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CROP PROTECTION

Individual and integrated methods on tough lovegrass control

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ABSTRACT: *The current study evaluated the efficiency of mechanical, physical, chemical and cultural methods, used exclusively or integrated, to control tough lovegrass. The experimental design was completely randomized, with 15 treatments and four repetitions. Physical control of tough lovegrass was based on the application of fire, whereas mechanical controls consisted in mowing and harrowing/plowing procedures. The herbicide clethodim and different glyphosate salts were evaluated for chemical control. Glyphosate and soil fertility correction were applied as cultural and integrated methods, in addition to isopropylamine + potassium salts combination, soil fertility correction and implantation of one of the following forage plants: Elephant grass, Pangola grass, Forage peanut and Birdsfoot trefoil. The effect of treatments on the incidence of tough lovegrass and on its botanical composition was evaluated one year after their applications. Isolated control methods, except for glyphosate using, did not present efficient tough lovegrass control. Glyphosate salts could control tough lovegrass plants, but their association with improved soil fertility and Pangola grass implantation was the best strategy to control the invasive plant.*
Key words: *Eragrostis plana Nees, native pasture, weed control.*

Eficiência de métodos individuais e integrados no controle de capim-annoni

RESUMO: *O objetivo desse estudo foi avaliar a eficiência de métodos mecânicos, físico, químicos e culturais de forma isolada ou integrada, no controle de capim-annoni. O delineamento experimental utilizado foi inteiramente casualizado, com 15 tratamentos e quatro repetições. O controle físico do capim-annoni foi baseado na aplicação de fogo enquanto os controles mecânicos consistiram em roçada e gradagem/aração. Para o controle químico, foram testados os herbicidas clethodim e diferentes sais de glifosato. Para os métodos culturais e integrados, foi realizada aplicação de glifosato isopropilamina + potássio e correção da fertilidade do solo, além dos tratamentos com combinação de isopropilamina + potássio, correção de fertilidade do solo e implantação das seguintes espécies forrageiras: Capim-elefante, Capim Pangola, Amendoim forrageiro e Cornichão. Avaliou-se o efeito dos tratamentos sobre a ocorrência de capim-annoni e sobre a composição botânica, um ano após suas aplicações. Métodos de controle isolados, com exceção do uso de glifosato, não apresentam controle eficiente de plantas de capim-annoni. Os sais de glifosato controlam plantas de capim-annoni, mas sua associação com a melhoria da fertilidade do solo e implantação de Capim Pangola é a melhor estratégia para controle da planta invasora.*
Palavras-chave: *controle de planta daninha, Eragrostis plana Nees, pastagem nativa.*

INTRODUCTION

Tough lovegrass (*Eragrostis plana* Nees) is an exotic plant native from South Africa that is one of the main limitations to forage production of native species in the Pampa biome (LISBOA et al., 2009). It stands out in native pasture degradation areas in this biome, since it spreads and occupies spaces in detriment of native plant used for grazing such as *Paspalum* spp. and *Axonopus* spp.

Farmers usually adopt manual and/or mechanized techniques based on plough the soil to control tough lovegrass. This management technique is not recommended; since it enables seeds on soil surface to integrate the soil seed bank, whereas seeds in deeper soil layers are exposed to soil surface (FERREIRA et al., 2008). Mowing the weed can be initially efficient; however, this method can spread the seeds around, specially during reproductive stage. Tough lovegrass as a perennial plant requires

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several mowing procedures in order to effectively being eliminated once there are reserves in its roots (FAVARETTO et al., 2015).

Although, the use of fire to control tough lovegrass infestation is forbidden by Rio Grande do Sul State Law N. 9,519/92 of Rio Grande do Sul State Forest Code, it is still a practice adopted by several farmers. However, further studies on the use of fire to control the herein investigated weed species should be conducted.

