Original Research Article

Effect of sugar and alcohol industry byproducts on pre-emergence herbicide efficacy

.

ABSTRACT

Aims: Evaluate the effects of vinasse and filter cake on the efficacy of indaziflam, saflufenacil, and sulfentrazone for the control of morning glory **(***Ipomoea triloba* L.) and crabgrass (*Digitaria horizontalis* Wiild), as well as the effects of these byproducts on the emergence of these weeds.

Study design: The experiments were established in a greenhouse with a completely randomized design and four replications

Place and Duration of Study: Agricultural Science Center, Sao Paulo, Brazil, between May 2017 and May 2018.

Methodology: In the first assay, four herbicide doses: indaziflam (0, 37.5, 75, and 150 g ai ha^{-1}), saflufenacil (0, 42, 84, and 168 g ai ha^{-1}), and sulfentrazone (0, 300, 600, and 1200 g ai ha^{-1}) were applied for pre-emergent weeds in three soil covers (without byproduct, with vinasse, and with filter cake).In the second assay, seven treatments were evaluated, comparing the effects of the different vinasse and filter cake doses, and absence of byproduct on the weeds emergence.

Results: When the doses required for 80% effective control were considered, the results showed that for indaziflam, the filter cake negatively affected crabgrass control. In contrast, vinasse had a positive effect on morning glory control by saflufenacil. For sulfentrazone, the filter cake had a negative effect, requiring twice the dose used on the treatment without byproduct for effective morning glory control. Relative to assay 2, the vinasse addition affected the emergence of morning glory but not of crabgrass; however, the filter cake increased the weed biomass accumulation.

Conclusion: Vinasse and filter cake byproducts can negatively or positively affect the performance of pre-emergence herbicides, according to the active ingredient used. However, these effects occur at doses below those recommended for the herbicides. Byproducts can affect the emergence and the weed biomass accumulation.

Comment [MF1]: Abstract should reflect the various sub headings but should not be written out as indicated in this case. Authours should only bear in mind those important sections.

Keywords: vinasse, filter cake, chemical control, emergence

1. INTRODUCTION

Production of sugarcane for alcohol production generates several organic byproducts, such as vinasse and filter cake, which are used in agriculture for soil fertilization [1]. For each liter of alcohol produced, 12 L of vinasse is generated, on average [2]. For filter cake, an average of 30 kg is produced per ton of crushed sugarcane [3]. Vinasse is generated from the distillation process that transforms sugarcane into wine [4]. Vinasse use can improve sugarcane (grass) planting because it reduces soil acidity, thus making liming unnecessary, and vinasse also has a large amount of water, which is fundamental to plant development [5].

Filter cake is the result of sugarcane juice filtration. The use of filter cake can be beneficial for sugarcane cultivation and for the soil since its organic matter contains micronutrients and the minerals contained in it experience little leaching; in addition, filter cake increases the cation exchange capacity, it retains more water, and it improves the soil characteristics, among others factors. In general, these two byproducts reduce the cost of production [1].

Herbicides are also widely used in sugarcane cultivation [6]. Most molecules registered for sugarcane are applied pre-emergence and generally have high mobility and a prolonged residual effect in soils [7].

A production system with or without the presence of straw and the application of vinasse in sugarcane plantations can lead to changes in the soil properties, thereby affecting the availability of herbicides in the soil solution. The addition of vinasse promoted, for example, greater availability of diuron and tebuthiuron in various soil types, whereas for the herbicides clomazone, hexazinone, and sulfentrazone, no effect was observed [8].

Prata and Lavorenti [9] demonstrated a reduction in the persistence of diuron and ametrine molecules with the addition of vinasse to the soil because vinasse increases the microbial activity and biomass, causing the mineralization of these herbicides. Studies have shown that herbicide sorption may change depending on the macromolecular structure and size of the humic substances. A lower amount of aromatic carbon results in greater sorption of the herbicide molecule because of the lower stereochemical rigidity of the humic molecule, facilitating the entry of the herbicide molecule into the reactive sites of the humic molecule.

Because vinasse comprises several organic acids, in addition to being used in soil correction, it can also be used to control some weed species, altering the weed emergence flux and herbicide amount and action [10]. A reduction in the emergence of *Digitaria horizontalis*, *Cyperus rotundus*, *Sida rhombifolia*, and *Emilia sonchifolia* has been observed using vinasse [11].

Indaziflam and saflufenacil herbicides for pre-emergence applications are the most recently registered products for sugarcane cultivation, and no information is available on their interaction with vinasse or filter cake.

The objective of this study was to determine the effect of vinasse and filter cake on the efficacy of saflufenacil and indaziflam on *Ipomoea triloba* and *Digitaria horizontalis* control, respectively, as well as the influence of these byproducts on weed germination.

