








Use of foliar fertilizers as attenuators of injuries caused by glyphosate drift in young coffee plantations

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ABSTRACT

Glyphosate is the most used product for weed control in young coffee planting rows. The application is carried out in a directed way, avoiding the contact of the product with the crop. However, drift and consequent plant injuries frequently occur. An alternative to reduce these injuries is the use of attenuators capable of reducing the negative effects caused by this herbicide. Therefore, the objective of this study is to verify the efficiency of foliar fertilizers (Fertiactyl Pós[®] and Crop⁺) as attenuators of the toxic effects caused by the use of glyphosate in the coffee crop. Thus, coffee seedlings were subjected to different doses of the mixture of Fertiactyl Pós[®] with glyphosate and Crop⁺ with glyphosate. The treatments were applied on top of the plants. The percentage of coffee intoxication was evaluated at 14, 21, 28, 35, 42 and 90 days after application. At 90 days after application, height, leaf area and shoot and root dry matter were evaluated. Higher doses of glyphosate (1.44 and 2.88 kg ha⁻¹) without the use of attenuators caused intoxication levels close to 80% at 28 and 90 DAA. The use of Fertiactyl Pós[®] and Crop⁺ reduced the injuries caused by the application of glyphosate, regardless of the dose of herbicide and fertilizers, but with different levels of action. All the morphological variables measured suffered a negative action with the isolated use of glyphosate, with a tendency to recover when the attenuators were applied. It is concluded that the two attenuators were efficient in suppressing the deleterious effects of glyphosate on coffee plants affected by this herbicide. For 0.720 kg ha⁻¹ of glyphosate, the dose most used in the field, 8 L ha⁻¹ is recommended for Fertiactyl Pós[®] and 4 L ha⁻¹ for Crop⁺.

Key words: *Coffea arabica*; Crop⁺; Fertiactyl Pós[®]; Injury; Weed control.

1 INTRODUCTION

Coffee (*Coffea* sp.) is a very important commodity for the national economy (Companhia Nacional de Abastecimento - CONAB, 2019) and Brazil is the world's largest producer (Empresa Brasileira de Pesquisa Agropecuária Ministério da Agricultura, Pecuária e Abastecimento - EMBRAPA, 2018). Such importance and demand require an effective management to guarantee and increase yield, thus making phytosanitary management necessary, with the control of diseases, pests and weeds.

Since weeds cause losses (most of the times not as notorious in the short term, such as the attack of pests and diseases), they frequently present a less intensive management than necessary (Pucci et al., 2019; Alcântara et al., 2009). One point that complicates this control is the phenology of coffee, with a slow initial growth (Gomes et al., 2019; França et al., 2013; Silva et al., 2008), once it is a crop that takes a long time to totally shade the planting row, consequently reducing the competitive capacity of weeds (Magalhães et al., 2012; Meschede et al., 2004).

Species such as *Brachiaria decumbens*, *Digitaria horizontalis*, *Brachiaria plantaginea* and *Mucuna aterrima*, in coexistence with coffee seedlings for 90 days, show a significant decrease in crop growth and development (Fialho

et al., 2011), and glyphosate is the main control alternative adopted (Matos et al., 2013).

Glyphosate is non-selective, that is, its contact with coffee plants can cause injuries that affect yield (França et al., 2010). Thus, there are several reports of drift in coffee plantations during application on the streets, showing intoxications such as the appearance of chlorotic, small and brittle leaves (Carvalho et al., 2014; Yamashita et al., 2013; Malavolta, 2006). Therefore, it is necessary to search for ways to mitigate these intoxications, without the need to suspend the use of herbicides.

The hypothesis of this study is that products as Fertiactyl Pós[®] and Crop⁺ have the potential to mitigate the toxic effects caused by glyphosate drift in coffee plants, as found by Machado et al., 2017a; Machado et al., 2017b; Machado et al., 2017c, in eucalyptus. It is expected that, in the near future, coffee producers will be able to carry out the initial management without fear of damaging their crops with intoxication of non-selective herbicides, without losses in development and yield.

