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Article

PROTECTIVE EFFECT ON EUCALYPTUS PLANTS AND SIGNAL GRASS CONTROL WITH A TANK MIXTURE OF GLYPHOSATE AND LIQUID FERTILIZER

Efeito Protetor em Plantas de Eucalipto e Controle de Capim-Braquiária com a Mistura em Tanque de Glyphosate e Fertilizante Líquido

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ABSTRACT - What is expected from an effective antidote, applied with an herbicide, is that it protects crops from damages by the herbicide without reducing its action on weeds. In this context, the goal of this study was to evaluate the effect of liquid fertilizer as a protector of eucalyptus plants and to control signal grass (*Urochloa brizantha*) submitted the application of glyphosate when applied in tank mixture. Plants were submitted to doses of liquid fertilizer and glyphosate; the application was performed so that the syrup would reach all aerial parts of the plants. The intoxication percentage of eucalyptus plants was evaluated on day 14, 35 and 49 after application (DAA). On day 49 DAA, the morphologic parameters of eucalyptus plants and the dry mass of signal grass were evaluated. The increase in glyphosate doses reduced the dry mass of signal grass, and 1,080 g ha^{-1} of glyphosate caused the death of the plant, regardless of the use of the liquid fertilizer. At 90, 180, 360 and 540 g ha^{-1} doses of glyphosate, the mixing tank with liquid fertilizer reduced glyphosate damages to signal grass. Higher doses of glyphosate caused greater toxicity in eucalyptus and the use of liquid fertilizer reduced this poisoning. High doses of glyphosate increased the control of signal grass, but they also increased the damages to eucalyptus, and the liquid fertilizer tends to reduce such damage. The tank mixture of glyphosate + liquid fertilizer (540 g ha^{-1} + 3 L ha^{-1}) controlled signal grass without causing damages to eucalyptus.

Keywords: application technology, antidotes, *Eucalyptus urophylla*, *Urochloa brizantha*, weed.

*RESUMO - O que se espera de um antídoto eficaz, aplicado junto com um herbicida, é que ele proteja a cultura dos danos provocados pelo herbicida sem reduzir sua ação sobre as plantas daninhas. Nesse sentido, objetivou-se neste estudo avaliar o efeito do fertilizante líquido como protetor em plantas de eucalipto e no controle de capim-braquiária (**Urochloa brizantha**) submetidas à aplicação de glyphosate, quando aplicados em mistura em tanque. As plantas foram submetidas às doses do fertilizante líquido e de glyphosate, sendo a aplicação realizada de modo que a calda atingisse toda a parte aérea das plantas. Avaliou-se a porcentagem de intoxicação das plantas de eucalipto aos 14, 35 e 49 dias após a aplicação (DAA). Aos 49 DAA, foram avaliadas as variáveis morfológicas das plantas de eucalipto e a massa seca do capim-braquiária. O aumento na dose do glyphosate reduziu a massa seca do capim-braquiária, e 1.080 g ha^{-1} de glyphosate provocou a morte dessa planta, independentemente do uso ou não do fertilizante líquido. Nas doses de 90, 180, 360 e 540 g ha^{-1} do glyphosate, a mistura em tanque com fertilizante líquido reduziu os danos desse herbicida sobre o capim-braquiária. As maiores*

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doses de glyphosate provocaram maior intoxicação no eucalipto, e o uso do fertilizante líquido reduziu essa intoxicação. As altas doses do glyphosate aumentaram o controle do capim-braquiária; contudo, elas aumentam também os danos causados ao eucalipto, e o fertilizante líquido tende a reduzir esses danos. A mistura em tanque de glyphosate + fertilizante líquido (540 g ha^{-1} + 3 L ha^{-1}) controlou o capim-braquiária sem causar danos ao eucalipto.

Palavras-chave: tecnologia de aplicação, antídotos, *Eucalyptus urophylla*, *Urochloa brizantha*, planta daninha.

INTRODUCTION

Glyphosate is the main herbicide used to manage weed in the eucalyptus culture. It acts inhibiting the biosynthesis of aromatic amino acids, causing the paralysis of protein synthesis and the deregulation of the shikimic acid route, leading to metabolic disorders and death of sensitive plants (Reddy et al., 2010).

