SEED GERMINATION, GROWTH AND YIELD OF *Abelmoschus esculentus* L. (OKRA) AND *Vigna unguiculata* L. (BUSHITA) INFLUENCED BY AQUEOUS LEAF EXTRACT OF INVASIVE PLANT *Clidemia hirta* (KATAKALUWA)

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Introduction

Alien invasive plant species have recognized as a major threat to the native biodiversity as they act as very effective competitors and cause enormous damage to the native and agro-biodiversity. *Clidemia hirta* (Melastomataceae) is native to Tropical America and it has included among the hundreds of world's worst invaders. *Clidemia hirta* was introduced to Sri Lanka as an ornamental plant in 1894 through Royal botanic gardens. Since then, it has become an invasive species affecting both subsistence and commercial agriculture, and it has invaded a wide array of our natural vegetation types in all major climatic zones now. As this plant is included among the top ten invasive flora in Sri Lanka, the present study was mainly focused on finding the possibility of utilizing this plant as an organic fertilizer as it is difficult to control the spreading of this plant in the environment. The present study was aimed at finding the impact of aqueous leaf extract of *C. hirta* on seed germination, seedling growth and its potential use as a liquid organic amendment to enhance the growth and yield performance of Okra, *Abelmoschus esculentus* L. (Malvaceae) and Bushita, *Vigna unguiculata* L. (Fabaceae).

Methodology

Air dried and powdered leaves of *C. hirta* (100 g) were soaked in 1 L of distilled water to formulate 100 gL^{-1} stock solution suggested by Namkeleja *et al*. (2013). Concentrations of 25, 50, 75 and 100 gL^{-1} of aqueous *C. hirta* leaf extracts were used for the laboratory and pot experiments with distilled water as the control. Viabilities of *V. unguiculata* and *A. esculentus* seed lots were tested for randomly selected seeds using 1% Triphenyl Tetrazolium Chloride (TTC) solution. Seed lots which have shown over 70% of viability were used for the seed germination experiments. Laboratory experiments of *V. unguiculata* cultivar "BS1" and *A. esculentus* cultivar "Haritha" (Department of Agriculture) were conducted in sterilized petri dishes (four replicates for each treatment containing 20 seeds in each petri dish) and seed trays (eight replicates for each treatment containing 3 seeds in each hole, sand as the growth medium) according to the completely randomized design. In both experiments, 10 mL of *C. hirta* 25, 50, 75, 100 gL^{-1} leaf extracts were added to investigate their influences on germination and seedling growth of both crop seeds separately.

In the pot experiment, same concentrations of leaf extracts were tested for growth performance of Bushita and Okra seedlings using pots containing 7 kg of solar sterilized garden soil. The pots were treated with 300 mL of the extract every other day starting from one week after seed sowing. Pots were arranged according to the complete randomized design (five replicates for each treatment in each species). To avoid the

influence of direction of sunlight, the pots were randomly repositioned in fortnightly intervals. Following growth parameters were recorded 60 days after seed sowing: In Okra, mean fresh weight of fruit / plant, leaf area, days to anthesis, number of leaves per plant, mean fruit length and in Bushita, total fresh weight of fruits/vine, total number of filled seeds and sterile seeds, number of fruits, leaf area, length of the vine, mean fruit length/ vine. Results were statistically analyzed by one Way ANOVA and Pearson correlation coefficient using MINITAB R.16.

Results and Discussion

The mean seed germination percentages in controls were higher than all the other treatments in petri dishes for both crop species and in Okra, seed germination percentage of control was significantly higher than all other treatments (One way ANOVA, $p<0.05$) and in Bushita significantly lower seed germination percentages were recorded in 50, 75 and 100 gL^{-1} treatments compared to control ($p<0.05$) and the mean shoot and root lengths of seedlings were negatively correlated to concentrations of *C. hirta* leaf extracts (Table1).

In Okra and "Bushita" the highest germination percentages were recorded in 25 gL^{-1} treatments and the control in seed trays (Table 2). There is a phytotoxic effect in leaf extracts of *C. hirta* on seed germination and seedling growth of Bushita (BS1) and Okra (Haritha). Intensity of Inhibitory effect on seed germination of Okra was higher than that of Bushita. The reduction of root length may be due to the presence of high amounts of water soluble allelochemicals in the extracts. Chon *et al.* (2000) reported that root length is a good indicator of allelopathic effect of plant extracts as they are more sensitive to phytotoxic compounds than shoots.