Therefore, the objective of this research was to verify the efficiency of foliar fertilizers Fertiactyl Pós and Crop⁺, as attenuators of the toxic effects caused by glyphosate drift in young coffee crop.

2 MATERIAL AND METHODS

The experiment with the two foliar fertilizers (Fertiactyl PóS and Crop⁺) were carried out in different assays, but with the same methodology. The assays were conducted in a greenhouse at Universidade Federal de Viçosa - Rio Paranaíba Campus, from March to June 2019. For this purpose, 8 dm³ pots were used and filled with Red-Yellow Latosol (LVAd) (Table 1), fertilized with Super Simples at a dose of 180 kg ha⁻¹. In each pot, a 'Catucaí Vermelho' coffee seedling was transplanted, constituting an experimental unit. The seedlings were standardized as to the size and number of leaves.

Table 1: Chemical analysis of the soil used in the experiment.

¹ M.O.S (g.dm ³)	² C.O.T (g.dm ³)	³ pH (CaCl ₂)	³ pH	⁴ CTC (mmol _c dm ³)
0.31	18	5.8	6.52	88.5

¹M.O.S.: soil organic matter; ²C.O.T.: total organic carbon; ³pH: hydrogen potential; ⁴CTC: cation exchange capacity.

The first experiment consisted of applying four doses of glyphosate alone (360; 720; 1440 and 2280 g ha⁻¹ a.e.), and four doses of glyphosate associated with different doses of Fertiactyl PóS (0.36 kg ha⁻¹ a.e.; + 1.0 L ha⁻¹; 0.72 kg ha⁻¹ a.e. + 2.0 L ha⁻¹; 1.44 kg ha⁻¹ a.e. + 4.0 L ha⁻¹; 2.88 kg ha⁻¹ a.e. + 8.0 L ha⁻¹), in addition to a control, without application of products. The design was completely randomized (CRD), with three replications.

The second experiment followed the same pattern: four isolated doses of glyphosate (0.36, 0.72, 1.44 and 2.88 kg ha⁻¹ a.e.) were applied, and four doses of glyphosate associated with Crop⁺ (0.36 kg ha⁻¹ a.e. + 0.5 L ha⁻¹; 0.72 kg ha⁻¹ a.e. + 1.0 L ha⁻¹; 1.44 kg ha⁻¹ a.e. + 2.0 L ha⁻¹; 2.88 kg ha⁻¹ a.e. + 4.0 L ha⁻¹), in addition to a control, without the herbicide. The design was completely randomized (CRD), with three replications.

Spraying was carried out with a costal electric sprayer, containing three dual fan tips, with an adjusted flow rate of 200 L ha⁻¹.

At 14, 21, 28, 35, 42 and 70 days after application (DAA), plant intoxication, plant height, number of leaves, number of nodes and expanded leaf diameter were evaluated from the third pair of leaves. For the obtention of the percentage of intoxication, scores ranging from zero (absence of symptoms) to 100 (plant death) were attributed (Sociedade Brasileira da Ciência de Plantas Daninhas - SBCPD, 1995) (Table 2).

In the last evaluation, the leaf area of coffee plants was measured; in addition, shoots and roots were collected. The samples were weighed on a scale to two decimal places, for the obtention of root and shoot fresh matter.

Subsequently, these samples were dried in a forced air oven at 68 °C for 48 hours. Again, they were weighed, but for the obtention of root and shoot dry matter.

Injuries to plants caused by the herbicide were evaluated by comparison with control plants that did not receive herbicide application. Injury data on coffee plants were analyzed descriptively and plotted using the SigmaPlot software for Windows (Version[®] 12.0), the data being plotted in bar graphs and the other data were submitted to regression analysis; in case of significance, the means were adjusted to regression equations. The significance of the equation parameters was tested in the Minitab[®] 16.2.1 software and the graphs were plotted in the SigmaPlot for Windows (Version[®] 12.0).

