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RESEARCH ARTICLE

Effect of cogongrass [*Imperata cylindrica* (L.) Beauv.) extract as a botanical herbicide on the growth of itchgrass [*Rottboellia exaltata* (L.) L. f.] in maize (*Zea mays* L.) fields

Aditya Murtilaksono[1*], Muh Adiwena[1] & Ika Yulianti[2]

[1]Department of Agrotechnology, Universitas Borneo Tarakan, Tarakan 77 115, Indonesia
[2]Department of midwifery, Universitas Borneo Tarakan, Tarakan, 77 115, Indonesia

*Correspondence email - aditwalker02@gmail.com

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Abstract

Weeds are one of the plant pests commonly found in maize fields. The weed often encountered in maize fields is *Rottboellia exaltata* at Tarakan City, Indonesia. This will have an impact on reducing the productivity of maize plants, So it is necessary to take measures to control this weed. To control *R. exaltata* in maize fields, a botanical herbicide derived from *Imperata cylindrica* is employed. This research aims to determine the influence of *I. cylindrica* extract as a botanical herbicide on the growth of *R. exaltata* in maize plants. The study utilizes a Completely Randomized Block Design with one factor and 4 replications. The treatments are as follows: P0=control, P1=20% concentration of *I. cylindrica* extract, P2=40% concentration of *I. cylindrica* extract, P3=60% concentration of *I. cylindrica* extract, P4=80% concentration of *I. cylindrica* extract and P5=100% concentration of *I. cylindrica* extract. The observed parameters include the height of *R. exaltata* weed, the number of leaves on *R. exaltata* weed, the % of leaf damage on *R. exaltata* weed, the % of leaf damage on maize plants, the height of maize plants, the number of leaves on maize plants, the fresh weight of *R. exaltata* weed and the dry weight of *R. exaltata* weed. The data analysis involves Analysis of Variance (ANOVA) with a confidence level of 95%. If the ANOVA results indicate significant differences, the analysis is further conducted using Duncan's New Multiple Range Test (DMRT) Test. The research results show the study establishes the efficacy of 100% *I. cylindrica* extract, especially in the P5 treatment, in inhibiting *R. exaltata* growth. It significantly reduced weed height by 29.59%, leaf number by 27.68%, offspring by 30.69% and caused leaf damage of 25.83% in the weed and 32.92% in maize. Additionally, it decreased the fresh and dry weights of the weed by 18.89% and 23.43% respectively.

Keywords: extract, *Imperata cylindrica*, *Rottboellia exaltata*, weed, *Zea mays*

Introduction

Maize is a carbohydrate-producing crop widely cultivated to fulfil domestic food requirements and act as an export commodity (1). Following rice, maize is designated as a primary food crop with diverse uses (2), including as a food source, oil producer, livestock feed ingredient and raw material for various industries (3). In 2022, maize production in Tarakan City experienced a decline of 4.5% compared to 2021, attributed to plant pests such as pests, diseases and weeds (4).

Weeds are unwanted plants that grow in cultivation areas, either around main crops or in unwanted locations (5). The presence of weeds in an area can harm other crops in cultivation (6, 7). *Rottboellia exaltata* is a weed species commonly found in maize cultivation in Tarakan City (8). According to Spaunhorst (9), *R. exaltata* is an annual weed species influenced by environmental conditions. It reproduces generatively, using seeds and vegetatively, through rhizomes (10). Therefore, *R. exaltata* is an aggressive weed due to its rapid vegetative and generative reproduction (11). *R. exaltata* competes for water, light, nutrients and space with other plants in the cultivation area (12). It also releases toxic compounds into the soil, inhibiting the germination and growth of surrounding species, including weeds and cultivated plants (13).

There is a report on the prevalence of *R. exaltata* in maize crops in the Central Tarakan Subdistrict (14). This is corroborated by the findings of another study, which indicates the widespread presence of *R. exaltata* in the North Tarakan Subdistrict of Tarakan City (15). Hence, effective control measures are essential to suppress the growth of *R. exaltata* (16). Chemical herbicides have traditionally been effective but come with drawbacks, such as being composed of relatively hazardous chemicals that can harm non-target plants, trigger human poisoning, cause long-term environmental pollution and induce weed resistance (17). Nevertheless, chemical herbicides persist until new weed management technologies emerge (18). A novel weed management technology involves botanical herbicides (19). Botanical herbicides are derived from plantbased active ingredients. *I. cylindrica* is a weed that can serve as a botanical herbicide.

