A Test of Reduced Rates of Glyphosate for the Control of Invasive Plants

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ABSTRACT

After the World Health Organization International Agency for Research on Cancer (IARC) determined that the herbicide glyphosate is a probable carcinogen, many public agencies have either restricted or suspended its use. The City of San Francisco, for example, has limited its use within the city limits to more critical applications, such as protection of sensitive species and habitats, where alternatives are not available. Furthermore, the City has requested that its departments develop a plan to reduce or eliminate the use of this herbicide in the future.

Several studies have indicated that with cut-stump applications the rate of application of glyphosate can be reduced without losing efficacy. This study is a test of the efficacy of reduced rates of glyphosate for the control of three non-native invasive plants: blue gum eucalyptus (*Eucalyptus globulus*), jubatagrass (*Cortaderia jubata*) and French broom (*Genista monspessulana*). Reduced rates of glyphosate were also tested for the management of coyote brush (*Baccharis pilularis*), a native plant that invades serpentine grassland. It was found that 5%, 10% and 20% of glyphosate product (Aquamaster), equivalent to 2.7%, 5.4% and 10.8% active ingredient, may be as effective as the conventional rate of 50% product or 26.9% active ingredient. The results of this study suggest that it may be possible to substantially reduce the amount of glyphosate applied and the associated worker exposure risks without entirely losing the use of this valuable tool for the management of invasive plants.

INTRODUCTION

The herbicide glyphosate is the active ingredient in Monsanto Roundup Promax, Roundup Custom and many generic products. Its mode of action is the inhibition of the enzyme involved in the synthesis of the three aromatic amino acids tryptophan, tyrosine and phenylalanine through the shikimic acid pathway. Because this biosynthetic pathway is only present in plants, glyphosate has been considered to have relatively low toxicity for humans (Williams et al. 2000).

However, the recent determination by the International Agency for Research on Cancer (IARC) that the herbicide should be classified as a probable carcinogen, based on animal studies, effects on DNA and links to Hodgkin's lymphoma in humans, has resulted in a reconsideration of its use by many public agencies and non-profit organizations. For example, the California EPA issued a notice of intent to list glyphosate as a Proposition 65 carcinogen. Some organizations, such as the San Francisco Presidio Trust, have decided to suspend the use of glyphosate. Others, such as the National Park Service, have been waiting for a risk assessment to be concluded by the U.S. EPA before changing their policies regarding use of glyphosate. On September 12, 2016 the EPA issued a report concluding that glyphosate is not likely to cause cancer in humans (U.S. EPA 2016).

The City of San Francisco has pursued an intermediate approach. The City Department of Environment adopted a policy of allowing use of glyphosate and other Tier I herbicides on City property only with additional conditions and restrictions, such as no use for purely cosmetic purposes (SF Environment 2016), and reserving it for uses where there are no other practical alternatives. However, City departments have been instructed to develop plans for reducing and possibly suspending the use of glyphosate in the future.

This study is a preliminary small scale test of the effectiveness of applying glyphosate at reduced rates in cut-stump applications, with the objective of lowering the amount applied and the corresponding human and animal exposure. The standard cut-stump method involves the application of concentrated herbicide, usually a 50-100% solution, to the ring of cambial tissue in the outer part of a freshly cut stem (see Monsanto label in References section below). The herbicide is then translocated downward through the vascular tissue to the roots, resulting in the eventual death of the plant due to protein starvation.

A number of studies have found that it may be possible to reduce the rate of application of glyphosate in cut-stump applications without losing efficacy. Kegley and Toy (2012) summarized the results of a number of studies employing reduced rates of glyphosate, including several listed in a report published by the Ontario Ministry of Natural Resources (Mallik et. al. 1997). For example the University of California, Berkeley, reported successfully using reduced rates (5-20% of product) in cut-stump applications in a fire fuel management program (Klatt 2004). A UC IPM Pest Notes publication (UC Statewide Integrated Pest Management Program 2008) recommends use of products with 8-10% active ingredient at full strength for cut-stump treatment of woody plants.

In this study I evaluated the efficacy of three reduced rates of glyphosate for cut-stump treatment: 5%, 10% and 20% by volume of glyphosate herbicide product (Monsanto Aquamaster or Roundup Custom). These are equivalent to 2.7%, 5.4% and 10.8% active ingredient, respectively. This was tested on three invasive plant species: blue gum eucalyptus (*Eucalyptus globulus*), jubatagrass (*Cortaderia jubata*), French broom (*Genista monspessulana*) and also on a native plant, coyote brush, that invades serpentine grassland and other sensitive habitats (Barbella et al. 2014, Thomas 2015). These species were selected for the purpose of including in the test different plant families and plant growth forms. All tests were performed in the Crystal Springs watershed of the San Francisco Public Utilities Commission.

