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Water use efficiency and photosynthesis of glyphosate-resistant soybean as affected by glyphosate

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ABSTRACT

Previous studies comparing cultivars of different maturity groups in different soils demonstrated that early maturity group cultivars were more sensitive to glyphosate injury than those of other maturity groups. In this work, we evaluated the effect of increasing rates of glyphosate on water absorption and photosynthetic parameters in early maturity group cultivar BRS 242 GR soybean. Plants were grown in a complete nutrient solution and subjected to a range of glyphosate rates either as a single or sequential leaf application. Net photosynthesis, transpiration rate, stomatal conductance, sub-stomatal CO_2, carboxylation efficiency, fluorescence, maximal fluorescence and chlorophyll content were monitored right before and at different stages after herbicide application; water absorption was measured daily. All photosynthetic parameters were affected by glyphosate. Total water absorbed and biomass production by plants were also decreased as glyphosate rates increased, with the affect being more intense with a single full rate than half the rate applied in two sequential applications. Water use efficiency (WUE) was significantly reduced with increasing rates of glyphosate.

1. Introduction

The expanding global land area for crop production combined with climate change factors of increasing atmospheric CO_2 [1] and surface air temperature [2] are raising important concerns regarding water availability for crops. Knowledge of water requirements by crops and their water use efficiency (WUE) are important for assessing effects of climate change on crop water balance and water resources. It is anticipated that predicted changes in the global climate such as increased CO_2 and temperature, may increase transpiration by plants to impact the input of water required for crop production [3].

Many farmers have noticed that some transgenic soybeans are sensitive to water stress and others have reported visual plant injuries in glyphosate-resistant (GR) soybean varieties after glyphosate application [4,5]. The nutritional status of GR soybeans also is strongly affected by glyphosate [6]. Glyphosate is a wide-spectrum, foliar-applied herbicide that is translocated throughout the plant to actively growing tissues where it inhibits 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) in the shikimate pathway. This biochemical route is responsible for the biosynthesis of aromatic amino acids, plant defense compounds, and numerous phenolic compounds [7–9].

Despite the widespread adoption of GR technology and the importance of glyphosate in weed control in worldwide cropping systems, few data have been available to understand effects of glyphosate in GR soybean physiology, especially those related to water absorption and photosynthesis as the basic processes for biomass production. A deeper understanding of such effects may lead to a better use of this technology. An initial experiment was conducted at the State University of Maringá during the 2007 summer crop season with cultivars of different maturity groups grown in different soils to evaluate glyphosate injury. Zobiole et al. [6] demonstrated that such effects were pronounced in the early maturity group (cv. BRS 242 GR), with significant decreases in photosynthetic parameters, shoot mineral concentration and biomass dry weight [6]. In this present work, we evaluated the effect of increasing rates of glyphosate on water absorption and photosynthetic parameters in the previously studied cultivar (cv.) BRS 242, an early maturity group GR soybean. The objective of this research was to evaluate photosynthesis, water absorption and water use efficiency in an early maturity group cultivar of a GR soybean treated with glyphosate at various application rates.

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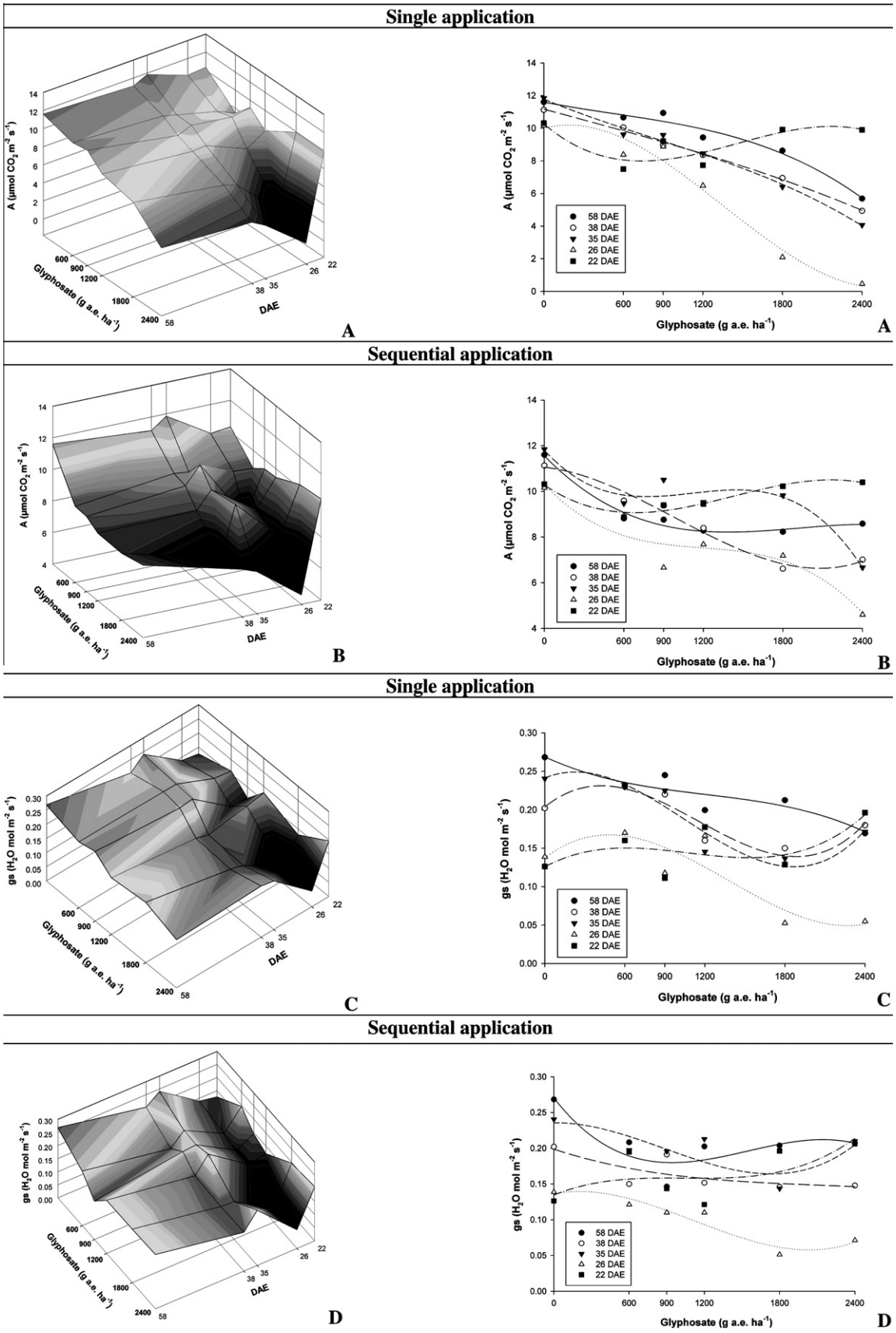

Fig. 1. Photosynthetic rate (A), transpiration rate (E), stomatal conductance (gs), sub-stomatal CO_2 (Ci) and carboxylation efficiency (A/Ci) in GR soybean as affected by increasing rates of glyphosate applied as a single treatment or sequential, half-rate applications ($n = 8$, $P < 0.01$).