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Original article

Chemical control of *Cyperus rotundus* in pre and post emergent application

Controle químico de *Cyperus rotundus* em aplicaçao pré e pós-emergente

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Abstract
Objective: the objective of this work was to test potential herbicides, tested in a single dose of each commercial product as indicated in the package insert. **Materials and Methods:** the experiment was carried out in two trials, pre- and post-emergent, in a completely randomized block design with eight treatments and three replications in an 8x3 factorial scheme. The test was carried out in a BOD oven at 25º and 12 hours/light photoperiod in sand beds containing sedge rhizomes, visual evaluations were performed 7 and 14 days after herbicide application, in both tests, followed by a tretrazolium test at the end. of visual evaluation in tubers that did not germinate, thirty days after pre-emergent application. **Results:** the most efficient control was the herbicide of the Organoarsenic group (MSMA) which presented 0.67% of viable rhizomes in the pre-emergent assay and 0.33% of viable rhizomes in the post-emergent assay. **Conclusion:** the herbicide of the organoarsenic chemical group (MSMA) was the most efficient for the control of nutsedge in both trials. The herbicides ethoxysulforan and glyphosate showed control efficiency in the post-emergence assay.
Keywords: Weed. Seed. Sedge.

Resumo
Objetivo: testar potenciais herbicidas, testados em dose única de cada produto comercial conforme indicação na bula. **Materiais e Métodos:** o experimento foi realizado em dois ensaios, pré e pós-emergente em delineamento de blocos inteiramente casualizados com oito tratamentos e três repetições em esquema fatorial 8x3. O teste foi conduzido em estufa BOD à 25º e 12 horas/luz de fotoperíodo em leitos de areia contendo rizomas de tiririca, as avaliações visuais foram feitas 7 e 14 dias após aplicação do herbicida, em ambos ensaios, seguido de teste de tretrazólio ao final da avaliação visual em tubérculos que não germinaram, trinta dias após aplicação pré-emergente. **Resultados:** o controle mais eficiente foi do herbicida do grupo Organoarsênico (MSMA) que apresentou 0,67 % de rizomas viáveis no ensaio pré-emergente e 0,33% de rizomas viáveis no ensaio pós-emergentes. **Conclusão:** o herbicida do grupo químico organoarsênico (MSMA) foi o mais eficiente para o controle da tiririca em ambos os ensaios. Os herbicidas etoxissulforan e glifosato apresentou eficiência de controle no ensaio pós-emergente.
Palavras-chave: Planta daninha. Semente. Tiririca.

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Introduction

Cyperus rotundus L. (Cyperaceae), known in Brazil as tiririca, is considered the most widespread and aggressive weed in the world[1].

The sedge is one of the most difficult weeds to control worldwide and also the one that causes the most damage in agricultural cultivation areas[2]. In Brazil, it grows substantially in a few days if subjected to favorable soil and climatic conditions, in soils of excellent agricultural aptitude, it can spread at an alarming level of 3000 tubers per m² in which up to 2000 plants can emerge[3].

The adequacy of post-emergence herbicide application to the stage of maximum susceptibility is fundamental for the success in the control of nutsedge. It is important that the leaf area is sufficient for good retention and absorption of the spray applied[4]. There is a need to know the ability of the herbicide to act at the vital point after reaching the plant, directly on the leaves, or indirectly, by entering the soil solution, a herbicide that eliminates tubers of this weed will present better results in pre-emergent application[3]. Other studies have been carried out in order to seek the most appropriate management for this weed, as in the studies by[5,6] in which these authors seek to reduce the impacts of the growth of this plant in agricultural crops.

Due to the rapid ability to show resistance to herbicides, many commercial products are no longer effective in controlling sedge. This study aimed to evaluate the effectiveness of chemical control of the sedge *Cyperus rotundus* with pre-emergence and post-emergence treatment, with different commercial products available on the market.

Materials and Methods

Two experiments were set up (one with pre-emergent treatment of the tuber and the other with post-emergence of the tuber) in a controlled environment in a BOD-type greenhouse, adopting a completely randomized block experimental design, with eight treatments and three replications, conducted in a sand bed. (gerbox), containing ten healthy tubers of defined mass collected in a crop area, placed in a BOD-type oven at 25º C and 12 hours of photoperiod.