2. MATERIAL AND METHODS

Interaction of vinasse and filter cake with pre-emergence herbicides

The experiments were conducted in a greenhouse, and the experimental units comprised 5-L pots filled with Dark Red Latosol (according to the Brazilian soil classification system), with a texture classified as clayey (66% clay). The vinasse doses were calculated according to the soil chemical analysis. The chemical analysis of the soil, carried out before trial installation at 0- 20 cm depth, showed the following results: pH 5.3; 2.9 g kg^{-1} of organic matter; 10 mg dm^{-3} P; 2.2 $mmol_c/dm^3$ K; 29 mmolc/dm^3 Ca; 15molc dm^{-3} Mg and 0.4 % Al;61% V and 75.2 CEC.

The experimental design for each herbicide was completely randomized, with four replications, in a 4 x 3 factorial scheme, with four herbicide doses and three soil cover treatments (without byproduct, with vinasse, and with filter cake).

The herbicides and doses used were indaziflam (0, 37.5, 75, and 150 g ai ha^{-1}), saflufenacil (0, 42, 84, and 168 g ai ha^{-1}), and sulfentrazone (0, 300, 600, and 1200 g ai ha^{-1}), which were applied for pre-emergent weeds.

Comment [MF2]: in which part of the world?

Comment [MF3]: Materials

Comment [MF4]: This heading should not come under materials and methods

Comment [MF5]: This is an article meant for international Journa of reputel. There should be proper desciption of the geographical location and climate of the experimental site.Although the location was mentioned under abstract, the full discription is necessary under materials and methods

The indaziflam target weed was *D. horizontalis,* and for saflufenacil and sulfentrazone, it was *I. triloba.* Seeds of the two weed species were sown separately one day before the byproduct application and in sufficient amounts to obtain five plants per pot.

The byproducts were placed superficially on the soil prior to herbicide application. The dose of filter cake was equivalent to 50 t ha^{1} and that of vinasse was equivalent to 330 m^3 ha^{-1}. To calculate the vinasse dose, the criterion established by the State of São Paulo Environmental Company [12] was used, which recommends the following calculation for sugarcane: vinasse (m^3 ha^{-1}) = [(0.05 x CEC – ks) x 3744 + 185] / kvi, where 0.05 = 5% CEC; CEC = the cation exchange capacity of the soil, expressed in cmolc dm^{-3}; ks = the soil potassium concentration, expressed in cmolc dm^{-3}; 3744 = the constant to convert the results of the fertility analysis, expressed in cmolc dm^{-3} or meq 100 cm^{-3}, to kg of potassium in a volume of 1 ha per 0.80 m depth; 185 = weight, in kilograms of K_2O extracted by the crop per hectare, per cut; and kvi = the vinasse potassium concentration, expressed in kilograms of K_2O m^{-3}, presented in the analytical results.

The herbicides were applied two days after sowing (DAS) using a CO_2-pressurized backpack sprayer equipped with a spray bar with Teejet 110.02 fan nozzles and an application volume of 200 L ha^{-1}. Weather conditions at the time of application were wind speed of 0.5 m s^{-1}, relative humidity of 60.5%, and air temperature of 25.7 °C.

At 10, 20, and 40 days after application of the herbicide treatments (DAT), visual evaluations were performed based on the criteria of ALAM [13], which use a percentage scoring scale, where 0 (zero) corresponds to the absence of control and 100% to absolute control. At 40 DAT, the plants were cut close to the ground and dried to constant weight in a forced air oven at 60 ºC.

The data obtained for each herbicide were subjected to analysis of variance by the F test, and the means were compared using the Tukey test at 5% probability. Regression curves were fitted for the quantitative data.

Effect of sugarcane byproducts on* I. triloba *and* D. horizontalis *germination

The experimental units comprised 5-L pots filled with Dark Red Latosol soil from the previously sieved arable layer.

The experiment compared seven treatments: three doses of vinasse (82.5, 165, and 330 m^3 ha^{-1}), three doses of filter cake (20, 40, and 50 t ha^{-1}), and one treatment with no byproducts, in a completely randomized design with 4 replications. In accordance with the germination analysis, the *I. triloba* and *D. horizontalis* seeds were sown in sufficient quantity to obtain 25 plants per pot.

Emergence was evaluated weekly until 42 DAS, and the emerged plants were counted daily. The total seedling emergence data at the last evaluation were transformed into percentage, according to the total number of seeds in the pots. The emergence speed index (ESI) was calculated using the following formula proposed by Maguire [14]: ESI= N1/D1 + N2/D2 +....+ Nn/Dn, where ESI = the emergence speed index, N = the number of emerged seedlings on the count day, and D = the number of days after sowing when the counting was performed. At 42 DAS, the plants were cut close to the ground, and the shoot dry mass was determined by drying the plants to a constant weight in a forced air oven at 60 ºC.

The percent emergence and ESI data were subjected to analysis of variance, and the means were compared using the Tukey test at 5% probability.

3. RESULTS AND DISCUSSION

In all evaluations, indaziflam application over the filter cake led to lower control of *D. horizontalis* compared to the treatments with vinasse or without byproduct (Figure 1). Although vinasse did not alter the control of the species in the first evaluation relative to the treatment without byproduct, during the evaluations, a negative interaction was observed with the herbicide.

