

**GLYPHOSATE-RESISTANT HORSEWEED (*Conyza canadensis* L. Cronq.)  
BIOTYPE FOUND IN THE SOUTH CENTRAL VALLEY.**

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**Abstract:**

Glyphosate-resistant horseweed biotypes have been reported in 10 states in the US, mainly in annual row-crop systems. This study showed that glyphosate-resistant (R biotype) horseweed also exists in California. The level of resistance to glyphosate, however, was influenced by the stage of growth of horseweed at the time of glyphosate application. There was a probability of controlling some of the 'R' biotype horseweeds at the 5-8 leaf stage with a 2x or 4x rates of glyphosate. After the 18-21 leaf stage, the horseweed plants were able to survive glyphosate application rates up to 4 lb ai/ac. At later stages, even some plants of the 'S' biotype escaped the lower rates of glyphosate. Therefore, it is important to control horseweed at an early stage of growth. This is the first case of glyphosate-resistant horseweed biotype existing in a non-crop situation. An integrated weed management program will have to be developed to manage glyphosate-resistant horseweed biotype in the South Central Valley.

**Introduction:**

Herbicide resistance is defined by the Weed Science Society of America as “the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis.” Herbicide resistance was first reported in 1957. Since then, several weeds have developed resistance to several groups of herbicides (Heap, 2005).

Glyphosate [*N*-(phosphonomethyl)glycine] is a non-selective, broad spectrum, systemic, post-emergence herbicide. This herbicide kills weeds by metabolic disruptions in the plant (Franz et al. 1997). It inhibits the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) which is essential for biosynthesis of aromatic amino acids (Mueller et al. 2003). Because of the complex manipulations of the target EPSPS enzyme required for developing glyphosate-resistant crops, it was commonly believed that weeds developing resistance to glyphosate was improbable (Bradshaw et al. 1997). However, it has been repeatedly found that development of herbicide resistance in weed populations is greatly increased by repeated use of a single herbicide (Holt, 1992). Eventually, glyphosate-resistance was documented in rigid ryegrass (*Lolium rigidum* L.) in 1996 in Australia (Powles et al. 1998). Since then, 15 weed species are reported to have developed resistance to glyphosate (Nandula et al. 2005).

Horseweed or mare's tail (*Conyza canadensis* L. Cronq.) is an annual plant belonging to the Asteraceae family and it is native to North America (Weaver, 2001). The first case of a glyphosate-resistant horseweed in North America was reported from Delaware in 2000 (VanGessel, 2001). Since then, nine other states in the US have reported the

occurrence of glyphosate-resistant horseweed (Heap, 2005). All of these cases were from annual row crop systems, viz. glyphosate-resistant cotton and soybean. It is believed that intense use of glyphosate in glyphosate-resistant crops has caused the evolution of several weed populations with natural resistance to glyphosate (Nandula et al. 2005). No case of glyphosate-resistant horseweed has been reported in California and in non-crop areas. Poor control of horseweed with glyphosate was reported in an irrigation canal bank in Dinuba, CA with suspected glyphosate- resistance (personal communication J. Heringer). Therefore, the objective of this study was to confirm the existence of glyphosate-resistant horseweed in seeds collected from Dinuba, CA and to evaluate the interaction of glyphosate rate and plant growth stage.

### **Materials and Methods:**

Horseweed seeds were collected from a suspected glyphosate-resistant population in Dinuba, CA and a suspected susceptible population in western Fresno, CA in the fall of 2004. Seeds were stored under room temperature in the lab. On April 4, 2005, seeds were planted in plastic germination trays in the lab and moved to a greenhouse soon after emergence (April 13, 2005). The seedlings were allowed to establish and then transplanted into plastic pots (6 inches deep, 4 inches wide) containing a potting mix (Promix 5, Sungro Horticulture, Canada) on May 5, 2005. The suspected glyphosate-resistant plants were designated as 'R' biotype and the suspected susceptible biotype was designated as 'S' biotype. One seedling of each biotype was planted in each pot for a total of 200 pots. Of these, 80 pots were assigned each to five greenhouse benches as five replications. The 80 pots were then separated into five groups of 'R' and 'S' biotype. The group designations were based on the plant growth stage for glyphosate application as follows:

1. Glyphosate spray at 5-8 leaf stage of horseweed.
2. Glyphosate spray at 11-15 leaf stage of horseweed.
3. Glyphosate spray at 18-21 leaf stage of horseweed.
4. Glyphosate spray at bolting to 6 inch (height) stage of horseweed.
5. Glyphosate spray at 6 inch to 1 foot (height) stage of horseweed.

