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Evaluation of Allelopathic Influence of *Calotropis procera* on Seed Germination and Seedling Growth of Some Range Plant Species

Wafa'a A. Al-Taisan

Department of Biology, Girls College of Science, Dammam University, Saudi Arabia

Abstract: The present study was conducted to investigate the allelopathic effects of *Calotropis procera* on seed germination and seedling growth of eight range plant species in Saudi Arabia. Leaf aqueous extracts from *Calotropis procera* at 5, 10, 30, 50 and 100% concentrations were applied to determine their effect on seed germination and seedling growth under laboratory conditions. The effects of different concentrations of aqueous extract were compared to distilled water (control). The results showed that the extracts brought about considerable inhibition in the seeds germination of the tested plants and in the growth of its radicle and plumule. The final germination percentage and rate of germination in the extract-treated seeds were decreased with the increase in the concentration of the extracts thus indicating that the degrees of inhibition were concentration dependent. The highest inhibitory effect was found in *Salsola vermiculata, Salsola cyclophylla, Salsola maritimus*, *Atriplex leucoclada* and *Haloxylon salicornicum* and no germination found in *Traganum nudatum* and *Ranterium epapposum* at all treatment. It was apparent that *Calotropis procera* extracts had more inhibitory effects on seeds of the tested plants and no germination observed of all selected species at treatment 100%. Hence, it could be concluded that the *Calotropis procera* leaf aqueous extract containing water-soluble allelochemicals could inhibit the seeds germination and reduce radicle length of some range plant species. Inhibitory effect was more pronounced in radicle length rather than germination. Radicle length was relatively more sensitive to allelochemicals of *Calotropis procera* than was in plumule length. These results have some practical importance when selecting for species in revegetation programs in *Calotropis procera* -dominated sandy areas. However, more work is needed to determine ecological requirements of seedling survival and establishment of that the range plant species as well as investigating the sensitivity of the allelopathic factors.

Key words: Allelopathy · Seed germination · *Calotropis procera* · Range plants

INTRODUCTION

Calotropis procera (Ait.) Ait.f. (*Asclepidaceae*) Shurb with copious latex, widely distribution in Asia and Africa and can survive over abroad range of altitudes [1]. The species is commonly found in the sandy warm parts of Saudi Arabia, especially in the western coastal plain (Tehama plain) [2]. The seeds of *Calotropis procera* don't go through a dormant period and can germination fast if proper water and temperature are available [3,4]. This plant is often considered to be poisonous, used in some tropical countries in the preparation of arrow poisons. Various alkaloids or other principles toxic. Apowerful cardiac poison, cause blisters and rash in sensitive person [5,6]. The plant not used as forage because of its milky poisonous sap, but it is used in folk medicine for the temperature such as the relief of rheumatic pain and swelling [7]. Allelopathy is a process by which a plant releases chemicals that can either inhibit or benefit other plants and are generally evaluated by testing some physiologic mechanisms that result in the inhibition/stimulation of seed germination, plant growth and development due to the presence of another plant [8,9]. Allelochemicals are present in almost all plants and their tissues such as leaves, stems, roots, flowers, seeds, bark and buds [9], from where they are released to the soil through volatilization, root exudation, leaching and decomposition of plant residues [10,11]. Since most allelopathic plants cause harm to other plants. Allelopathy is effects of compounds excreted from the plant to get rid of some other neighboring plants or to stop their seed germination and growth. These compounds cause

Corresponding Author: Dr. Wafa'a Al-Taisan, Department of Biology, Girls College of Science, Dammam University, P.O. Box 838, Dammam 31113, Saudi Arabia

disturbance in the different activities of the receptor plant. *C. procera* is one of the widely distributed plants throughout the different areas of Saudi Arabia. Such phenomena may be governed by direct competition for necessary growth factors or through addition of allelopathic chemicals into the soil environment [10].

