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Allelopathic Potential of *Centella asiatica* Leaves on Seed Germination and Seedling Growth of Selected Field Crops

M. K. Kemboi[1*], P. Jeruto[1], L. Mwamburi[1] and R. Korir[2]
[1]*Department of Biological Sciences, University of Eldoret, Kenya*
[2]*Kenya Medical Research Institute (KEMRI)*
**Corresponding Author's Email: moses.kemboi.mk@gmail.com*

Abstract

Centella asiatica is a small, faintly aromatic, greenish-yellow leafy ubiquitous herbaceous plant of the Apiaceae family. It is a member of a weed community termed Hydrocotylo-Centelletum asiaticae association. Losses due to weeds have been estimated to be even more than those caused by insect pests and diseases. The objective of this study was to determine the allelopathic potential of Centella asiatica. Plant leaves were collected, shade dried followed by extraction using water and ethanol. The extracts were tested against maize, oats, rice, sorghum and wheat seeds. Ten (10) surface sterilized seeds were placed in each Petri dish. 25 millilitres of test extracts were used with double distilled water set as positive control and DMSO set as negative control. This was laid out in a Completely Randomized Design (CRD) with three replications at 25±2°C. The emerged plumule and radicle lengths were recorded after five (5) days and germination percentages calculated. The aqueous and ethanol extracts of Centella asiatica exhibited significant inhibitory effect on plumule and radicle lengths of maize, oats, rice, sorghum and wheat (p = 0.0000). On the number of seeds germinated, it showed increasing number of seeds germinated with reducing concentration of extracts. Oats and wheat did not germinate on ethanol extracts. Maize had the highest germination percentage of 97.5 while oats had the lowest of 24.17 in aqueous extracts. The ANOVA p-values of 0.0000 means that the leaf extracts of Centella asiatica had a statistically significant effect on plumule and radicle lengths of the test plants at P ≤ 0.05. It suggests that the extracts of C. asiatica interfered with the germination and growth of the test plants. This implies that there is a high likelihood for poor growth performance of these major staples in the presence of C. asiatica. The good allelopathic activity of C. asiatica can be utilised for making herbicides crucial for weed control. The results of study may be used to assess allelopathic potential against other field crops as well as further studies on the growth and development.

Keywords: Allelopathy, Allelochemicals, *Centella asiatica*, Weeds and Seed germination

INTRODUCTION

Centella asiatica is a small, faintly aromatic, greenish-yellow leafy ubiquitous herbaceous plant of the *Apiaceae* family. This perennial, herbaceous creeper with kidney shaped leaves can attain a height of up to 6 inches and flourishes in shady, marshy, damp as well as wet places such as paddy fields, river banks forming a dense green carpet (Singh et al., 2015). *C. asiatica* is a member of a weed community termed *Hydrocotylo-Centelletum asiaticae* association dominated by *C. asiatica* and *Hydrocotyle mannii* (Mbokuyo, Mosango, 2017).

Weeds are a diverse group of non-economic plants that grow in places where they are not required or may grow in association with crops causing economic losses like reduced yields through competition or releasing allelochemicals, in a process known as allelopathy (Anwar et al., 2019). Allelochemicals may influence the survival, germination, reproduction as well as growth and development of neighboring plants directly or indirectly (Nazir et al., 2014). Allelopathic interactions is an important factor in determining species distribution and abundance within plant communities that is necessary in the success of invasive plants, a common characteristic of most weeds (Nazir et al., 2014).

Weeds alter the normal growth and cause a reduction in the yield of crops by interfering with different metabolic processes stemming from weed-crop competition and allelopathy (Anwar et al., 2019). Most studies have undermined yield losses due to weed-crop allelopathic interactions (Ali et al., 2015). There is limited information that emphasized the injurious effects of weeds on crops due to weed-crop allelopathic interactions even though losses due to weeds have been estimated to be even more than those caused by insect pests and diseases (Zohaib et al., 2016). It is estimated that weeds may cause reduction in the yields of field crops, depending on the types of weeds, weed density, management practices, duration of the competition as well as weather conditions (Zohaib et al., 2016).

This study determined the allelopathic potential of *Centella asiatica* leaf extracts on seed germination and seedling growth of maize, oats, rice, sorghum and wheat.

