An Acad Bras Cienc (2020) 92(Suppl. 1): e20190601 DOI 10.1590/0001-3765202020190601
Anais da Academia Brasileira de Ciências | *Annals of the Brazilian Academy of Sciences*
Printed ISSN 0001-3765 I Online ISSN 1678-2690
www.scielo.br/aabc | www.fb.com/aabcjournal

AGRARIAN SCIENCES

Eradication of eucalyptus sprouts after chemical weeding over time in State of Bahia, Brazil

CAIQUE C. MEDAUAR, SAMUEL A. SILVA, LUIS CARLOS C. CARVALHO, RAFAEL A.S. TIBÚRCIO, JULIÃO S.S. LIMA & PHILIPPE S. OLIVEIRA

Abstract: This study evaluated the eradication of eucalyptus sprouts after chemical weeding using a diagrammatic scale over time. The research was conducted in fields planted with eucalyptus in forest reform areas, in Itabela, Bahia, Brazil, during the pre-planting herbicide application. The application was carried out in five fields, which were considered as sample units of the different treatments. The effectiveness of chemical weeding for controlling sprout growth was evaluated in fifty plants per treatment, randomly selected in three periods after application. The plants were evaluated visually using a diagrammatic scale to assign scores between 1 and 5 to the sprout control percentage. After the visual evaluations, the frequency distribution of the sprouting percentage for each score was calculated. Subsequently, the scores were submitted to a clustering analysis by the Ward method, to evaluate the relationship between different fields and periods for each treatment in homogeneous clusters. The results showed that treatments only controlled the sprouts in the short term, without providing effective eradication. The diagrammatic scoring scale allowed evaluating the vegetative vigor of the eucalyptus sprouts, generating interpretable information on the different evaluated treatments, making it a useful tool for managing silvicultural treatments and evaluating the application efficacy of phytosanitary products.

Key words: diagrammatic scale, forest management, forestry, spraying.

INTRODUCTION

In the last five years, the productivity of eucalyptus has stabilized in Brazil while yield has been increasing only 0.2% per year (IBÁ 2017). This deceleration has been attributed to several factors, from deficient forest management to highly unstable climate parameters that affect negatively essential stages of tree development (IBÁ 2017). Another factor associated with slowing advances in productivity is the competition for water, light, and nutrients between eucalyptus trees and weeds or sprouts in reform areas (Silva et al. 2014).

Under reform conditions, eucalyptus sprouts become a major problem that needs to be eradicated during certain periods (Tibúrcio 2014). In this respect, the chemical control using herbicides is the most used, with emphasis on the active principle glyphosate (Santos et al. 2007). Furthermore, undesirable eucalyptus plants are currently being controlled in the field with a mixture of herbicides and foliar fertilizers (Machado et al. 2017).

When chemical weeding is used to control sprout, it is necessary to monitor the status of plants over time to evaluate control efficacy (Medauar et al. 2018). According to the same authors, the monitoring process usually consists of assigning scores based on diagrammatic scales that vary according to the control level of sprouting, which is conducted by a field evaluator on random samplings.

The vegetative vigor of the sprouts evaluated using diagrammatic scales is a well-established practice in the forestry field and is usually carried out in different periods subsequent to the application of the phytosanitary product (Tibúrcio 2014). According to the same authors, the data obtained from this practice, allows the management to evaluate the efficiency of the chemical treatment, thus guiding the decision on new interventions when weeds or sprouts were not controlled.

The vegetative state of sprouts is monitored at intervals of 30 days after product application and, when control is ineffective, additional practices ranging from new herbicide applications to using mechanical methods are recommended, avoiding weed competition interfering with the development of seedlings planted between the rows. (Medauar et al. 2018). This sense, it is of paramount importance to evaluate periodically the behavior of sprouts after chemical weeding, as they may present different results on the health (Medauar et al. 2018). Thus, it is essential to use a diagrammatic scale with control notes amplitude, because besides being a simple and practical tool, it allows monitoring the effectiveness of chemical control and assisting the operational management in fields of eradication of eucalyptus sprouts.

This work aimed at evaluating the eradication of eucalyptus sprouts over time after chemical weeding, using a diagrammatic scale.

MATERIALS AND METHODS

The study was conducted in eucalyptus plantations located in Itabela (16°34'19"S and 39°33'33"W Gr.) in the most southern region of Bahia, Brazil. The regional climate is classified as Af, humid tropical, with precipitations throughout the year (Alvares et al. 2013). The average annual rainfall in the region is 1100 mm, with temperatures varying between 23°C and 27°C. The soil of the experimental fields was classified as Yellow Latosol Dystrophic, according to the Brazilian Soil Classification System (Santos et al. 2013).

The studies focused on evaluating the efficacy of herbicide application in replanting areas to control eucalyptus sprouts up to 75 cm tall during the pre-planting stage. The plants were spaced 5.0 m between rows and 2.40 m between sprouts (hybrid clones of *Eucalyptus urophylla* and *Eucalyptus grandis*). At the time of experiment implementation, the height and width of the crown were measured in the middle third of 100 sprouts randomly sampled in each field, to characterize the area. At the time of application, the average height and width of the sprouts were 1.57 and 1.27 m, respectively.

