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Article

Herbicidal Potential of Dryland Plants on Growth and Tuber Sproutingin Purple Nutsedge (*Cyperus rotundus*)

*Potencial Herbicida de Plantas de Regiões Áridas no Crescimento e Brotação de Tubérculos de Tiririca (**Cyperus rotundus**)*

IQBAL, J.[1]
ZAHRA, S.T.[2]
AHMAD, M.[2]
SHAH, A.N.[3]*
HASSAN, W.[4]

ABSTRACT - In the current study the herbicidal potential of different dryland plant species to suppress tuber sprouting and growth in the purple nutsedge (*Cyperus rotundus*) was investigated. The plant species evaluated were *Fagonia indica*, *Aerva javanica*, *Calotropis procera*, *Rhazya stricta* and *Withania coagulans*. In a greenhouse experiment, 5 sprouted and 5 non-sprouted tubers of nutsedge were planted in pots containing 250g field-collected soil. Pots were irrigated regularly with aqueous extracts of test plants at five concentrations (0, 25, 50, 75 and 100%; original extract was concentrated 20 times and was considered as 100% concentrated and further concentrations were made accordingly). Extracts of all test plants significantly inhibited nutsedge tuber sprouting and growth. A significant interaction was observed between sprouting index (SI) and final sprouting percentage. While a non-significant interaction was observed between the timing of sprouting initiation and mean sprouting time (MST). Maximum reductions in SI and final sprouting percentage were recorded with *Rhazya stricta* extracts. Extracts of *Rhazya stricta* showed maximum suppressive potential of nutsedge density, root and shoot length, root and shoot fresh and dry weight. Overall, the least effective suppression of purple nutsedge was observed for extracts of *Fagonia indica*. *Calotropis procera* extracts resulted in the lowest reductions in nutsedge root length of all test plants but all test plants showed similar effects on timing of sprouting initiation and mean sprouting time. The 100% and 75% concentrations provided complete suppression of nutsedge. For all test plants, the 25% extract concentration was least effective and in some cases results were similar to the water-only control treatment. Our findings suggest that several dryland plant species with strong allelochemical properties have the potential to substantially reduce the deleterious impacts of purple nutsedge in dryland cropping systems and warrant further study.

Keywords: allelopathy, dry land plants, water extract, purple nutsedge.

*RESUMO - No presente estudo, investigou-se o potencial herbicida de diferentes espécies de plantas de regiões áridas na supressão do crescimento e da brotação de tubérculos de tiririca (**Cyperus rotundus**). Foram avaliadas as espécies **Fagonia indica**, **Aerva javanica**, **Calotropis procera**, **Rhazya stricta** e **Withania coagulans**. Em um experimento em casa de vegetação, 5 tubérculos de tiririca brotados e 5 tubérculos não brotados foram plantados em vasos contendo 250 g de solo coletado no campo. Os vasos foram submetidos a irrigação regular com extratos aquosos de plantas-teste em cinco concentrações (0, 25, 50, 75 e 100%. O extrato original foi concentrado 20 vezes e foi considerado 100% concentrado, e outras concentrações foram preparadas em conformidade). Os extratos de todas as*

*** Corresponding author:**
<ans786@webmail.hzau.edu.cn>

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[1] Ghazi University, Dera Ghazi Khan 32200, Punjab, Pakistan; [2] Quaid-i-Azam University Islamabad, Pakistan; [3] MOA Key Laboratory of Crop Ecophysiology and Farming System in the Middle Reaches of the Yangtze River, College of Plant Science and Technology, Huazhong Agricultural University, Wuhan 430070, P.R. China; [4] Department of Soil and Environmental Sciences, Muhammad Nawaz Shareef University of Agriculture, Multan, Pakistan.