Glyphosate-based herbicide use enable controlling *Eragrostis plana* in a satisfactory way (FALEIRO et al., 2021). However, attention should be given to the efficiency of herbicides presenting different action modes, such as acetylcoenzyme A carboxylase (ACCase) inhibitors, which are specifically used to control plants belonging to Poaceae family (TAKANO et al., 2020). These herbicides should be applied with the aid of selective-application tools to avoid contact between herbicides and the forage plants of interest (GOULART et al., 2009). However, exclusive herbicide using, as isolated form to enable long-term control, can increase the resistance of this weed species to the adopted herbicide and make it even difficult to be controlled.

The use of integrated management combining soil fertility correction and maintenance, weed control through herbicide using and forage species' introduction to compete with and outperform this weed (SCHUSTER et al., 2018), are factors to be taken into account at the time to plan the best set of actions aimed at weed control. Embrapa has provided data confirming tough lovegrass infestation reduction over the years, based on the Integrated Pasture Recovery Method - MIRAPASTO (PEREZ et al., 2015; LAMEGO et al., 2020). Therefore, this set of associated practices appears to be more effective in controlling tough lovegrass than unique practices without continuity. Thus, the present study evaluated isolated and integrated methods to control tough lovegrass aiming to recover the native pasture.

MATERIALS AND METHODS

A study was conducted in the experimental area of Federal University of Pampa, Campus Itaqui - RS (latitude 29 ° 9 ′ 21.37 ″ S and longitude 56 ° 33 ′ 9.97 ″ W) from February 7, 2019 to March 15, 2020. Climate in the region is Cfa type, according to Köppen classification and the soil is classified as Haplic Plinthosol of widespread occurrence in lowlands on the Western Frontier of Rio Grande do Sul.

Fifteen treatments were implemented based on a completely randomized design, with four repetitions including the untreated check (CONTROL) (Table 1). Sixty plots of 9 m², presented tough lovegrass infestation level of 65%, on average, at flowering and seed production stages. The treatments consisted of: a) Mechanical method: mowing (MOWING) carried out with manual mowing, lefting residual height of 5 cm and revolved (REVOLV) the soil at 10 cm depth; b) physical method: technical fire (FIRE) applied in a controlled manner throughout the plot; c) chemical method: application of herbicides such as clethodim (CLET) and glyphosates salts; d) integrated methods: herbicide + soil fertility correction and implantation of forage species.

The chemical method was based on herbicide application with controlled manual applicator (PEREZ, 2008). CLET was used at usual dose of 120 g a.i. (active ingredient) ha^{-1}. Glyphosate was used in different formulations (salts): ammonium (AMMONIUM), di-ammonium (DI-AMMONIUM), isopropylamine (ISOP), potassium (POT) and isopropylamine + potassium (ISOP + POT). The adopted dose was 356 g a.e. (acid equivalent) ha^{-1} and the herbicide tank mix was prepared at total volume of 1.350 L, according to recommendations (PEREZ, 2008).

Integrated methods consisted in applying the ISOP + POT herbicide in association with liming and fertilization (HLF); as well as the combination of the ISOP + POT herbicide, liming, fertilization and forage species implantation, as follows: HLFK (herbicide + liming and fertilization + elephant grass (*Pennisetum purpureum* Schum., cv. BRS Kurumi)), HLFDIGDE (herbicide + liming and fertilization + Pangola grass (*Digitaria decumbens*)), HLFARAPI (herbicide + liming and fertilization + forage peanut (*Aranchis pintoi*)) and HLFLOTCO (herbicide + liming and fertilization + birdsfoot trefoil (*Lotus corniculatus* L., cv. São Gabriel)).

Liming (2.8 ton ha^{-1}) was spread out one month before plant species implantation and the fertilization was carried out at the time of implanting the forages; 200 kg of N ha^{-1}, 190 kg ha^{-1} of P_2O_5 and 140 kg ha^{-1} of K_2O were used in the HLF, HLFK and HLFDIGDE treatments, respectively; wereas 170 kg P_2O_5 and 100 kg K_2O ha^{-1} were used in the HLFARAPI and HLFLOTCO treatments, respectively.

