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Cientific Paper

Recovery of *Cynodon nlemfuensis* pasture after desiccation with glyphosate in pre-sowing of maize

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Abstract

The aim of this study was to assess the recovery capacity of the African-star-grass (*Cynodon nlemfuensis*) desiccated with glyphosate in pre-sowing of maize crop. The experimental design was a completely randomized block, with four repetitions. In experiment 1 were applied doses of the equivalent acid (e.a.) of glyphosate herbicide: 0; 720; 1.440; 2.160; 2.880 e 3.600 g ha^{-1}. In experiment 2, was done the no till of the maize, after application of the same doses of glyphosate on African-star-grass and on a hoed control. African-star-grass usually is tolerant to normally recommended doses of the glyphosate herbicide (720 - 2.160 g ha^{-1}). Doses ranging from 1.206 to 1.492 g ha^{-1} results on suppression of the African-star-grass, avoiding its competition with the maize crop and allowing the recovery of pasture.

Keywords: forage grasses; African-star-grass; crop-livestock integration; no-till.

Restabelecimento de pastagem de *Cynodon nlemfuensis* após a dessecação com Glifosato em pré-semeadura de milho

Resumo

O objetivo deste trabalho foi avaliar a capacidade de recuperação da grama-estrela-africana (*Cynodon nlemfuensis*) dessecada com glifosato em pré-semeadura da cultura do milho. O delineamento experimental foi em blocos casualizados, com quatro repetições. No experimento 1, foram aplicadas as doses do equivalente ácido (e.a.) do herbicida glifosato: 0, 720, 1.440, 2.160, 2.880 e 3.600 g ha^{-1}. No experimento 2, foi realizada a semeadura direta do milho após a aplicação das mesmas doses de glifosato sobre a grama-estrela-africana e uma testemunha capinada. A grama-estrela-africana é tolerante a doses normalmente recomendadas do herbicida glifosato (720 a 2160 g e.a. ha^{-1}). Doses de glifosato de 1206 a 1492 g e.a. ha^{-1} resultam na supressão da grama-estrela-africana, evitando sua competição com a cultura do milho e permitindo a recuperação da pastagem.

Palavras-chave: forrageiras; grama-estrela-africana; integração lavoura-pecuária; plantio direto.

Recuperación del pasto Cynodon nlemfuensis posterior a desecación con glifosato en pre-siembra de maíz

Resumen

El objetivo de este estudio fue evaluar la capacidad de recuperación de pasto estrella africana (*Cynodon nlemfuensis*) desecado con glifosato antes de la siembra del maíz. El diseño experimental fue de bloques al azar con cuatro repeticiones. En el experimento 1 se aplicaron las dosis del equivalente ácido (e.a.) del herbicida glifosato: 0, 720, 1440, 2160, 2880 y 3600 g ha^{-1}. En el experimento 2 se realizó la siembra directa de maíz después de la aplicación de las mismas dosis de glifosato en el pasto estrella africana y un control realizado manualmente con azada. El pasto estrella africana es tolerante a dosis habitualmente recomendadas del herbicida glifosato (720-2160 g e.a. ha^{-1}). Dosis de glifosato de 1206-1492 g e.a. ha^{-1} dieron como resultado la supresión del pasto estrella africana, evitando la competencia con el maíz y permitiendo la recuperación de las pasturas.

Palabras clave: forraje; pasto estrella africana; integración cultivo-ganadería; siembra directa.

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Introduction

The exploitation of annual crops with intense mechanization and indiscriminate use of inputs can result in degradation of physical and chemical properties of the soil, such as the compressing and the disruption of soil, as well as the reduction of organic matter. Furthermore, it can result in increase of the number of harmful biotic elements to cultivated plants, with possibility of productivity reduction and intensification of phytosanitary products use.

The implantation of technologies which come to minimize the effects caused by the traditional agriculture are of fundamental importance and, within this scope, there are the systems of crop-livestock-forest integration (CLFI). This practice is based in different productive systems of grains, fibers, wood, meat, milk and agroenergy, implemented in the same area, in intercropping, rotation or in succession, involving the planting of grains, pastures and associated arboreal crops.