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*plantas-teste causaram a inibição significativa da brotação e do crescimento dos tubérculos de tiririca. Observou-se uma interação significativa entre o índice de brotação (IB) e a porcentagem de brotação final, embora tenha sido observada uma interação não significativa entre a época de início da brotação e o tempo médio de brotação (MST). Houve redução máxima do IB e da percentagem de brotação final nos extratos de **Rhazya stricta**. Os extratos de **Rhazya stricta** apresentaram potencial máximo de supressão da densidade, do comprimento da raiz e da parte aérea, e da massa fresca e seca da raiz e da parte aérea da tiririca. Em geral, a supressão menos eficaz da tiririca foi observada para os extratos de **Fagonia indica**. Os extratos de **Calotropis procera** causaram as menores reduções do comprimento da raiz da tiririca em todas as plantas-teste; no entanto, todas elas apresentaram efeitos semelhantes para época de início da brotação e tempo médio de brotação. As concentrações de 100% e 75% resultaram na supressão completa da tiririca. Para todas as plantas-teste, o extrato na concentração de 25% foi o menos eficaz e, em alguns casos, os resultados foram semelhantes aos do tratamento controle apenas com água. Os resultados sugerem que várias espécies de plantas de regiões áridas com fortes propriedades aleloquímicas apresentam o potencial de reduzir substancialmente os impactos negativos da tiririca em sistemas de cultivo de terras áridas; por esta razão, é necessária a realização de mais pesquisas.*

Palavras-chave: alelopatia, plantas de regiões áridas, extrato aquoso, tiririca.

INTRODUCTION

Pakistan is an agricultural country. Agriculture covers about 25% of Pakistan's area. It accounts for 21.4 percent of GDP and employs 45% of total labor (Pakistan, 2013). There are so many factors limiting yields of different crops including poor quality seed, soil fertility management, irrigation water shortage and pest management. As for pest management, weeds cause the highest loss recorded as high as 24% of yield depending on ecological and climatic conditions.

Among the worst weeds found in the world, purple nutsedge is known as one of the most common and damaging weed. It is herbaceous, colonial, and perennial with fiber roots that grow from 7 to 40 cm long and regenerate massively by tubers and rhizomes. This weed is found in 52 various crops and in 92 countries including tropical and sub-tropical regions (Rao, 2000). As in other countries, purple nutsedge is a huge and emerging threat to the agriculture of Pakistan. In Pakistan, it is commonly found in main summer crops such as sugarcane, pulses, cotton, maize and rice (direct seeded). It can suppress the production of associated crops from 23-89%. The allelopathic suppression in growth and production of crops in addition to competition for moisture, light and nutrients have also been reported by purple nutsedge (Quayyum et al., 2000). Rhizomes and tubers are key factors in the establishment of this species as a weed. The function of rhizomes is to supply the most important way by which plants may take possession of an area. Tubers provide a means of asexual reproduction and they are the key scattering component that can remain alive in severe condition Tubers and rhizomes both make a major set of connections in the soil. The dangerous purple nutsedge is difficult to control because of longevity of tubers, capability to germinate many times (Keeley, 1971), modes of multiple promulgation and unavailability of herbicides for seasonal long control. There are few selective herbicides for eradicating purple nutsedge in the market but their result is only for short period of time; thus, tubers are capable of resprouting. Keeping in view such capability of tubers, the present study was designed to test the plant extracts on sprouted and unsprouted tubers. So it is need that to search the allelopathic interaction of plants which provides safe weedicides (Miri, 2011). Allelopathy is a discharge of biologically active chemical compounds into environment by one sort of species that affect other plants, very often in an inhibitory way (Golisz, 2008). It can be used in different means to control weeds (Shah et al., 2016; Shah and Iqbal, 2017).

Weed management is a current need because weeds are widely distributed in agricultural systems, and there is 9.7% yield loss as a result of 1,800 different types of weeds in agricultural crops per year (Li and Wang, 2010). Weeds not only compete with crops for water, nutrients and sunlight but also suppress crop plants by secreting some inhibitory chemicals known as allelochemicals into the rhizosphere which are responsible for the reduction in growth and yield of crops (Batish et al., 2007; Tanveer et al., 2010; Gatti et al., 2010). There are about 250 species of weeds which are responsible for agricultural losses all over the world (Dangwal et al., 2010). The reduction in yield in different crops of Pakistan is huge due to unchecked growth of weeds. The production may decrease by more than 50% in some of the crop systems (Mahmood and Niaz, 1992).