The application was carried out in five fields (TAL 35, TAL 40, TAL 41, TAL 43 and TAL 44) of different sizes (areas, in ha), which were considered as sample units of the different treatments (T01, T02 and T03). These treatments consisted of different products and dosages, namely: a) T01: Scout® herbicide with 4kg.ha^{-1}, in ammonium salt of glyphosate; b) T02: Scout® herbicide with 4kg.ha^{-1} + 100 ml.ha^{-1} Taiyô foliar fertilizer; c) T03: Scout® herbicide with 4kg.ha^{-1} + 100 ml.ha^{-1} Taiyô foliar fertilizer + 100 L.ha^{-1} Finale herbicide, in glufosinate ammonium salt. All three treatments were applied in each field; the experimental parcels were distributed according to field sizes, allowing a minimum of 65 sprout rows.

Spraying was carried out in November 10 and 11, 2016 using a self-propelled sprayer John Deere, model 4630E, with 123 kW nominal power, 6 cylinders, and 6.8 L total displacement. The spray system consisted of a 2270 L reservoir, a

265 L rinse tank, and hydraulic stirring. The spray bar had full hydraulic control, length and height of 24.3 m and 0.38 m to 1.93 m, respectively, but the bar height varied between 1.50 and 1.80 m during application due to uneven sprouts. The application was carried out in the sprout rows at approximately 6.5 $km.h^{-1}$.

The pressure during application was 3.0 bar with a flow rate of 1.18 $L.min^{-1}$. The spray nozzles used had flat air induction of fan type, AIUB85-03 model, and spaced 50 cm apart.

The climate parameters were monitored during the application (between 8:00 and 10:00 in the morning) at 30-min intervals. The temperature, relative humidity, and wind speed data were provided by a weather station near the fields. The data indicated 26.3°C average temperature, 75.5% average humidity, and 6.5 $km.h^{-1}$ average wind speed.

Fifty plants per treatment were randomly selected to evaluate the effectiveness of chemical weeding to control the sprouts. The plants were visually evaluated and a score was assigned to the control percentage, according to the diagrammatic scale shown in Table I. To avoid subjectivity when using the scale, the evaluations were performed by a single field evaluator with extensive experience in its use.

The evaluations were performed 30 days after the chemical weeding in December 2016, and 60 and 90 days after treatment in January and February 2017. After the visual evaluations, the frequency distribution of the sprout percentage for each score was calculated to evaluate the effectiveness of sprout control over time for the different treatments and respective fields studied.

Subsequently, the scores were submitted to the clustering analysis by the Ward hierarchical method to evaluate the relationship between different fields and periods for each treatment in homogeneous clusters. This multivariate analysis did not take into account the data distribution since clustering was based on the similarity between individual measurements because the hierarchical Ward method calculates the distance between two clusters, through the sum of the square between clusters (SS_C) based on all variables (Silva & Lima, 2012). Its working principle consists of a multidimensional generalization of the variance analysis model (equation 1) (Asensio 1989).

Table I. **Diagrammatic scale for evaluating the control of eucalyptus sprouts.**

Control percentage	Scores	Level of control
0 – 10	5	Regrowth
10 – 70	4	Bad
70 – 80	3	Average
80 – 90	2	Satisfactory
90 – 100	1	Effective

$$SS_C = \sum_{i=1}^{n} x_i^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2 \qquad (1)$$

Where: (c) is the cluster in question, (*n*) is the total number of objects in the cluster and (x_i) is the *i*-th object in the cluster.

RESULTS AND DISCUSSION

The frequency distribution of sprout percentage scores for treatments T01, T02 and T03 are shown in Figures 1, 2 and 3, respectively.

The histograms show similar frequency distribution for T01 (Figure 1) in fields TAL 35 and TAL 41 in the same periods, especially for February. Also, the chemical weeding control was satisfactory for most eucalyptus sprouts in December, demonstrating that the active principle of the product frequently used to manage undesirable plants in forest reform areas has acceptable efficiency 30 days after application. According to Andrade Neto et al. (2016) used a diagrammatic scale to evaluate the use of glyphosate in *Brachiaria* sp. in an area cultivated with eucalyptus, reporting control efficiency 30 days after application. The glyphosate used to control weeds and undesirable plants provides a greater mobility to the active substance, thus facilitating its distribution so that the phytotoxic action vary from satisfactory to efficient (Minguela & Cunha 2010).