The pastures use the residual nutrients of the previously implemented crops and can recycle nutrients in the deeper layers, thanks to the abundance and depth of exploitation of its roots. They are also great accumulators of biomass, enriching the soil with organic matter. The increment of this organic matter favors the increase of soil microorganism activities (MARTIUS et al., 2001), assisting in aggregation of particles, favoring the greater infiltration of water in the profile and reduction of erosion. The tropical forages are mostly known by adaptation and tolerance to biotic effects harmful to the annual crops, breaking the cycle of diseases and plagues (KLUTHCOUSKI et al., 2000).

The mostly used forage plants in the establishment of pastures are of the genus *Brachiaria*, *Panicum* and *Cynodon*. This last one has been increasingly used due to development of cultivars with high nutritive value and good productive characteristics. Within the group of the *Cynodon*, are the grasses: coast-cross, tifton 85, florona, florakirk and the African-star-grass (*Cynodon nlemfuensis*) (GARCIA et al., 2004).

The African-star-grass is perennial, possess long stolons over the soil, leaves with large blade and thick stems, and do not present rhizome (ATHAYDE, 2005). It has been widely indicated in the formation of pastures, because besides of the high yield and nutritional potential, it is of easy handling and can be used as dead cover for some crops in succession (OLIVEIRA et al., 2005). Moreover, for being a species of vegetative propagation, it stores a greater quantity of reserves than the seminiferous plants, recovering itself and quickly reestablishing the pasture (SANTOS et al., 2007).

In the CLFI systems, there is the necessity of correctly handling the forage species, so that there is no interference of this on the other crops. In this sense, the correct application of herbicides, both those applied in pre-sowing as those in post-emergence, is of primordial importance for the establishment of the system (KLUTHCOUSKI et al., 2000).

The objective of this study was to assess the capacity of recovery of the African-star-grass (*Cynodon nlemfuensis*) desiccated with glyphosate in pre-sowing of the maize crop.

Material and Methods

Two experiments were implemented in the municipality of Coronel Pacheco/MG, (21^0 33′ 22′′ of latitude south and 43^0 16′ 15′′ of longitude west). The region climate is of the Cwa type (mesothernal), defined as subtropical, rainy in summer and dry in winter. The average annual rainfall is of approximately 1500 mm and the average temperature of 19.5^o, between June and August, and 22^o from December to March.

In both experiments, the experimental design used was of randomized block, with four repetitions, being the area of the plots of 32^2 (3.2 x 10 m).

In the experiment 1, the treatments were constituted of application of six doses in equivalent acid (e. a.) of the glyphosate herbicide: 0, 720, 1.440, 2.160, 2.880 and 3.600 g ha^{-1}. The area destined to implantation of the experiment was a pasture established of African-star-grass, in Latossolo Vermelho Amarelo[1]. A uniformity cut of the plants height was done with a brushcutter at the thirty days after the glyphosate application. The treatments were applied in March 04th, 2008, when the plants achieved mean height of 0.70 m. For application of the herbicide, it was used an experimental sprayer, kept at constant pressure by compressed CO_2, equivalent to 2 kgf cm^{-2}. The spray bar had 1.5 m of useful width, with four nozzles of flat spray 110 02 AVI, spaced in 0.5 m, and pulverization volume equivalent to 170 L ha^{-1}. The effect of the herbicide was visually evaluated on the forage plants at the 10, 20 and 30

1 Brazilian soil classification.

days after the application of the treatments (DAA), using the percentage scale of control from 0 to 100% (GAZZIERO et al., 1995).

The experiment 2 was implemented in an adjacent area to the experiment 1, with the same characteristics already described. The treatments were the same of the experiment 1, and in addition, the hoed control. The uniformity cut of the forage plants height was also done at the thirty days before the implementation of the treatments. The application of the glyphosate doses was done in November 17th of 2009, when the African-star-grass plants achieved mean height of 0.70 m. It was used the same sprayer, bar and pressure already described. The flat spray nozzles (110 015 AVI) had a spacing of 0.5 m, and the volume of pulverization was equivalent to 150 L ha^{-1}. The maize sowing (AG 1051) was done in December 1st of 2009, using a seeder of no till model SAM 200 (Semeato, Ltda, Passo Fundo/RS, Brazil). The spacing between lines was of 0.80 m and the stand of approximately 56.000 plants ha^{-1}. The fertilization of sowing was of 370 kg ha^{-1} of the fertilizer NPK (8-28-16 more 0.5% of zinc). The cover fertilization was done at the 25 days after the maize emergence, with 350 kg^{-1} of the fertilizer NPK (20-05-20). Each plot was composed by four rows of maize, establishing as useful area the two central rows.