The pre-emergent experiment of sedge tubers was applied via surface spraying of 1.00 kg ha^{-1} of (Roundup WG, 792.5 kg g^{-1} i.a., WG); 5.00 L ha^{-1} de (Proof, 500 L g^{-1} a.i., SC); 5.00 L ha^{-1} of (Atrazine Atanor 50 SC, 500 L g^{-1} a.i., SC, Atanor); 0.250 kg ha^{-1} of (Gladium, 600 kg g^{-1} a.i., WG); 0.250 L ha^{-1} de (Sovereign, 450 L g^{-1} a.i., SC, Bayer) 0.250 L ha^{-1} de (Verdict); 3.00 L ha^{-1} of (Volcane, 790 L g^{-1} i.a., SL, Luxenbourg).

The post-emergence experiment of sedge tubers was applied 15 days after sowing the tubers via surface sprinkling of 1.00 kg ha^{-1} of (Roundup WG, 792.5 kg g^{-1} i.a., WG, Monsanto); 5.00 L ha^{-1} de (Proof, 500 L g^{-1} a.i., SC, Syngenta); 5.00 L ha^{-1} of (Atrazine Atanor 50 SC, 500 L g^{-1} a.i., SC, Atanor); 0.250 kg ha^{-1} of (Gladium, 600 kg g^{-1} a.i., WG, Bayer); 0.250 L ha^{-1} of (Sovereign, 450 L g^{-1} a.i., SC, Bayer) 0.250 L ha^{-1} of (Verdict); 3.00 L ha^{-1} of (Volcane, 790 L g^{-1} i.a., SL, Luxenbourg).

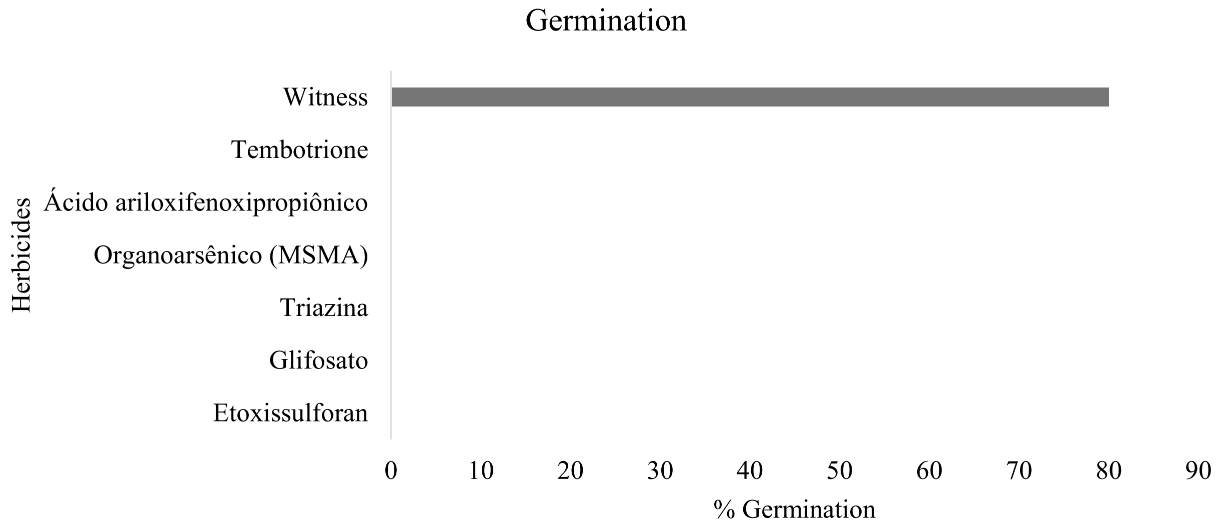
In both tests, 250 mL of spray volume were prepared for each treatment and 75 mL were applied in each repetition. For unit transformations, the spray volume per hectare indicated on the package insert of each product was used.

The germination was evaluated daily and after 15 days of the treatments application, the tuber mass of each repetition were evaluated and the treatments that did not germinate were submitted in the pre-emergent test to the tetrazolium test in an aqueous solution of 0.1% of the salt of Trazolium. They were conditioned in BOD at 30° for 1.5 hours to determine their viability, being considered viable those that stained pink.