3 RESULTS

The use of Fertiactyl PóS and Crop⁺ reduced the injuries caused by the application of glyphosate, regardless of the dose of herbicide and fertilizers, but with different levels of action (Figures 1 and 2). It is observed that there was a trend of direct relationship between the increase in the dose of fertilizers with the smallest injuries, an effect less pronounced when the highest glyphosate doses were used.

The accumulation of dry matter in the shoot and roots was linearly reduced when the seedlings were subjected to increasing applications of glyphosate doses in the absence of attenuators (Figure 3, A, B, C and D). The increase in the dose of Fertiactyl PóS and Crop⁺ linearly reduced the effects of glyphosate on the accumulation of dry matter.

Table 2: Score scale for the visual assessment of intoxication in coffee plants.

Concept	Score	Observation
Very mild	0-5	Weak or barely evident symptoms. Score zero when there are no changes in the plant.
Mild	6-10	Clear, low-intensity symptoms.
Moderate	11-20	Clear symptoms, more intense than in the previous class.
Acceptable	21-35	Pronounced symptoms, but fully tolerated by the plant.
Worrisome	36-45	More drastic symptoms than in the previous class, but still recoverable.
High	46-60	Irreversible damage, with drastic reduction in plant development.
Very high	61-100	Very severe, irreversible damage. Score one hundred for plant death.

Adapted from the SBCPD (1995).



Figure 1: Coffee plants treated with the mixture of glyphosate + Fertiactyl Pós and glyphosate + Crop+ at different doses at 28 days after application (A, B, C and D) at 82 DAA.

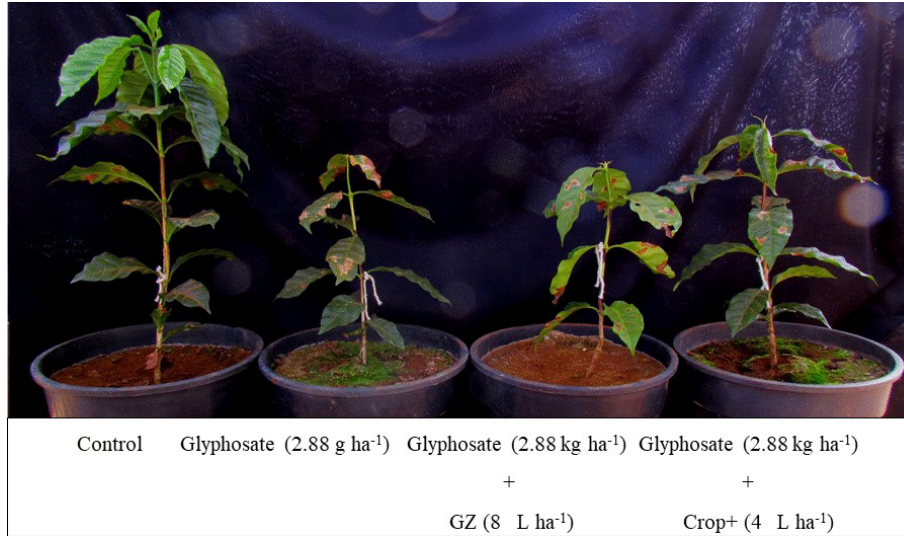


Figure 1: Continuation.