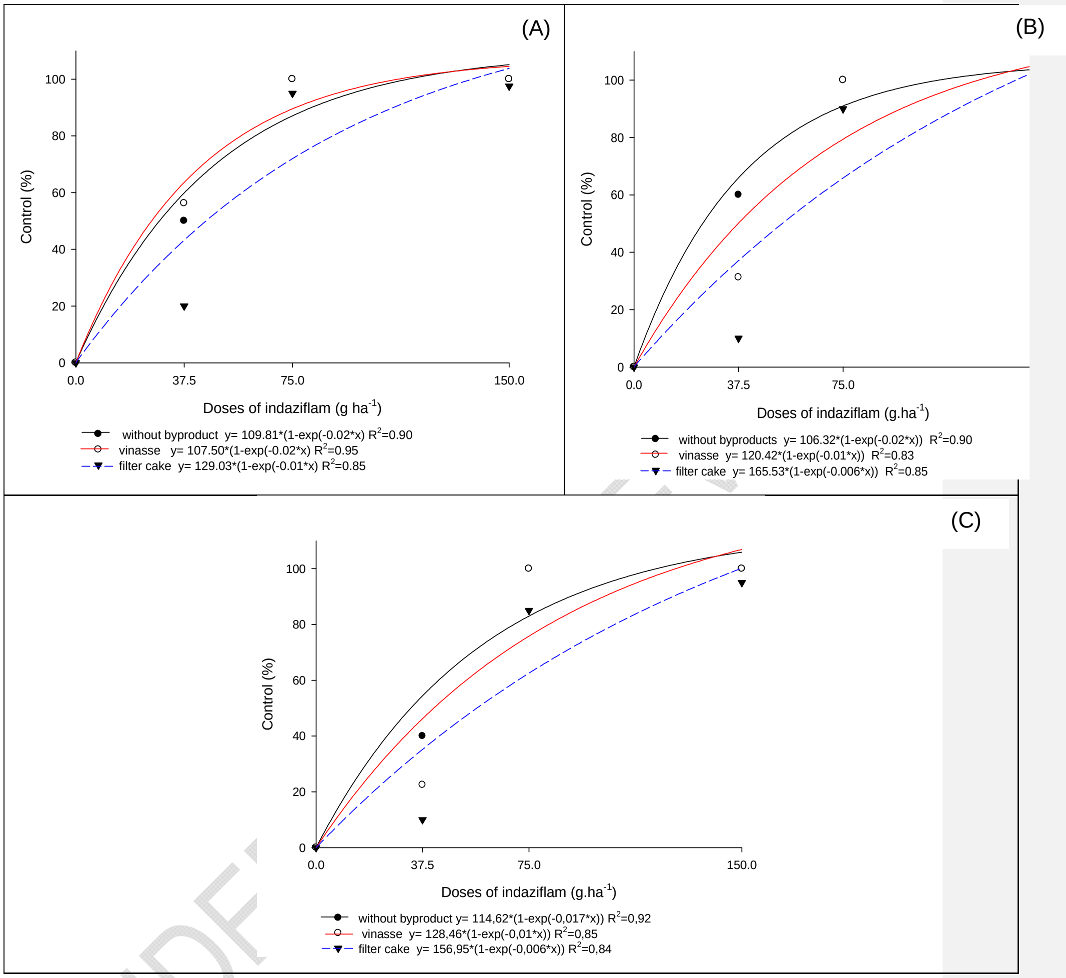


Fig. 1. Percent control of *D. horizontalis* treated with different doses of indaziflam without byproducts or with vinasse or filter cake in the soil at 10 (A), 20 (B), and 40 days after treatment (DAT) (C).

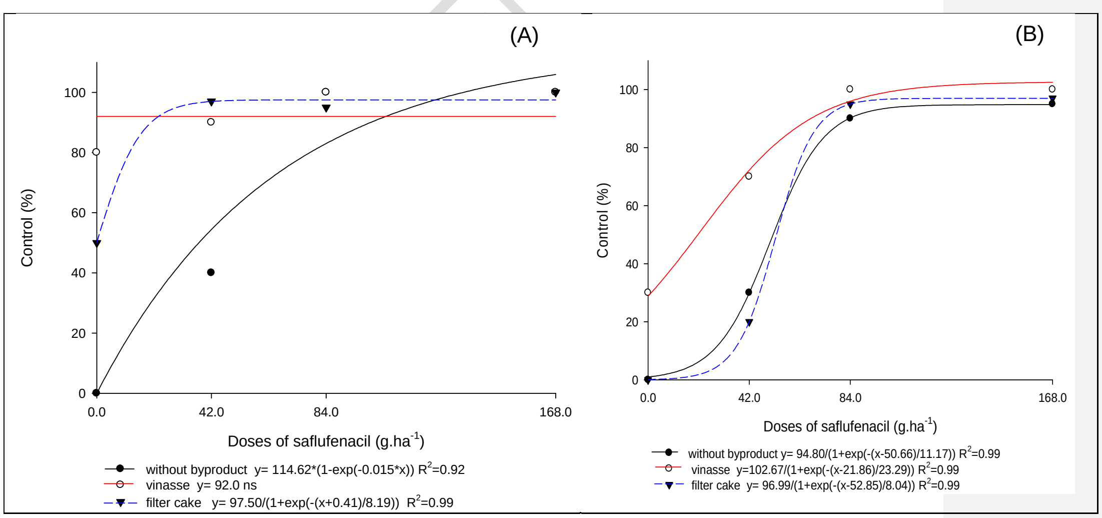
For the doses, starting at 71 g ha^{-1}, *D. horizontalis* control by indaziflam, without byproducts in the soil, was satisfactory at 40 DAT (considering 80% control) (Figure 1). For vinasse, this dose was 98 g ha^{-1} (38% higher), and for filter cake, it was 119 g ha^{-1} (67.6% higher). Therefore, byproducts have a high impact on the performance of this herbicide. Amim et al. [15] observed effective control of this weed starting at the 30 g ha^{-1} dose of indaziflam. However, Kaapro and Hall [16] observed 100% control for *Digitaria horizontalis* using 100 g ha^{-1}.