Results

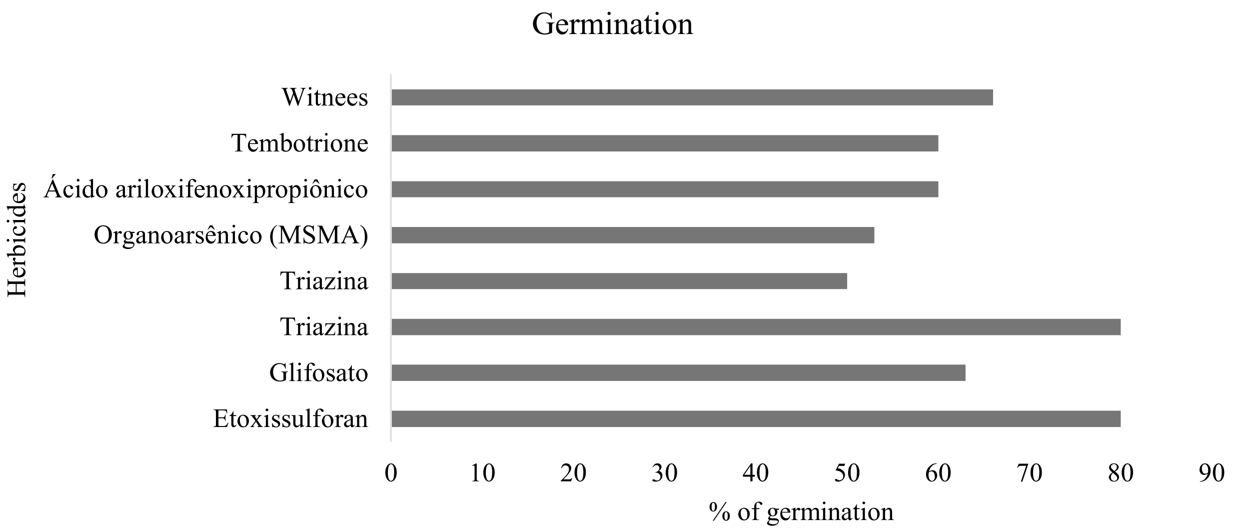
In the pre-emergent treatment of tubers, it was observed 15 days after sowing that there was no germination of nutsedge tubers in any of the herbicides tested (Graph 1).

Graph 1 - Percentage of seedling tubers germination in pre-emergent treatment with herbicides.



When the treatment was post-emergent of the bulbs, it was observed that the efficiency of the active principles was lower in controlling the sedge (Graph 2).

Graph 2 - Percentage of sprouted sedge bulbs as a function of post-emergence control.



The viability of the bulbs after the treatments had Organoarsenic (MSMA) as the most effective active principle, which in both pre-emergent and post-emergent treatments showed a better control of the nutsedge (Table 1).

In this experiment, there was no significant result for the pre-emergent test, where the rhizomes remained viable, as shown by the tetrazolium test (Table 1), but in the post-emergent test the result was effective in controlling the nutsedge.

Table 1 - Vigor of *Cyperus rotundus* tubers using the Tetrazolium test

Product	**Pre-emergent**	**Post-emergent**	**Mean**
Witness	10 aA	10 aA	10
Tembotrione	8,7 aA	7,0 abA	7,8
Aryloxyphenoxypropionic acid	8,0 aA	7,0 abA	7,5
Organoarsenic (MSMA)	0,67 bB	0,33 cB	0,5
Triazine	8,67 aA	5,0 bA	6,83
Triazine	*9.0 aA*	8,0 abA	8,5
Glyphosate	9,0 aA	0,33 cB	4,66
Ethoxysulforan	7,33 aA	1,0 cB	4,16
Mean	7,67	4,87	

Means followed by the same lowercase letter in the column and uppercase in the line differed statistically by Tukey's test $p>0.05$.

We can observe the results obtained through the pre-emergent and post-emergent tests (Figure 3).

Figure 3 - Tetrazolium test result of Cyperus rotundus bulbs with pre-emergent herbicide treatment.

Discussion

The triazine group acts as an inhibitor of photosystem II site A, translocated only via the xylem, plants are not affected by the process until they emerge and begin photosynthesis[7-10]. In the post-emergent control, this substance did not show efficiency in the control, so the nutsedge can metabolize or compartmentalize the triazine before reaching the site of action[9], reports that when used in a post-emergent way, the translocation is limited, therefore it may interfere with the action of the product.

Derived from glycine (glyphosate), the enzyme enolpyruvyl-shikimate-phosphate (EPSP) synthetase is involved in the synthesis of the aromatic amino acids tyrosine, tryptophan and phenylalanine. These amino acids are precursors of compounds that have numerous essential functions in plants, herbicides that inhibit the enzyme EPSPs are readily taken up by plant foliage and translocated in the phloem to drains, metabolites, storage organs, buds[11].