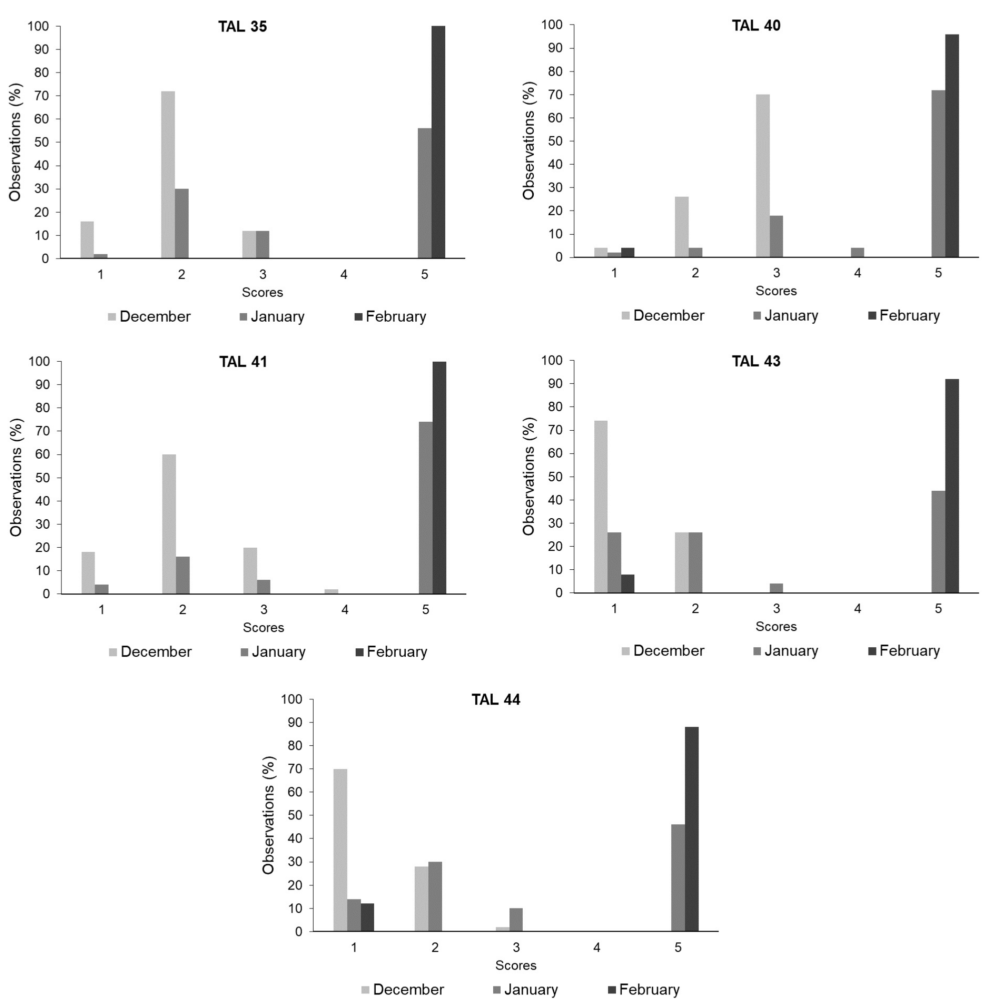

Figure 1. Histograms of the scores for treatment T01 in fields TAL 35, TAL 40, TAL 41, TAL 43, and TAL 44 in December 2016, January and February 2017.