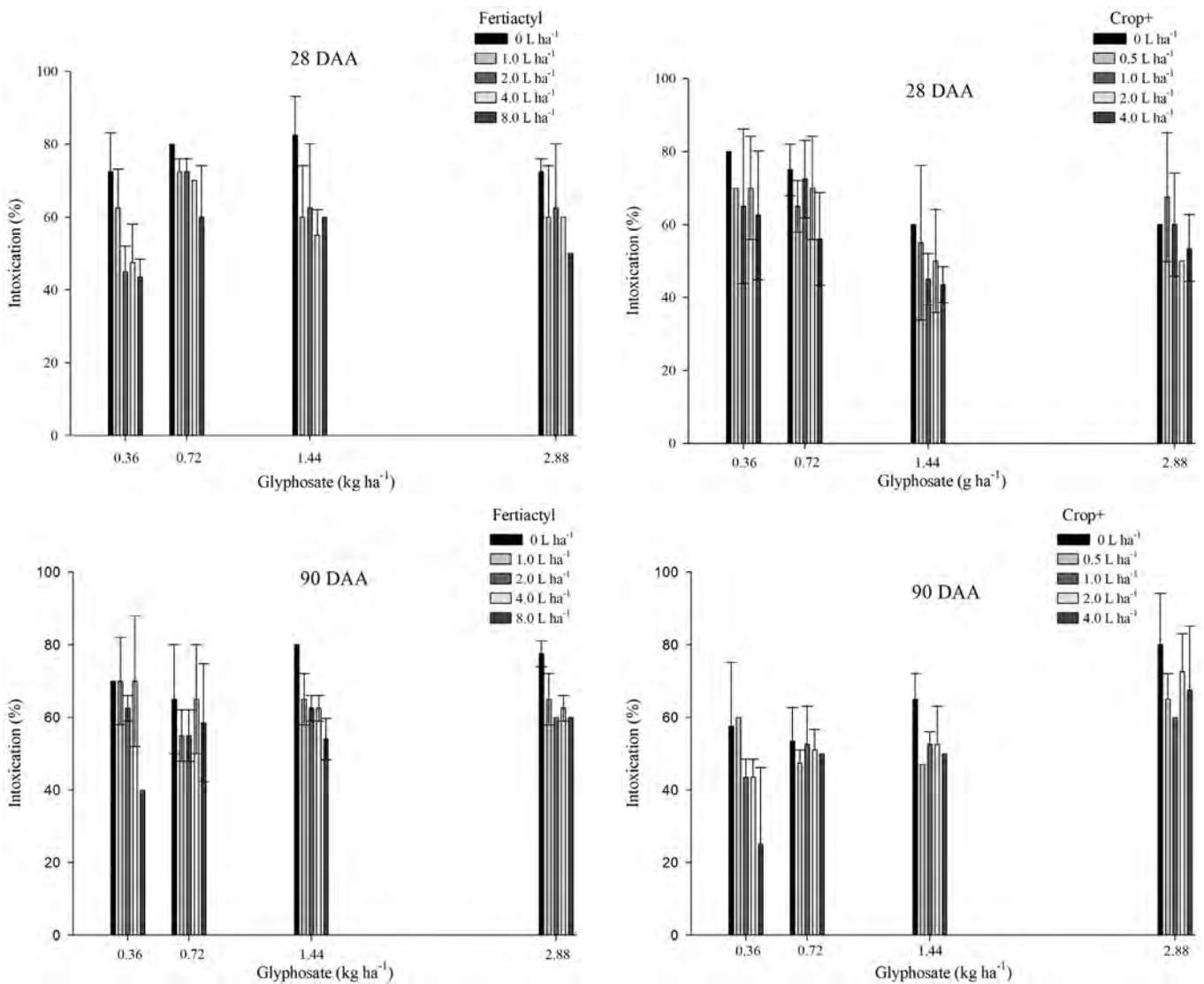


Figure 2: Intoxication percentage of coffee plants submitted to the application of glyphosate (kg ha⁻¹) in mixture with Fertiactyl Pós and Crop+ at 28 and 82 days after application. Bars represent mean ± standard deviation (n = 3).