The herbicide effect was visually evaluated on the forage plants at the 10, 20 and 30 days after the application of the treatments (DAA), using the same percentage scale described for the experiment 1.

The determinations of plants height and height of insertion of maize ears were done in ten plants per plot, with the use of a graduated ruler, at the time of crop flowering. At the recommended time for maize silage, the plants of half of each plot from the two central rows (8 m^2) were harvested and weighed and then it was calculated the fresh mass yield (kg ha^{-1}). The plants of the other half of the plot from the two central rows (8 m^2) were left up to their maturation. It was done the harvest, weighing and the calculation of grains yield (kg ha^{-1}).

The recovery capacity of the African-star-grass pasture was assessed at the thirty days after the harvest of the maize crop for grains. The forage plants were cut close to the soil in an area of 1 m^2 and weighed, being the values converted in kg ha^{-1}.

The statistical analyses were done using the program SAEG (RIBEIRO JR. 2001). The obtained data for plants height, height of maize ears, fresh mass yield and maize grains were submitted to variance analyses and adjusted non-linear equations (model "Broken Stick") (COLWEEL et al., 1988; SPADOTTO et al., 1994; BRIGHENTI et al., 2004). The equation used was $Y = A + \left(B\left((X-P) - |X-P|\right)\right)$, being A the height or maximum productivity, B is the half of the angle between the projection of the maximum level and the inclined line and P is the value of X when the curve changes its behavior.

Furthermore, it was adjusted the regression model of square root type ($Y = A - B\sqrt{X} + CX$), having as response variable the productivity of fresh mass of the African-star-grass, at the 30 days after the maize harvest.

Results and Discussion

The monthly average of air temperature and of total rainfall, occurred during the experimental period, is found in Table 1.

When the African-star-grass plants are observed, in both experiments, it is verified that the intermediate doses which vary from 720 to 2.160 g e.a. ha^{-1} caused slight symptoms of phytotoxicity. The symptoms of injury were characterized by tiny chlorotic spots in the leaves. Part of the tissue became necrotic, however, the remainder was kept alive (Tables 2 and 3).

Even in the last assessment (30 DAA), the dose of 2.160 g e.a. ha^{-1} provided an average control of 74% and 76% for the experiments 1 and 2, respectively. This result is important in the systems of CLFI, because it slows the growth of the forage, minimizing the effects of competition forage/crop. Furthermore, this glyphosate dose is effective in the control of many weed plants, which supposedly could reduce the productive capacity of the species in intercropping.

When the tifton 85 (*Cynodon* spp.) submitted

Table 1. Monthly averages of air temperature (^{0}C) and rainfall (mm) during the period of conduction of the experiments (month/year).

Variable	Experiment 1				Experiment 2				
	02/08	**03/08**	**04/08**	**05/08**	**10/09**	**11/09**	**12/09**	**01/10**	**02/10**
Temperature	23.9	23.3	22.6	19.1	22.8	23.9	24.5	25.6	23.2
Rainfall	273.6	475.3	135.0	0.0	245.0	312.0	236.4	176.0	243.0

Table 2. Percentage of control of African-star-plants plants at the 10, 20 and 30 days after the application (DAA) of the glyphosate herbicide doses (Experiment 1).

Treatments (g e.a. ha^{-1})	10 DAA	20 DAA	30 DAA
0	0	0	0
720	23	33	54
1.440	26	58	70
2.160	33	71	74
2.880	47	82	91
3.600	55	88	100

Table 3. Percentage of control of African-star-plants plants at the 10, 20 and 30 days after the application (DAA) of the glyphosate herbicide doses (Experiment 2).