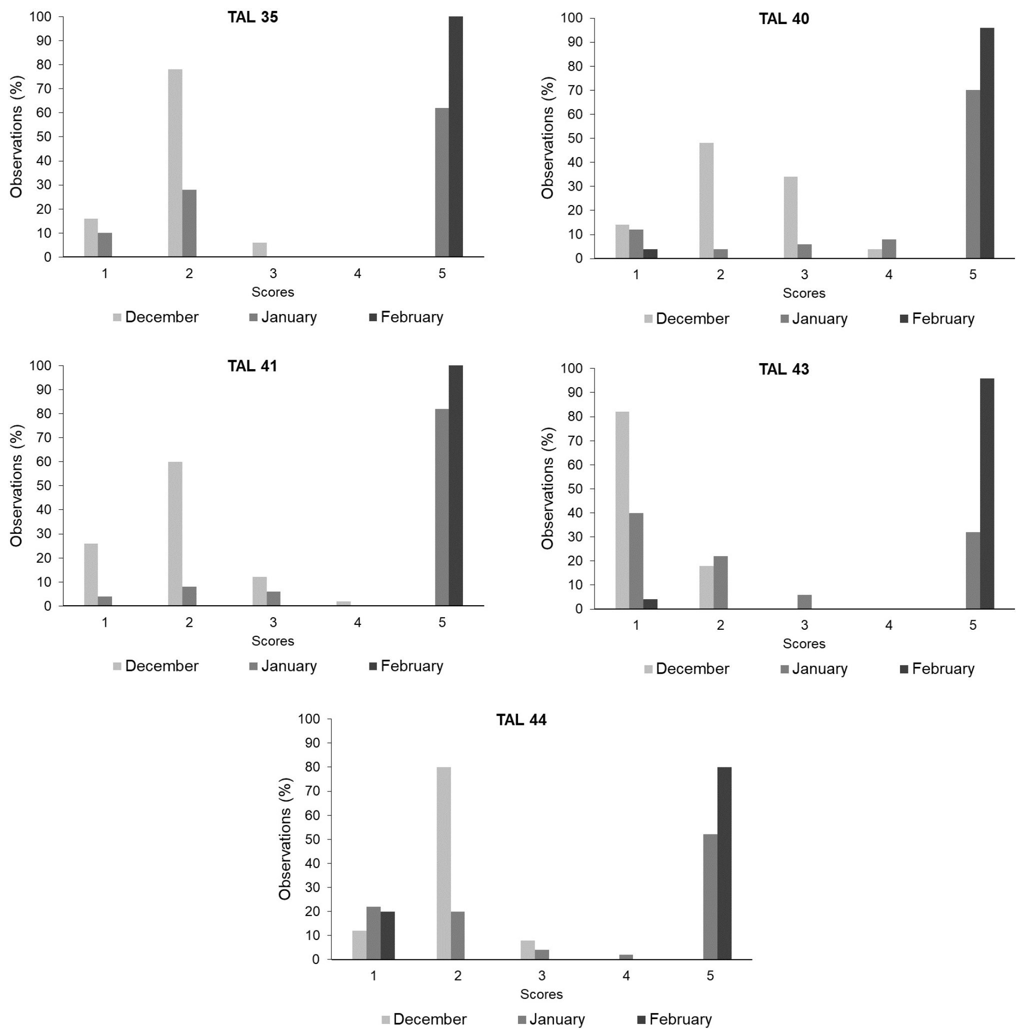

Figure 2. Histograms of the scores for treatment T02 in fields TAL 35, TAL 40, TAL 41, TAL 43 and TAL 44 in December 2016, January and February 2017.

The same fields were evaluated in January and scored 5 for most sprouts, indicating an average regrowth of 65%, allowing to conclude that the plants started developing new sprouts 60 days after application that intensified in February, reaching 100% of the plants, leading to the conclusion that T01 did not eradicate the sprouts three months after chemical weeding. According to Santos et al. (2007) the products applied in eucalyptus areas post-emergence, resulted in highly unstable control of the undesired plants and weeds while, in some cases, may even lead to generalized regrowth especially due to the lack of residual effect of the active principle glyphosate on the soil.

T01 showed similar results for fields TAL 40 similar to TAL 35 and TAL 41, except for December, which scored 3, indicating an average control for 70% of the sprouts. Moreover, because treatment application methodology was the same for all fields, it is assumed that the lower control efficiency of sprouts in TAL 40 30 days after application is related to inadequate field conditions. According to Ferreira et al. (2009) to obtain efficient results from the application technology, it is necessary