Alonso et al. [16] found a positive correlation between indaziflam sorption and the organic carbon content of several Brazilian soils. Both vinasse and filter cake, in general, contain high concentrations of nitrate, potassium, and organic matter; their use may alter soil characteristics by promoting changes in its chemical properties.

In addition, the use of the filter cake provided greater vigor to the weeds, favoring their growth, a finding explained by the large amount of organic matter present in the filter cake [17] [3].

Indaziflam water solubility is low (0.0028 kg m^{-3} at 20 °C), with K_{oc} < 1.000 mL g^{-1} of organic carbon, pka = 3.5, and log K_{ow} at pH 4, 7 or 9 = 2.8; this herbicide is considered moderately mobile to mobile or slightly mobile (Jhala et al. 2012; Jhala & Singh 2012) in the soil. The lower the water solubility of the herbicide is, the greater the affinity of the molecule for organic matter, which explains the interaction of this herbicide with the byproducts, especially the filter cake, which is basically an organic compound with variable chemical composition; high organic matter, phosphorus, nitrogen, and calcium content; and considerable potassium and magnesium content [17].

Vinasse had a negative effect on *I. triloba* at 10 DAT, regardless of the dose of saflufenacil (Figure 2), which was evident from the delayed germination of this species. In the evaluations conducted at 20 and 40 DAT, emergence occurred in the plants in the vinasse without herbicide treatment. Similarly, but to a lesser extent, filter cake promoted a delay in the establishment of the species. Ramos et al. [18] observed that the application of 150 m^3 ha^{-1} of vinasse to the soil is harmful to the emergence and early development of peanut plants and, to a lesser extent, sunflowers. According to the authors, the higher concentration of salts in the soil solution may lead to a higher osmotic potential around the seeds, thereby delaying germination and seedling emergence. These data also corroborate the results of Azania et al. [19], who found a reduction in the emergence speed and percentage of *Sida rhombifolia* (arrowleaf sida) and *Urochloa decumbens* (signalgrass) with the addition of vinasse at doses up to 150 $m^3 ha^{-1}$, but no reduction was observed in the final stand at 40 DAT. Novo et al. [20] also observed a negative effect of vinasse on the percent emergence of castor bean seedlings.



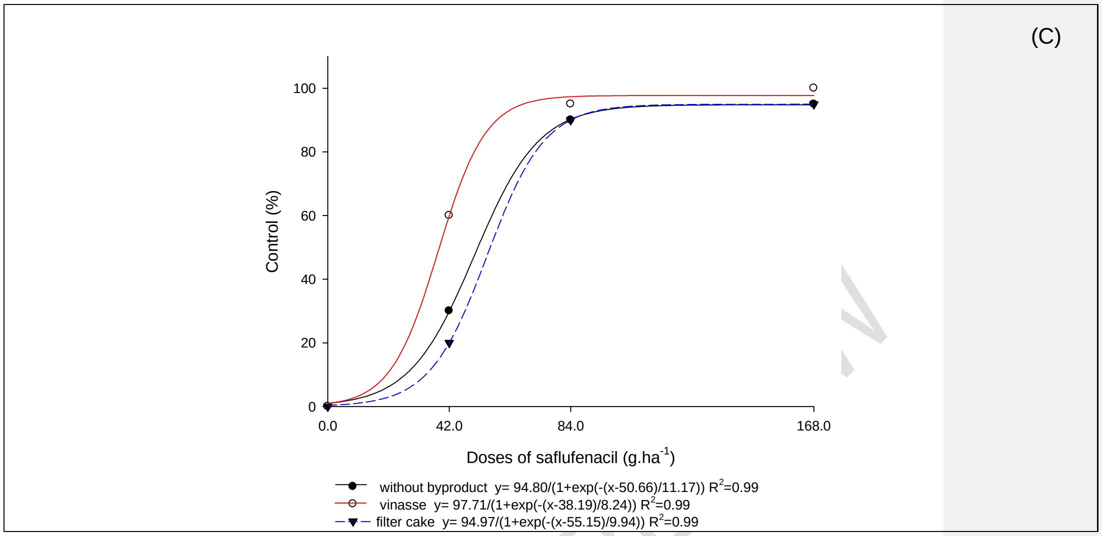


Fig. 2. Percent control of *I. triloba* treated with different doses of saflufenacil without byproducts or with vinasse or filter cake in the soil at 10 (A), 20 (B), and 40 days after treatment (DAT) (C).

