

Evaluation of a New Formulation of Reward Landscape and Aquatic Herbicide for Control of Duckweed, Waterhyacinth, Waterlettuce, and Hydrilla

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ABSTRACT

A new formulation of Reward Landscape and Aquatic Herbicide (Reward QIT) was recently developed by Syngenta to alleviate problems associated with particulates in the former formulation (Reward). Reward QIT was tested in outdoor tanks to compare its herbicidal activity to the older Reward formulation. No differences in herbicidal activity were observed between the two formulations when applied to hydrilla (*Hydrilla verticillata* L.f. Royle) at 0.25 ppm diquat dibromide cation or 0.25 ppm diquat dibromide cation plus 1.0 ppm copper. Also, no differences in herbicidal activity were observed between the two formulations when applied to, duckweed (*Lemna minor* L.), waterhyacinth (*Eichhornia crassipes* Mart Solms), or waterlettuce (*Pistia stratiotes* L.). Greater than 95% control was observed against all floating species tested when either formulation was applied at 4.7 or 7.0 l/ha. Reward QIT applied at 2.3 l/ha resulted in 92% control of duckweed and waterhyacinth and 96% control of waterlettuce. Additional waterlettuce plants were treated with 0.09, 0.18, 0.28, 0.56, or 0.84 l/ha of either formulation to determine if subtle differences in herbicidal activity could be observed at the lower rates. No differences were observed between equal rates of the two formulations at these lower rates, and all rates resulted in lower dry weights of waterlettuce after 24 days as compared to untreated plants.

Key words: diquat dibromide, chemical control, Reward, formulation, *Hydrilla verticillata*, *Lemna minor*, *Eichhornia crassipes*, *Pistia stratiotes*.

INTRODUCTION

Diquat (6,7-dihydrodipyrido[1,2- α :2',1'-c]pyrazinediium ion) was shown to have herbicidal properties in 1955 (Brian et al. 1958). It is a contact herbicide that interferes with electron flow in photosynthesis and results in rapid desiccation

of green plant tissue (Ashton and Crafts 1973). It is manufactured as the water soluble dibromide salt and is used to control algae, submersed aquatic weeds, floating aquatic weeds, and cattails (*Typha* spp.) in ponds, lakes, and drainage ditches (Ahrens 1994). Reward Landscape and Aquatic Herbicide (Reward) (Syngenta Crop Production, Inc., Greensboro, NC) contains 240 g diquat dibromide cation per liter of formulation (2 lb cation/gal) and is currently the most commonly used diquat containing product in the United States.

Diquat formulations have had undesirable characteristics related to particulates that can cause nozzle clogging and staining of spray tanks, clothing and concrete. Syngenta recently developed a "Quality Improved Technology" formulation of Reward Landscape and Aquatic Herbicide (Reward QIT) to alleviate the problems associated with the particulates in the former formulation. Reward QIT results in a more clear solution when mixed with water and causes less staining and has no nozzle clogging characteristics. The following studies were conducted to compare the herbicidal activity of Reward QIT and the former Reward formulation for control of the aquatic weeds hydrilla, waterhyacinth, waterlettuce, and duckweed for which diquat is commonly used. Reward is often used as a tank-mix with copper based herbicides to control submersed vegetation; therefore, Reward QIT was also evaluated in combination with Clearigate (Applied Biochemists, Inc., Milwaukee, WI), a copper based herbicide/algicide for control of hydrilla.

METHODS

Hydrilla. Apical hydrilla sections 15 cm in length were planted August 15, 1999, in 85 mm square by 75 mm deep plastic culture containers with commercial top soil (Earthgro, Marysville, OH) and allowed to establish for 2 weeks in 218 cm by 76 cm by 48 cm deep outdoor-concrete tanks filled with 803 l of well water. Thirty six pots were placed in each of seven tanks. One tank each was treated with 0.25 ppm diquat (cation) from Reward, 0.25 ppm diquat (cation) from Reward QIT, 1.0 ppm copper from Clearigate, 0.25 ppm diquat from Reward + 1.0 ppm copper from Clearigate, 0.25 ppm diquat from Reward QIT + 1.0 ppm copper from Clearigate, and one tank not treated with herbicide served as the control.

Experimental Reward QIT (WF2706) and Reward (WF1695) were supplied by Syngenta Crop Protection, Inc. Diquat

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formulations and Clearigate were diluted in 500 ml water and the solutions were distributed evenly over the water surface of the tanks. Three replicate culture containers containing hydrilla were removed from each treatment tank 3, 7, 14, and 21 days after application of herbicide. Plants were rinsed, dried to constant weight in a forced air dryer, and dry weight was measured on an analytical balance.

Application of moderate rates to floating plants. Duckweed, waterhyacinth, and waterlettuce plants were collected locally and placed in outdoor-concrete tanks similar to those previously described. The tanks were filled with water and fertilized with 15/30/15 water soluble fertilizer (Miracle-Gro All Purpose Plant Food, Miracle-Gro Products, Inc., Port Washington, NY) sufficient for 0.5 ppm total nitrogen. The three species were separated and given equal area in the tanks. Plants were allowed to acclimate for 2 weeks then received foliar treatment on September 29, 1998 with Reward or Reward QIT at 4.7 or 7.0 l/ha (2 or 3 qt/acre) or Reward QIT at 2.3 l/ha (1 qt/acre). Three replicate tanks of each treatment and untreated controls were included. Herbicides were applied in a spray volume equivalent to 1402 l/ha (150 gal/acre) containing 0.25% silicone surfactant (Pro-Mate Kinetic, Helena Chemical Company, Memphis, TN) with a hand-held CO₂ microsprayer. Visual ratings of percent necrotic tissue were made 1, 3, 7, and 14 days after application.