Imperata cylindrica belongs to the group of weeds with natural allelopathic compounds (20, 21). It contains phenolic compounds with allelopathic properties that can inhibit and influence plant growth (22). Phenolic compounds are aromatic ring compounds containing one or more hydroxyl (OH^-) groups and accompanying side groups (23). Phenolics are secondary metabolites found widely in plants and are part of allelochemical compounds that can be used to inhibit weed growth (24). A study demonstrated that the pre-sprouting application of *I. cylindrica* rhizome bioherbicide effectively controls weeds in oil palm plantations (25).

Additionally, it was stated that *I. cylindrica* rhizome extract can inhibit the growth of *Cleome rutidosperma* weeds (26). Moreover, the application of *I. cylindrica* rhizome extract influenced weeds' dry weight and percentage coverage (27). There are reports that extracts of *I. cylindrical* restrict the distribution and growth of *Parthenium hysterophorus* (28), adversely affects the colonization by mycorrhizal fungi (29) and controls the growth of pathogenic fungus *Macrophomina phaseolina* (30).

There is limited research on using *I. cylindrica* as a botanical herbicide to control *R. exaltata* weeds in maize crops. Therefore, this study aims to determine the impact of *I. cylindrica* weed extract as a herbicide in controlling *R. exaltata* weeds in maize plants.

Materials and Methods

Research time and site

The study was conducted from August to November 2023 during the rainy season at the Experimental field, Faculty of Agriculture, University of Borneo Tarakan, Indonesia.

Work procedure

The topsoil was extracted from a 0-10 cm depth and subsequently sterilized. After soil sterilization, the planting media was formulated by preparing polybags filled with a mixture of sterilized soil and chicken manure in a 4:1 ratio. 72 polybags were prepared, each with a soil weight of 10 kg. The planting of maize and *R. exaltata* weed seeds followed. The weed seeds were planted first due to their longer germination than maize seeds. In each polybag, as many *R. exaltata* weed seeds were planted as possible and 5 *R. exaltata* weed plants were selected for research sampling. Once *R. exaltata* weed sprouts emerged, maize seeds were planted. The application of *R. exaltata* weed extract was done once a week when the weed was 1, 2, 3, 4, 5 and 6 weeks after sowing (WAS). The preparation of the botanical herbicide extract involved chopping 2 kg of I. cylindrica, soaking it in 2 L of water for 24 h and then filtering the mixture. The filtered extract was subsequently transferred into plastic bottles for storage. Botanical herbicide was applied by diluting the extract in water according to predetermined treatments and applying it to the experimental plots. The preparation of *I. cylindrica* weed extract was done every 1 week when the *R. exaltata* weed was 1, 2, 3, 4, 5 and 6 WAS. The harvest of *R. exaltata* weed was done at 7 WAS and then the weed was weighed fresh and placed in an oven for 3x24 h to determine dry weight.

Research design

This research used a Completely Randomized Block Design with one factor and 4 replications. The design included: P0=control, P1=20% concentration of *I. cylindrica* extract, P2=40% concentration of *I. cylindrica* extract, P3=60% concentration of *I. cylindrica* extract, P4=80% concentration of *I. cylindrica* extract and P5=100% concentration of *I. cylindrica* extract.

Observation parameters

Research parameters included the height of *R. exaltata* weed, the number of leaves on *R. exaltata* weed, the number of leaves on maize plants, the number of offspring on *R. exaltata* weed, the height of maize plants at 1, 2, 3, 4, 5 and 6 WAS, the % of leaf damage on *R. exaltata* weed, the % of leaf damage on maize plants at 3, 4, 5 and 6 WAS, the fresh weight of *R. exaltata* weed and the dry weight of *R. exaltata* weed.