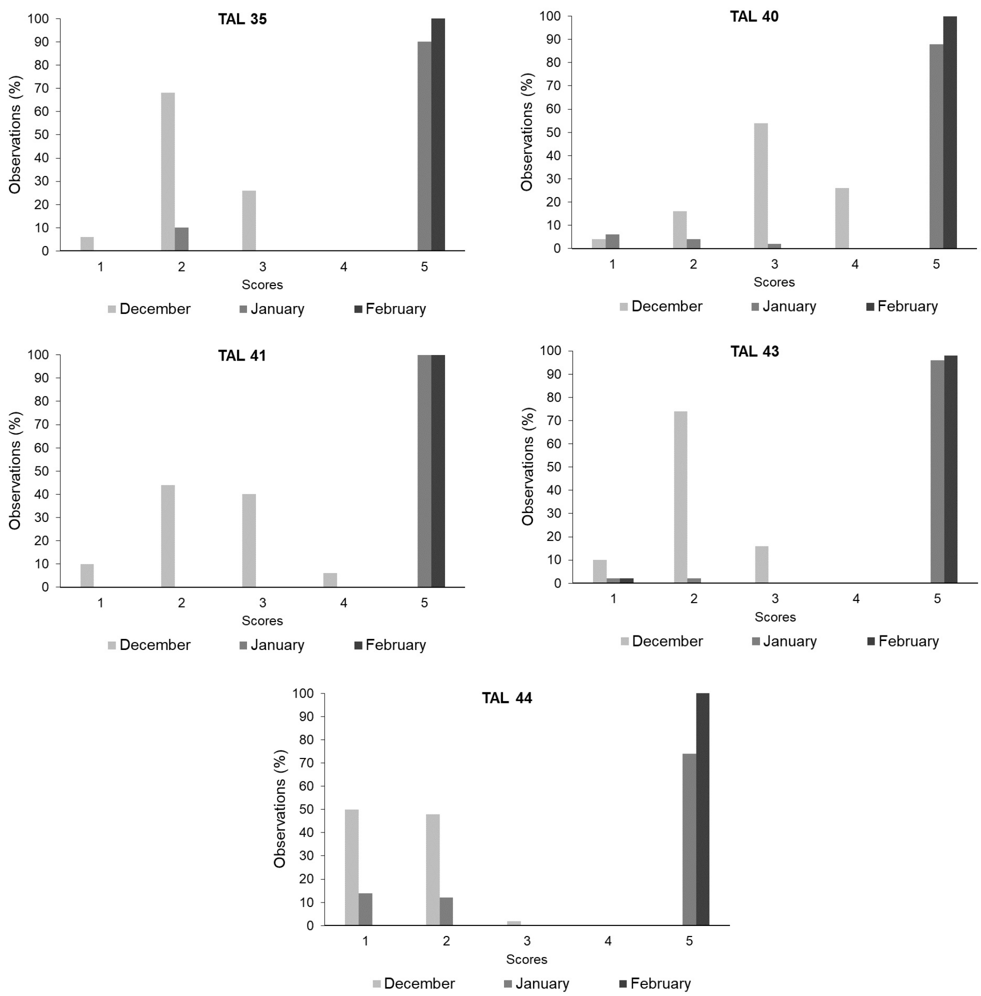

Figure 3. Histograms of the scores for treatment T03 in fields TAL 35, TAL 40, TAL 41, TAL 43 and TAL 44 in December 2016, January and February 2017.

to know the deposition properties provided by the equipment, product, form of application and especially the characteristics of the cultivated areas, such as canopy volume and vegetative state of the plants.

The frequency distribution of most scores for fields TAL 43 and TAL 44 resembles those of other fields only in February whereas both fields scored 1 in approximately 72% of the observations in December. Despite the effectiveness of the control in these fields 30 days after the application, an intense regrowth is observed in the subsequent month, evidenced by the 52% of score 1 and more than 40% increase of score 5. According to Santos et al. (2007) was conducted an experiment in a eucalyptus area and reported that all glyphosate-sprayed plants had new sprouts 45 days after application.

The scores of T02 over time were similar to T01 (Figure 2) for all fields, in February. In this period, there was 100% regrowth in TAL 35 and TAL 41, 98% in TAL 40 and TAL 43, and 80% in TAL 44. The results observed for T02 indicate that foliar fertilizer added to the spray mixture did not contribute to sprout control during the studied period, showing that adding ineffective products to assist in the control of undesirable plants and weeds only increases the application cost and, sometimes, may even affect adversely the operation result.

In the previous periods (30 and 60 days after chemical weeding), T02 showed similar behavior in all fields (with the exception of TAL 43), the histograms indicated scores 2 and 5 for most of the evaluated sprouts, respectively. It is noteworthy that in the period, the scores ranged between near ideal and far from recommended, showing that the adjuvant in the spray mixture caused only stress to the sprouts, and emission of new sprouts later on. Generally, in experimental eucalyptus plantations, the applications are efficient in some periods, but not so efficient in others (Cunha et al. 2004), and even more so when a mixture of products with different active principles is used.

T02 had the best results in TAL 43 since it was the only one where the majority of the sprouts scored 1 in the first two months of evaluation. An explanation for the effective control of sprouts is probably the low vegetative vigor that these plants presented in the pre-application period, thus facilitating the total eradication of the sprouts. Under pre-application stress conditions, adding foliar fertilizer in the spraying mixture may increase the amount of the biologically active product that affects or is absorbed by the plant (Agostineto 2015). According to Theisen et al. (2004) was concluded that using adjuvants in the spraying mixture contributes to better absorption of the herbicides, consequently, aiding the control of undesirable plants and weeds over longer periods.

The contrast observed over time in T02 corroborates the affirmation of Cunha et al. (2010), who reported that adding adjuvants might change spraying performance; however, it may affect positively or negatively the efficiency of sprout control.

The histograms (Figure 3) for T03 show that all studied fields scored 5 for almost all sprouts in January (89.6%) and February (99.6%), indicating that the mixture of the three products applied in the sprouts were not significantly different over time between 60 and 90 days post-application.

It is important to note that in the periods mentioned previously, adding contact herbicide to the spraying mixture did not contribute to controlling eucalyptus sprouts. According to Araújo et al. (2008) evaluated the effects of the same active principles of T03 on bean culture, and reported very poor control of the weed *Cyperus* sp., thus corroborating the results of this work.

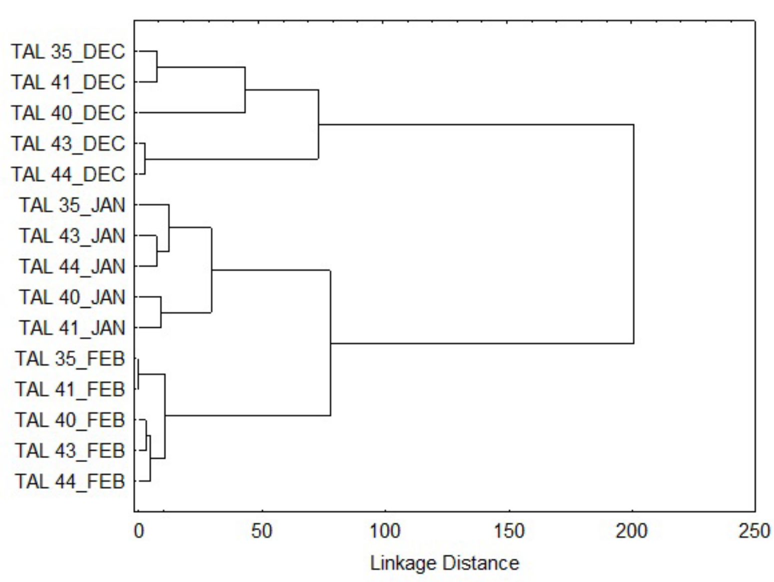

Figure 4. Dendrogram of the clustering analysis results of the different fields and evaluation periods for the scores in T01.