Within each groups, the pots were further divided into four sub-groups each of which to receive 0 (control), 1x (1 lb ai/ac glyphosate i.e. recommended label rate), 2x (2 lb ai/ac), and 4x (4 lb ai/ac). Therefore within each replication, there were 40 pots each of 'R' and 'S' biotype divided into five growth stages and four herbicide rates. Each pot containing a seedling was an experimental unit. The experimental design was a two factor (glyphosate rate and plant growth stage) completely randomized block with five replications. The plants were watered regularly and fertilized twice during the growing season with a commercial fertilizer (Miracle Gro, 4 g per gallon of water).

Glyphosate (Roundup Weathermax ®) was applied at the designated growth stage of the plants with a CO<sub>2</sub> backpack sprayer with a ..... nozzle calibrated to spray for each glyphosate rate (Figure 1). *Kurt please add details of the sprayer.* The plants were moved outside the greenhouse, sprayed, and moved back to the greenhouse after the

leaves were dry. The survival of each plant was evaluated weekly and data were recorded as 'alive' or 'dead'. The plants were designated as 'dead' when the above-ground plant parts started disintegrating and showed no traces of green tissue. Data were compiled as percent 'dead' or 'alive' plants and analyzed using GLM procedures in SAS. The level of significance used for the analysis was 0.05.



Figure 1. Glyphosate application with a backpack sprayer.

### Results and Discussion:

The 'R' and 'S' biotypes differed significantly in their ability to survive the various glyphosate treatments. A significant interaction occurred between horseweed growth stage and glyphosate application rate for both biotypes. When glyphosate was applied at the 5-8 leaf stage of horseweed, 100% of the 'R' biotype plants survived the 1x glyphosate rate (Figure 2a). The survival of the plants was reduced to 60% at the 2x rate while none of the horseweed plants survived the 4x rate. However, none of the 'S' biotype plants survived any of the glyphosate application treatments (Figure 2a).

When glyphosate was applied at the 11-15 leaf stage of horseweed, 100% of the 'R' biotype plants survived the 1x and 2x glyphosate rates (Figure 2b). However, the survival of the plants was reduced to 40% at the 4x rate. Unlike the 5-8 leaf stage, 20% of the 'S' biotype plants survived the 1x glyphosate treatment (Figure 2b). At the 18-21 leaf stage of horseweed, 100% of the 'R' biotype plants survived the 1x and 2x glyphosate rates whereas 80% of plants survived the 4x rate (Figure 2c). At this growth stage, the survival of the 'S' biotype at the 1x glyphosate treatment was 40% (Figure 2c). An example of the visual damage symptoms on the horseweed plants at the 18-21 leaf stage is shown in Figure 3.

After the plants bolted, the 'R' biotype plants survived all rates of glyphosate (Figure 2d, e). Similarly, glyphosate application at a 1x rate after bolting, also increased the survival capability of the 'S' biotype and it was observed that 20% of the plants were even able to survive the 2x rate (Figure 2d, e).

These results showed that the 'R' biotype was resistant to glyphosate but the level of resistance varied with growth stage. There was a probability of controlling some of the 'R' biotype horseweed at the 5-8 leaf stage with a 2x and 4x rates. At later stages, even some plants of the 'S' biotype escaped the lower rates of glyphosate. This demonstrated the importance of controlling horseweed at an early stage of growth. Therefore, efforts should be directed to control horseweed plants as soon as they emerge. Growers and land managers should not wait for all the horseweed plants to emerge before applying glyphosate. If the population of horseweed is to be reduced, several successive herbicide applications may have to be made to control the flushes of horseweed emergence over the growing season. An integrated weed management program will have to be developed to manage the glyphosate-resistant horseweed population.