Data analysis

The analysis used was analysis of variance (ANOVA) with a confidence level of 95%. If ANOVA results indicated significant differences, DMRT (Duncan's Multiple Range Test) was employed.

Results and Discussion

Height of *Rottboellia exaltata* weed

The results of observing the height of the *R. exaltata* weed 1, 2, 3, 4, 5 and 6 WAS were then continued the analysis used was ANOVA with a confidence level of 95%. The results of the DMRT test for parameters of the height of the *R. exaltata* weed are presented in Table 1.

Table 1 indicates that the DMRT test findings for the height parameter of the R.exaltata weed reveal no significant differences in observations at 1 WAS, whereas observations at 2, 3, 4, 5 and 6 WAS exhibit significant differences. Treatment P5, utilizing a 100% concentration of *I. cylindrica*, demonstrated maximum efficacy in inhibiting the growth of *R. exaltata* at observations 2, 3, 4, 5 and 6.

The higher the concentration of *I. cylindrica* extract given, the higher the suppression of the test weed tends to be. A study reported that the more concentrated the extract, the higher the biochemical compounds contained, so weeds are increasingly suppressed (31). The test weed suppression is thought to be caused by the inhibition of cell division by the bioactive compounds of *I. cylindrica* extract (32). According to a report, plant allelochemicals generally inhibit growth through various physiological processes: cell division, cell differentiation, water and nutrient absorption, water stress, phytohormone metabolism, respiration and photosynthesis (33). So, the height growth of the *R. exaltata* weed given *I. cylindrica* extract is higher, which lowers the growth of *the* R. exaltata weed.

Number of leaves on *Rottboellia exaltata* weed

The findings of observing the number of leaves on the *R. exaltata* weed at stages 1, 2, 3, 4, 5 and 6 WAS were subsequently continued. The analysis used was ANOVA with a

Table 1. Average of height on *Rottboellia exaltata* weed given *Imperata cylindrica* extract

Treatment	Average of Height on *Rottboellia exaltata* weed (cm)					
	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS
P0	15.77 a	33.90 d	47.39 d	62.39 d	73.13 d	83.25 d
P1	15.61 a	32.15 d	45.59 d	55.61 c	65.64 c	75.80 c
P2	15.64 a	29.69 c	43.81 cd	52.69 c	62.71 c	72.94 c
P3	15.53 a	26.70 b	41.19 bc	46.94 b	56.98 b	66.96 b
P4	15.47 a	24.64 a	38.39 ab	41.83 a	51.86 a	61.86 a
P5	15.45 a	24.14 a	37.17 a	39.01 a	49.01 a	58.61 a
$DMRT_{(0.05)}$	**0.33**	**38.28**	**10.68**	**55.36**	**51.82**	**55.03**
CV(%)	**0.37**	**4.03**	**4.48**	**8.54**	**8.75**	**8.91**

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

confidence level of 95%. The results of the DMRT Test for parameters of the number of leaves on the *R. exaltata* weed are presented in Table 2.

Table 2 presents the DMRT test results for the number of leaves on *R. exaltata* weed, indicating no significant differences in observations at 1 WAS. However, significant differences were observed at 2, 3, 4, 5 and 6 WAS. Treatment P5, with a 100% concentration of I. cylindrica extract, was the most effective in suppressing leaf growth in R. exaltata weed, as observed at 2, 3, 4, 5 and 6 WAS.

Imperata cylindrica extract treatment with 100% concentration showed the highest suppression of the number of leaves of the *R. exaltata* weed among the other treatments. A study reports that plant responses to herbicides depend on multiple factors, including species type, organ tissue development, herbicide type and the surrounding environment (34). This was further supported by another study, which confirmed that *I. cylindrica* extract primarily affects meristematic and old tissues (35). The response shown in old tissue is very typical, including chlorosis and necrosis. Another report states that damage symptoms due to treatment with *I. cylindrica* extract include wilted leaves, chlorosis and necrotic spots (36).

Height of maize plants

The height of maize plants 1, 2, 3, 4, 5 and 6 WAS were analyzed using ANOVA with a confidence level of 95%. The results of the DMRT test for parameters of the height of maize plants are presented in Table 3.