Forage species were implanted 15 days after herbicide application by vegetative parts of adult plants spaced 0.5 x 0.5 m from each other in HLFK, HLFDIGDE and HLFARAPI treatments. Sowing (6 kg ha^{-1}) in the HLFLOTCO treatment was carried out in rows (0.2 m spacing between rows).

All the evaluations were performed one year after treatment applications, in March 2020.

Table 1 - Treatments used to tough lovegrass control. UNIPAMPA, Itaqui-RS, 2019.

Treatments*	Herbicide	Liming	Fertilizer	Forage
1-CONTROL	-	-	-	-
2- MOWING	-	-	-	-
3- FIRE	-	-	-	-
4- REVOL	-	-	-	-
5- CLET	Clethodim	-	-	-
6-AMMONIUM	Ammonium	-	-	-
7- DI- AMMONIUM	Di-ammonium	-	-	-
8- ISOP	Isopropilamina	-	-	-
9- POT	Potassium	-	-	-
10- ISOP+POT	Isopropylamine + potassium	-	-	-
11- HLF	Isopropylamine + potassium	Ok	Ok	-
12- HLFK	Isopropylamine + potassium	Ok	Ok	Elephant grass
13- HLFDIGDE	Isopropylamine + potassium	Ok	Ok	Pangola grass
14- HLFARAPI	Isopropylamine + potassium	Ok	Ok	Forage peanut
15- HLFLOTCO	Isopropylamine + potassium	Ok	Ok	Birdsfoot trefoil

*Tough lovegrass plants were at flowering and seed production stages when the treatments were applied.
CONTROL: untreated check; REVOL: Revolved soil (plough); HLFK: Isopropylamine + potassium + liming + fertilizer + elephant grass cv. Kurumi; HLFLOTCO: Isopropylamine + potassium + liming + fertilization + *Lotus corniculatus* cv. São Gabriel; HLFARAPI: Isopropylamine + potassium + liming + fertilization + forage peanut (*Arachis pitoi*); HLFDIGDE: Isopropylamine + potassium + liming + fertilization + Pangola grass (*Digitaria decumbens*); HLF: Isopropylamine + potassium + liming + fertilization; Ok: Fertilization and/or liming was carried out.

Herbicide control efficiency was measured based on visual scale ranging from 0% (absence of herbicidal symptoms) to 100% (plant dead), 365 days after treatments application. The number, identification and dominance of species were evaluated by counting the total of species and the individuals in each species in each plot. Occupied area (%) assessments were based on the percentage of the plot occupied by tough lovegrass plants. The parameter Uncovered area (%) corresponded to the area that did not present plants of any species. Relative density (RD) indicated the participation of each species in comparison to the total number of tough lovegrass plants and it was calculated through the following equation:

$$DR = \left(\frac{n}{N}\right) * 100$$

Wherein n is the total number of tough lovegrass plants and N is the total number of plants of all species within the plot.

Statistical analyses and result presentation were divided into four stages. Stage 1 - Evaluation of mechanical/physical methods: CONTROL, MOWING, FIRE and REVOL treatments were compared through Fisher's least significant difference test (LSD). Stage 2 - Evaluation of chemical methods, including CONTROL, through the application of non-orthogonal contrasts (three): C1: CONTROL vs. glyphosate salts; C2: CLET vs. glyphosate salts; and C3: CONTROL vs. CLET. Glyphosate salts were compared through Fisher's test (LDS). Stage 3 - Evaluating fertility management and forage species inclusion, based on the application of orthogonal contrasts (five): C1: effect of soil fertility (ISOP + POT vs. fertilized treatments); C2: effect of forage addition (HLF vs. forage treatments); C3: effect of forage family (*Poaceas* vs. Fabaceas); C4: effect of Poaceae species (Elephant *grass* vs. Pangola grass) and C5: effect of *Fabaceae* species (Forage peanut vs. Birdsfoot trefoil). Stage 4 - Treatments presenting the best results in the previous stages were compared to each other through Fisher'stest (LDS).