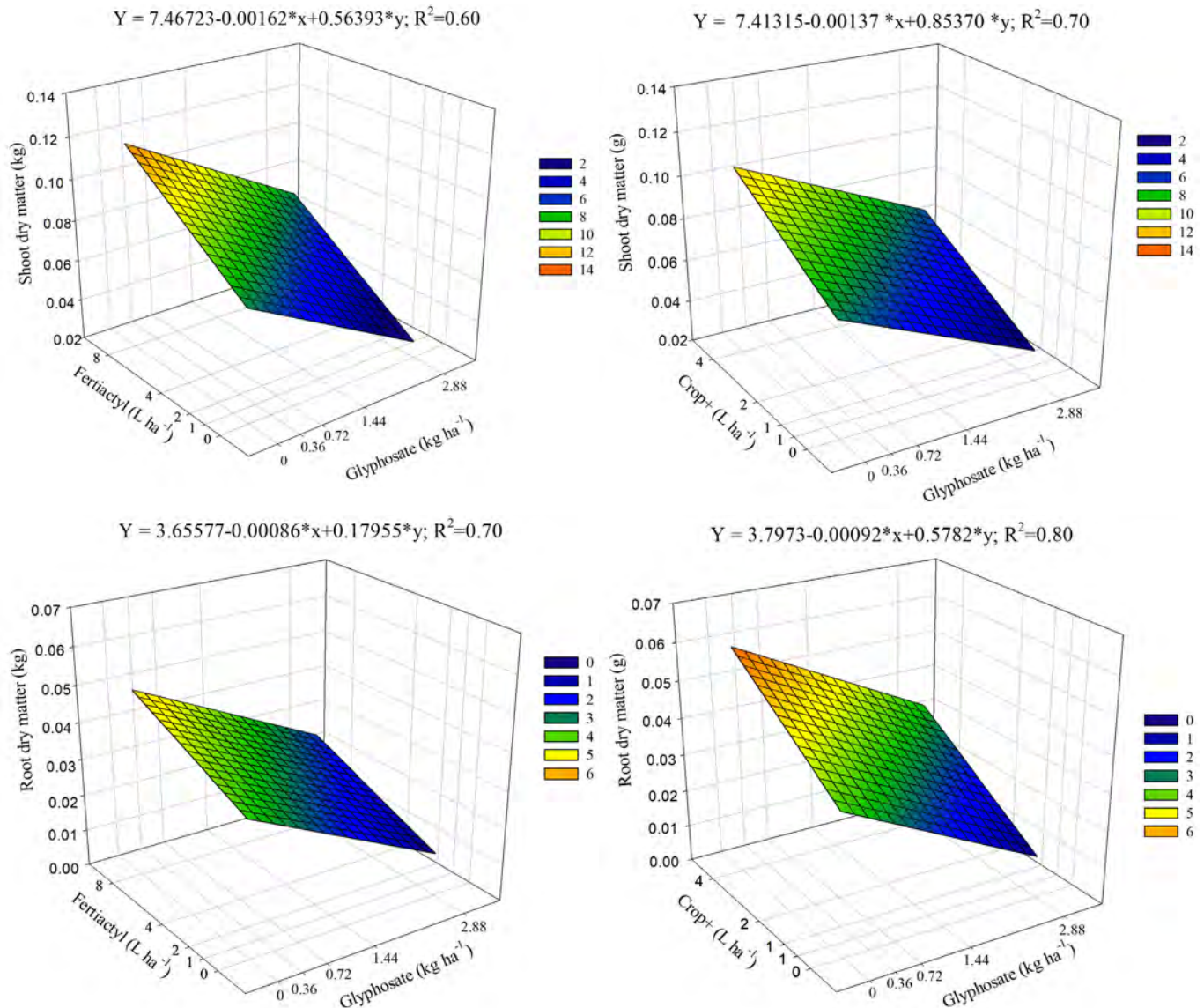


Figure 3: Estimates of shoot (A and B) and root (C and D) dry matter of coffee plants submitted to the application of glyphosate in mixture with Fertiactyl Pó and Crop+ at 90 DAA.