Table 3 indicates that the DMRT Test findings for the height parameter of maize plants reveal no significant differences in observations at 1 WAS, but observations at 2, 3, 4, 5 and 6 WAS exhibit significant differences. Treatment P5, with a 100% concentration of *I. cylindrica* extract, was the most effective in suppressing maize plant height, as observed at 2, 3, 4, 5 and 6 WAS.

Number of leaves on maize plants

The number of leaves on maize plants 1, 2, 3, 4, 5 and 6 WAS were examined using ANOVA at a 95% confidence level. The results of the DMRT test for the number of leaves on maize plants are presented in Table 4.

Table 4 indicates that the DMRT Test findings for the parameter of leaf count on maize plants reveal no significant differences in observations at 1 WAS. In contrast, observations at 2, 3, 4, 5 and 6 WAS exhibit significant differences. Treatment P5, utilizing a 100% concentration of

Table 2. Average of number of leaves on *Rottboellia exaltata* weed Given *Imperata cylindrica* extract

Treatment	Average of Number of Leaves on *Rottboellia exaltata* Weed (Sheet)					
	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS
P0	4.50 a	16.27 c	26.83 d	33.85 e	43.85 e	54.50 e
P1	4.32 a	15.40 bc	25.57 cd	30.98 d	40.82 d	50.67 d
P2	4.35 a	14.12 abc	23.98 c	28.02 c	38.02 c	48.03 c
P3	4.28 a	13.57 abc	23.30 c	27.08 c	37.03 c	47.03 c
P4	4.25 a	12.58 ab	19.87 b	23.35 b	33.37 b	42.22 b
P5	4.22 a	12.37 a	17.27 a	20.53 a	30.55 a	39.42 a
$DMRT_{(0.05)}$	**1.45**	**3.05**	**19.17**	**45.93**	**44.66**	**44.44**
CV(%)	**0.17**	**2.18**	**3.65**	**4.69**	**4.67**	**5.31**

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

Table 3. Average height of maize plants given *Imperata cylindrica* extract

Treatment	Average of Height of Maize Plants (cm)					
	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS
P0	15.87 a	23.97 a	44.90 a	66.31 a	93.56 a	123.48 a
P1	15.85 a	23.40 a	44.54 a	66.26 a	93.28 a	123.19 a
P2	15.78 a	23.21 a	43.01 a	65.88 a	93.24 a	123.16 a
P3	15.63 a	22.89 a	42.39 a	65.57 a	93.18 a	123.01 a
P4	15.60 a	22.45 a	41.59 a	64.97 a	92.67 a	122.67 a
P5	15.33 a	22.90 a	40.13 a	64.10 a	92.22 a	122.22 a
$DMRT_{(0.05)}$	**0.16**	**0.59**	**2.58**	**0.72**	**2.59**	**2.36**
CV(%)	**0.88**	**1.21**	**2.59**	**1.94**	**0.69**	**0.67**

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

Table 4. Average of number of leaves on maize plants given *Imperata cylindrica* extract

Treatment	Average of Number of Leaves on Maize Plants (Sheet)					
	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS
P0	3.67 a	5.25 a	8.08 a	9.58 a	11.58 a	12.58 a
P1	3.67 a	5.25 a	8.08 a	9.50 a	11.50 a	12.50 a
P2	3.58 a	5.17 a	8.08 a	9.42 a	11.42 a	12.42 a
P3	3.58 a	5.25 a	8.00 a	9.33 a	11.33 a	12.33 a
P4	3.58 a	5.25 a	7.92 a	9.33 a	11.33 a	12.33 a
P5	3.58 a	5.08 a	7.92 a	9.25 a	11.25 a	12.25 a
$DMRT_{(0.05)}$	0.25	0.47	0.10	1.40	1.33	1.33
CV(%)	0.16	0.19	0.46	0.22	0.24	0.24

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

I. cylindrica weed, demonstrated maximum efficacy in inhibiting leaf growth in maize plants throughout observations at 2, 3, 4, 5 and 6.

Number of offspring on *Rottboellia exaltata* weed

Observations on the number of offspring in *R. exaltata* weed were conducted at 1, 2, 3, 4, 5 and 6 WAS. The data were analyzed using ANOVA at a 95% confidence level. The DMRT test results for the number of offspring in *R. exaltata* weed are presented in Table 5.