Having a systemic and non-selective action, glyphosate is used in applications on the eucalyptus culture. However, despite the attention during applications, reports of intoxications caused by the drift of this herbicide are frequent (Tuffi Santos et al., 2006a,b). Even in glyphosate-resistant cultures, like soybean RR, the occurrence of intoxications by this herbicide is common (Zobiole et al., 2009, 2011). In these cases, the use of antidotes with the ability to protect cultures from the damages caused by glyphosate has been recommended (Zobiole et al., 2011; Kraehmer et al., 2014; Serciloto et al., 2014).

Antidotes are substances that stop the action of a toxin over any organism (Ferreira, 2010). Thus, what is expected from an effective antidote, applied in association with an herbicide, is that it protects the culture from the damages caused by the herbicide, without affecting its action on weeds. Some authors have already reported the effects of antidotes in the protection of various cultures [Jaworski (1972) on *Lemna gibba*; Gresshoff (1979) on carrot and soybean; Silva et al. (2009), on eucalyptus; Zobiole et al. (2011), on soybean; Serciloto et al. (2014), on common bean]; however, little is known about the effects of these products over tree crops such as eucalyptus, as well as their influence over weed control.

The use of antidotes whose composition contains specific amino acids may contribute to the reduction of intoxication symptoms caused by glyphosate (Zobiole et al., 2011; Serciloto et al., 2014). On the other hand, the presence of these amino acids may also result in weed protection and, consequently, in a lower effectiveness to control some species, mainly the ones that are difficult to control.

The liquid fertilizer Fertiactyl Pós® is a product of the TIMAC Agro Company, which has the goal to maintain the productive genetic expression of cultures over management in controlling weeds and, consequently, the profitability of the producer. Composed by an organic fraction selected to provide humic and fulvic acids, glicin-betain and zeatin (GZA complex) and a mineral fraction, the company keeps under secrecy other complementary information about the product (Silva et al., 2014).

The definition of management strategies, based on the use of antidotes, which aim at mitigating the damages of glyphosate over eucalyptus without compromising its herbicide action is fundamental to grant the productive potential of eucalyptus, as well as turning the operations to apply this herbicide easier. Thus, the goal of this research was to evaluate the protective effect of Fertiactyl Pós® on eucalyptus plants and the control of *U. brizantha* submitted to glyphosate application.

MATERIAL AND METHODS

Standardized eucalyptus seedlings (GG100 clone) together with brachiaria seeds were planted in 10 dm^3 pots filled with soil coming from the region of Viçosa - Minas Gerais state, corrected and fertilized according to soil analysis (Table 1) and the recommendation for the culture, based on CFSEMG (1999).

Table 1 - Physical-chemical characteristics of the soil used in the experiment in Viçosa - Minas Gerais state

Chemical analysis									
pH	P	K	Ca^{2+}	Mg^{2+}	Al^{3+}	H+Al	SB	CEC (t)	CEC (T)
(H_2O)	(mg dm^{-3})		(cmol$_c$ dm^{-3})						
4.4	1.2	70	1.7	0.4	0.3	3.96	2.28	2.58	6.24
V	m	OM	P-rem	Zn	Fe	Mn	Cu	B	
(%)		(dag kg^{-1})	(mg L^{-1})		(mg dm^{-3})				
37	12	1.65	20	1	75.3	28.9	1.5	0.2	
Physical analysis									
Granulometric analysis and texture classification									
Clay	Silt	Sand	Texture classification						
(%)									
49	10	41	Clayey						

Analysis conducted in the Laboratório de Análise de Solos Viçosa Ltda. pH: in water, relation 1:2.5. P-K: Mehlich-1 Extractor. Ca-Mg and Al: KCl extractor – 1 mol L^{-1} . H + Al: calcium acetate extractor 0.5 mol L^{-1} – pH 7.0. BS: sum of exchangeable bases. CEC (t): effective cation exchange capacity. CEC (T): cation exchange capacity at 7.0 pH. v: saturation by bases. m: saturation by aluminum. OM: organic matter = C.org x 1.724 – Walkley-Black.