In the pot experiment in Bushita significantly higher mean total fresh weight of fruits/vine (174.24±1.1), mean total number of filled seeds (170.2±11.53), mean number of fruits/vine (20.2±0.58), mean leaf area (326.36±4.22), mean length of the vine (204.6±6.8) and mean fruit length per vine (27.38±0.68) were recorded in 50 gL^{-1} treatment compared to the control (One-way ANOVA, $p<0.05$). In Okra significantly higher mean fresh weight of fruit/plant (18.48±0.15), mean leaf area (276.03±2.0) were recorded in 25 gL^{-1} treatment compared to the control (One-way ANOVA, $p<0.05$). In Okra compared to the control treatment, in 100 gL^{-1} treatment significantly lower values were recorded for mean fresh weight of fruit (13.82±0.52), mean leaf area (163.98±3.12), mean number of leaves/plant (11.20±0.58) and mean fruit length (13.50±0.36) (One-way ANOVA, $p<0.05$) and The highest mean number of days to anthesis was recorded in 100 gL^{-1} treatments while the lowest mean number of days to anthesis was recorded in control. In Okra strong negative correlation coefficient ($r^2>0.5$) was revealed between concentrations of the aqueous extracts and growth parameters. The lowest growth performance was recorded in the plants treated with 100 gL^{-1} treatments. This may be due to the presence of allelochemicals in leaf extracts of *Clidemia hirta* that badly affect to the growth of Okra and Bushita with increasing its concentrations.

Studies on seed germination, seedling growth and growth performance of crops in the presence of *Clidemia hirta* aqueous extracts are scarce. However, Devi *et al.* (2013) found that there is an allelopathic effect of leaf, stem and root aqueous extracts of

Chromolaena odorata **on seed germination and growth of** ***Oryza sativa*****. Hamidi** ***et al.*** **(2014) found that the methanolic extracts of** ***C. odorata*** **leaves reduce seed germination and cause slower rate of seedling growth, and inhibit shoot and root elongation of** ***Vigna radiata*** **(Mung bean).**

Table 1. Effect of ***Clidemia hirta*** **aqueous leaf extracts on seed germination shoot and root lengths of** ***Vigna unguiculata*** **"BS1" and** ***Abelmoschus esculentus*** **"Haritha" in petri dishes.**

Treatments	*Clidemia hirta* aqueous leaf extracts on *A. esculentus* "Haritha"			*Clidemia hirta* aqueous leaf extracts on *V.unguiculata* " BS1"		
	Germination percentages	Mean Root length (cm)	Mean shoot length (cm)	Germination %	Mean Root length (cm)	Mean shoot length (cm)
25 gL-1	$88.7^{b} \pm 0.01$	$1.6^{b} \pm 0.13$	$3.3^{b} \pm 0.15$	$92.5^{ab} \pm 0.04$	$3.0^{b} \pm 0.22$	$3.6^{b} \pm 0.44$
50 gL-1	$67.5^{c} \pm 0.03$	$1.3^{b} \pm 0.06$	$1.2^{c} \pm 0.18$	$86.3^{b} \pm 0.01$	$0.5^{c} \pm 0.10$	$1.3^{c} \pm 0.22$
75 gL-1	$42.5^{d} \pm 0.01$	$0.4^{c} \pm 0.05$	$0.8^{c} \pm 0.07$	$53.7^{c} \pm 0.07$	$0.4^{c} \pm 0.07$	$1.2^{c} \pm 0.05$
100 gL-1	$28.7^{d} \pm 0.02$	$0.4^{c} \pm 0.04$	$0.5^{c} \pm 0.03$	$18.7^{d} \pm 0.04$	$0.5^{c} \pm 0.13$	$0.9^{c} \pm 0.10$
Control	$98.7^{a} \pm 0.01$	$4.0^{a} \pm 0.30$	$4.7^{a} \pm 0.25$	$98.7^{a} \pm 0.01$	$10.7^{a} \pm 0.18$	$6.4^{a} \pm 0.21$

Values are means of four independent replicates ± SE. Values in a column with same superscript letter are not significantly different.

