Re-evaluating the Test of the Herbicide Weed Slayer for the Control of Invasive Plants

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ABSTRACT

The natural herbicide Weed Slayer, containing clove oil (eugenol) as its active ingredient, was claimed by its manufacturer to have a systemic herbicidal activity. This distinguishes it from all other organic herbicides, which have only a burn-down effect. A study was conducted to test for this effect on invasive plants in the Peninsula Watershed of the San Francisco Public Utilities Commission, and some efficacy was observed. The results of this test were reported in a poster for the 2020 Cal-IPC Symposium. Weed Slayer is sold as two components that are mixed together, one containing clove oil, called Weed Slayer, and another called Agro Gold containing biological amendments. It was subsequently revealed the Agro Gold component contained two synthetic herbicides, glyphosate and diquat. The present study is a follow-up to the previous study, conducted to determine how much of the observed herbicidal effect of Weed Slayer was due to the clove oil-containing component and how much was due to the other component containing glyphosate and diquat. Each component was applied separately and in combination in spray treatments to test plots containing a mixture of grasses and English plantain (*Plantago lanceolata*). Each component was also applied separately in cut-stem treatments to jubatagrass (*Cortaderia jubata*), to coyote brush (*Baccharis pilularis*) and to Spanish broom (*Spartium junceum*) to test for systemic effect. The results of the follow-up test indicate that all of systemic activity is attributable to the Agro Gold component but that the clove oil-containing component also produced a foliar herbicidal effect.

INTRODUCTION

Invasive plant control practitioners have for many years relied largely on the use of glyphosate for chemical control in their integrated pest management programs. It has the advantages of broad-spectrum control, systemic activity and absence of residual soil activity. However, lately they have been seeking alternatives because of problems with the use glyphosate. These include increasing genetic resistance, regulatory restrictions and the classification of glyphosate as a probable carcinogen.

Recently, a new herbicide, Weed Slayer, containing clove oil (eugenol) plus other proprietary natural ingredients was introduced. This was purported to have some of the benefits of glyphosate, including broad-spectrum control, systemic activity and lack of soil residual, while not having the undesirable characteristics.

At the 2020 California Invasive Plant Council Symposium I presented a poster (Thomas 2020) on a test of the efficacy of Weed Slayer for the control of several invasive plants. This test involved both foliar applications and cut-stump treatments of Weed Slayer. The results indicated some efficacy of both types of treatments, with somewhat mixed effectiveness.

Weed Slayer Herbicide is sold as two components: Weed Slayer, containing clove oil, and Agro Gold WS, containing a proprietary combination of micro-organisms and other ingredients. These two components are combined as a tank mixture to form Weed Slayer Herbicide. In December 2020 it was revealed that the Agro Gold WS component illegally contained the two synthetic herbicides glyphosate and diquat. This disqualified it for use in organic agriculture. A Stop Use Notice and state-wide quarantine was then issued for Agro Gold by the state of California (California State Department of Food and Agriculture 2020), and this was shortly followed up by similar actions by the states of Oregon and Washington.

The present study is a follow-up to the previous test of Weed Slayer, conducted to disaggregate the separate effects of the clove oil and Agro Gold WS components. Each component was tested separately for phytotoxic effects in both foliar-spray and cut-stump treatments, and the results are presented in this study.

METHODS

Both foliar spray and cut-stump applications were employed in the tests of the two components of Weed Slayer Herbicide: Weed Slayer (hereafter referred to as Part A) and Agro Gold WS (hereafter referred to as Part B). All applications were made in the Peninsula Watershed of the San Francisco Public Utilities (SFPUC).

Foliar Spray Applications. Applications of Part A and of Part B were made separately and also in combination, for comparison, to rectangular test plots 5 feet by 11 feet in dimension. The spray solution was acidified to approximately pH 4, according to directions, using citric acid. There were 3 replicates per treatment and also an untreated buffer strips between plots that functioned as controls. All applications were made at the maximum label rate of 5 fl. oz. per gal for the component. The adjuvant CMR Can-Hance was used as a wetting agent. The vegetation of the test plots was composed mostly of non-native grasses, such as *Avena* species, native bunchgrass (Stipa lepida) and English plantain (Plantago lanceolata). All applications were made in February and March 2021.