The test was conducted in completely randomized design with three replications; each pot had one eucalyptus plant and four signal grass plants, which constituted an experimental plot. The test was installed in a 4 x 7 factor scheme; factors were Fertiactyl Pós® (0, 1, 2 and 3 L ha^{-1}) and glyphosate doses (0, 90, 180, 360, 540, 720, 1,080 g ha^{-1}). Glyphosate doses corresponded respectively to 0; 0,125; 0,25; 0,5; 0,75; 1,0; and 1,5 kg ha 1 of the commercial product Scout® (glyphosate ammonium salt). Treatments were applied 40 days after the transplanting of eucalyptus seedlings, when they presented an average height of 41.3 cm and an average diameter of 5.33 mm, close to the soil, and signal grass plants were 35 cm high, on an average.

To apply the products, a backpack sprayer was used, pressurized by CO_2 with constant pressure, equipped with two TTI 11002 fan type nozzles, spaced 0.5 m apart, operating at 250 kPa pressure and applying the mixture volume corresponding to 150 L ha^{-1}. The application was performed with no protection, so that the mixture could reach all the aerial part of plants. During application, the room temperature was 23 °C, the relative air humidity was 72% and the wind speed was 1.6 km h^{-1}. Plant leaves remained protected from the contact with irrigation water for 24 hours, in order to avoid washing off the product.

On day 14, 35 and 49 after application (DAA), the intoxication percentage was determine, giving grades that varied from zero (no symptoms) to one hundred (plant death), following recommendations by SBCPD (1995).

On day 49 DAA, masses of the aerial part dry matter and roots were evaluated, as well as the leaf area of eucalyptus plants. Plants were separated into stems, leaves and roots. After separating the morphological components, the leaf blades had their areas measured in a LI-COR integrator of the foliar area (model LAI-3100). After that, all the material was placed in paper bags and taken to a forced air-circulation oven (65 ± 3 °C) until reaching constant mass. On the same date, the dry matter mass of signal grass plants was evaluated.

Data about brachiaria dry matter mass and eucalyptus intoxication were analyzed descriptively, with the use of standard deviation; the other data were submitted to analysis of variance (p>0.05) and, if significant, regression equations were adjusted.

RESULTS AND DISCUSSION

The increase in the glyphosate dose reduced the accumulation of signal grass dry matter mass; the 1,080 g ha^{-1} dose of glyphosate caused the death of this species, regardless of the use of liquid fertilizer (Figures 1 and 2). In the 90, 180, 360 and 540 g ha^{-1} glyphosate doses, the use