Regarding the doses, 70 g ha^{-1} and 72 g ha^{-1} of saflufenacil were necessary for satisfactory weed control (80%) in the treatments without byproduct and with filter cake, respectively, at 40 DAT. However, with the addition of vinasse, this same level of control was reached with a dose of 51 g ha^{-1}. Thus, the results indicate that vinasse may contribute to reducing the saflufenacil dose required for control of the species.

A phytotoxic response to saflufenacil should occur in soils with organic matter content lower than 1.5% [21]. The soil used in the experiment contained 2.9% organic matter, without considering the organic byproducts represented by the filter cake and vinasse. Nevertheless, the product still had phytotoxic action. In the anionic form of the molecule, a lower force of attraction exists between the herbicide and the soil, leading to lower herbicide sorption, with the herbicide remaining available in the soil solution [22].

Vinasse had a suppressive effect on *I. triloba* in the evaluation of sulfentrazone, which corroborates the results presented previously with saflufenacil. However, filter cake interacted negatively with this herbicide. The necessary doses for 80% control of the species at 40 DAT were 301 g ha^{-1} and 365 g ha^{-1} for the treatments without byproduct and vinasse, and 600 g ha^{-1} with the addition of filter cake; thus, a 100% increase in the treatment dose was required over that of the treatment without the byproduct (Figure 3).

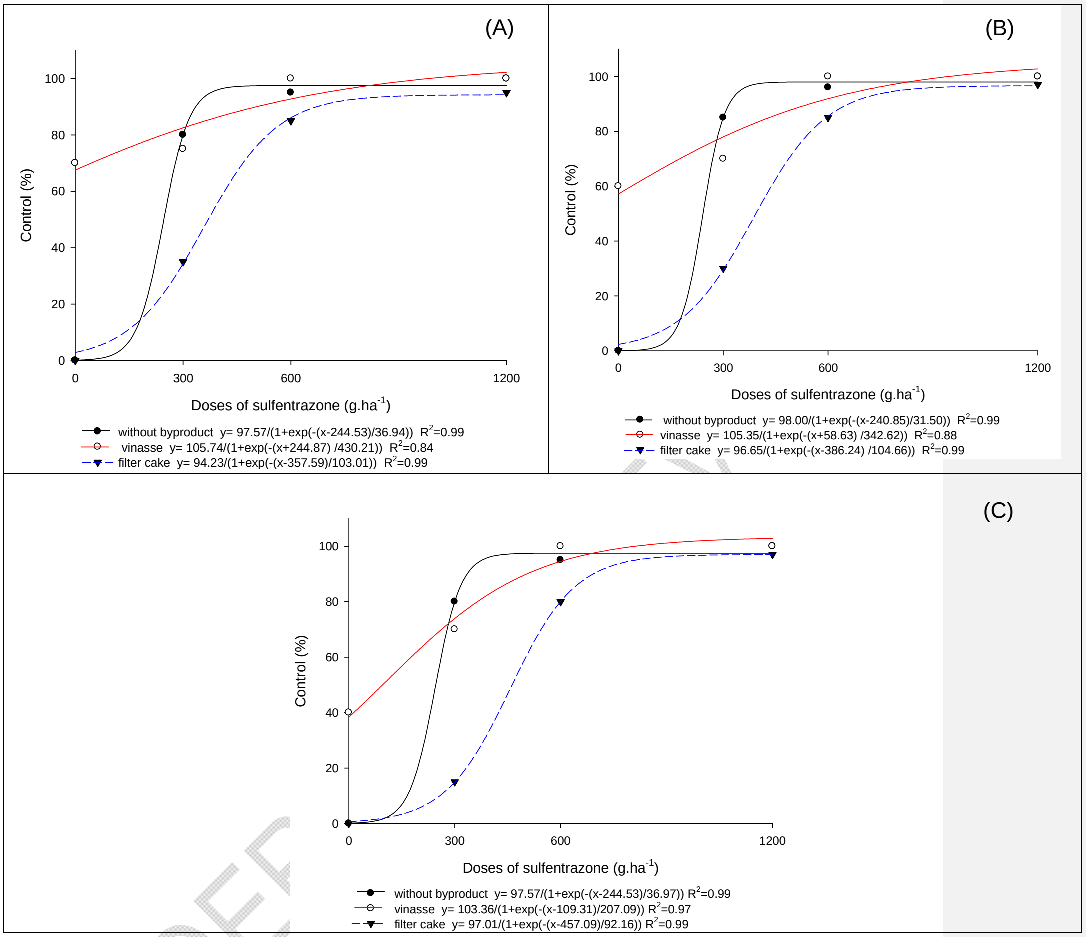


Fig. 3. Percent control of *I. triloba* treated with different doses of sulfentrazone without byproducts or with vinasse or filter cake in the soil at 10 (A), 20 (B), and 40 days after treatment (DAT) (C).

