

Effect of Glyphosate Application Rates, Timings, and Formuations on Apple Trees

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ABSTRACT: A field experiment was conducted in 2013-2014 at Kearneysville, West Virginia, USA, to evaluate the effect of formulations, timings, and application rates of glyphosate on trunk diameter and phytotoxicity of 'Macoun' and 'Golden Delicious' apple varieties. Roundup WeatherMax (a formulation with built-in surfactants) and Shore-Klear formulation (a formulation with no surfactants) of glyphosate was applied at rates of 2.24 and 4.48 kg ai/Ha, during June, August, and October. Treatments were arranged factorially, and replicated thrice, employing appropriate statistics to analyze the data. No interactions were detected between any variables for 'Macoun' apple. One main-effect was detected (application rate) where the higher application rate resulted in reduced levels of trunk diameter compared to that resulted by low application rate. In 'Golden Delicious' apple, there was an interaction between timing and formulation, however no trends could be ascertained due to variability. No visual symptoms of phytotoxicity were observed for any of the treatments on either apple varieties up to one year after treatment.

Keywords: herbicide injury, orchard floor management, phytotoxicity

INTRODUCTION

Obnoxious broadleaf weeds and grasses hinder orchard productivity and growers have limited options to manage such weeds. Glyphosate is an effective herbicide to control perennial weeds in apple orchards. Typically a late-season (fall) application is more effective to control perennial weeds compared to early-season (spring) application (Yonce and Skroch, 1989). However, concerns exist among growers about potential herbicide injury, especially from fall application of glyphosate to certain apple varieties (Roseberger *et al.* 2013). Similar injuries have also been reported in certain woody ornamentals (Mathers, 2010). Reports suggested apple trees developing nondescript trunk cankers making them susceptible to winter injury. Limited information is available to elucidate such observations based on field experiments conducted in apple orchards. The objective of this one-year experiment was to evaluate the effect of formulations, timings, and application rates of glyphosate on trunk diameter and phytotoxicity of 'Macoun' and 'Golden Delicious' apple varieties.

MATERIALS AND METHODS

A field experiment was conducted in 2013-2014 at the Tree Fruit Research and Education Center in

Kearneysville, West Virginia, USA on an established orchard. The varieties tested included 'Macoun' /M9 planted in 1982, and 'Golden Delicious' /EMLA planted in 2000. Trunk girth was measured at a height of 30 cm facing north prior to applying treatments. Roundup WeatherMax (a formulation with built-in surfactants) and Shore-Klear formulation (a formulation with no surfactants) of glyphosate was applied at rates of 2.24 and 4.48 kg ai/Ha, on June 12th, August 8th, and September 26th, respectively using a CO₂-pressurized sprayer with water as a carrier to deliver a spray volume of 187 L/Ha using flat-fan nozzles. Herbicide spray was intentionally allowed to come into contact with the tree trunk at a height of 15 to 20 cm. All treatments were arranged factorially with a single tree serving as a replicate and each treatment replicated thrice. Data collected included difference in trunk girth diameter recorded one year after treatment and the same recorded before treatment, and visual phytotoxicity symptoms. All data were subjected to Analysis of Variance (ANOVA) and the means were separated using LSD at $P=0.05$.

RESULTS AND DISCUSSION

No interactions were detected between any variables for 'Macoun' apple (Table 1). The only main-effect

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detected was that from application rate where the higher application rate of glyphosate resulted in 45 to 700% reduction of trunk diameter compared to that from low application rate (Figure 1). The lowest level of reduction in trunk diameter was recorded from the October treatments and the highest level, from the August treatment. Formulation did not have an effect on tree growth.

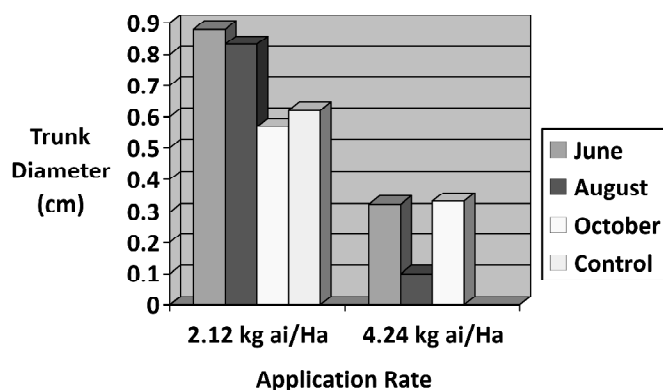


Figure 1: Effect of Roundup WeatherMax on 'Macoun' apple tree growth

In 'Golden Delicious' apple, there was an interaction between timing and formulation (Table 2). June application of Roundup WeatherMax resulted in increased trunk growth compared to August applications of the same; but there were no differences between October application timing and August or June application timing (Table 3). In Golden Delicious, August application timings resulted in increased trunk diameter compared to October application timing. However, there were no differences in trunk growth as a result of applying Shore-Klear in June compared to other application timings.

No visual symptoms of phytotoxicity were observed for any of the treatments on either apple varieties up to one year after treatment (data not presented). Based on data generated from this one-year study on well-established apple trees, no trends could be ascertained. It is speculated that lack of experimental units within replicates (due to limitations in plant material), and variability of data may limit the conclusions or recommendations that can be drawn from this experiment. However, application rates used in this experiment (the lowest rate tested was two times the standard use rate) and direct application of spray on to the tree trunk (as opposed to drift or inadvertent contact) may also have been taken into consideration while drawing conclusions.

Table 1
ANOVA Table for 'Macoun' Apple

Source	Prob. (F)	LSD (0.05)
Replication	0.92	0.39
Application Timing	0.92	0.39
Formulation	0.68	0.32
Application Timing X Formulation	0.75	0.55
Rate of Application	0.04	0.32
Application Timing X Rate of Application	0.64	0.55
Formulation X Rate of Application	0.27	0.45
Application Timing X Rate of Application X Formulation	0.17	0.78

Table 2
ANOVA Table for 'Golden Delicious' Apple

Source	Prob. (F)	LSD (0.05)
Replication	0.31	0.69
Application Timing	0.28	0.45
Formulation	0.20	0.36
Application Timing X Formulation	0.04	0.40
Rate of Application	0.80	1.34
Application Timing X Rate of Application	0.44	1.05
Formulation X Rate of Application	0.52	0.46
Application Timing X Rate of Application X Formulation	0.83	1.37

Table 3
Interaction between formulation and Application timing for 'Golden Delicious' Apple

Application Timing X Formulation	Trunk growth (cm)
June Roundup WeatherMax	0.86
August Roundup WeatherMax	0.44
October Roundup WeatherMax	0.65
June Shore-Klear	0.88
August Shore-Klear	1.06
October Shore-Klear	0.49
LSD*	0.4

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