Treatments (g e.a. ha^{-1})	10 DAA	20 DAA	30 DAA
Hoed Control	100	100	100
0	0	0	0
720	16	27	46
1.440	25	56	69
2.160	33	72	76
2.880	45	79	92
3.600	53	89	100

to application of 2.160 g e.a. ha^{-1} of glyphosate is observed, the visual symptoms of injury are verified later and in lesser intensity, being characterized by a light yellowing of leaves, of the lateral buds shoots and reduction of green mass production (SANTOS et al., 2006; SANTOS et al., 2008). However, the dose 2.880 g e.a. ha^{-1} provided an earlier and more intense appearing of symptoms, with great yellowing, followed by necrosis of the aerial part and pronounced reduction of green mass. Nevertheless, there was no finding of death of the tifton 85 plants, in function of the dose 2.880 g e.a. ha^{-1}. Probably, this tolerance can be related to the great amounts of starch reserves situated in the vegetative structures of the plant which would act as barriers to the translocation of the glyphosate (MACHADO, 2005; SANTOS et al., 2007). Another factor which can contribute so there is need of higher doses of glyphosate for achievement of more effective results in the control of species of the genus *Cynodon* would be the greater quantity of vegetative structures in which the herbicide needs to translocate, after being absorbed by the leaves (MARTINI et al., 2002).

The doses of 720, 1.440 e 2.160 g e.a. ha^{-1} caused suppression of the aerial part of the African-star-grass plants. This fact favored the initial development of the maize crop and allowed the emergence of new shoots of the forage plant at the 114 DAA (Figure 1).

The African-star-grass plants submitted to the doses of 1.292.58 and 1.206.63 g e.a. ha^{-1} did not impaired the growth and development of the maize crop which reached mean values of plants height and height of insertion of maize ears corresponding to 2.4 and 1.2 m, respectively (Figures 2 and 3).

The dose of 1.492.0 g e.a. ha^{-1} provided 43.624 kg ha^{-1} of fresh mass productivity of the maize plants (Figure 4). With regard to the maize grains productivity, the application of 1.214.35 g e.a. ha^{-1} resulted in 9.736 kg ha^{-1} (Figure 5).

At the 30 days after the maize harvest, there was reestablishment of the African-star-grass pasture. Taking in consideration the maize crop with the objective of obtaining grains, the dose of 1.214.35 g e.a. ha^{-1} provided 9.386.58 kg ha^{-1} of fresh mass of the African-star-grass, at 30 days after harvest of the maize (Figure 6).

The glyphosate is potentially capable of slowing the growth of the African-star-grass, allowing the initial establishment of the maize crop and avoiding the competition forage/crop. Moreover, after the maize crop harvest, occurred the recovery of the pasture and soil cover. In this sense, is possible to use the African-star-grass both for the pasture of animals and for vegetal cover in the formation of straw for implantation of the no till system.

A B C

Figure 1. Shoots of the African-star-grass (*Cynodon nlemfuensis*) at the 114 days after the application of glyphosate in the maize crop pre-sowing. (A = 720 g e.a. ha^{-1}, B = 1.440 g e.a. ha^{-1} and C = 2.160 g e.a. ha^{-1}).

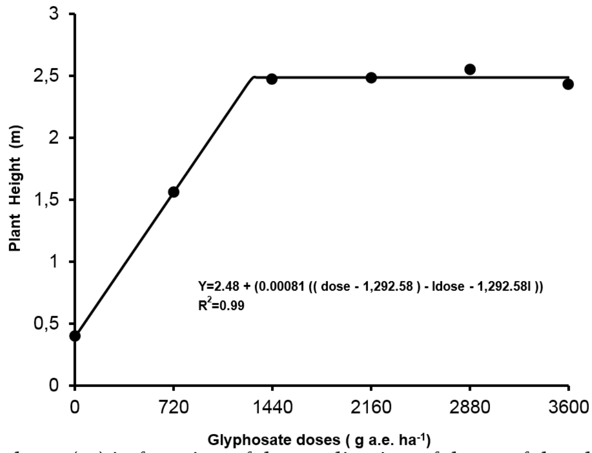

Figure 2. Height of maize plants (m) in function of the application of doses of the glyphosate herbicide (Hoed control = 2.08 m).