The allelopathic effects of some plants were studied including germination inhibition [12-15]. Allelochemicals inhibit seed germination by blocking hydrolysis of nutrients reserve and cell division [16] and cause reductions in the growth of plumule and radicle [17-20], retardation of seedling growth [21-23] and poor seedling survival [24,25]. Allelopathy has been suggested as a mechanism for the impressive success of invasive plants by establishing virtual monoculture and may contribute to the ability of particular exotic species to become dominants in invaded plant communities [26,27]. Allelopathy is expected to be an important mechanism in the plant invasion process because the lack of co-evolved tolerance of resistant vegetation to new chemicals produced by the invader could allow these newly arrived species to dominant natural plant communities [27]. In fact, allelopathic interference is one of the important mechanisms for the successful establishment of invasive exotic weeds [28] some plant of extracts may be used as herbicide to control the germination and growth of some other weeds [29]. Weidenhamer, *et al*. [30] suggested that allelopathic effect might be intensified in natural communities where overall plant densities are lower for example because of harsh environmental conditions and other constraints. Therefore, the objective of the current study was to determine the allelopathic potential of *C. procera* leaves extract on seed germination and seedling growth of eight range plant species in Saudi Arabia.

MATERIALS AND METHODS

Preparation of C. Procera Leaves Extract: The leaves extract of *C. procera* plants were air-dried for two weeks after which they were pounded using a mortar and pestle. Portions of 5, 10, 30, 50 and 100g, each of the crop residues were measured out and each was soaked in 200ml of distilled water for 24 hours at room temperature (23±2°C). The extracts were filtered and the filtrates used a fresh either as such or stored in a freezer for further use.

Experimental Design: Eight of range plant species were chosen for this study, they are Wildlife plants commonly planted in different areas in Saudi Arabia and which are:

- (Qataf) *Limonium axillare* (Forssk.)O.Kuntze. Family: *Plumbaginaceae*.
- (Ruth) *Salsola vermiculata* L.s.I. Family: *Chenopodiaceae*.
- (Arad) *Salsola cyclophylla* Bak. Family: *Chenopodiaceae*.
- (Dumran) *Traganum nudatum* Del. Family: *Chenopodiaceae*.
- (Arfaj) *Ranterium epapposum* Oliv. Family: *Compositae*.
- (Faras) *Sonchus maritimus* L. Family: *Compositae*.
- (Rughl) *Atriplex leucoclada* Boiss. Family: *Chenopodiaceae*.
- (Rimth) *Haloxylon salicornicum* (Moq.)Bge. Family: *Chenopodiaceae*.

Seeds of all selected species were obtained from the Camel and Range Research Centre, Saudi Arabia. The seeds were germinated on double-layered with Whatman No. 1 filter papers placed in 10cm diameter plastic dishes. The filter papers were moistened daily with the five different concentrations of the extracts was used. Control experiments whose filter papers were moistened with distilled water were set up(25 seeds each). Treatments were arranged in a completely randomized design with four replications. All of the Petri dishes were kept in dark incubators maintained at room temperature at 27°C. Germination was determined by counting the number of germinated seeds at 24 hours. The germinated seeds were recorded every day for a period of 15 days. In addition, growth of the radicle and the plumule was recorded for 5 days starting from the first day of emergence. Germination was expressed as the final percentage of germination and rate of germination was calculated by dividing the number of germinated seed each day by the number of days according to the method of Maguire [31].

Statistical Analysis: The results obtained from the extract-treated seeds were compared statistically to those obtained from the control experiments at $P<0.0001$ applying post hoc Dunnett's test. All values are expressed as mean± SEs. Statistical analysis was done with SPSS 11.0 for Windows statistical software package.