MATERIALS AND METHODS

Centella asiatica leaves were identified and collected under shaded areas and on moist soils near ponds, rivers, in ruderal areas and abandoned cultivation areas within Nandi County. They were then transported to the UOE Laboratory, hand washed in tapped water 2-3 times and then be placed on stands to be air-dried in a shed. They were turned daily to allow even circulation of air and complete dryness. The dried leaves were then ground using an electronic grinder to make fine powder. The samples were then placed in sterile sample collection containers, labelled and stored in awaiting further analysis.

Two hundred and fifty grams of *C. asiatica* crushed leaf powders were soaked in 1000 ml of aqueous and ethanol in separate conical flasks for 48 hrs. Dilutions of extracts with double distilled water were also prepared for concentrations of 10^0 to 10^{-3}. Before germination test, the seeds were first surface sterilized using 1% sodium hypochlorite (NaOCl) for 1 minute, then rinsed twice with double distilled water to remove excess chemical. Allelopathic effects of aqueous and ethanolic extracts on seed germination and seedling growth was tested by placing seeds of maize, oats, rice, sorghum and wheat in petri dishes.

The effect of the plants' extracts on germination was determined by placing 10 surface sterilized seeds in each Petri dish. Twenty-five millilitres of test extracts were then poured into it. The petri dishes treated with distilled water were set as positive control with those with DMSO set as negative control. The experiment was laid out in a Completely Randomized Design (CRD) with three replications for each plant extracts and test seed species. The setup was then left undisturbed at room temperature (25±2°C) in the laboratory. The emerged plumule and radicle lengths were recorded after 5 days. The number of seeds germinated was also counted after 5 days and the germination percentage calculated using the formula below:

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds}} \times 100$$

The germination percentage, plumule and radicle lengths were used as parameters for determining the allelopathic potential. Plant extract effect on plumule and radicle lengths was determined using analysis of variance (ANOVA) and considered statistically significant at $P \leq 0.05$.

RESULTS

Allelopathic Potential of Aqueous Extracts

Effects on Germination Percentages

The number of germinated seeds after five days was used to calculate the germination percentages of each plant species. Both the number of germinated seeds and germination percentages are shown in Table 1 below.

Table 1: Number of seeds germinated in aqueous extracts after five days

Plant	10^0	10^{-1}	10^{-2}	10^{-3}	Total	Germination%	+ve	-ve
Maize	29	29	30	29	117	97.5	120	0
Oats	3	7	5	14	29	24.17	119	0
Rice	21	28	30	29	108	90	120	0
Sorghum	29	27	29	28	113	94.17	120	0
Wheat	11	19	14	19	63	52.5	120	0

Maize had the highest germination percentage of 97.5 in aqueous extracts while oats had the lowest germination percentage of 24.17 respectively. Sorghum, rice and wheat had 94.17%, 90% and 52.5% respectively (Table 1). The results also showed increasing number of seeds germinated with reducing concentration of extracts.

Effects on Plumule Length

The highest reduction in the plumule length was observed in oats (63.29%) with the lowest reduction being in wheat (16%). The aqueous extracts also inhibited the plumule length of maize (46.15%), sorghum (32.38%) and rice (28.21%) as compared to control on distilled water. Figure 1 shows the mean plumule lengths (cm).

The ANOVA p-value of 0.0000 at 95.0% confidence level means that the aqueous leaf extracts of *Centella asiatica* had a statistically significant effect on plumule length at $P \leq 0.05$.

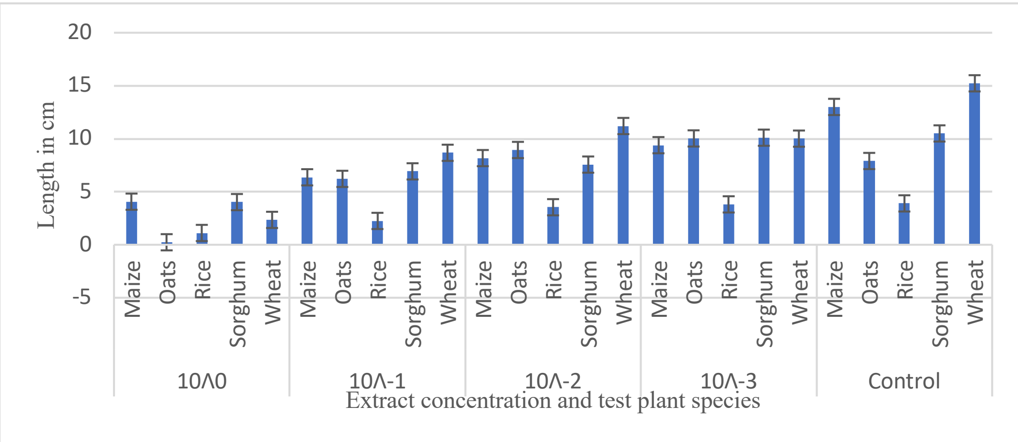

Figure 1: Effects of aqueous leaf extracts of *Centella asiatica* on Plumule lengths.