Estimates of leaf area and plant height also followed the dry matter trend, with Fertiactyl Pó and Crop+ reducing the negative effects of glyphosate on coffee plants (Figure 4, A, B, C and D). The use of Crop+ results in a larger leaf area than Fertiactyl Pó. It can be observed that, with the use of 2.88 kg ha⁻¹ of glyphosate and 0.008 kg ha⁻¹ and 0.004 kg ha⁻¹ of Fertiactyl Pó and Crop+, respectively, the leaf area of Fertiactyl Pó is close to 0.0004 m², against 0.006 m² of Crop+. For both, at a dose of 1.44 kg ha⁻¹ of glyphosate, the dose of attenuators that led to the highest leaf area index was 8 L ha⁻¹ for Fertiactyl Pó and 4 L ha⁻¹ for Crop+.

4 DISCUSSION

Machado et al. (2017) observed injury levels below 20% in eucalyptus seedlings submitted to different doses of

Fertiactyl Pó mixed with 1.44 kg ha⁻¹ of glyphosate at 49 DAA. In this study, higher doses of glyphosate (1.44 and 2.88 kg ha⁻¹), without mixing with the stress attenuators Fertiactyl Pó and Crop+, showed intoxication levels close to 80% at 28 and 90 DAA (Figure 2). França et al. (2010) report that doses of glyphosate from 0.2304 kg ha⁻¹ already show symptoms of injuries and doses close to 0.4608 kg ha⁻¹ reduce the content of P in the plant by 19.38%. Thus, it is important to observe that high doses of glyphosate are extremely harmful to coffee since, in addition to compromising its development and causing injuries, they decrease significant amounts of essential nutrients.

Similar results were found by Machado (2017a), to the accumulation of dry matter in the shoot and roots, where it was observed that the accumulation of dry matter of leaves, stem, roots and total in eucalyptus decreased as glyphosate