This result may be explained by the fact that sulfentrazone was applied to soils with high organic matter (36 g dm^3) and clay (560 g kg^{-1}) content, and thus, because of the ionization constant of the herbicide and the soil pH, sorption of the herbicide to the colloids is favored, with the amount of organic matter present in this byproduct explaining the sorption of sulfentrazone to the filter cake [23] and [24]. At the highest dose of this herbicide, the result was similar to the use of the same herbicide dose in the treatment without the byproducts.
However, the weed control dose with the filter cake is in agreement with Campos et al. [25] and Ribeiro et al. [26], who found that the recommended dose of sulfentrazone (600 g ha^{-1}) provided excellent control of *Ipomoea quamoclit*, *I. triloba,* and *Merremia cissoides* as early as the first evaluation, which was conducted at 15 DAT, and this control was maintained until 60 DAT.
In addition, vinasse is constituted by several organic acids, and in addition to being used in soil correction, it can be used to control some weeds by altering the weed emergence flux

and herbicide amount and action [10]. According to Novo et al. [27], sulfentrazone (700 g ha^{-1}), when applied alone and on straw, or when combined with vinasse, on which the pesticide was applied before being added, controlled the initial development of *Cyperus rotundus* (nut grass).

Table 2 shows the final dry biomass accumulation values with the interaction between byproducts and herbicides. With regard to sulfentrazone, and in corroboration with the phytotoxicity results, a high biomass accumulation of *I. triloba* was observed when filter cake was used, and double the dose of herbicide was required to reduce the biomass in comparison with the other treatments.

Table 2. Shoot dry biomass of weeds treated with different doses of sulfentrazone, saflufenacil and indaziflam with or without byproducts in the soil.

Dry biomass - *Ipomoea triloba* (g pot^{-1})			
Sulfentrazone g a.i ha^{-1}	Vinasse	Filter cake	Without byproducts
0	0.15 aB	3.34 bA	0.26 aB
300	0.20 aB	4.66 aA	0.05 abC
600	0.00 bA	0.07 cA	0.02 bA
1200	0.00 bA	0.01 cA	0.02 bA
*CV line	17.28	*CV column	16.10
**MSD 5%	0.16	**MSD 5%	0.10
Dry biomass - *Ipomoea triloba* (g pot^{-1})			
Saflufenacil g a.i ha^{-1}	Vinasse	Filter cake	Without byproducts
0	0.05 aC	4.25 aA	0.27 aB
42	0.07 aC	1.78 bA	0.32 aB
84	0.00 aA	0.07 cA	0.05 bA
168	0.00 aB	0.15 cA	0.02 bB
*CV line	11.14	*CV column	11.04
**MSD 5%	0.08	**MSD 5%	0.06
Dry biomass - *D. horizontalis* (g pot^{-1})			
Indaziflam g a.i ha^{-1}	Vinasse	Filter cake	Without byproducts
0	0.13 aB	1.29 aA	0.04 abB
37.5	0.07 aB	0.42 bA	0.10 aB
75	0.00 bA	0.03 cA	0.00 bA
150	0.00 bA	0.07 cA	0.00 bA
*CV line	44.19	*CV column	38.97
**MSD 5%	0.10	**MSD 5%	0.06

The averages followed by the same letter do not differ statistically from each other, lower case letters are compared vertically and upper case horizontal by the Tukey test 5%. *CV (coefficient of variation); **MSD (minimum significant difference).

The influence of filter cake on biomass production was observed by Vasconcelos [28] in sugarcane, where the presence of filter cake in the soil led to a shoot biomass production of 12.9 kg ha^{-1} and the absence of the byproduct to 10.3 kg ha^{-1}.

Concerning saflufenacil, vinasse had a positive effect on the control of *I. triloba* at the lowest herbicide doses (0 and 42 g ai ha^{-1}), as this treatment was superior to the treatment without byproduct and with filter cake, with the filter cake promoting an increase in biomass accumulation at these doses.

For indaziflam, the filter cake also interacted negatively. Vinasse showed no difference in biomass accumulation relative to the treatment without byproduct.

Overall, analysis of the biomass revealed that at the two highest doses of all the herbicides, high weed control was obtained, regardless of the addition of vinasse or filter cake. Therefore, the byproducts evaluated have an effect on herbicide efficacy at doses below those recommended.

Because one factor that affects the downward movement of herbicides in the soil is the content and type of organic matter [29], at herbicide doses below that recommended, the process tends to be more affected by the byproducts, leading to greater difficulty of the herbicide to descend to the soil layer housing the weed seeds.

Effect of sugarcane byproducts on I. triloba *and* D. horizontalis *germination*

Table 3 shows a significant difference for all variables involving the *I. triloba* at different doses of vinasse and filter cake, in addition to a control treatment without the addition of byproducts. Higher doses of vinasse negatively affected both the ESI and the percent weed emergence. Filter cake stood out positively relative to the vinasse for weed biomass accumulation, especially at the 50 $t.ha^{-1}$ dose. According to Santos et al. [3], the positive effects of the filter cake probably result not only from the nutrient supply but also from the increased soil moisture accumulation and increased cation exchange capacity, thus causing an improvement in the utilization of nutrients originally present in the soil.