Data were analyzed through PROC MIXED (normal distribution) and PROC GLIMMIX (non normal distribution) using SAS (version 9.4) at the 5% level of significance. The experimental model was: Yi = µ + Ti -i + ei, wherein: Yi is the observed value of the dependent variable; µ is the general average; Ti is the fixed effect of the treatment; -i is the random error associated with the plots; and ei is the experimental error. Heterogeneous variances were used in each treatment.

RESULTS

Soil turning (REVOLV) has reduced the number of tough lovegrass plants present in 365 DATA but increased the number of other species, in comparison to mowing (Table 2). In addition, REVOLV has increased the uncovered area rate and reduced the occupied area rate in comparison to the others strategies (mechanical/physical control). Thus, REVOLV has reduced the relative density of species, in comparison to the CONTROL and MOWING treatments. FIRE treatment did not reduce the number of tough lovegrass plants 365 DATA. However, it reduced the uncovered area.

All the glyphosate salts were efficient in tough lovegrass control (=100%) compared to CONTROL (Table 3). Comparing CLET herbicide with glyphosate salts, these herbicides were superior, as showed by reduced tough lovegrass plants m^{-2}. CLET did not differ from CONTROL according to tough lovegrass plants m^{-2} and control 365 DATA. However, the number of species was not affected by herbicides.

The orthogonal contrast C1 showed that the liming and fertilization even with the herbicide application increase the number of tough lovegrass m^{-2} compared with the herbicide alone (Table 4); however, HLF also increase the number of species once tough lovegrass is controlled and more space is available. When the grass forages were compared with legume forages (C3), Pangola and Kurumi showed higher reduction of tough lovegrass plants m^{-2}.

REVOLV, POT + ISOP and HLFDIGDE treatments were selected to compare the best mechanical/physical, and chemical strategies associated with increased soil fertility and forage establishment in tough lovegrass control (Table 5). All treatments based on the chemical method (POT + ISOP + HLFDIGDE) have reduced the number of plants, the occupied area and the relative density of species in comparison to the REVOLV. In relation to REVOLV, the POT + ISOP treatment has increased the uncovered area, whereas the HLFDIGDE treatment has significantly reduced it.

DISCUSSION

Mowing is often used to control weeds, but it is not significantly effective in controlling grasses, especially perennial as tough lovegrass. HANSEN & WILSON (2006) have shown reduced growth rate of *Agropyron cristatun* L. only two years after the first mowing. The single mowing performed in the present study may have compromised the effectiveness of this treatment in controlling tough lovegrass infestation. This procedure should have been performed many times since this plant species has broad reserve structure in the roots (FAVARETTO et al., 2015), and an importat fact to be considered is the amount

Table 2 - Effect of mechanical and physical tough lovegrass control methods on plant community composition 365 days after treatment application (DATA). UNIPAMPA, Itaqui- RS 2019/20.

Treatments [1]	Tough lovegrass plants [2]	Number of species [3]	Uncovered area [4]	Occupied zone [5]	RD [6]
CONTROL	12.11 ab*	5.50 ab	27.75 b	50.00 a	254.42 a
FIRE	19.86 ab	5.75 ab	25.00 b	57.50 a	100.63 ab
REVOL	8.70 b	6.00 a	52.50 a	15.00 b	39.03 b
MOWING	16.00 a	5.50 b	35.00 b	46.25 a	213.80 a
Mean	14.16	5.68	35.06	42.18	151.97
SEM[7]	2.27	0.68	3.65	3.93	36.59