RESULTS

Germination: The allelopathic effect of the aqueous extract from *C. procera* on the germination of eight selected species is shown in Table 1 and the rate of seed germination in Table 2. The maximum seed germination

Table 1: Effect of the different aqueous extract from *C. procera* on the final seeds germination percentage of some range plant species

	Concentration of leaf extraction				
Plant name	0%	10%	30%	50%	100%
Limonium axillare	100.00±0.00	12.00±1.50	7.00±1.00	5.00±1.00	0.00
Salsola vermiculata	81.00±2.52	7.00±1.91	5.00±1.00	3.00±1.00	0.00
Salsola cyclophylla	84.00±1.63	9.00±1.91	5.00±1.00	0.00	0.00
Traganum nudatum	50.00±2.58	0.00	0.00	0.00	0.00
Ranterium epapposum	67.00±1.91	5.00 ±1.00	0.00	0.00	0.00
Sonchus maritimus	79.00±1.00	8.00±2.31	2.00±1.15	0.00	0.00
Atriplex leucoclada	73.00±1.00	4.00±0.00	0.00	0.00	0.00
Haloxylon salicornicum	71.00±1.91	8.00±2.31	4.00±0.00	3.00±1.00	0.00

Table 2: Effect of the different aqueous extract from *C. procera* on the seed germination rate(% day-1) of some range plant species

	Concentration of leaf extraction				
Plant name	0%	10%	30%	50%	100%
Limonium axillare	0.61±0.01	0.62±0.10	0.35±0.01	0.28±0.03	0.00
Salsola vermiculata	0.61±0.04	0.56±0.26	0.23±0.08	0.13±0.01	0.00
Salsola cyclophylla	0.44±0.013	0.21±0.07	0.53±0.22	0.00	0.00
Traganum nudatum	0.51±0.01	0.00	0.00	0.00	0.00
Ranterium epapposum	0.58±0.02	0.23±0.08	0.00	0.00	0.00
Sonchus maritimus	0.48±0.02	0.28±0.01	0.13±0.01	0.00	0.00
Atriplex leucoclada	0.60±0.02	0.24±0.04	0.00	0.00	0.00
Haloxylon salicornicum	0.57±0.02	0.24±0.02	0.24±0.04	0.33±0.13	0.00

percentage was shown at control of *L. axillare* 100% in 7th day (Table 1). The highest inhibitory effect was found in *S. vermiculata*, *S. cyclophylla*, *S. maritimus*, *A. leucoclada* and *H. salicornicum* and no germination found in *T. nudatum* at all treatment, while reached 5% in *R. epapposum* at 10%. The rate of germination of *L. axillare* at the first day for10, 30, 50 and 100 concentrations respectively were 0% compared to the control, 40%, (Figure 1), while the rate of germination percentages for *S. vermiculata*, *H. salicornicum*, *A. leucoclada*, *R. epapposum*, *S. maritimus*, *S. cyclophylla* and *T. nudatum* were 0% at the first day in all treatments compared to the control with 33, 29, 28, 26, 24, 16 and 15% respectively (Figure 1). On the other hand, there is a pronounced effect of the aqueous extract from *C. procera* on the *A. leucoclada*, *S. maritimus* seeds. The germination was delayed for one day at 10 and 30 % respectively, while was delayed tow days at the 50% concentration. However, the percentage seed germination decreased with increasing concentration of aqueous leaf extract of *C. procera* for the all treatments. The highest germination rates were observed at control treatment in all selected species.

Radicle Elongation: Effect of the aqueous extract from *C. procera* on the radicle length (cm.) of eight range plant species is shown in Table 3. The highest radicle length was recorded in the control treatment of all selected species. It reached 8.11, 7.78 and 6.00cm in three plants *S. maritimus*, *L. axillare* and *H. salicornicum* respectively. Then decreased by increasing leaf extract concentration, it reached 0.96 and 0.96cm in *L. axillare* and *H. salicornicum* respectively at 50% (Table 3). However, the radicle of *T. nudatum* and *R. epapposum* have no emergence at 10, 30, 50 and100 respectively. Also, no emergence for the radicle of *A. leucoclada* at 30, 50 and 100 respectively. All plant parameters measured were reduced with the increase in different extract concentrations.