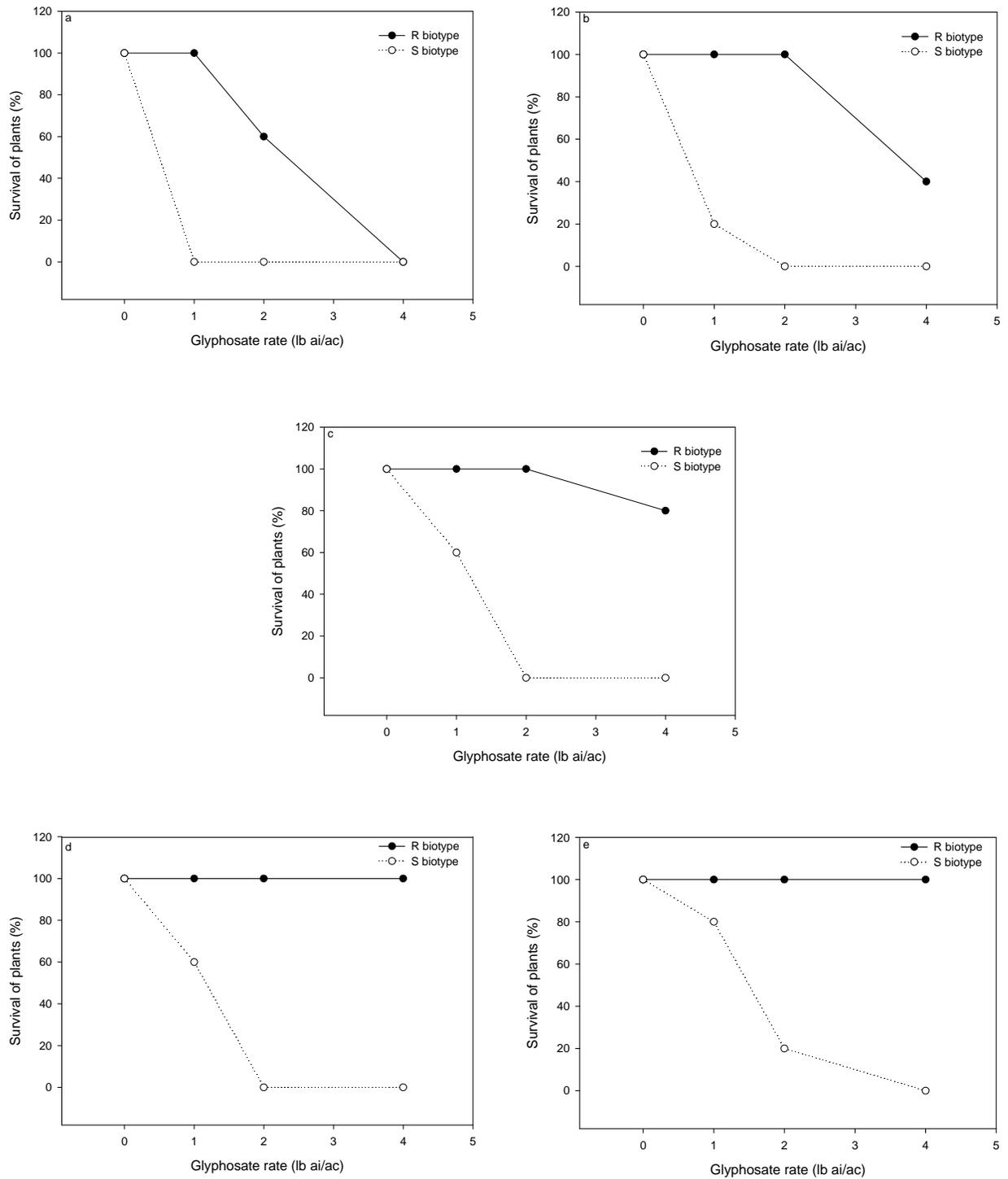


Figure 2. Plant survival under different glyphosate rates sprayed at the 5-8 leaf stage of horseweed.



Figure 3. Visual damage symptoms on the horseweed plants at the 18-21 leaf stage. ‘R’ biotype (L) and ‘S’ biotype (R) sprayed at 0x, 1x, 2x, and 4x rates of glyphosate (foreground to background, respectively).

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