area of all ponds was covered with waterhyacinth.

Plant and insect densities were sampled periodically before and after herbicide application during the course of the study. A 0.25 m^2 frame was placed at random in the weed mat at three locations within each pond on each sampling date. The total number of plants in a frame were counted and multiplied by 4 to obtain plant density per square meter. To estimate adult weevil densities, 10 plants were removed from each frame and the total number of adult weevils on each plant was recorded. These weevils were then preserved in alcohol for later species identification.

Ponds were sprayed on 30 April 1986 with Rodeo™ (glyphosate) at a rate of 6.7 kg/ha (1.5 g/acre) and sprayed plants died within 2 weeks. Two different herbicide treatments (Figure 1) were used and randomly assigned to the 7 ponds. In Treatment 1 (Ponds 1, 4 and 5), the dimensions of the sprayed area were 30m x 75m, whereas in Treatment 2 (Ponds 2, 3, 6, and 7), the dimensions of the sprayed area were 15m x 150m. The objective of using these two spray patterns was to provide both short-edged mats (30 m in Ponds 1, 4 and 5) and long-edged mats (150 m in Ponds 2, 3, 6 and 7) from which waterhyacinths could grow and move into open water following herbicide application.

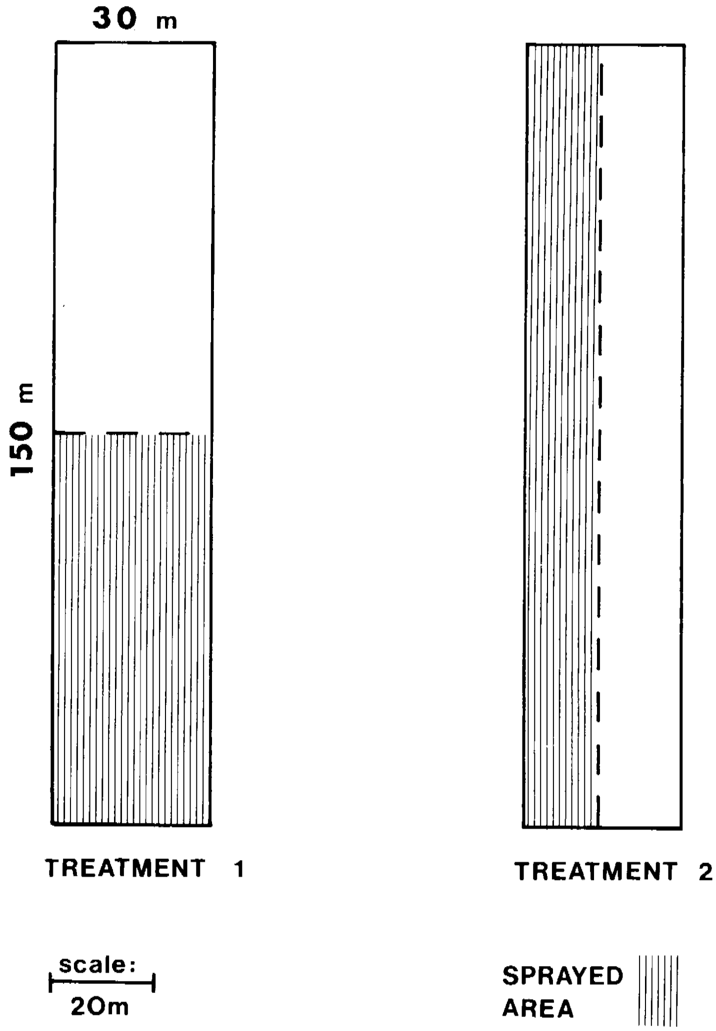

Figure 1. Diagram of herbicide application patterns used in experimental ponds. In Treatment 1 (Ponds 1, 4, 5), the area sprayed was 30m x 75m, resulting in short-edged mats. In Treatment 2 (Ponds 2, 3, 6, 7), the area sprayed was 15m x 150m, resulting in long-edged mats. White area represents unsprayed waterhyacinths allowed to remain in the ponds.

RESULTS AND DISCUSSION

In April of 1984, prior to herbicide application, mean plant density in Treatment 1 ponds (1, 4 and 5) was 63.1 ± 7.7 plants per m^2. The density of unsprayed plants increased somewhat to a maximum of 93.8 ± 3.9 in July, before falling to 60.4 ± 7.1 in October. By January 6, 1987 no waterhyacinth plants remained in these three ponds. Mean plant density in Treatment 2 ponds (2, 3, 6 and 7) in April was 46.7 ± 3.4. The maximum mean plant density in these ponds (75.3 ± 9.7) was found in July, and plant density fell through the early fall so that by October we found a mean plant density of 54.0 ± 5.7 plants per m^2 in these 4 ponds. As of January 6, 1987 waterhyacinths were still found in ponds 2, 3, 6 and 7, at a mean density of 54 ± 13.4 plants per m^2.