Allelopathy has many advantages over synthetic herbicide including nitrogen conservation; in fact it is now referred to as sustainable weed management (Kohli et al., 1997). Proper use of allelopathic crops in agriculture could decrease the herbicide and pesticide application which can reduce costs in agriculture, decrease environmental pollution, and enhance soil productivity as well as biodiversity and sustainability in the agro ecosystem (Shah et al., 2016). Iqbal and Cheema (2008) studied the effect of different crops on purple nutsedge through extract application and intercropping and found promising results against this weed. Dryland plants are considered to have higher herbicidal potential since salinity, water stress, and overgrazing are features of this ecosystem that favor the release of allelochemicals. Keeping in view the possible allelopathic potential of dryland plants as natural weed control, the present study was conducted to explore the allelopathic potential of dryland plants (*Fagonia indica*, *Aerva javanica*, *Calotropis procera*, *Rhazya stricta and Withania coagulans*) against purple nutsedge.

MATERIALS AND METHODS

Experimental site

A pot experiment was conducted under open environment to test the herbicidal potential of five dryland plants (*Fagonia indica*, *Aerva javanica*, *Calotropis procera*, *Rhazya stricta*, *Withania coagulans*) against purple nutsedge at the College of Agriculture, Dera Ghazi Khan Sub-campus University of Agriculture, Faisalabad during summer season 2013. Mature plants were collected from the dry areas of Dera Ghazi Khan. The tender shoots and leaves of *Calotropis procera*, *Rhazya stricta*, and *Withania coagulans* were selected for the experiment. While in case of *Fagonia indica* and *Aerva javanica* mature plants of the test species were harvested from ground level because it was difficult to separate the leaves of these plants. The selected plants and plant parts were dried for a few days under shade (35 °C ± 2) and then, with the help of an electric fodder cutter, they were cut into 2 cm pieces. The chopped plant materials (5 kg dry weight of each) were soaked in distilled water at room temperature (35 °C ± 2) for 24 hours in a ratio of 1:10 (w/v) (Cheema and Khaliq, 2000). The extract was filtered with the help of sieves of 10 and 60 meshes gradually. After filtration, the plant extracts were boiled at 100 °C to evaporate water in order to reduce the volume up to twenty times for easy handling. The initial reduced extract through boiling was considered as 100% concentration. Further concentrations were prepared by diluting the extract with distilled water i.e. 0, 25, 50, 75% concentrated to check herbicidal potential of these test plant species. Tubers of purple nutsedge (*Cyperus rotundus*) were collected from nearby village. To ensure physical purity, the tubers were cleaned manually. For surface sterilization these tubers were soaked in water: bleach solution (10:1) for 15 minutes. Then, the tubers were rinsed with distilled water for at least four times. Soil was selected from fertilized area of Dera Ghazi Khan. Each pot was filled with air dried, sieved well mixed soil (with pH of saturated soil paste and electrical conductivity (EC) of the saturation extract of 7.9 and 0.4 dSm^{-1} respectively).

Experimental design

The experiment was laid out in a Completely Randomized Design (CRD) with three replicates.

Collection of plant samples

For the experiment 30 plastic pots with 250 g soil capacity were selected and labeled as treatment with respective concentrations and control. The pots were filled with 200 g of soil after sieving and drying. Healthy tubers were selected based on their appearance and eight tubers per pot were placed and were covered with one cm depth of soil. The pots were placed in complete random manner in a greenhouse under natural conditions. The extracts were obtained and the desired concentrations were prepared. The pots were irrigated regularly with the required concentrations and every day at noon the pots were shifted under shade to avoid dehydration. Emergence count was recorded according to the AOSA (1990) method; the experiment was visited daily until a constant reading was achieved. The experiment was discontinued after 15 days. Shoot and root lengths were measured with the help of a scale (cm), shoot and root fresh weights were determined separately with an electric balance immediately after uprooting the plants and shoot and root dry weights were measured after drying in an oven at 70 °C for 48 hours. Other parameters such as sprouting index (SI), mean sprouting time (MST), time to start sprouting and final sprouting percentage were computed according to the formulae described below.