Plumule Length and Emergence: The results of the tests conducted on the effects of the different aqueous extracts from the *C. procera* on the plumule length (cm.) of eight range plant species are shown in Table 4. The results revealed that the growths of the radicle in the extract-treated seeds were retarded when compared to the control. The degree of retardation increased with

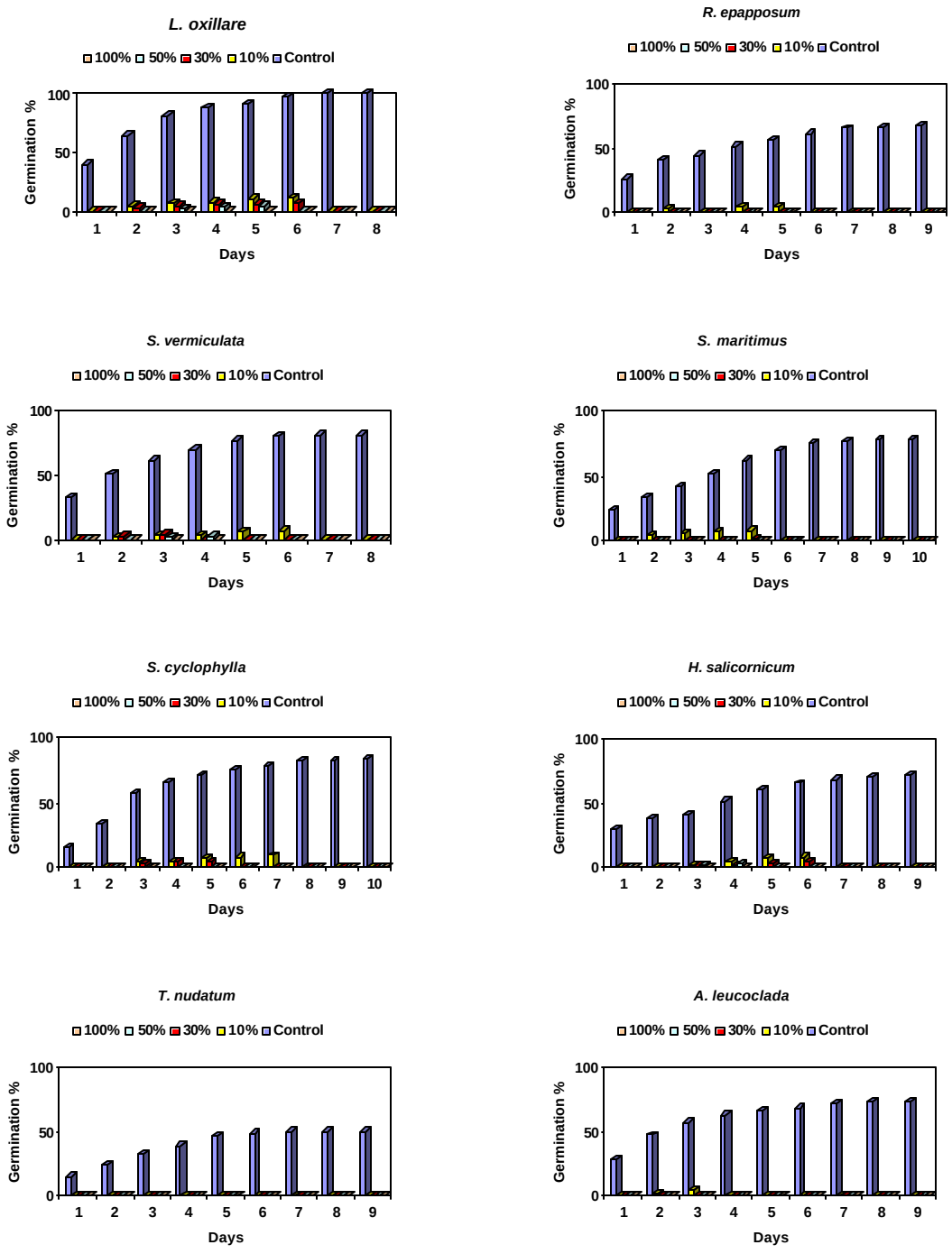

Fig. 1: Effect of the different aqueous extract from *C. procera* on the seed germination rate (% day-1) of some range plant species