Application of Low Rates to Waterlettuce. Tanks similar to those previously described were divided into thirds for three random replications of each herbicide treatment and controls. Plants were treated on June 26, 2001 with 0.09, 0.19, 0.28, 0.56, and 0.84 l/ha (0.04, 0.08, 0.12, 0.24, and 0.36 qt/acre) of Reward or Reward QIT in 748 l/ha (80 gal/acre) spray volume with 0.25% non-ionic d-limonene surfactant (Cide-Kick, Brewer International, Vero Beach, FL). Plants were harvested 24 days after application, dried to constant weight in a forced air dryer, and dry weight was measured on an analytical balance.

All data were statistically analyzed using the Statistical Analysis System (SAS Institute, Inc., Cary, NC) General Linear Models (GLM) Procedure Means statement and T (LSD) option. This procedure performs pairwise *t* tests, equivalent to Fisher's least-significant-difference test (SAS Institute, Inc. 1985).

RESULTS AND DISCUSSION

All herbicide treated hydrilla plants were severely necrotic indicating mortality 14 and 21 days after application, while plants not treated were healthy and growing vigorously. Dry weights of all herbicide treated hydrilla plants were different from untreated plants but not different from each other after 14 and 21 days (Table 1).

Greater than 95% control (necrotic tissue) of all duckweed, waterhyacinth, and waterlettuce was observed 14 days after application of 4.6 or 7.0 l/ha of Reward or Reward QIT (Table 2). No differences were observed among rates or between the two formulations for any species. Rates recommended on the Reward Landscape and Aquatic Herbicide label are 4.7 to 7.0 l/ha for waterlettuce and waterhyacinth and 9.3 l/ha for duckweed, but Reward QIT applied at 2.3 l/ha resulted in 92% control of duckweed and waterhyacinth

TABLE 1. DRY WEIGHT (G PER CULTURE CONTAINER) OF HYDRILLA AFTER TREATMENT WITH REWARD (0.25 PPM DIQUAT CATION), REWARD QIT (0.25 PPM DIQUAT CATION), CLEARIGATE (1.0 PPM COPPER), OR COMBINATIONS.

Treatment	Days after application			
	3	7	14	21
Control	0.85 a ¹	1.62 a	1.33 a	1.14 a
Reward	1.51 a	1.10 a	0.60 b	0.43 b
Reward QIT	1.90 a	1.39 a	0.27 b	0.10 b
Clearigate	1.27 a	1.57 a	0.25 b	0.04 b
Reward + Clearigate	1.28 a	1.04 a	0.59 b	0.03 b
Reward QIT + Clearigate	1.36 a	0.89 a	0.17 b	0.06 b
LSD (p = 0.05)	1.14	1.58	0.62	0.56

¹Values represent the average of three replications. Values in a column followed by the same letter are not different.

and 96% control of waterlettuce. Therefore, both formulations resulted in excellent control at or below the recommended rates.

Low rates of diquat were tested on waterlettuce to determine if subtle differences in the formulations were present that could not be detected at the higher rates. As with higher rates of application, differences in the two formulations were not detected. Dry weights of waterlettuce plants 24 days after application, were not different between plants treated with the same rate of either Reward or Reward QIT (Table 3). Al-

TABLE 2. AVERAGE PERCENT NECROTIC TISSUE OF FLOATING PLANTS BASED UPON VISUAL ESTIMATES OF THREE REPLICATE TANKS TREATED WITH REWARD, OR REWARD QIT.

Herbicide	Rate (l/ha)	Days after application			
		1	3	7	14
Duckweed					
Reward QIT	2.3	13 a ¹	33 b	76 a	92 a
Reward QIT	4.6	63 a	100 a	99 a	97 a
Reward	4.6	48 a	88 a	100 a	99 a
Reward QIT	7.0	63 a	98 a	99 a	96 a
Reward	7.0	37 a	97 a	99 a	100 a
LSD (p = 0.05)	—	55	16	26	12
Waterhyacinth					
Reward QIT	2.3	43 a	87 b	88 b	92 a
Reward QIT	4.6	38 a	87 b	96 a	100 a
Reward	4.6	47 a	93 ab	97 a	100 a
Reward QIT	7.0	50 a	100 a	100 a	100 a
Reward	7.0	40 a	92 ab	97 a	100 a
LSD (p = 0.05)	—	15	9	5	8
Waterlettuce					
Reward QIT	2.3	43 ab	99 a	97 a	96 b
Reward QIT	4.6	55 a	99 a	100 a	100 a
Reward	4.6	50 ab	99 a	98 a	99 a
Reward QIT	7.0	0 c	99 a	99 a	99 ab
Reward	7.0	30 b	99 a	98 a	100 a
LSD (p = 0.05)	—	24	1	4	2

¹Values in a column for each species followed by the same letter are not different.

TABLE 3. RESPONSE OF WATERLETTUCE TO LOW APPLICATION RATES OF REWARD AND REWARD QIT 24 DAYS AFTER APPLICATION.

Herbicide	Rate (l/ha)	Dry weight (g)
Untreated	—	448 a ¹
Reward QIT	0.09	281 b
Reward	0.09	232 bc
Reward QIT	0.18	183 cde
Reward	0.18	225 bcd
Reward QIT	0.28	174 cde
Reward	0.28	210 cd
Reward QIT	0.56	166 cde
Reward	0.56	158 de
Reward QIT	0.84	126 e
Reward	0.84	131 e
LSD (p = 0.05)	—	68.7

¹Values represent the average of three replications. Values followed by the same letter are not different (p = 0.05, LSD = 68.7).

though the rates applied in this experiment were sublethal, all rates of both formulations reduced growth when compared to untreated checks (Table 3).

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