Sprouting index was calculated by the formula given by AOSA (1983):

$$SI = \frac{\text{No. of of sprouted tubers}}{\text{Days of first count}} + ------ + \frac{\text{No. of of sprouted tubers}}{\text{Days of fiinal count}}$$

Mean sprouting time (MST) was calculated according to the formula of Ellis and Robert (1981) as: where D represents the count of days which were counted from the start of tuber sprouting, while n is the count of tubers that sprouted on day D.

Statistical analysis of data

The recorded data was analyzed statically by using MSTAT C (Russel, 1986) for analysis of variance (ANOVA) followed by Duncan's Multiple Range (DMRT) Test (Duncan, 1955) for treatment means comparison at 1% probability level.

RESULTS AND DISCUSSION

Four germination parameters i.e. time to start sprouting, final sprouting percentage, and purple nutsedge stem count were calculated based on the data collected on daily germination count. There was a non-significant interaction between plant extracts and concentration for time to start sprouting and mean sprouting time; however, there was a significant interaction (plants vs concentration) in SI, final sprouting percentage and purple nutsedge stem count (Table 1). All test plants showed complete inhibition of growth and sprouting in nutsedge at 100 and 75% extract concentration. However, *Rhazya stricta* showed maximum reduction in SI and final sprouting percentage but all plants behaved similarly about time to start sprouting and mean sprouting time (Table 2).

Purple nutsedge density, shoot and root length, shoot and root fresh and dry weights were inhibited completely at 100 and 75% concentrations by all test plants but there were some variations at 50% concentration by some plants (Table 3). *Fagonia indica* showed the least effective herbicidal potential against purple nutsedge. The highest suppressive potential was presented by *Rhazya stricta* for purple nutsedge density, shoot and root length, shoot and root fresh and dry weights; *Fagonia indica* was found to be the least effective for purple nutsedge density, shoot length, shoot fresh and dry weight and root fresh weights while in the case of root length *Calotropis procera* was found to be the least effective as compared to other plants (Table 4). In the comparison with concentration, complete inhibition was recorded at 100 and 75% concentrations, followed by 50% as compared to control in all parameters recorded. Concentration of 25% was found to be the least effective and in some cases, it was similar to control. Similar is the case in the present studies *Rhazya stricta* was also found to be very effective in controlling purple nutsedge specially in sprouting of tubers; however, for sprouted tubers the results were somewhat different in certain cases. *Rhazya stricta* is a significant species that has large amount of alkaloids (Atta-ur-Rahman et al., 1991). More than a few studies have found that alkaloidal components or extracts from plants are responsible for a great deal of allelopathic effects (Elakovich and Yang, 1996). Many secondary metabolites such as alkaloids, phenolic acids and terpenoids which are discharged by different plants affect the growth of plant seedlings (Fang et al., 2009). Suppression of growth and development may be due to loss of water uptake by plants. Allelochemicals disturb the metabolic activities and result in reduction of root and shoot length (Tawaha and Turk, 2003). In this study there is reduction in root and shoot length of purple nutsedge by applying

Table 1 **-** Effect of selected dryland plant extracts on the germination parameter of purple nutsedge (interaction between plant extracts x concentration)