Glyphosate is, therefore, a post-emergent herbicide, which cannot be used as a pre-emergent, as it undergoes strong adsorption to soil particles and, therefore, does not act on plants, as observed in the tetrazolium test (Table 1). Considered a non-selective herbicide for its broad aspect, it has currently been considered for genetically modified crops[9]. In the post-emergent control (Graph 2) there was significant control by the synthesis of glycine, similar to the result of[12], who obtained positive results when using glyphosate to control the nutsedge.

Ethoxysulforan, a selective herbicide from the pre- and post-emergent group of sulfonylureas, are inhibitors of open-chain amino acid synthesis. The enzyme acetolactate synthetase (ALS) catalyzes the first step in the synthesis of the amino acids leucine, isoleucine and valine, these amino acids are essential components in proteins and required for the production of new cells. They are readily taken up by roots and leaves and translocated through the xylem and phloem to the site of action at growing points. These herbicides mainly control dicots, and some sulfonylureas can suppress sedges, such as sedge.

In this experiment, there was no significant result for the pre-emergent test with ethoxysulforan, where the rhizomes remained viable, as shown by the tetrazolium test (Table 1), but in the post-emergent test the result was effective in controlling the nutsedge[6], were successful in reducing tubers viability with the use of ethoxysulforan in post-emergence, with 94% efficiency at 30 DAT, 94% at 45 DAT and 100% at 60 DAT.

There were no significant results in both pre-emergence and post-emergence tests with the tested herbicide from the tembotrione group, these herbicides act as inhibitors of the synthesis of 4-hydroxyphenylpyruvate dioxygenase (4-HPPD).

It is considered that herbicides of this group act in a general way in some enzymatic sites of the route of synthesis of carotenoid pigments. Blocking the synthesis of these pigments is the phenomenon responsible for the appearance of the characteristic symptom of “albinism” or depigmentation. HPPD inhibitor, enzyme that acts in the synthesis of plastoquinone, enzyme cofactor of the carotenoid synthesis pathway (PDS) and integrant of the electron flow of photosynthesis[13].

However, this process may not inhibit chlorophyll synthesis, which may explain the low efficiency of these products[9,14], as well as the rapid metabolism of some plants in relation to these products. Products, not producing toxic metabolites capable of producing an effect on nutsedge.

The test with the herbicide of the Aryloxyphenoxypropionic Acids group that acts as inhibitors of lipid synthesis, did not present significant results in the effective chemical control both in the pre-emergence test and in the post-emergence test, it is known that this herbicide acts from the first reaction in the metabolic route of lipid synthesis involves the carboxylation of acetyl coenzyme A (Acetyl-CoA), mediated by the enzyme Acetyl-Coa carboxylase (ACCase). ACCase accelerates the formation of malonyl-CoA from acetyl-CoA and CO2. Malonyl-CoA and acetyl-CoA are phospholipids and triacylglycerols. The latter combine to form lipid bilayers that serve as the cell membrane.

Lipid biosynthesis occurs mostly in the meristems of roots and shoots, where new cells are being formed. The stoppage of its production interrupts the formation of new cell membranes, and thus, new cell formation. If lipids are not produced within the plant, there is no production of cell membranes and plant growth is stopped.

These herbicides inhibit the production of lipids, but alone they may not be enough to kill the plant[9], describe reports of weed resistance to this active ingredient, as well as the need to use adjuvants to increase absorption and translocation in the plant.

The herbicide that showed the highest efficiency in this experiment in both tests was from the organoarsenic group (MSMA) as shown in the tetrazolium test (Table 1), this herbicide has an unknown mechanism of action, since the sites of action of these herbicides are not known , it is possible that they present differences in the mechanism of action between them and in relation to the other groups, with MSMA being the only Brazilian herbicide registered with this mechanism of action[9].

These herbicides are described as post-emergent, since their absorption occurs in the foliar form, thus being considered a contact product. Widely used in association with hormonal herbicides as a desiccant[9].

Another point to be highlighted is the effect of the substance Organoarsenic (MSMA), which, regardless of the form of treatment, proved to be highly effective on the viability of sedge bulbs, as in the study carried out[6], where this herbicide showed efficiency in reducing the viability of tubers.

Conclusion

It was concluded that the herbicide of the organoarsenic chemical group (MSMA) was the most efficient for the control of nutsedge in both trials. The herbicides ethoxysulforan and glyphosate showed control efficiency in the post-emergence assay.

Authors' contribution

All authors have approved the final version of the manuscript and declared themselves to be responsible for all aspects of the work, including ensuring its accuracy and integrity.

Conflicts of interest

The authors declared that they have no conflicts of interest.

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