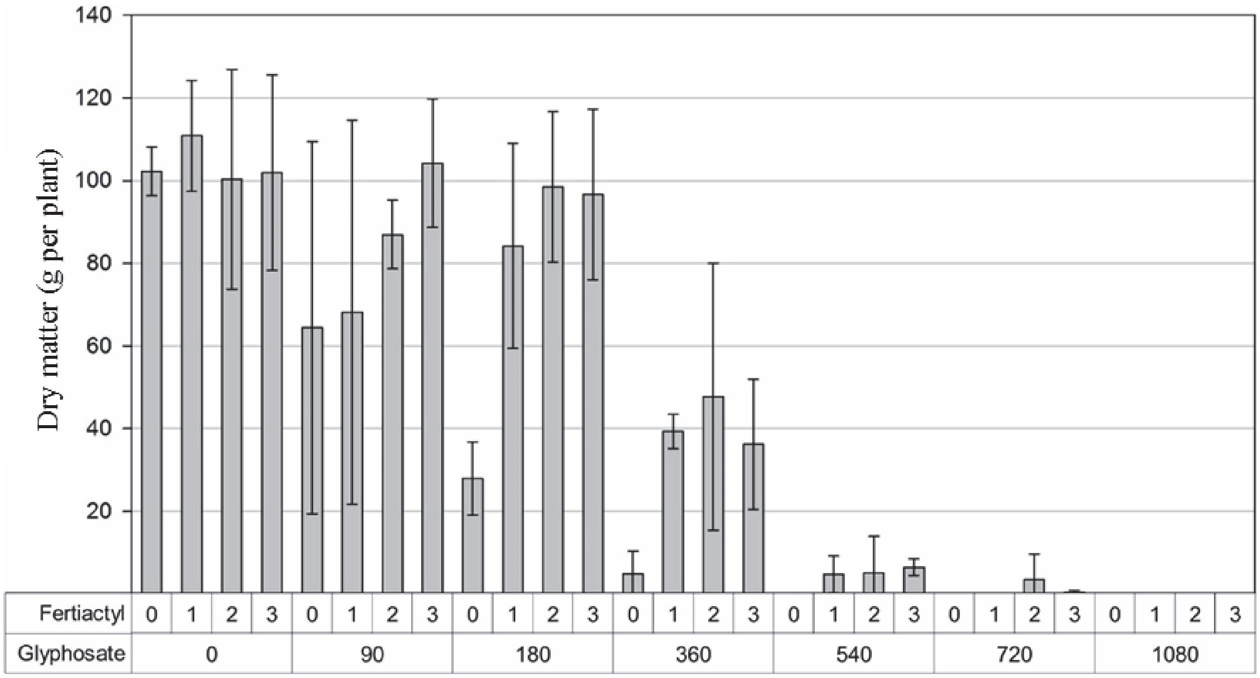

Figure 1 - Dry matter mass of signal grass plants on day 49 DAA submitted to the application of glyphosate (g ha^{-1}) in tank mixture with liquid fertilizer (L ha^{-1}).

of liquid fertilizer reduced the intensity of glyphosate damages on signal grass; the higher the glyphosate dose, the lower the influence of the liquid fertilizer over the weed (Figure 1).

The highest doses of glyphosate caused higher intoxication on eucalyptus, but the use of liquid fertilizer significantly reduced the levels of plant damages (Figure 3). According to Tuffi Santos et al. (2009), the intoxication caused by glyphosate depends on the quantity of this product that reaches and is absorbed by the plant. In spite of this, the application of the highest glyphosate dose (1,080 g ha^{-1}), associated with 3 L ha^{-1} of liquid fertilizer resulted, on day 49 DAA, in lower intoxication symptoms on eucalyptus, in relation to the application of 360 g ha^{-1} with no liquid fertilizer (Figure 3). These results indicate that the liquid fertilizer has potential to protect the eucalyptus from the damages caused by glyphosate.

The need to conduct new researches that have the goal to understand the mechanism that gives the protection provided by the liquid fertilizer becomes evident. However, since this is a product containing amino acids in its formula (TIMAC AGRO, 2014), it is believed that this protection is given through the supply of amino acids. The exogenous supply of amino acids has already been related as a way of reducing the damages caused by glyphosate on soybean (Zobiole et al., 2011).

The results about the dry matter mass of leaves, stems, roots and plant total followed the same tendency of eucalyptus intoxication; the increase in the glyphosate dose linearly reduced these variables, and the use of liquid fertilizer tended to relieve the dangerous effects of this herbicide (Figure 4). The application of 1,080 g ha^{-1} of glyphosate with no liquid fertilizer resulted in an estimate of the total plant dry matter mass of 12.1 g per plant. When this glyphosate dose was applied in association with 3 L ha^{-1} of liquid fertilizer, the dry matter estimate was 36.8 g per plant, that is, three times higher than the application without the protector (Figure 4D).

The increase in the liquid fertilizer dose, as well as reducing the effects of glyphosate over eucalyptus, also stimulated the accumulation of plant dry matter. This stimulating effect becomes evident with the use of increasing doses of liquid fertilizer in the absence of glyphosate (Figure 4). The biostimulating effect of the liquid fertilizer was already reported by Costa et al. (2008) on watermelon and by Bezerra et al. (2007) in the production of lettuce seedlings.

The liquid fertilizer also reduced the damaging effects of glyphosate on the leaf area of eucalyptus (Figure 5). The increase in the glyphosate dose resulted in the quadratic response