*Means followed by lowercase letters in the column differed from each other in the Fisher's least significant difference test (LSD) at 5% significance level. SEM: Standard error of the mean.
[1]CONTROL - untreated check; FIRE: technical fire; REVOL- Revolved soil (plough); MOWING – mowing lefting residual height of 5 cm.
[2]Number of tough lovegrass plants per m²
[3]Mean incidence of species that are not equivalent to tough lovegrass, such as: *Andropogon bicornis, Brachiaria plantaginea, Echinochloa crusgali, Eragrostis plana Nees, Paspalum urvillei and Setaria viridis* (*Poaceae*); *Cyperus rotundus* and *Poptochaetium montevidense* (*Cyperaceae*); *Ipomoea purpurea* (*Convolvulaceae*); *Aeschynomene denticulata* and *Mimosa bimucronata* (*Fabaceae*); *Polygonum hydropier* (*Polygonaceae*).
[4]Area of the plot that did not present plants (uncovered soil), %.
[5]Plot area occupied by tough lovegrass plants, %.
[6]Relative density of species in each treatment, %.
[7]SEM: Standard error of the mean.

Table 3 - Herbicides used to control tough lovegrass plants at post-flowering stage, evaluated 365 days after treatment application (DATA). UNIPAMPA, Itaqui-RS 2019/20.

Treatment	Tough lovegrass plants [2]	Number of species [3]	Uncovered area [4]	Occupied zone [5]	RD [6]	Control [7]
CONTROL	12.11	5.50	23.75	50.00	254.42	0
CLET	10.67	5.00	40.00	36.25	267.92	16
AMMONIUM	0.31	6.50	73.75 a*	1.00	3.3	100
DI-AMONIUM	0.84	6.00	62.50 c	2.00	7.55	100
ISOP	1.08	7.50	61.25 c	2.00	9.64	100
POT	0.25	6.00	78.75 a	0.50	4.73	100
ISOP+POT	0.39	5.50	67.25 b	1.00	4.96	100
Mean	3.66	5.96	58.17	13.25	78.93	73.71
SEM[9]	0.47	0.63	2.94	1.30	30.85	0.37
------------------------------ *P* [8] ------------------------------						
C1	<0.0001	0.1190	0.0027	0.0001	<0.0001	-
C2	<0.0001	0.1535	<0.0001	0.0006	<0.0001	<0.0001
C3	0.2793	0.4924	0.0627	0.0050	0.8745	-

* Means followed by lowercase letters in the column differed from each other in the Fisher's least significant difference test (LSD) at 5% significance level.
[1]Treatments: CONTROL - untreated check; CLET-clethodim; AMMONIUM-ammonium salt; DI-AMMONI- salt Di-Ammonium; ISOP- Isopropylamine salt; POT- potassium salt; ISOP + POT- isopropylamine salt + potassium salt.
[2]Number of tough lovegrass plants per m²
[3]Mean incidence of species that are not equivalent to tough lovegrass, such as: *Andropogon bicornis, Brachiaria plantaginea, Echinochloa crusgali, Eragrostis plana Nees, Paspalum urvillei and Setaria viridis* (*Poaceae*); *Cyperus rotundus* and *Piptochaetium montevidense* (*Cyperaceae*); *Ipomoea purpurea* (*Convolvulaceae*); *Aeschynomene denticulata* and *Mimosa bimucronata* (*Fabaceae*); *Polygonum hydropier* (*Polygonaceae*).
[4] Area of the plot that did not present plants (uncovered soil), %.
[5]Plot area occupied by tough lovegrass plants, %.
[6]Relative density of species in each treatment, %.
[7]Herbicide control efficiency was measured based on visual scale ranging from 0% (absence of symptoms) to 100% (dead plant).
[8]Effect of treatment on the evaluated variables: Orthogonal contrasts - C1: Control x glyphosate salts; C2: Clethodim x Glyphosate; C3: Clethodim x Control.
[9]SEM: Standard error of the mean.

of seeds that can be spread, which is a disadvantage of this method.

Ploughing control plants on soil surface must be avoided (MEDEIROS et al., 2014) because it leaves the soil uncovered. In this situation, tough lovegrass can reestablish if no other plant fast occupies the uncovered soil (FERREIRA et al., 2008), especially if there is a constant renewal of the soil seed bank (LISBOA et al., 2009). Futhermore, this method is not recommended if the aim is to preserve the native pasture, since it may lead to disappearance of some species of interest and to the emergence of new weeds and/or opportunistic plants.