Cut-Stump Applications. Cut-stump applications involved cutting of stems near ground level with either loppers or a saw. Either full-strength Part A or full-strength Part B was applied to the cut stem surface with a paint brush. Some cut stems were left untreated as controls. Three species were selected as test plants: Spanish broom (*Spartium junceum*), jubatagrass (*Cortaderia jubata*) and coyote brush (*Baccharis pilularis* ssp. *consanguinia*). All treatments were made in January and February 2021.

Table 1 presents a list of the treatments, the observation dates and the observed results.

Figure 1. View of test plots used for the tests of foliar applications of Weed Slayer (Part A), Agro-Gold WS (Part B) and the combination of Part A plus Part B.

Figure 2. Appearance of test plots receiving foliar treatments. Top row left: Part B. Top row right: Part A plus Part B. Bottom row left: Part A. Bottom row right: Control

Figure 3. Appearance of test plot treated with eugenol combined with molasses (used to simulate the formulation of Part A).

Figure 4. The effect of cut-stump treatments 6 months after application. Top row left: Coyote brush Part B. Top row center: Coyote brush Part A. Top row right: Coyote brush Control. Bottom row left: Spanish broom Part B. Bottom row center: Spanish broom Part A. Bottom row right: Spanish broom Control.

Conclusions: The results of this follow-up study indicate that all of systemic activity is attributable to the Agro Gold component (assumed to contain glyphosate and diquat) but that the clove oil-containing component also produced a foliar herbicidal effect.

Type of Treatment	Plant or Vegetation Treated	Treatment	Date Evaluated for Effect of Treatment Effect	Effect of Treatment
Foliar Spray	Weedy grassland composed of English plantain (*Plantago lanceolata*), wild oats (*Avena* species), native bunch grass (*Stipa lepida*) and other species	Weed Slayer (Part A)	8/23/2021	Extensive phytotoxicity to grasses and English plantain, but this was followed by recovery of some perennial plants including hayfield tarplant (*Hemizonia congesta*) and native bunchgrass.
Foliar Spray	Weedy grassland composed of English plantain (*Plantago lanceolata*), wild oats (*Avena* species), native bunch grass (*Stipa lepida*) and other species	Agro Gold WS (Part B)	8/23/2021	Extensive phytotoxicity of all annual and perennial plants, without later regrowth.
Foliar Spray	Weedy grassland composed of English plantain (*Plantago lanceolata*), wild oats (*Avena* species), native bunch grass (*Stipa lepida*) and other species	Weed Slayer (Part A) plus Agro Gold WS (Part B)	8/23/2021	Extensive phytotoxicity of all annual and perennial plants, without later regrowth.
Foliar Spray	Weedy grassland composed of English plantain (*Plantago lanceolata*), wild oats (*Avena* species), native bunch grass (*Stipa lepida*) and other species	Untreated Control	8/23/2021	Vegetation was composed of a dense cover of yellow starthistle (*Centaurea solstitialis*), hayfield tarplant (*Hemizonia congesta*), English plantain (*Plantago lanceolata*), and grasses, including wild oats (*Avena* species and native bunchgrass (*Stipa lepida*).
Cut-Stump Treatment	Coyote brush (*Baccharis pilularis*)	Weed Slayer (Part A)	8/27/2021	Vigorous regrowth from cut stems, comparable to untreated control.
Cut-Stump Treatment	Coyote brush (*Baccharis pilularis*)	Agro Gold WS (Part B)	8/27/2021	Complete suppression of re-sprouting of cut stems.
Cut-Stump Treatment	Coyote brush (*Baccharis pilularis*)	Untreated Control	8/27/2021	Vigorous regrowth from cut stems, comparable to untreated control.
Cut-Stump Treatment	Spanish broom (*Spartium junceum*)	Weed Slayer (Part A)	8/27/2021	Vigorous regrowth from cut stems, comparable to untreated control.
Cut-Stump Treatment	Spanish broom (*Spartium junceum*)	Agro Gold WS (Part B)	8/27/2021	Complete suppression of re-sprouting of cut stems.
Cut-Stump Treatment	Spanish broom (*Spartium junceum*)	Untreated Control	8/27/2021	Vigorous regrowth from cut stems, comparable to untreated control.
Cut-Stump Treatment	Jubatagrass (Cortaderia jubata)	Weed Slayer (Part A)	8/27/2021	Vigorous re-growth following cutting of stems,.
Cut-Stump Treatment	Jubatagrass (Cortaderia jubata)	Agro Gold WS (Part B)	8/27/2021	Re-growth of stems but with reduced growth, compared with plant treated with Part A.