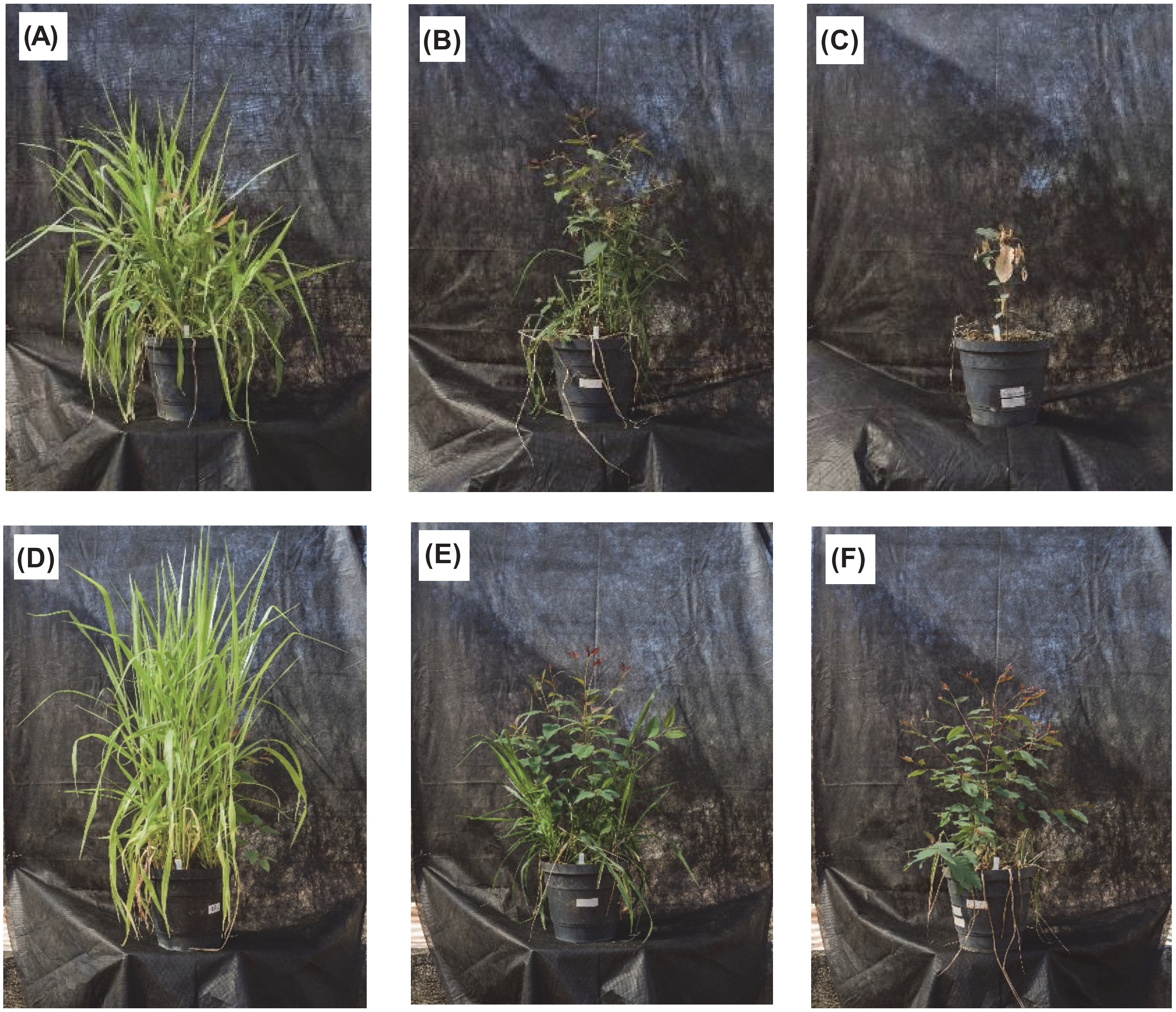

Figure 2 - Experimental units on day 49 DAA, submitted to the application with 0 g ha^{-1} (A), 360 g ha^{-1} (B) and 1,080 g ha^{-1} (C) of glyphosate, both without liquid fertilizer, and 0 g ha^{-1} (D), 360 g ha^{-1} (E) and 1,080 g ha^{-1} (F) of glyphosate, both with 3 L ha^{-1} of liquid fertilizer.