Treatment	Time to start germination	Sprouting index	Final sprouting %	Mean sprouting time	Purple nutsedge density
P1 x C0	4	6.53 b	83.33 ab	8.04	5.00 a
P1 x C1	4	3.45 d	70.83 bc	9.31	4.67 ab
P1 x C2	4	2.21 f	45.83 d	9.00	267 cd
P1 x C3	0	0.00 g	0.00 g	0.00	0.00 e
P1 x C4	0	0.00 g	0.00 g	0.00	0.00 e
P2 x C0	4	3.27 de	70.83 bc	9.04	3.67 bc
P2 x C1	11	0.65 g	20.83 e	11.50	0.00 e
P2 x C2	6	0.20 g	8.33 efg	0.00	0.00 e
P2 x C3	0	0.00 g	0.00 g	0.00	0.00 e
P2 x C4	0	0.00 g	0.00 g	0.00	0.00 e
P3 x C0	4	8.39 a	87.50 ab	8.00	4.00 b
P3 x C1	5	2.74 def	70.83 bc	9.62	3.67 bc
P3 x C2	7	0.41 g	16.67 ef	12.00	2.33 d
P3 x C3	0	0.00 g	0.00 g	0.00	0.00 e
P4 x C0	4	2.61 ef	45..83 d	8.94	2.67 bc
P4 x C1	7	0.70 g	16.67 ef	0.00	0.00 e
P4 x C2	0	0.22 g	4.17 fg	0.00	0.00 e
P4 x C3	0	0.00 g	0.00 g	0.00	0.00 e
P4 x C4	0	0.00 g	0.00 g	0.00	0.00 e
P5 x C0	4	5.51 c	58.33 cd	8.00	3.67 bc
P5 x C1	6	2.71 def	45.83 d	9.15	2.67 cd
P5 x C2	7	0.52 g	12.50 efg	0.00	0.00 e
P5 x C3	0	0.00 g	0.00 g	0.00	0.00 e
P5 x C4	0	0.00 g	0.00 g	0.00	0.00 e

Table 2 **-** Effect of selected dryland plant extracts on the germination parameter of purple nutsedge (individual comparisons of plant extracts and concentrations)

Treatment	Time to start germination	Sprouting Index	Final sprouting %	Mean sprouting time	Purple nutsedge density
Plant extracts					
P1: *Fagoniaindica*	2.53 a	2.44 a	40.00 a	1.76 a	2.47 a
P2: *Rhazyastricta*	3.53 a	0.82 c	20.00 b	1.37 a	0.73 d
P3: *Calotropisprocera*	3.67 a	2.31 a	35.00 a	1.97 a	2.00 b
P4: *Rhazyastricta*	2.13 a	0.70 c	13.33 c	0.59 a	0.53 d
P5:*Withania coagulans*	2.87 a	1.75 b	23.33 b	1.14 a	1.27 c
Concentrations					
C0:Control	4.13 a	5.26 a	69.17 a	2.80 a	3.80 a
C1: 25% concentrated	5.20 a	2.05 b	45.00 b	2.64 a	2.20 b
C2: 50% concentrated	5.40 a	0.71 c	17.50 c	1.40 a	1.00 c
C3: 75% concentrated	0.00 b	0.00 d	0.00 d	0.00 a	0.00 d
C4: 100% concentrated	0.00 b	0.00 d	0.00 d	0.00 a	0.00 d

Table 3 - Effect of selected dryland plant extracts on the germination parameter of purple nutsedge (interaction between plant extracts x concentration)

Treatment	Purple nutsedge density	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Shoot dry weight (mg)	Root fresh weight (g)	Root dry weight (mg)
P1 x C0	5.00 a	12.00 a	4.33 b	79.33 b	25.43 a	30.00 ab	3.03 b
P1 x C1	4.67 ab	10.40 b	3.67 b	62.00 c	14.92 c	19.33 cde	1.22 cde
P1 x C2	267 cd	8.80 c	2.90 c	35.00 f	10.26 de	15.33 def	0.80 cde
P1 x C3	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	000 g	0.00 e
P1 x C4	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	000 e
P2 x C0	3.67 bc	12.25 a	5.20 a	86.67 a	9.35 def	35.67 a	2.00 bc
P2 x C1	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P2 x C2	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P2 x C3	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P2 x C4	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P3 x C0	4.00 b	8.40 c	5.60 a	25.33 g	11.13 d	17.14 de	2.00 bc
P3 x C1	3.67 bc	6.73 d	3.70 b	21.00 g	8.43 def	11.00 ef	0.70 de
P3 x C2	2.33 d	5.30 e	2.40 cd	12.33 h	7.83 ef	7.67 fg	0.40 e
P3 x C3	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P4 x C0	2.67 bc	5.00 e	1.97 d	51.67 d	7.00 f	26.67 bc	2.00 bc
P4 x C1	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P4 x C2	0.00 e	0.00 f	0.00 e	000 i	0.00 g	0.00 g	0.00 e
P4 x C3	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P4 x C4	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	6.33 a
P5 x C0	3.67 bc	8.08 c	5.58 a	44.67 e	22.67 b	24.33 bcd	1.70 cd
P5 x C1	2.67 cd	4.50 e	4.08 b	24.00 g	14.67 c	17.33 de	0.00 e
P5 x C2	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P5 x C3	0.00 e	000 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e
P5 x C4	0.00 e	0.00 f	0.00 e	0.00 i	0.00 g	0.00 g	0.00 e