Fire use was not effective in controlling tough lovegrass plants. In addition, this action disturbe the development of desirable native species due to high temperature. Fire application under field conditions tends to cause less damage in plants with erect habit than in plants with prostrate habit; it happens because the second type is less protected against the fire (GOULART et al., 2009). Thus; although, the use of fire is forbidden by law, tough lovegrass plants are favored by such a practice in comparison to several species with prostrate habit grown in native pasture.

The efficiency observed for the glyphosate herbicide used was similar than reported by FALEIRO et al. (2021), who recorded levels of control higher than 98%. Long period (years) without regrowing these plants provides more time for desirable species to develop. This will happen if an enough seedbank exists and not only tough lovegrass seeds predominate. RODRIGUEZ & JACOBO (2013) have reported significant reduction in the number of perennial species in pastures subjected to total spraying of this herbicide. Low effectiveness of herbicides belonging to the ACCase group, such as the CLET evaluated in the current study, was reported in the literature (GOULART et al., 2009), which has classified them as insufficient for tough lovegrass post-emergence

Table 4 - Integrated methods used to control tough lovegrass plants, evaluated 365 days after treatment application (DATA). UNIPAMPA, Itaqui-RS 2019/20.

Treatments[1]	Tough lovegrass plants [2]	Number of species [3]	Uncovered area [4]	Occupied zone [5]	RD [6]
ISOP+POT	0.39	5.50	67.25	1.00	4.96
HLF	0.72	7.50	63.75	1.00	3.67
HLFK	0.17	4.25	30.00	0.75	7.41
HLFDIGDE	0.08	5.00	6.25	0.50	1.64
HLFARAPI	1.92	6.00	56.25	5.75	19.35
HLFLOTCO	2.56	8.25	71.25	3.50	34.34
Mean	0.973	6.08	49.12	2.08	11.89
SEM[8]	0.36	2.65	0.86	0.54	8.88
----------P [7]----------					
C1	0.0022	0.5333	<0.0001	0.0012	0.2255
C2	0.2270	0.2668	0.0022	0.0175	0.1004
C3	0.0003	0.0184	<0.0001	0.0005	0.0112
C4	0.5713	0.5373	0.0003	0.5371	0.1626
C5	0.4281	0.0124	0.0150	0.1166	0.4268

[*] Means followed by lowercase letters in the column differed from each other in the Fisher's least significant difference test (LSD) at 5% significance level.
[1]Treatments: ISOP + POT: isopropylamine salt + potassium salt; HLF: isopropylamine salt + potassium salt + liming + fertilization; HLFK: isopropylamine salt + potassium + liming + fertilizer + Elephant grass cv. Kurumi; HLFDIGDE: isopropylamine salt + potassium salt + liming + fertilization + Pangola grass; HLFARAPI: isopropylamine salt + potassium salt + liming + fertilizer + forage peanut; HLFLOTCO: isopropylamine salt + potassium salt + liming + fertilizer + *Lotus corniculatus* cv. São Gabriel.
[2]Number of tough lovegrass plants per m².
[3]Mean incidence of species that are not equivalent to tough lovegrass, such as: *Andropogon bicornis*, *Brachiaria plantaginea*, *Echinochloa crusgali*, *Eragrostis plana* Nees, *Paspalum urvillei* and *Setaria viridis* (*Poaceae*); *Cyperus rotundus* and *Piptochaetium montevidense* (*Cyperaceae*); *Ipomoea purpurea* (*Convolvulaceae*); *Aeschynomene denticulata* and *Mimosa bimucronata* (*Fabaceae*); *Polygonum hydropier* (*Polygonaceae*).
[4]Area of the plot that did not present plants (uncovered soil), %.
[5]Plot area occupied by tough lovegrass plants, %.
[6]Relative density of species in each treatment, %.
[7]Effect of treatment on the evaluated variables: Orthogonal contrasts - C1: ISOP + POT x HLF + forage; C2: HLF x forage; C3: grasses vs. legumes; C4 pangola x elephant; C5 birdsfoot trefoil x forage peanut.
[8]SEM: Standard error of the mean.

control, especially in the more advanced stage of plant development. This inefficiency in the control was also observed in *Digitaria insularis* plants (PRESOTO et al., 2020).