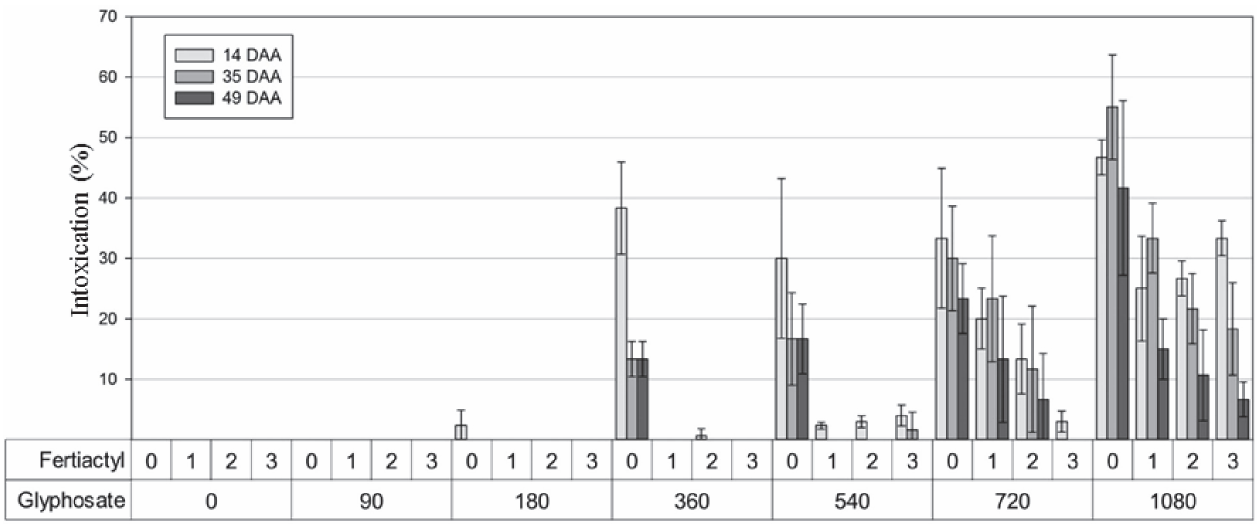

Figure 3 - Percentage of intoxication of eucalyptus plants on day 14, 35 and 49 after application (DAA), submitted to the application of glyphosate (g ha^{-1}) in tank mixture with liquid fertilizer (L ha^{-1}).