Table 3. Shoot dry mass (g), emergence (%) and ESI of *I. triloba* e *D. horizontalis* treated with different doses byproducts in the soil.

Treatments	**Doses (t or m^3 ha^{-1})**	**Shoot dry mass (g)**	**ESI**	**Emergence (%)**
		I. triloba		
Control	0.0	1.22 b	2.23 a	35.00 a
Vinasse	82.5	1.77 b	2.16 a	30.50 a
Vinasse	165.0	2.27 b	1.09 b	25.00 b
Vinasse	330.0	1.45 b	1.00 b	21.00 b
Filter cake	20.0	3.45 ab	2.02 a	30.00 a
Filter cake	40.0	4.32 ab	2.45 a	41.50 a
Filter cake	50.0	7.50 a	4.79 a	62.00 a
*CV %		58.57	44.79	27.89
**MSD 5%		4.22	3.18	35.25
		D. horizontalis		
Treatments	**Doses (t or m^3 ha^{-1})**	**Shoot dry mass (g)**	**ESI**	**Emergence (%)**
Control	0.0	0.46 c	7.91 a	88.57 a
Vinasse	82.5	2.36 c	9.15 a	96.42 a
Vinasse	165.0	1.02 c	7.44 a	84.28 a
Vinasse	330.0	1.25 c	8.03 a	90.71 a
Filter cake	20.0	1.72 c	7.19 a	82.85 a
Filter cake	40.0	6.64 b	6.94 a	77.14 a
Filter cake	50.0	12.06 a	4.63 a	62.85 a
*CV %		38.81		

**MSD 5%	3.25

Equal lowercase letters between columns do not differ statistically at 5% significance. *CV (coefficient of variation); **MSD (minimum significant difference).

For *D. horizontalis*, the lowest filter cake dose used did not differ from the treatments with vinasse or from the control; however, the biomass accumulation was 3.9 and 7.0 times higher at 40 t ha^{-1} and 50 t ha^{-1}, respectively, compared to 20 t ha^{-1} (Table 3).
No significant differences were detected regarding the percent emergence and ESI of *D. horizontalis* with the use of the byproducts as a function of the doses. According to Ramos et al. [18], the effect of vinasse on the plant emergence and initial development can be positive or negative depending on the species involved. For carrots, Cavatte et al. [30] found that the addition of vinasse contributed to a reduction in seed germination; however, the addition of filter cake had no effect compared to the control.

4. CONCLUSION

It can be concluded that the vinasse and filter cake byproducts from the sugar and alcohol industry may negatively or positively affect the performance of pre-emergence herbicides, depending on the active ingredient used, especially at herbicide doses below those recommended. Byproducts can affect the emergence and the weed biomassa accumulation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Fravet PRF De, Soares RAB, Lana RMQ, Lana AMQ, Korndorfer GH. Efeito de doses de torta de filtro e modo de aplicação sobre a produtividade e qualidade tecnológica da soqueira de cana-de-açúcar. Ciência e Agrotecnologia. 2010; 34:618-624. Portuguese.
2. Zolin CA, Paulino J, Bertonha A, Freitas PSL, Folegatti MV. Estudo exploratório do uso da vinhaça ao longo do tempo. I. Características do solo. Revista Brasileira de Engenharia Agrícola e Ambiental. 2011; 15:22–28. Portuguese.
3. Santos DH, Tiritan CS, Foloni JSS, Fabris LB. Produtividade de cana-de-açúcar sob adubação com torta de filtro enriquecida com fosfato solúvel. Pesquisa Agropecuária Tropical**.** 2010; 40:454-461. Portuguese
4. Marques GM. Vinhaça: o futuro da fertilização. Meio Ambiente. 2015; 66:1-5. Portuguese
5. Silvestre AAF, Reis ACS, Gomes AO, Silva DF Da, Débia PJG, Gonçalves, AC. Utilização da Vinhaça na Agricultura. Journal of Agronomic. 2014:47-62. Portuguese
6. Victoria FR, Christoffoleti PJ. Manejo de plantas daninhas e produtividade da cana. Visão Agrícola. 2014: 1-3. Portuguese
7. Blanco FMG, Velini ED, Filho AB. Persistência do herbicida sulfentrazone em solo cultivado com cana-de-açúcar. Bragantia. 2010; 69: 71-75. Portuguese
8. Matos AKA. Influence of vinasse and straw of cane sugar on the sorption of herbicides in different soils (Mater thesis). Universidade Estadual Paulista, Faculdade de Ciências Agronômicas de Botucatu, 2014.Sao Paulo, Bazil. Portuguese