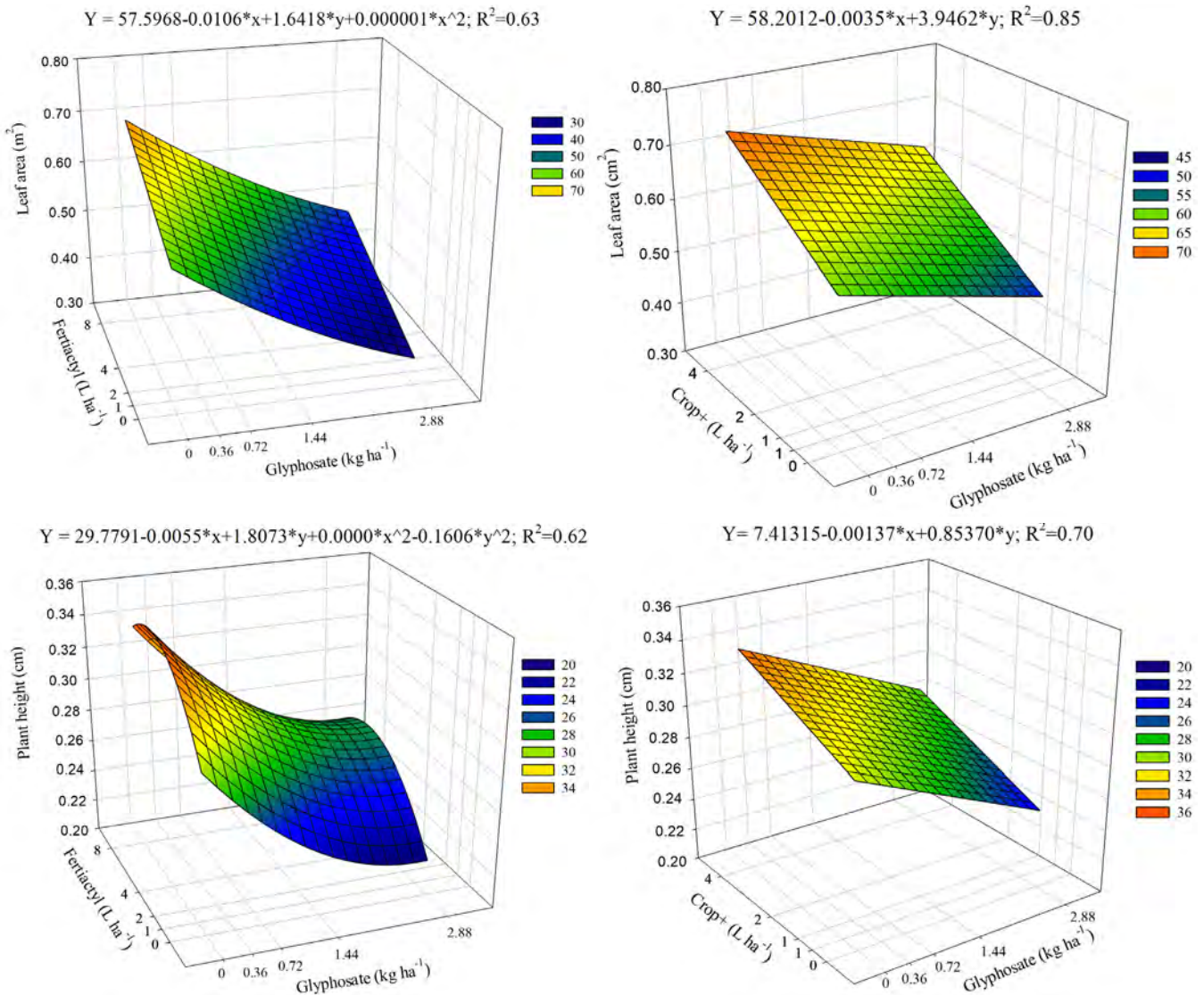


Figure 4: Estimates of leaf area (A and B) and height (C and D) of coffee plants submitted to the application of glyphosate in mixture with Fertiactyl Pó and Crop+ at 90 DAA.

increased but, in the presence of Fertiactyl Pó, these effects were reduced. It is possible to notice that, in relation to shoot dry matter, the increase in the dose of Fertiactyl Pó was greater than the corresponding dose of Crop+. Regarding dry matter accumulation in the roots, the opposite occurs, there was a greater increase in the dry matter accumulation at higher doses of Crop+ compared to Fertiactyl Pó. França et al. (2010) explained that the behavior of the root system of coffee plants after exposure to glyphosate is due to the translocation of carbohydrates from the roots for plant recovery.

França et al. (2010), also proved that the doses of attenuators necessary to reduce the harmful effects of glyphosate on coffee vary according to the amount of the herbicide that reaches the plant. There was also a reduction in the leaf area of Arabica coffee with an increase in the

dose of glyphosate (Schrübbbers et al., 2014). Plant height followed the tendency of leaf area, showing higher height in relation to the plants affected by glyphosate in mixture with Crop+. Nascimento et al. (2019) also carried out a study on the use of Fertiactyl Pó as an attenuator of injuries caused in coffee seedlings, with results similar to those observed in this study for the variables plant height, leaf area and dry matter. The author also reports the presence of overgrowth caused by the herbicide, which was mitigated with the use of Fertiactyl Pó.

In this study, it was possible to prove the efficiency of Fertiactyl Pó in reducing the harmful effects of glyphosate drift in coffee seedlings, adding information to the studies by Nascimento et al. (2019) in coffee and Machado et al. (2017a, 2017b, 2017c) in eucalyptus. It also proved the same attenuation capacity when the seedlings

were submitted to Crop⁺, an action never before tested in coffee crop. In addition, the study compared the efficiency of the two products. The results of this research are an important contribution to the future use of these attenuators in the field, requiring further studies to prove what are the mechanisms involved in the mitigating action of these products in coffee seedlings.

5 CONCLUSIONS

The attenuators Fertiactyl Pós and Crop⁺, applied in mixture with glyphosate, have the potential to be used to protect the damage caused by glyphosate in young coffee plants. For 0.720 kg ha⁻¹ i.a. of glyphosate, the dose most used in the field, 8 L ha⁻¹ is recommended for Fertiactyl Pós and 4 L ha⁻¹ for Crop⁺.

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