Effects on Radicle Length

The highest reduction in the radicle length was observed in sorghum (52.81%) while the lowest reduction being in rice (0%). The aqueous extracts also inhibited the radicle length of wheat (35.56%), oats (26%) and maize (12.24%) as compared to control on distilled water. Figure 2 shows the mean radicle lengths (cm). The ANOVA p-value of 0.0000 at $P \leq 0.05$ means that the aqueous leaf extracts of *C. asiatica* had a statistically significant effect on radicle lengths.

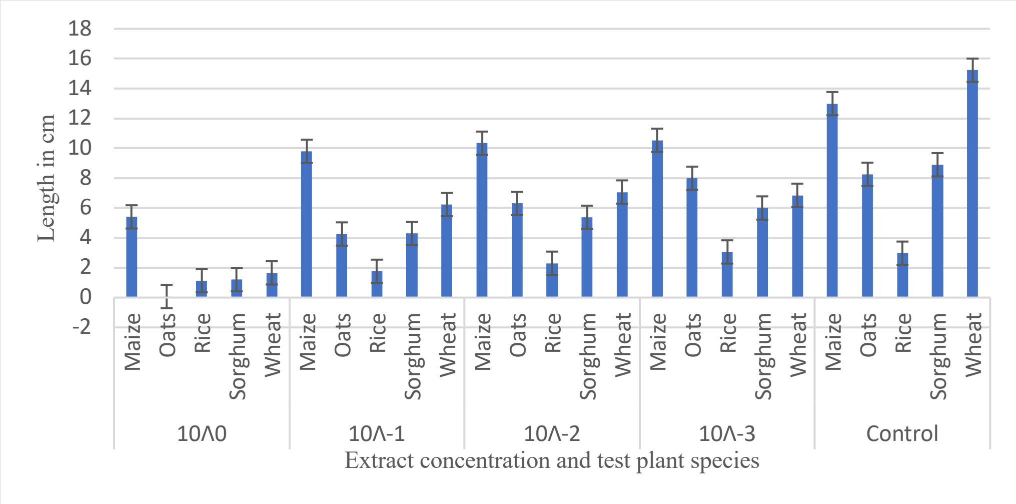

Figure 2: Effects of aqueous leaf extracts of *Centella asiatica* on Radicle lengths.

Allelopathic Potential of Ethanolic Extracts

Effects on Germination Percentages

Oats and wheat did not germinate in ethanolic extracts. The number of germinated seeds after five days was used to calculate the germination percentages of each plant species. The number of germinated seeds and germination percentages are shown in Table 2.

Table 2: Number of seeds germinated in ethanolic extracts after five days

Plant	10^0	10^{-1}	10^{-2}	10^{-3}	Total	Germination%	+ve	-ve
Maize	15	21	27	24	87	72.5	120	0
Oats	0	0	0	0	0	0	120	0
Rice	10	17	19	24	70	58.33	120	0
Sorghum	21	24	24	26	95	79.17	120	0
Wheat	0	0	0	0	0	0	120	0

Sorghum had the highest germination percentage of 79.17 in ethanolic extracts *C. asiatica* followed by maize with 72.5 while rice had the lowest germination percentage of 24.17 (Table 2). The results of germination percentages also showed increasing number of seeds germinated with reducing extracts concentration.

Effects on Plumule Length

The ethanolic extracts of *C. asiatica* inhibited the plumule length of maize by 42.69%, followed by sorghum at 17.86% with the lowest reduction being in rice (2.7%) when compared to control on distilled water. Wheat and oats seeds did not germinate in ethanolic extracts of *C. asiatica*. Figure 3 shows the mean plumule lengths (cm).

The ANOVA p-value of 0.0000 at 95.0% confidence level means that ethanolic leaf extracts of *Centella asiatica* had a statistically significant effect on plumule lengths at $P \leq 0.05$.