Table 5 indicates that the DMRT Test findings for the parameter of offspring quantity in *R. exaltata* weed reveal no significant differences in observations at 1 WAS. In contrast, observations at 2, 3, 4, 5 and 6 WAS exhibit significant differences. Treatment P5 with *I. cylindrica* weed concentration of 100% in observations at 2, 3, 4, 5 and 6 is the best treatment for suppressing the growth of the number of offspring on *R. exaltata* weed.

Imperata cylindrica extract treatment with 100% concentration showed the highest suppression of the number of offspring on *R. exaltata* among the other treatments. According to a study, the symptoms of this damage occur due to allelopathic toxicity, which disrupts physiological processes, including water and nutrient absorption, water stress, phytohormone metabolism, respiration and photosynthesis (37). So the number of offspring on *R. exaltata* given *I. cylindrica* extract produced the number of offspring on *R. exaltata* than other treatments.

Table 5. Average of number of offspring on *Rottboellia exaltata* weed given *Imperata cylindrica* extract

Treatment	Average of Number of Offspring on *Rottboellia exaltata* Weed (Piece)					
	1 WAS	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS
P0	0 a	2.63 a	5.27 c	7.67 d	10.67 d	14.77 c
P1	0 a	2.60 a	4.97 bc	7.30 cd	10.30 cd	14.27 c
P2	0 a	2.50 a	4.63 abc	6.52 bc	9.52 bc	12.57 b
P3	0 a	2.48 a	4.38 abc	5.97 ab	8.87 ab	11.87 b
P4	0 a	2.33 a	3.93 ab	5.67 ab	8.63 ab	10.72 a
P5	0 a	2.32 a	3.78 a	5.35 a	8.35 a	10.23 a
$DMRT_{(0.05)}$	**0**	**0.19**	**3.17**	**7.54**	**8.58**	**32.39**
CV(%)	**0**	**0.59**	**0.79**	**1.02**	**1.02**	**1.79**

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

Percentage of leaf damage on Rottboellia exaltata weed

The examination of the % of leaf damage on *R. exaltata* weed 3, 4, 5 and 6 WAS was subsequently conducted using ANOVA with a confidence level of 95%. The results of the DMRT Test for the % of leaf damage on *R. exaltata* weed are presented in Table 6.

Table 6 indicates that the DMRT Test results for the % of leaf damage on *R. exaltata* weed demonstrate significant differences in observations at 3, 4, 5 and 6 WAS. Treatment P5, utilizing a 100% concentration of *I. cylindrica*, exhibited the most effective results for *R. exaltata* leaf damage, recording a damage value of 25.83 at WAS observation for assessments 3, 4, 5 and 6.

Table 6. Average of the percentage of leaf damage on *Rottboellia exaltata* weed given *Imperata cylindrica* extract

Treatment	Average of the Percentage of Leaf Damage on *Rottboellia exaltata* Weed (%)			
	3 WAS	4 WAS	5 WAS	6 WAS
P0	0.00 a	0.00 a	0.00 a	0.00 a
P1	0.58 b	0.83 b	3.67 b	8.17 b
P2	0.83 b	1.58 c	4.17 b	13.92 c
P3	1.42 c	1.75 c	6.92 c	18.25 d
P4	2.08 d	2.75 d	9.58 d	24.58 e
P5	2.58 e	3.08 e	10.33 e	25.83 e
$DMRT_{(0.05)}$	97.83	308.57	514.17	287.34
CV(%)	0.92	1.09	3.67	9.31

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

Percentage of leaf damage in maize

The percentage of leaf damage in maize at 3, 4, 5 and 6 WAS was examined. The results of the DMRT Test for the percentage of leaf damage on maize weed are presented in Table 7.

Table 7 indicates that the DMRT Test results for the % of leaf damage on maize reveal substantial differences in observations at 3, 4, 5 and 6 WAS. Treatment P5, with a 100% concentration of *I. cylindrica* weed, demonstrated the most effective results for maize leaf damage at observations 3, 4, 5 and 6, with a recorded damage value of 32.92% at 6 WAS.