9. Prata F, Lavorenti A. Comportamento de herbicidas no solo: influência da matéria orgânica. Revista Biociências. 2000; 6: 17-22. Portuguese
10. Quintela ACR. et al. Controle de plantas daninhas em cana crua (cultivar RB835089) no sistema integrado palhiço, herbicida e vinhaça. STAB. 2002; 20: 38-42. Portuguese
11. Christoffoleti PJ, Bacchi OOS. Efeitos da aplicação de vinhaça sobre a população e controle químico de plantas daninhas na cultura da cana-de-açúcar (*Saccharum spp.*). Planta Daninha. 1985; 8:60-70. Portuguese.
12. CETESB Norma P4.231 **-** Vinhaça – critérios e procedimentos para aplicação no solo agrícola. 2006. Portuguese
13. Asociation Latinoamericana De Malezas (ALAM). Recomendaciones sobre unificación de los sistemas de evaluación em ensayos de control de malezas. ALAM. 1974; 1: 35-38.
14. Maguire JD. Speed of germination aid in selection and evaluation for seedling emergence and vigor. Crop Science. 1962; 2:176-77.
15. Amim RT, Freitas SP, Freitas ILJ, Gravina GA, Paes H.M.F. Controle de plantas daninhas pelo indaziflam em solos com diferentes características físico-químicas. Planta Daninha. 2014; 32: 60-64. Portuguese
16. Kaapro J, Hall J. Indaziflam - A new herbicide for pre-emergent control of weeds in turf, forestry, industrial vegetation and ornamentals. Weed Science Research. 2012; 18: 267-270.
17. Nunes Júnior D. Torta de filtro: De resíduo a produto nobre. Revista Idea News. 2008; 92:22-30. Portuguese
18. Ramos, N.P.; Novo, M.C.S.S.; Ungaro, M.R.G.; Lago, A.A.; Marin, G.C. Efeito da vinhaça no desenvolvimento inicial de girassol, mamona e amendoim em casa de vegetação. Bragantia. 2008; 67:685-692. Portuguese
19. Azania AAPM, Azania CAM, Marques MO, Pavani MCMD. Emergência e desenvolvimento de guanxuma (*Sida rhombifolia*), capim-braquiária (*Brachiaria decumbens*) e cana-de-açúcar (*Saccharum spp*.) influenciados por subprodutos da destilação do álcool. Planta Daninha. 2004; 22:331-336. Portuguese
20. Novo MCSS, Ramos N P, Lago, A A, Marin G C. Efeito da adição de palha de cana-de-açúcar e da aplicação de vinhaça ao solo no desenvolvimento inicial de três cultivares de mamona**.** Revista brasileira de sementes. 2007; 29:125-130. Portuguese
21. Hixson A.C. Soil Properties Affect Simazine and Saflufenacil Fate, Behavior, and Performance. Faculty of North Carolina State University, Raleigh, North Carolina. 2008.
22. Inoue MH. et al. Calagem e o potencial de lixiviação de imazaquin em colunas de solo. Planta Daninha. 2002; 20:125-132.Portuguese
23. Grey TL. et al. Sulfentrazone adsortion and mobility as affected by soil and pH. Weed Science. 1997; 45: 733-738.
24. Monquero PA. et al. Lixiviação e persistência dos herbicidas sulfentrazone e imazapic. Planta Daninha**.** 2010; 28: 45-54. Portuguese
25. Campos LH. et al. Suscetibilidade de *Ipomoea quamoclit, I. triloba e Merremia cissoides* aos herbicidas sulfentrazone e amicarbazone. Planta Daninha. 2009; 27: 831-840. Portuguese
26. Ribeiro NM, Torres BA, Ramos SK, Santos PHV, Simões CT, Monquero P A. Differential susceptibility of morning glory (*Ipomoea* and *Merremia*) species to residual herbicides and the effect of drought periods on efficacy. Australian Journal of Crop Science. 2018; 4:1090-1098.
27. Novo MCSS et al . Interação de imazapic no sistema integrado palha de cana-de-açúcar, herbicida e vinhaça no crescimento inicial da tiririca. Planta Daninha. 2008; 26: 439-449. Portuguese

28. Vasconcelos R.L. Fontes de fósforo e torta de filtro sobre o estado nutricional e produtividade da cana-planta (Master thesis). Universidade Estadual Paulista, Faculdade de Ciências Agrárias e Veterinárias de Jaboticabal, Sao Paulo, Brazil.2013
29. Prata F. et al. Glyphosate sorption and desorption in soils with different phosphorous levels. Scientia Agricola. 2003; 60: 175-180.
30. Cavatte PC, Zonta J B, Lopes JC, Souza LT, Zonta J.H. and Cavatte R.P.Q. Germination and vigor of carrot seeds in limestone mining Soil under different light intensities and fertilizations. Volum. 2009; 2: 25-32.

Comment [MF6]: Prata, F., pleae give proper reference. et al., should not come under references. It is appropriate only in the body of your write up. Give the names of all the Authours under references. Sur name first followed by the initials of each Authour. Full stop should follow each initial. Please apply this method to all your references where necessary.

Comment [MF7]: Wrong referencing style please. The acceptable order is names of Authours first, year of publication, topic of article, name of journal (in italics), volume, number and pages. How ever, this order depends on the policy by the editor of this journal. Please go through your references and effect necessary corrections.