The implantation of grass forages was more efficient in the control of tough lovegrass compared to leguminous forages as they can present faster initial establishment (BELGERI et al., 2020). Based on the perspective of having biomass for pasture and improve the diversity of native species, birdsfoot trefoil may be an option. This forage provides greater area available for the emergence of native forage species, compared to the peanut forage, which has a prostrate growth habit that makes it difficult for other species to establish. Pangola grass has a potential to adapting and establishing under different environmental conditions (TIKAM et al., 2017). These makes it the one of the most efficient forage used to cover the soil and disturb tough lovegrass growth (BITTENCOURT et al., 2017; BELGERI et al., 2020).

REVOL, POT + ISOP and HLFDIGDE treatments recorded the best indices for weed control. High value recorded for uncovered area in the POT + ISOP is explained by the tough lovegrass biomasss plants that remained after herbicide aplication, which difficulted other species to germinate, by shading or allelopathic effect (FIORENZA et al., 2016). Pangola grass can be an alternative for weed control due to its rapid establishment and competition for solar radiation, which is one of the main limitations in the germination of new tough lovegrass plants (BITTENCOURT et al., 2017; BELGERI et al., 2020). Futhermore, this forage specie presents satisfactory biomass yield, and adaptability to subtropical climate, for an implementation as a new pasture to recover areas infested by tough lovegrass (HADDAD et al., 1999).

Table 5 - Comparison between the best treatments based on plant community composition 365 days after treatment application (DATA). UNIPAMPA, Itaqui-RS 2019/20.

Treatments[1]	Tough lovegrass plants [2]	Number of species [3]	Uncovered area [4]	Occupied zone [5]	RD [6]
REVOL	8.70 a[*]	6.0	52.50 b	15.0 a	39.03 a
POT+ISOP	0.39 b	5.5	67.25 a	1.0 b	4.96 b
HLFDIGDE	0.08 b	5.0	6.25 c	0.5 b	1.64 b
Means	3.05	5.5	42	5.5	15.21
SEM[7]	0.73	0.72	2.49	2.04	7.17

[*] Means followed by lowercase letters in the column differed from each other in the Fisher's least significant difference test (LSD) at 5% significance level.
[1]Treatments: REVOL - Revolved soil; POT + ISOP - potassium salt + isopropylamine salt; HLFDIGDE - isopropylamine salt + potassium salt + liming + fertilization + Pangola grass.
[2]Number of tough lovegrass plants per m².
[3]Mean incidence of species that are not equivalent to tough lovegrass, such as: *Andropogon bicornis*, *Brachiaria plantaginea*, *Echinochloa crusgali*, *Eragrostis plana* Nees, *Paspalum urvillei* and *Setaria viridis* (*Poaceae*); *Cyperus rotundus* and *Piptochaetium montevidense* (*Cyperaceae*); *Ipomoea purpurea* (*Convolvulaceae*); *Aeschynomene denticulata* and *Mimosa bimucronata* (*Fabaceae*); *Polygonum hydropier* (*Polygonaceae*).
[4]Area of the plot that did not present plants (uncovered soil), %.
[5]Plot area occupied by tough lovegrass plants, %.
[6]Relative density of species in each treatment, %.
[7]SEM: Standard error of the mean.

CONCLUSION

Mechanical/physical methods isolate are not efficient in reducing tough lovegrass population. Glyphosate salts successfully control tough lovegrass plants; however, chemical control in association with soil fertility improvement and forage implantation (as pangola grass), is more effective in controlling tough lovegrass.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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AUTHORS' CONTRIBUTIONS

All authors have equally contributed to the stud design and manuscript writing.

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