Fresh weight and dry weight *Rottboellia exaltata* weed

The results of observing the fresh and dry weights *of R. exaltata* weed were then continued. The analysis used was ANOVA with a confidence level of 95%. The results of the DMRT Test for the fresh and dry-weight *R. exaltata* weed are presented in Table 8.

Table 7. Average of the percentage of leaf damage on maize given *Imperata cylindrica* extract

Treatment	Average of the Percentage of Leaf Damage on Maize (%)			
	3 WAS	**4 WAS**	**5 WAS**	**6 WAS**
P0	0.00 a	0.00 a	0.00 a	0.00 a
P1	0.00 a	1.67 b	9.58 b	13.33 b
P2	1.25 b	2.50 b	11.25 bc	17.50 c
P3	1.67 b	3.75 c	13.75 cd	23.75 d
P4	2.92 c	4.17 cd	16.25 d	27.50 e
P5	3.75 c	5.00 d	19.58 e	32.92 f
$DMRT_{(0.05)}$	**27.98**	**27.67**	**39.57**	**186.54**
CV(%)	**1.51**	**1.80**	**6.62**	**11.00**

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

Table 8 indicates that the DMRT Test findings for the fresh and dried weights of *R. exaltata* weed reveal no significant differences at 1 WAS. In contrast, significant differences are observed at 2, 3, 4, 5 and 6 WAS. Treatment P5, with a 100% concentration of *I. cylindrica* extract, was the most effective in suppressing the fresh and dry weight of *R. exaltata* weed, as observed at 2, 3, 4, 5 and 6 WAS. This effect is illustrated in Fig. 1.

Administration of *I. cylindrica* weed extract caused symptoms of chlorosis, necrosis, growth inhibition and a decrease in the fresh weight and dry weight of *R. exaltata* weed. The decrease in the fresh weight and dry weight of the *R. exaltata* weed was due to the loss of the roots' ability to absorb water and nutrients, inhibition of photosynthesis, blockage of phloem, disruption of meristematic cell division and stoppage of cell elongation. The damage mechanism of *I. cylindrica* is attributed to secondary metabolites that significantly inhibit weed germination by elevating peroxide compound levels in the roots, resulting in oxidative stress that diminishes both the fresh and dry weight of *R. exaltata* (38).

Conclusion

In conclusion, the study establishes the efficacy of 100% *I. cylindrica* extract, especially in the P5 treatment, in inhibiting *R. exaltata* growth. It significantly reduced weed height by 29.59%, leaf number by 27.68%, offspring by 30.69% and caused leaf damage of 25.83% in the weed and 32.92% in maize. Additionally, it decreased the fresh and dry weights of the weed by 18.89% and 23.43% respectively. These results underscore its potential as an effective, sustainable herbicide.

Fig. 1. Giving *I. cylindrica* extract to the fresh weight of *R. exaltata* weed.

Table 8. Average of fresh weight weed and dry weight weed given *Imperata cylindrica* extract

Treatment	Fresh Weight Weed (g)	Dry Weight weed (g)
P0	90.83 d	31.75 d
P1	83.33 c	23.33 c
P2	81.58 bc	21.83 bc
P3	77.83 ab	17.92 ab
P4	74.25 a	14.33 a
P5	73.67 a	13.83 a
$DMRT_{(0.05)}$	**21.47**	**17.88**
CV(%)	**6.47**	**6.83**

Note : **P0**=Control, **P1**=20% concentration of *I. cylindrica* extract, **P2**=40% concentration of *I. cylindrica* extract, **P3**=60% concentration of *I. cylindrica* extract, **P4**=80% concentration of *I. cylindrica* extract and **P5**=100% concentration of *I. cylindrica* extract. **DMRT** = Duncan's Multiple Range Test at 5% level and **CV%** = coefficient of variation

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Authors' contributions

AM conceived the study, coordinated the team, collected soil, sterilized soil, prepared the planting media and drafted the manuscript. MA contributed to the research by collecting weed and maize data and drafting the manuscript. IY performed the statistical analysis and drafted the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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