Table 3: Effect of the aqueous extract from *C. procera* on the Radicle Length (cm.) of eight range plant species

	Concentration of leaf extraction				
Plant name	0%	10%	30%	50%	100%
Limonium axillare	7.78±2.03	5.01±0.00	3.43±1.66	0.96±0.15	-----
Salsola vermiculata	4.91±1.30	3.22±0.22	1.43±0.22	-----	-----
Salsola cyclophylla	4.58±2.00	2.10±0.22	0.66±0.15	-----	-----
Traganum nudatum	3.30±2.22	----	----	-----	-----
Ranterium epapposum	5.61±3.80	----	----	-----	-----
Sonchus maritimus	8.11±3.27	7.14±2.03	3.66±1.35	-----	-----
Atriplex leucoclada	5.90±3.83	5.54±1.66	----	-----	-----
Haloxylon salicornicum	6.00±2.00	4.30±2.31	2.25±0.22	0.60±0.00	-----

Table 4: Effect of the aqueous extract from *C. procera* on the plumule length (cm.) of eight range plant species

	Concentration of leaf extraction				
Plant name	0%	10%	30%	50%	100%
Limonium axillare	4.10±0.66	3.63±1.60	2.05±0.11	1.77±0.11	-----
Salsola vermiculata	2.02±1.35	1.60±0.00	0.15±0.01	-----	-----
Salsola cyclophylla	2.80±1.44	1.66±0.15	0.22±0.15	-----	-----
Traganum nudatum	3.11±0.04	----	----	-----	-----
Ranterium epapposum	3.58±0.18	----	----	-----	-----
Sonchus maritimus	4.03±1.30	2.20±0.22	1.15±0.60	-----	-----
Atriplex leucoclada	2.16±0.01	2.00±0.00	-----	-----	-----
Haloxylon salicornicum	5.16±0.18	3.23±0.04	2.74±1.35	2.01±1.33	-----

the increase in the concentrations of the extracts. The highest growth appeared at the control treatment reaching 5.16 cm in *H. salicornicum*. The lowest plumule length reaching 0.15 and 0.22cm in length compared to the control with 2.02 and 2.80cm in both *S. vermiculata* and *S. cyclophylla* respectively, then the plumule growth decreased with increasing concentrations of the leaf extract (Table 4). In the *C. procera* extract-treated seeds, no growth of the plumule was obtained of *T. nudatum* and *R. epapposum* at 10, 30 and 50% concentrations. Also, no growth of the plumule was obtained of *A. leucoclada* at 30 and 50% respectively while the plumule did not appear at the high leaf extract concentration (100%) in all selected species.

DISCUSSION

In this study, the aqueous extract from *C. procera* on the germination of eight range plant species has resulted in retardation of the daily and total seed germination percentages of the seed of all selected species. However, there was no significant difference ($P<0.0001$) occurred between *C. procera* in respect of their allelopathic effects on seed germination of the eight range plant (Figure 1). The maximum reduction in germination was detected at the highest concentration coming from *C. procera* extract, the degree of inhibition increased with increasing extract concentrations degree. This finding is congruent with result of the results compatible with most of the previous results obtained by many other researchers, which asserted that extracts of many plants inhibit germination of many other plants [32-35]. Moreover, these findings agree with Mutlu and Atici [36] where they found that the root and leaf extracts of *N. meyeri* inhibited seed germination of barley and sunflower compared to respective controls. The difference between the species in the responses of their seeds for allelopathic coming from *C. procera* leaves agree with the findings of other works like Patil [37] who proved differences in seeds germination as a response to the leaf extract of *Glyricidia maculate*. Similar result was observed by Martin, *et al.* [38] who stated that *Conyza canadensis* fresh leaves inhibited the germination of maize seed. Additionally, Kayode and Ayeni [39] showed that the aqueous extracts from sorghum stem and rice husks inhibited the germination of maize seeds and they found that the degree of inhibition increased with increasing of concentrations of the extracts.