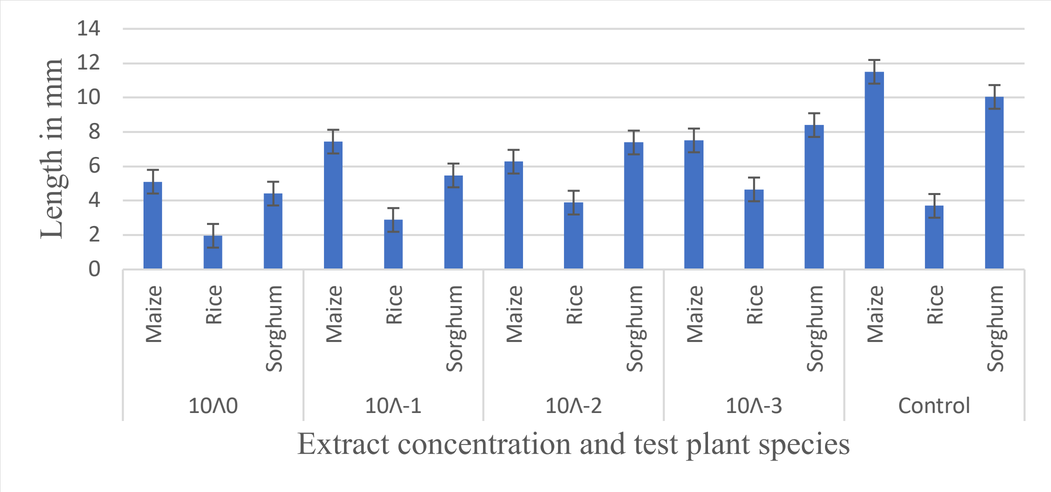

Figure 3: Effects of ethanol leaf extracts of *Centella asiatica* on Plumule lengths.

Effects on Radicle Length

The highest reduction in the radicle length was observed in sorghum (35.29%), followed by maize (25.93%) with the lowest reduction being in rice (10.34%) when compared to control on distilled water. Figure 4 shows the mean radicle lengths (cm).

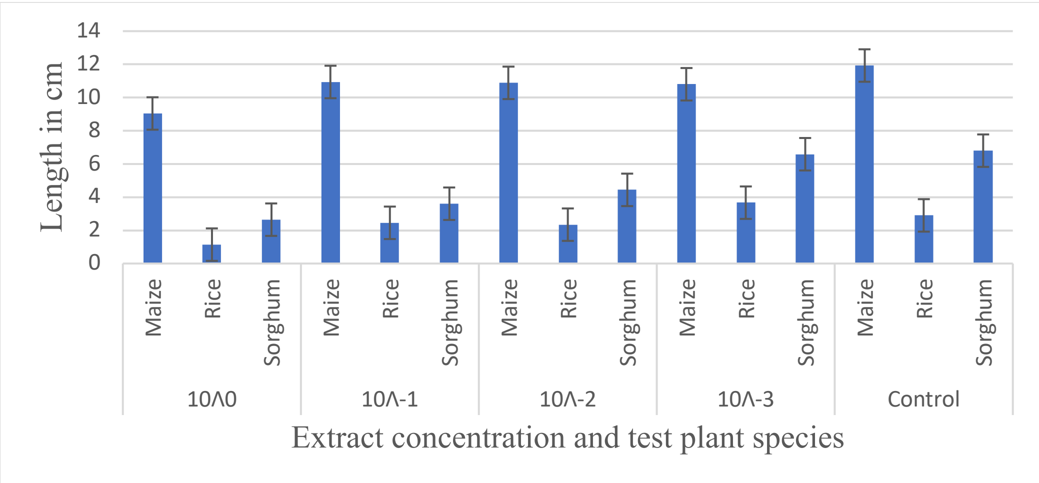

Figure 4: Effects of ethanol leaf extracts of *Centella asiatica* on Radicle lengths.

The ANOVA p-value of 0.0000 at 95.0% confidence level means that ethanolic leaf extracts of *C. dxasiatica* had a statistically significant effect on radicle length at $P \leq 0.05$.