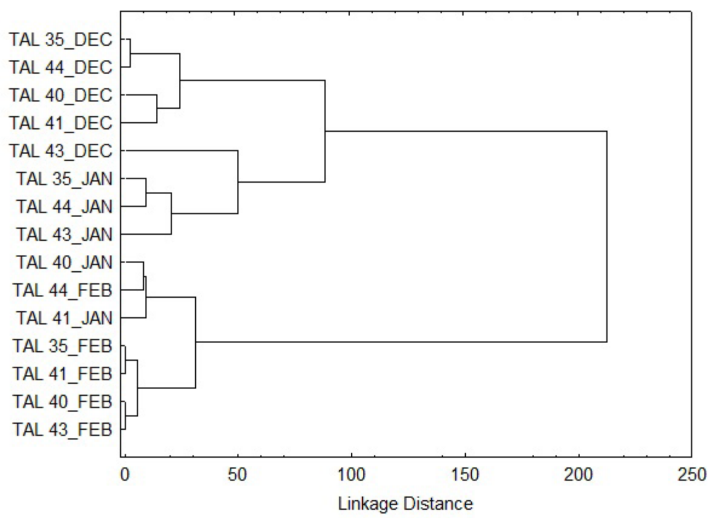

Figure 5. Dendrogram of the clustering analysis results of the different fields and evaluation periods for the scores in T02.

In December, T03 scored 2 for most sprouts in TAL 35 and TAL 43, scored 3 in TAL 40, scored between 1 and 2 in TAL 44, and between 2 and 3 in TAL 41. In general, sprouts were satisfactorily controlled 30 days after application, indicating that adding the contact herbicide in the mixture decreased the vegetative vigor of the sprouts slightly. Yamashita et al. (2009) stated that, currently, associating two or more active ingredients has become usual to increase the effectiveness of controlling undesirable plants in forest areas.

Furthermore, a clustering analysis was performed for the different fields and periods for T01 (Figure 4), T02 (Figure 5) and T03 (Figure 6) to evaluate more efficiently and complement the temporal study of sprout control.

The clustering analysis of the fifteen fields/periods used the Euclidean distance equal to 40 (cutoff distance) as similarity measurement for T01 and T02, whereas Euclidean distance was equal to 20 for T03. Distances shorter than these cutoff values would increase disagreement between clusters, thus hampering the comparison between clusters. Similarly, higher distances would compromise the differentiation between fields/periods.

For T01 (Figure 4), two of the five clusters of homogeneous plots grouped the fields from January (JAN) (cluster 4) and February (FEB) (cluster 5), evidencing similar score behavior in each field in the respective periods. These results can be attributed to the low dispersion of scores for most or all of the sprouts 60 and 90 days after application, respectively, as seen in the histograms of Figure 1.

The other clusters for T01 consider the fields of December (DEC) and are divided among TAL 35 and TAL 41 (cluster 1), TAL 40 (cluster 2), TAL 43 and TAL 44 (cluster 3), thus presenting dissimilar scores between the fields in that period. The lack of clustering for these fields can be attributed to the high score variation, in which cluster 3 scored 1 evidencing a more efficient control compared to clusters 1 and 2.

The dendrogram of T02 (Figure 5) shows that four clusters of homogeneous plots were formed. For December, except for TAL 43, all treatments were grouped in the same cluster (cluster 1) indicating similarity for T02 in that period. The clustering of the fields in December is due to more stable scores, with a predominantly 2 score. Unlikely, the result observed for T01 in the same period (Figure 4) showed higher dispersion of scores and, consequently, in the clusters.

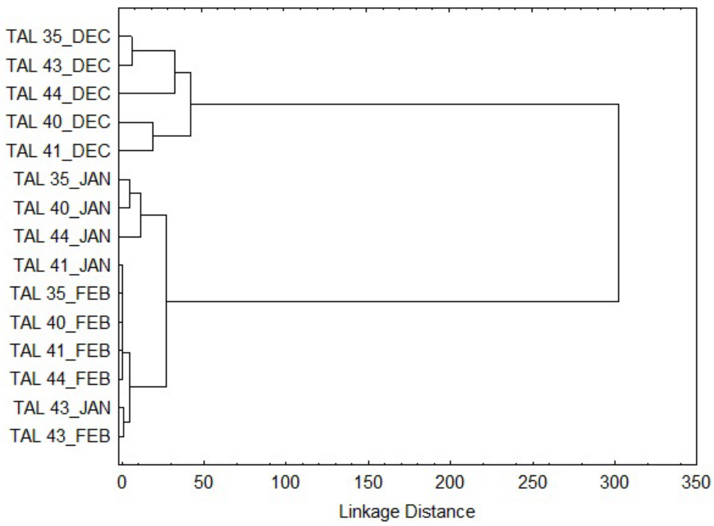

Figure 6. Dendrogram of the clustering analysis of the different fields and evaluation periods for the scores in T03.