Differences in germination rate, followed a similar pattern of total germination percentage, these findings agree with what was found by Yarnia, *et al.* [40] who reported that the leaf extracts of sorghum leaves decreased seedling growth in comparison with control and decrease in germination rate of *Amaranthus retroflexus* seeds with increasing of leaf extract concentration in comparison with control. The results of the tests conducted on the effects of the different aqueous extracts from the *C. procera* on the radicale and plumule lengths of eight selected species have shown in Tables 3 and 4 respectively. The results revealed that the growths of the radicle in the extract-treated seeds were retarded when compared to the control. The degree of retardation increased with the increase in the concentrations of the extract, the results agree with most of the previous results obtained by many other researchers [41,42]. However, the degree of inhibition between the varying concentrations was not significantly different in extracts from the *C. procera* at the 5% level. The inhibition on seedling were relatively enhanced with the increasing amount of extract concentrations agree with Oudhia [43] where he found an inhibition at growth in radicle and plumule of *Lathyrus sativus* by extracts from *Calotropis gigantean* and agree with the study of Oudhia and Tripthi [44] where they recorded the root and shoot elongation by extracts from *Ageratum conyzoides* on the seed germination and seedling vigour of rice.

The results found in this study are consistent with those of Kayode [45,46] who examined the effects of leaf extracts of *C. procera* on the radicle and plumule growth of maize cultivars and leaf extracts of *Parkia biglobossa* on the radicle and plumule growth of *Chromoleana odorata*. The results obtained from root elongation test supported by similar previous report of Turk and Tawaha [19] who reported that the leaf extracts of *Brassica nigra* L. inhibited the germination and growth of *Avena fatua L.* A number of studies have suggested that the plant residues, especially weed species, affect the growth and development of other plants including crops by releasing allelochemicals into the immediate soil environment [47-50].

Finally, radicle length was relatively more sensitive to allelochemicals of *C. procera* than was plumule length. These results agree with other studies reporting that the water extracts of allelopathic plants had more pronounced effects on radicle growth than on plumule growth [32,42,51,52]. This is likely because those roots are the first to absorb the allelochemicals from the environment [53]. An especially high degree of inhibition occurred with leaf extracts at the highest concentrations in all tested of eight range plant species. Thus, this plant could be exploited as a source of natural herbicides by maximizing its use for future weed management programmes. This suggestion agrees with the report of Ridenour and Callaway [28].

Generally, it can be concluded that *C. procera* plays an important role in the formation of its natural habitats as it contains the allelochemical compounds that enable the plant to compete with other species. The results in this study also showed that the range plant species more sensitive to allelochemicals than agricultural crops. However, more work is needed to determine ecological requirements of seedling survival and establishment of that the range plant species as well as investigating the sensitivity of the allelopathic factors.

CONCLUSION

Overall, this study obviously demonstrated that allelochemicals are produced in the leaves of *C. procera*. Such chemicals (phytotoxicity) are effect on the germination, radicle and plumule of eight selected species. These characteristics may influence the density and the composition of individual plant communities. Allelochemicals may, directly, prevent or promote germination when environmental conditions are conducive to growth and establishment, therefore, influencing the number of plants of each species in a community. Indirectly, allelopathic effects on germination and growth determine whether or not plants of other species have a competitive advantage. In turn, plant competition for limiting resources, facilitation and environmental conditions (rainfall) may also influence the plant community structure. Thus, intensive studies on allelochemicals are still desirable to provide detail information on their effects on intercropping or subsequent crops, range plant. Farmers should remove *C. procera* from the agricultural land.

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