Table 4 - Effect of selected dryland plant extracts on the growth of purple nutsedge (individual comparisons of plant extracts and concentrations)

Treatment	Purple nutsedge density	Shoot length (cm)	Root length (cm)	Shoot fresh weight (g)	Shoot dry weight (mg)	Root fresh weight (g)	Root dry weight (mg)
Plant extracts							
P1: *Fagoniaindica*	2.47 a	6.24 a	2.18 a	35.26 a	10.12 a	12.93 a	15.00 b
P2: *Rhazyastricta*	0.73 d	2.45 c	1.04 c	17.33 b	1.87 d	7.13 b	0.40 c
P3: *Calotropisprocera*	2.00 b	4.09 b	2.34 a	11.73 cd	5.48 c	7.16 b	0.62 bc
P4: *Rhazyastricta*	0.53 d	1.00 d	0.39 c	10.33 d	1.40 d	5.33 b	0.40 c
P5:*Withania coagulans*	1.27 c	2.25 c	1.93 a	13.73 c	7.47 b	8.33 b	1.61 a
Concentrations							
C0:Control	3.80 a	9.15 a	4.54 a	57.53 a	15.12 a	26.76 a	3.07 a
C1: 25% concentrated	2.20 b	4.33 b	2.29 b	21.40 b	7.61 b	9.53 b	0.72 b
C2: 50% concentrated	1.00 c	2.82 c	1.06 c	9.47 c	3.62 c	4.60 c	0.24 bc
C3: 75% concentrated	0.00 d	0.00 d	0.00 d	0.00 d	0.00 d	0.00 d	0.00 c
C4: 100% concentrated	0.00 d	0.00 d	0.00 d	0.00 d	0.00 d	0.00 d	0.00 c

extracts of dryland plants, possibly due to disturbance in metabolic activities in accordance with the results of Tawaha and Turk (2003). Reduction in root and shoot length might be due to interruption in physiological processes of purple nutsedge. Root and shoot suppression may be due to inhibition of cell cycle or decreased level of growth promoting hormones Indole acetic acid (IAA) and Abscisic acid (ABA) (Tomaszewseki and Thimann, 1996). Allelochemicals might result in arrested growth because of decreased ion absorption (Qasem and Hill, 1989). (Al Mutlaq, 2001) has reported the consequence of Rhyza stricta leaf leachate on wheat, alfalfa, Italian ryegrass, and wild radish. Seedling development of all experienced species was exaggerated by *Rhazya stricta* leachate, and wheat seedlings were the slightest sensitive species. Gilani et al. (2010) screened 81 medicinal plant species of North West Frontier Province (NWFP) Pakistan to test their allelopathic potential. They found that *Rhazya stricta* along with *Seriphidium kurramense* and *Andrachne cordifolia* have a strong allelopathic potential as compared to other test medicinal plants.

The present research was aimed to check the herbicidal potential of dryland plants (*Fagonia indica*, *Aerva javanica*, *Calotropis procera*, *Rhazya stricta* and *Withania coagulans*) against purple nutsedge. Water as compared to other solvents proved a best solvent for the extraction of all test plants; it inhibited the growth of purple nutsedge at the 100% and 75% concentrations of their extracts followed by the 50% concentration while the 25% concentration was the least effective in all test plants. In the first experiment, *Rhazya stricta* had the highest herbicidal potential for purple nutsedge as compared to other tests; thus, it can be recommended as a potential source of allelochemicals for suppression of purple nutsedge.

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