Also for December, TAL 43 was alone in the clustering analysis (cluster 2) due to the high frequency of scores 1 and the best sprout control compared to the other fields of treatment T02. This result, as already discussed, may be associated with the greater effectiveness of the adjuvant in physiologically stressed plants promoting a rapid absorption of the active principle, but without stability over long periods (Minguela & Cunha 2010).

The third cluster grouped TAL 35, TAL 44 and TAL 43 in January while the remaining fields TAL 40 and TAL 41 in the same period were clustered with the all fields in February (cluster 4). The high number of sprouts that scored 5 justified the grouping of TAL 40 and TAL 41 in January in cluster 4 referring to February (90 days after application). Thus, adding the adjuvant in the mixture did not affect significantly the sprouts in these fields 60 and 90 days after chemical weeding. Minguela & Cunha (2010) reported that the indiscriminate use and lack of knowledge about the adjuvant action might result in antagonistic effects between products, thus decreasing control effectiveness and, in some cases, increasing application costs.

T03 (Figure 6) presented high dissimilarity between fields/periods, with five homogeneous plot clusters. Furthermore, the high variability of scores attributed to sprout control in December resulted in dissimilar fields that formed three distinct sub-clusters (TAL 35 and 43; TAL 44; and 40 and 41).

Sixty days after the application, except for TAL 41 and TAL 43, the other fields were grouped in the same cluster (cluster 4), which is explained by the already mentioned ineffective control in the period, characterized by the expressive increase of scores 5. In February, all fields were clustered together (along with TAL 41 and TAL 43 from January), which was expected, given the score 5 assigned to almost all sprouts in these fields.

In general, it is possible to affirm that T03 provided the worst results for controlling eucalyptus sprouts since it presented high variability in the short term, with considerable regrowth 60 days after application. However, Santos et al. (2007) concluded that the physiological effects of using glyphosate mixed with other products to spray eucalyptus sprouts could cause biochemical disturbances resulting in an imbalance between the organic and inorganic compounds, and that would help control the sprouts.

Monitoring the control of eucalyptus sprouts over time using a diagrammatic scale is a useful tool for managing silvicultural treatments and for evaluating the application quality of phytosanitary products. Infield conditions, scores greater than or equal to 3 should suffice to recommend additional practices to control and eradicate sprouts in forest reform areas.

CONCLUSIONS

The diagrammatic scale allowed evaluating the vegetative vigor of eucalyptus sprouts, generating interpretable information on the different evaluated treatments.

The treatments only controlled the sprouts in the short term, without providing their effective eradication.

The addition of foliar fertilizer and combination of herbicides with different active principles showed as of 60 days of application similarity between fields, as well as expressive increase of notes equal to 5, compromised the control of eucalyptus sprouts.

Acknowledgments

To Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES), for the grant of the masters scholarship. To the Laboratório de Mecanização e Agricultura de Precisão (LabMAP - UFES) for help in the processing of the data. Veracel Celulose S/A for the availability of the study area.

REFERENCES

AGOSTINETO MC. 2015. Efeito de características da calda e estádio da corda de viola na eficácia de carfentrazone-ethyl e saflufenacil. Dissertação de Mestrado, Universidade Estadual de Santa Catarina, Lages, Brasil. (Unpublished).

ALVARES CA, STAPE JL, SENTELHAS PC, GONÇALVES JLM & SPAROVEK G. 2013. Köppen's climate classification map for Brazil. Meteo Zeitsch 22(6): 711-728.

ANDRADE NETO EF, SOUSA NJ, REZENDE EH, SOUZA MD, TETTO AF, MALINOVSKI RA & KANIA NETO L. 2016. Eficiência do herbicida haloxyfop-methyl no controle de *Brachiaria* sp. em plantios de eucalipto. Rev ESP 37(14): 20.

ARAÚJO GAA, SILVA AA, THOMAS A AND ROCHA PRR. 2008. Mistura de herbicidas com adubo molíbdico na cultura do feijão. Plant Dan 26(1): 237-247.

ASENSIO LJ. 1989. Técnicas de análises de dados multidimensionales. Madrid: M.A.P.A, 301 p.

IBÁ - INDÚSTRIA BRASILEIRA DE ÁRVORES. 2017. Relatório IBÁ. Retirado em 25 de Setembro, 2017, de http://iba.org/images/shared/Biblioteca/IBA_RelatorioAnual2017.pdf.

CUNHA JPAR, ALVES GS & REIS EF. 2010. Efeito da temperatura nas características físico-químicas de soluções aquosas com adjuvantes de uso agrícola. Plant Dan 28(3): 665-672.