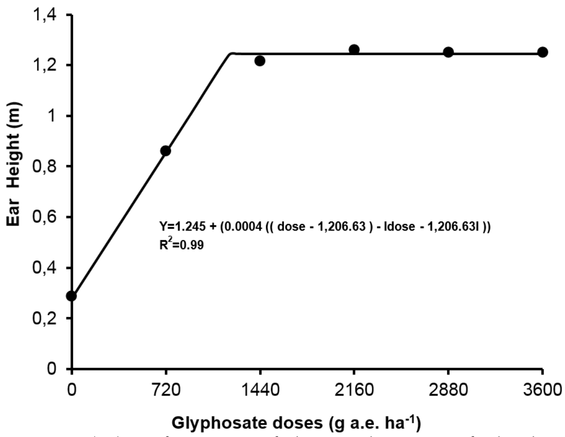

Figure 3. Height of the maize ears (m) in function of the application of glyphosate herbicide doses (Hoed control = 1.04 m).

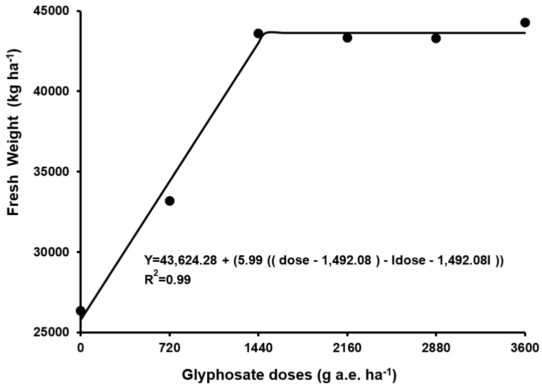

Figure 4. Fresh weight productivity of the maize plants (kg ha-1) in function of the application of glyphosate herbicide doses. (Hoed Control = 32.836 kg ha^{-1}) (experiment 1).

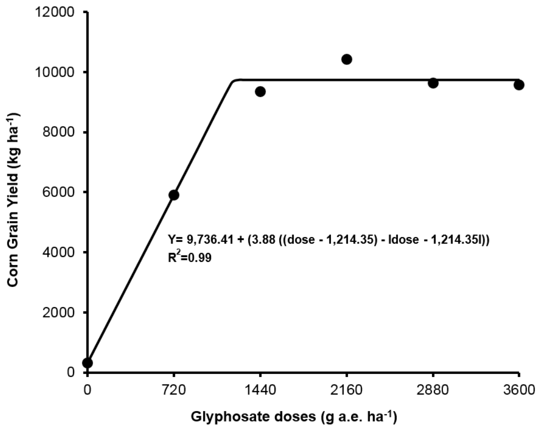

Figure 5. Yield of grains of the maize crop (kg ha^{-1}) function of the application of glyphosate herbicide doses. (Hoed Control = 13.413 kg ha^{-1}) (experiment 2).

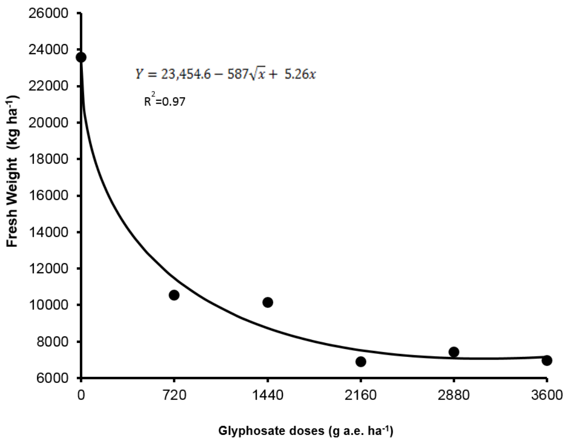

Figure 6. Fresh mass yield of the African-star-grass plants at 30 days after the harvest of the maize in function of the application of the glyphosate herbicide doses.

Conclusions

The African-star-grass is tolerant to glyphosate herbicide doses between 720 to 2.160 g e.a. ha^{-1}.

Doses of glyphosate of 1.206 to 1.492 g e.a. ha^{-1} slow the initial growth of the African-star-grass plants, avoid its competition with the maize crop and allow the recovery of the pasture.

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