DISCUSSIONS

The present study was conducted to understand the effect of *Centella asiatica* leaf extract on seed germination, radical length and plumule lengths of the selected field crops. The results showed that *C. asiatica* leaf extracts decreased germination percentages, radical length and plumule lengths of the test field crops as the extract concentration increases which concurs with Raoof & Siddiqui (2012). All the p-values were less than 0.05 at 95.0% confidence level. The p-values clearly indicate that the plumule and radicle lengths were affected significantly at $P \leq 0.05$. This therefore implies that *C. asiatica* leaf extracts can be used to control growth of the test plants used in the study. These results are consistent with other studies. Alagesaboopathi (2018) tested the effects of leaf and stem extracts of *C. asiatica* on fresh and dry weight in rice and reported that the plumule and radicle lengths were significantly reduced. The author also reported similar results on pearl millet and cow pea using aqueous extracts of *C. asiatica* (Alagesaboopathi, 2010).

Since *C. asiatica* grows as a weed, results of this study can also be compared to studies on other weeds. Alagesaboopathi (2013) tested the water extract of *Argemone mexicana* L. on seed germination and seedling growth of *Sorghum bicolor* (L.) Moench. The author reported a reduction of 30% and 49% in plumule and radicle lengths respectively. Majeed et al. (2012) and Mandal *et al.* (2016) tested the effects of weeds extracts on wheat. Aqueous extracts of *Chenopodium album* L. significantly suppressed the plant height of wheat corresponding to lower grain yield (Majeed et al., 2012). Mandal et al. (2016) on the other hand reported that aqueous leaf extracts of *Andrographis paniculata* nees decreased the shoot and root length as well as dry weight of wheat. Alagesaboopathi & Thamilazhagan (2010), reported that leaves and stem extracts of *Andrographis lineata* decreased significantly seedling growth and germination percentages of green gram and balckgram. Similar results have also reported using extracts of *Andrographis paniculata* on *Sesamum indicum* L. (Alagesaboopathi, 2011).

Allelopathic potential of different plant species as evident in this study, can be utilized as alternative weed management methods. That would greatly improve crop production, eliminating the use of environmentally harzadious herbicides use as well as decreasing the costs of production. Some studies have highlighted the use of allelochemicals in weeds control. Anwar et al. (2019) reported leaf extracts of *Carica papaya* against major weeds of wheat. The extracts inhibited seed germination of *Euphorbia helioscopia* (50%), *Phalaris minor* (45%) and *Avena fatua* (41%).

Raoof & Siddiqui (2012) tested the germination of weeds *Chenopodiastrum murale L., Chenopodium album L., Cassia tora L.* and *Cassia sophera L.* against aqueous extracts of *Tinospora cordifolia*. The author reported that aqueous root and aerial root extracts had a significant inhibitory effect on seed germination of test plants. Extracts from different parts of *Brassica nigra* have also been documented to inhibit the germination and radicle length of wild oat (Turk & Tawaha, 2003). Extracts of *Raphanus sativus* were tested on germination of different weed species with the author reporting that the extracts completely inhibited germination of *Alopecurus myosuroides*, *Alhagi sp.*, *Capsella bursa-pastoris*, *Cuscuta sp.*, *Sorghum halepense* and *Sisymbrium polyceratium* (Das et al., 2021).

Although not established in the current study, previous studies have alleged that extracts from weeds may possess some plant growth inhibitors and phototoxic chemicals which are involved in allelopathy (Raoof & Siddiqui, 2012). They include growth regulators, some nutrients, alkaloids, phenols, tannins, saponins, sterols and toxins (Mandal et al., 2016; Alagesaboopathi, 2018). All these compounds and the complex processes results in the allelopathic effects of some plant species which are weedicidal and would greatly improve crop production and food security when utilized for agronomic application.

CONCLUSION AND RECOMMENDATIONS

The present study has put to light the allelopathic potential of aqueous and ethanol extracts of *C. asiatica* against maize, oats, rice, sorghum and wheat. The results showed that the extracts had a statistically significant inhibitory effect on seed germination as well as plumule and radicle lengths of the test plants. This implies that there is a high likelihood for poor growth performance of maize, oats, rice, sorghum and wheat which are major staples in the presence of *C. asiatica*. This can lead to food insecurity and financial losses to farmers. Despite that, this study concluded that the good allelopathic activity of *C. asiatica* can be utilised for making herbicides crucial for weed control.

This study recommends assessing for allelopathic potential against other field crops not just maize, oats, rice, sorghum and wheat. It's also important for the effects on the growth and development to be explored. There is also a necessity for further studies to identify the inhibiting allelochemicals of weeds which can be used in developing environmentally friendly products for controlling growth of other plant species.

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