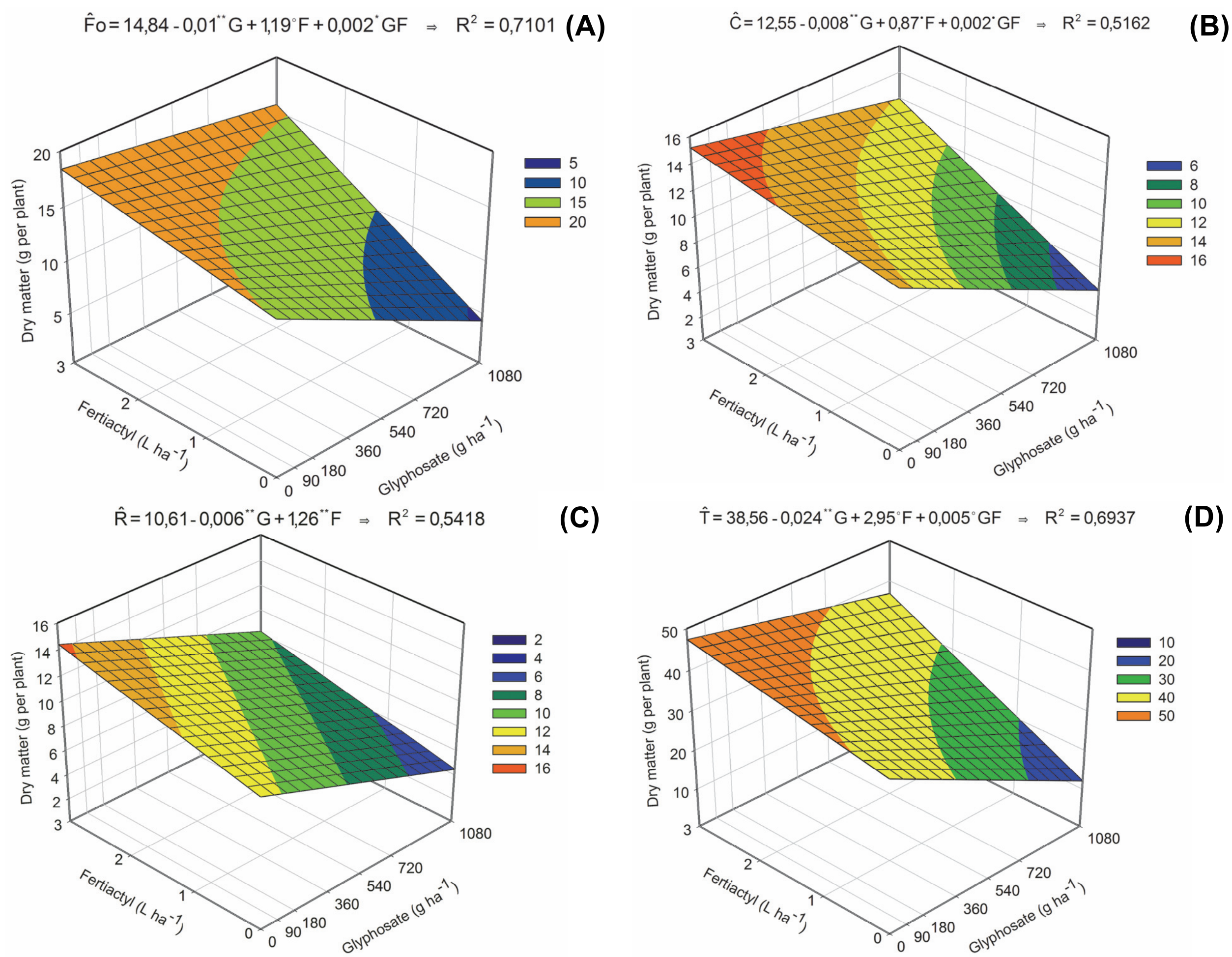

Figure 4 - Estimate of the dry matter masses of leaves (A), stem (B), roots (C) and total (D) of eucalyptus plants coexisting with *U. brizantha* on day 49 DAA submitted to the application of glyphosate in tank mixture with liquid fertilizer.

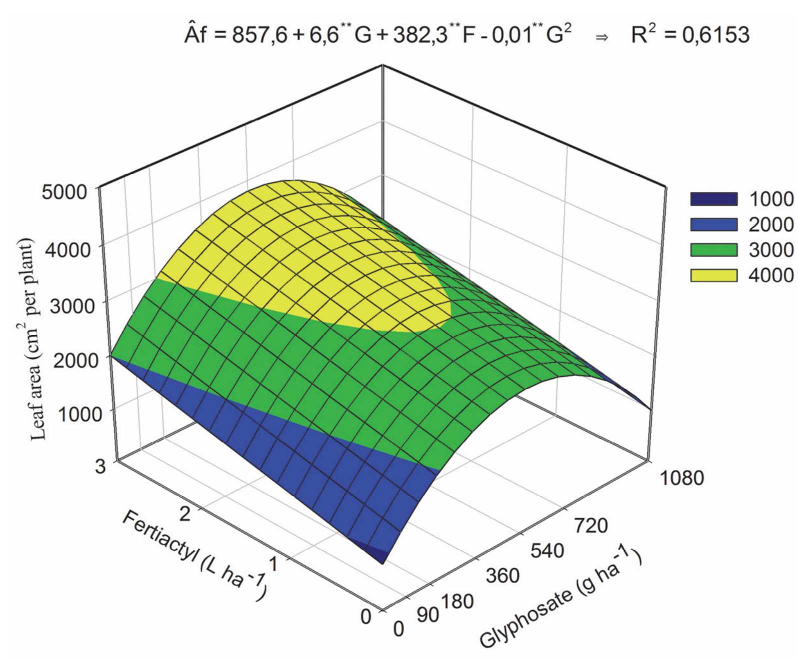

Figure 5 - Estimate of the leaf area of eucalyptus plants coexisting with *U. brizantha* on day 49 DAA, submitted to the application of glyphosate in tank mixture with liquid fertilizer.

for the leaf area; the dose promoting the highest accumulation of this characteristic was 549 g ha^{-1} (Figure 5). Lower doses than this one resulted in non control of signal grass (Figure 1), which had a strong competition with eucalyptus, whereas, in higher doses, glyphosate cause damages to eucalyptus (Figure 3). The combination of the mixture in tanks providing more leaf area was 549 g ha^{-1} of glyphosate with 3 L ha^{-1} of liquid fertilizer (Figure 5).

Even if the results of this work are promising, new researches must be conducted, both in laboratory and on the field, trying to elucidate the way in which the liquid fertilizer acts on plants, and the control of other weed species, as well as defining strategies to better use this technology.

High glyphosate doses increase the level of signal grass control, but they also increase the damages on eucalyptus, and the use of liquid fertilizer tends to reduce these damages. The tank mixture of glyphosate + liquid fertilizer (540 g ha^{-1} + 3 L ha^{-1}) controlled signal grass without causing damages to eucalyptus.

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