Figure 1. Appearance of representative examples of the cut stumps of the four test species treated with reduced rates of glyphosate. Blue flags indicate 20%, orange flags indicate 10% and red flags indicate 5% of glyphosate product. Top row: coyote brush stumps. Second row: eucalyptus stumps. Third row: French broom stumps. Bottom row: cut stems of jubatagrass.

METHODS

Three different rates of glyphosate, 5%, 10% and 20% of product by volume, were tested in this study. The three rates were tested on four different species (blue gum eucalyptus, jubatagrass, French broom and coyote brush).

The reduced rates of glyphosate were tested using the cut-stump method (Kyser et al.). The glyphosate solution was applied to the surface of the cut stump immediately after cutting. Treated plants were marked with colored flags. Plants treated with the 20% rate were marked with blue flags, those treated with the 10% rate with orange flags and those treated with the 5% rate with red flags (Figure 1). Treatments were randomly assigned to plants for each of the test species. The applications were made to French broom in November 2015, to eucalyptus and jubata grass in December 2015 and to coyote brush in February 2016.

These treatments were evaluated for effectiveness in August 2016. Cut stumps were examined for resprouts originating from the cut stump or, in the case of jubatagrass, within the same clump. Absence of resprouting was considered to be an indication of effective control.

RESULTS AND DISCUSSION

The results of the test of reduced rates of glyphosate are presented in Figure 2. Because of the small sample sizes involved, results are still preliminary, but they appear to indicate that the 20% glyphosate rate provided complete control for all of the test species. Furthermore, the 5% rate appears to have resulted in complete suppression of resprouting for French broom and eucalyptus. Figure 1 presents representative examples of cuts stumps of the four species treated at the three reduced rates, showing them as they appeared in August 2016. These illustrate the overall effectiveness of the reduced rates of glyphosate in suppressing resprouting.

There was, however, some recovery of coyote brush with the 5% rate and of jubatagrass with the 5% and 10% rates. This suggests that with these lower rates some retreatment may be required. For coyote brush, though there was some resprouting with the 5% treatment, this seems to have been delayed and reduced in vigor by the treatment compared to the untreated cut-stump control (Figure 3).

Though regrowth was observed for some clumps of jubatagrass, this amount may be no more than normally occurs with jubatagrass plants treated with the standard rate of 50% product. Some resprouting is usually observed for treated jubatagrass plants, perhaps for as much as 15-20% of plants (DiTomaso 2008). Therefore, lower rates of glyphosate may be as effective as the standard rate. However, additional tests with larger sample sizes comparing plants treated with reduced rates to plants treated with the standard rate would be required to determine whether there is no statistically significant difference in efficacy.

The results of this study are in agreement with the findings of other studies that found, for a variety of species, that glyphosate can be reduced to a rate of 5-25% of herbicide product (10-50% of the standard label rate) without losing efficacy in cut-stump treatments. For example, it was found that 5% glyphosate product was effective at preventing resprouting of eucalyptus treated in pine plantations in southwest Australia (Fremlin and Jones 1984). Aspen and birch were fully controlled with 25% glyphosate product (Expert Committee on Weeds 1982) and with 20% glyphosate product (Bons cited in Mallik et al. 1997). For hardwoods it was found that 5% glyphosate product gave complete control when applied in winter, while 10% product provided complete control when applied in spring and summer (Marrs 1985).

The results of this preliminary test of reduced rates of glyphosate seem to indicate that for cut-stump treatments the rate of application of glyphosate can be reduced substantially without loss of efficacy. This would significantly reduce worker exposure risk (Kegley and Toy 2012) without losing this valuable tool for the management of invasive plants. Before use of reduced rates is adopted as a general practice, however, it may be necessary to perform additional tests to confirm efficacy for additional species, employing larger samples sizes of treated plants compared with both untreated and standard rate controls.

One potential problem with using reduced rates of glyphosate is that, with incomplete control, there is the risk of selecting for genetic resistance. At present, at least 35 weeds have become resistant to glyphosate (Heap 2016). However genetic resistance can be delayed by having a resistance management program. This involves alternating the use of glyphosate with an herbicide with a different mode of action, such as an auxin analog or a branched chain amino acid synthesis inhibitor. Alternatively, glyphosate could be combined in a tank mix with an herbicide with a different mode of action, such as is done for the recommended treatment for cape ivy (Broussard et al. 2000).

	Species:	Eucalyptus		French broom		Jubatagrass		Coyote brush	
Treatment	Flag Color	Sample size	Number resprouting	Sample size	Number resprouting	Sample size	Number resprouting	Sample size	Number resprouting
5%	Red	5	0	12	0	6	2	17	5
10%	Orange	6	0	13	0	7	2	6	0
20%	Blue	9	0	15	0	7	0	3	0

Figure 2. Numbers of replicate plants treated with reduced rates of glyphosate and numbers of these resprouting after treatment.

Figure 3. Examples of plants resprouting after treatment. Left: coyote brush plant treated with 5% glyphosate product. Center: untreated cut-back coyote brush control. Right: jubatagrass plant treated with 10% glyphosate product.

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