Table 1 shows the increase in weevil density on unsprayed plants following limited herbicide application. Mean weevil density in Treatment 1 ponds (short-edge mats) at the beginning of the study was 2.7 ± 1.4 (range 0.7-4.7) weevils per 10 plant sample. The initial increase in weevil density on unsprayed plants (see 13 May data) was due to movement of insects from sprayed plants following herbicide application on 30 April. By October 1986, mean weevil density in these three ponds was 25.2 ± 6.2 (range 18.3-33.3) weevils per 10 plant sample. The sprayed plants apparently acted as a barrier before they sank, holding unsprayed plants together at one end of each pond and inhibiting formation of daughter plants along the 30 m boundary area between sprayed and unsprayed plants. Other factors combined to slow the availability of open water and subsequent growth of waterhyacinth mats in these ponds. They include a prevailing wind direction parallel to the long axis of all of the ponds which tends to blow plants into one end and never to one side of each pond. In addition, other competing aquatic plant species filled the habitat vacated by the sprayed waterhyacinth plants. They include smartweed, waterlettuce, frogbit, salvinia and waterfern. These plants could only compete for space effectively in those ponds in which waterhyacinth growth was slowed due to the heavy damage by insect feeding.

The mean weevil density in Ponds 2, 3, 6, and 7 (Treatment 2, long-edged mats) at the beginning of the study was 1.6 ± 1.2 (range 0.3-3.3) weevils per 10 plant sample. Insect density initially increased on unsprayed plants in these ponds due to weevil movement immediately following herbicide application. However, the waterhyacinth population also increased in size after sprayed plants died and sank leaving a long boundary area from which daughter plants could form and colonize open water. Sprayed

TABLE 1. CHANGES IN WATERHYACINTH WEEVIL POPULATIONS IN EXPERIMENTAL PONDS FOLLOWING LIMITED HERBICIDE APPLICATION ON 30 APR 1986.

	Mean No. of Adult Weevils ± St. Dev. per 10 Plants				
	11 Apr	13 May	9 Jun	29 Jul	16 Oct
Treatment 1: Short-edged mats: Sprayed area = 30 m x 75 m					
Pond 1	2.7 ± 0.5	3.3 ± 1.2	10.0 ± 7.1	7.7 ± 0.9	33.3 ± 5.2
Pond 4	4.7 ± 1.9	7.7 ± 4.2	5.0 ± 0.8	13.0 ± 4.3	18.3 ± 2.1
Pond 5	0.7 ± 0.5	2.3 ± 1.7	3.3 ± 2.9	7.0 ± 2.2	24.0 ± 3.6
Mean ($\bar{x}$)	2.7 ± 1.4	4.4 ± 1.7	6.1 ± 2.8	9.2 ± 2.7	25.2 ± 6.2
Treatment 2: Long-edged mats: Sprayed area = 15 m x 150 m					
Pond 2	0.3 ± 0.5	—	4.3 ± 4.2	3.3 ± 2.5	6.0 ± 3.7
Pond 3	0.7 ± 0.9	3.3 ± 2.1	5.7 ± 3.4	7.3 ± 3.8	19.0 ± 2.4
Pond 6	2.0 ± 1.6	11.3 ± 1.2	4.3 ± 1.2	1.3 ± 0.5	8.3 ± 3.4
Pond 7	3.3 ± 1.2	9.0 ± 2.4	11.0 ± 4.9	6.3 ± 1.2	5.3 ± 2.9
Mean ($\bar{x}$)	1.6 ± 1.2	7.9 ± 3.4	6.3 ± 2.8	4.6 ± 2.4	9.7 ± 5.5

plants presumably sank at a rate comparable to those in Ponds 1, 4 and 5. However, wind action served to move unsprayed plants apart, breaking up the mat and providing many additional boundary areas along which daughter plants could form. Thus the weed mats expanded faster in these ponds than in Treatment 1 ponds. The resulting level of biocontrol was inadequte to destroy the waterhyacinth mats since the weevil population could not increase at a comparable rate. Waterhyacinths were still found in these four ponds as of January 6, 1987 at densities approximating those found in October of 1986.

The mean weevil density in ponds 1, 4 and 5 (152.2/m^2) was significantly different (t-test, $p<0.01$) from the weevil density in ponds 2, 3, 6 and 7 (52.4/m^2) in October 1986. We attribute this difference to the different herbicide spray patterns used in the seven ponds. We surmise that an intact mat of waterhyacinths which was somewhat space restricted provided a stable habitat for the weevils. Insect population growth resulted in increasing levels of feeding damage and the subsequent collapse of the weed mat. Similar results were seen by Haag (1986b) in a 1-acre pond in Alachua Co. Ponds left with a long boundary area along which the waterhyacinth populations could expand to fill open water developed larger mats of waterhyacinth, reducing the intensity of insect feeding damage. Insect populations could not increase at a comparable rate, so the level of biocontrol was less than desired.

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