Table 1. Summary of the effects of the application of foliar spray treatment of Agro Gold WS (Part B) and Weed Slayer (Part A) on grassland vegetation and of cut-stump treatment of Agro Gold WS (Part B) and Weed Slayer (Part A) on coyote brush, Spanish broom and jubatagrass.

RESULTS AND DISCUSSION

Table 1 summarizes the results of the separate and combined effects of the application of the Weed Slayer clove oil (eugenol) component (Part A) and of the Agro Gold WS biological amendments component (Part B).

The results of the cut-stump treatments (displayed in Figure 2) indicate that all of the systemic activity observed for Weed Slayer Herbicide in the previous study (Thomas 2020) can be attributed to the Part B component. The cut-stem application of Part B to Spanish broom and to coyote brush completely suppressed regrowth of these plants. In contrast, application of Part A resulted in vigorous re-sprouting, similar to the regrowth of untreated control plants. Jubatagrass plants treated with Part B exhibited some regrowth, but this result is also often observed for plants treated with glyphosate (DiTomaso, Drewitz and Kyser 2008). The results of these tests are consistent with expected effect of cut-stump treatment with glyphosate, assumed to be the active ingredient in Part B.

The effect of the foliar spray treatments (displayed in Figure1), however, was less clear-cut. The application of a foliar spray of Part B alone produced extensive phytotoxicity for the treated plants in the test plots. This was to be expected because, if Part B contains glyphosate and diquat, it should have this phytotoxic effect. However, it was also found that the application of the foliar spray of Part A alone also produced extensive phytotoxicity for both the grasses and the English plantain. Later, tarplants (*Hemizonia congesta*) that apparently escaped treatment were able to emerge, grow up and flower in some of the test plots treated with Part A. The combined Part A plus Part B treatment produced effects similar to Part B alone, as expected.

The results of the foliar application of Part B indicate that this formulation of clove oil by itself may be a very efficacious “burn-down” product. The efficacy of clove oil (eugenol) as a non-selective post-emergent herbicide has been demonstrated in a number or studies (Tworkoski 2002, Bainard et al. 2006, Vaid et al. 2010 and Ahuja et al. 2015). However, the effectiveness of Part A exceeded expectations in its ability initially to burn down all of the vegetation in the test plots. The strong phytotoxic effect of Part A alone, the combination of clove oil plus molasses, indicates that this combination may have efficacy equal to or greater than many of the other commercial clove oil products. I tried to simulate this formulation by combining 94 per cent molasses with 6 per cent eugenol and tested it by applying it to a test plot at the rate of 5 fluid oz. per gallon in pH 4 water. Figure 3 displays the effect of this treatment. The observed effect was conspicuous phytotoxicity and reduced growth compared to untreated control plots. However, though it inhibited the growth of vegetation, it did not produce the level of phytotoxicity observed in the Weed Slayer Part A treatment plots. This suggests that I failed to replicate the formulation of the product or that the Part A component may contain some undisclosed ingredient that enhances its efficacy as an herbicide.

The results of the present study strongly indicate that the formulation of clove oil with molasses in the Part A component (called Weed Slayer) is lacking in the claimed systemic effect. After it was revealed that Agro Gold contained glyphosate plus diquat, the manufacturer, Agro Research International, dropped its claim of systemic activity and reformulated Agro Gold strictly as a surfactant adjuvant. However the results of this study showed that the Weed Slayer formulation of clove oil plus molasses, when adjusted to pH 4, is an effective burn-down product comparable or superior in effect to other burn-down products on the market. Therefore, Weed Slayer Herbicide, as presently formulated, may actually have good efficacy against annual weeds and perennial weed seedlings. If Weed Slayer is permitted to return to the market, as presently constituted, it may have some uses for invasive weed management.

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