CUNHA JPAR, TEIXEIRA MM, VIEIRA RF, FERNANDES HC & COURY JR. 2004. Espectro de gotas de bicos de pulverização hidráulicos de jato plano e de jato cônico vazio. Pesq Agropec Bras 39(10): 977-985.

FERREIRA MDC, DI OLIVEIRA JRG & DAL PIETRO IRPS. 2009. Distribuição da calda herbicida por pontas de pulverização agrícola utilizadas em áreas de reflorestamento com eucalipto. Eng Agríc 29(2): 267-276.

MACHADO MS, FERREIRA LR, PEREIRA GAM, PAULA JL, PAIXÃO GP & FREITAS PHM. 2017. Fertiactyl Pós® como protetor do eucalipto submetido à aplicação de glyphosate. Rev Bras Ciênc Agrár 12(2): 194-201.

MEDAUAR CC, SILVA SA, CARVALHO LCC, TIBURCIO RAS, LIMA JSS & MEDAUAR PAS. 2018. Monitoring of eucalyptus sprouts control using digital images obtained by unmanned aerial vehicle. Journ of Sustain For 37(7): 739-752.

MINGUELA J & CUNHA JPAR. 2010. Manual de aplicação de produtos fitossanitários. Viçosa, Brasil: Eds. Aprenda Fácil.

SANTOS HG, JACOMINE PKT, ANJOS LH, OLIVEIRA VA, LUMBRERAS JF, COELHO MR, ALMEIDA JA, ARAÚJO FILHO JC, OLIVEIRA JB & CUNHA TJF. 2013. Sistema Brasileiro de Classificação de Solos. Brasília, Brasil: Embrapa Solos.

SANTOS LDT, MACHADO AFL, VIANA RG, FERREIRA LR, FERREIRA FA & SOUZA GVR. 2007. Crescimento do eucalipto sob efeito da deriva de glyphosate. Plant Dan 25(1): 133-137.

SILVA BP, MACHADO ÂA, FONSECA ED & COSTA MF. 2014. Distribuição, diâmetro de gotas e fitoxicidade de herbicidas aplicados em mudas de eucalipto com pontas de indução de ar. Revi Bras de Herb 13(3): 225-234.

SILVA SA & LIMA JSS. 2012. Multivariate analysis and geostatistics of the fertility of a humic rhodic hapludox under coffee cultivation. Revi Bras de Ciênc do Solo 36(2): 467-474.

THEISEN G, RUEDELL J & BIANCHI MA. 2004. Aspectos técnicos da aplicação de herbicidas. [Chapter of the book Herbicide application technology: theory and practice], p. 25-54.

TIBÚRCIO RAS. 2014. Desenvolvimento de pulverizador visando o controle de brotações na reforma de eucalipto. Tese de Doutorado. Universidade Federal de Viçosa, Brasil.

YAMASHITA OM, BETONI JR, GUIMARÃES SC & ESPINOSA MM. 2009. Influência do glyphosate e 2, 4-D sobre o desenvolvimento inicial de espécies florestais. Scient Forest 37(84): 359-366.

How to cite

MEDAUAR CC, SILVA SA, CARVALHO LCC, TIBÚRCIO RAS, LIMA JSS & OLIVEIRA PS. 2020. Eradication of eucalyptus sprouts after chemical weeding over time in State of Bahia, Brazil. An Acad Bras Cienc 92: e20190601. DOI 10.1590/0001-3765202020190601.

Manuscript received on May 24, 2019;
accepted for publication on September 30, 2019

CAIQUE C. MEDAUAR[1]
https://orcid.org/0000-0001-8339-5244

SAMUEL A. SILVA[2]
https://orcid.org/0000-0002-0718-7328

LUIS CARLOS C. CARVALHO[1]
https://orcid.org/0000-0002-2790-3723

RAFAEL A.S. TIBÚRCIO[3]
https://orcid.org/0000-0003-3349-5436

JULIÃO S.S. LIMA[2]
https://orcid.org/0000-0002-8178-3937

PHILIPPE S. OLIVEIRA[3]
https://orcid.org/0000-0002-2213-3256

[1]Universidade Estadual de Santa Cruz, Departamento de Ciências Agrárias e Ambientais, Rod. Jorge Amado, Km 16, Salobrinho, 45662-900 Ilhéus, BH, Brazil

[2]Universidade Federal do Espírito Santo, Departamento de Engenharia Rural, Alto Universitário, s/n, Guararema, 29500-000 Alegre, ES, Brazil

[3]Departamento de Pesquisa e Desenvolvimento Florestal, Veracel Celulose S/A, Rod. Fazenda Brasilândia, 48820-000 Eunápolis, BH, Brazil

Correspondence to: **Caique Carvalho Medauar**
E-mail: caiquemedauar@hotmail.com

Author contributions

The authors Caique C. Medauar, Samuel de A. Silva, Rafael A. S. Tibúrcio and Philippe S. Oliveira are responsible for the development and execution of the research, as well as for the writing of the article. The authors Luis C. C. Carvalho and Julião S. S. Lima also helped in the writing of the manuscript, however they were more prominent in revising it.

CC BY