Table 2. Effect of ***Clidemia hirta*** **aqueous leaf extracts on seed germination shoot and root lengths of** ***Vigna unguiculata*** **"BS1" and** ***Abelmoschus esculentus*** **"Haritha" in seed trays.**

Treatments	*Clidemia hirta* aqueous leaf extracts on *A. esculentus* "Haritha"			*Clidemia hirta* aqueous leaf extracts on *V. unguiculata* " BS1"		
	Germination percentages	Mean Root length (cm)	Mean shoot length (cm)	Germination %	Mean Root length (cm)	Mean shoot length (cm)
25 gL-1	$100^{a} \pm 0.00$	$7.3^{b} \pm 0.15$	$9.4^{b} \pm 0.19$	$100^{a} \pm 0.00$	$8.2^{b} \pm 0.17$	$15.1^{b} \pm 0.69$
50 gL-1	$96^{ab} \pm 0.04$	$5.5^{c} \pm 0.15$	$7.4^{c} \pm 0.25$	$96^{a} \pm 0.00$	$7.5^{bc} \pm 0.14$	$10.1^{c} \pm 0.29$
75 gL-1	$87^{ab} \pm 0.09$	$4.4^{d} \pm 0.15$	$5.9^{d} \pm 0.20$	$92^{a} \pm 0.04$	$6.3^{cd} \pm 0.12$	$7.8^{d} \pm 0.36$
100 gL-1	$71^{b} \pm 0.11$	$3.4^{d} \pm 0.14$	$4.3^{e} \pm 0.28$	$87^{a} \pm 0.05$	$4.6^{d} \pm 0.44$	$5.3^{e} \pm 0.33$
Control	$100^{a} \pm 0.00$	$9.9^{a} \pm 0.51$	$11.9^{a} \pm 0.31$	$100^{a} \pm 0.09$	$12.3^{a} \pm 0.87$	$18.8^{a} \pm 0.14$

Values are means of eight independent replicates ± SE. Values in a column with same superscript letter are not significantly different

Table 3. Effects of ***Clidemia hirta*** **aqueous leaf extracts on growth performance and yield of** ***Abelmoschus esculentus*** **"Haritha"**

Growth Parameters \ Treatment	T1 (25 gL^{-1})	T2 (50 gL^{-1})	T3 (75 gL^{-1})	T4 (100 gL^{-1})	T0 (Control)
Mean Number of leaves per plant	$14.60^{a} \pm 0.40$	$13.20^{ab} \pm 0.49$	$11.80^{b} \pm 0.58$	$11.20^{b} \pm 0.58$	$14.20^{a} \pm 0.20$
Mean fresh weight of fruit (g/plant)	$18.48^{a} \pm 0.15$	$15.52^{c} \pm 0.28$	$14.69^{cd} \pm 0.27$	$13.82^{d} \pm 0.52$	$17.01^{b} \pm 0.22$

Mean Leaf area (cm^2)	**276.03^{a} ±2.0**	**197.49^{c} ±2.25**	**182.98^{d} ±2.34**	**163.98^{e} ±3.12**	**254.79^{b} ±1.13**
Mean Days to anthesis	**45^{ab} ±0.45**	**45.2^{ab}±0.37**	**45.2^{ab} ±0.2**	**$45.^{a}$±0.2**	**44^{b}±0**
Mean fruit length (cm)	**15.68^{a}±0.4**	**14.54^{abc}±0.4**	**13.89^{bc}±0.32**	**13.50^{c}±0.36**	**15.41^{ab}±0.5**

Values are means of five replicates ± SE. Different superscripts in each row mentions significantly different (P < 0.05) of growth parameters at different concentrations of aqueous leaf extracts

Table 4. Effects of *Clidemia hirta* aqueous leaf extracts on growth performance and yield of *Vigna unguiculata* "BS1"

Treatments growth parameters	T1 (25 gL^{-1})	T2 (50 gL^{-1})	T3 (75 gL^{-1})	T4 (100 gL^{-1})	T0 (Control)
Total filled seeds per vine	93.8^{b}±4.87	170.2^{a} ±11.53	120.6^{ab}±13.23	108.6^{b} ±11.97	90.4^{b} ±18.97
Total fresh weight of fruits per vine (g/plant)	142.32^{c}±3.28	174.24^{a}±1.1	168.84^{ab}±2.75	162.32^{b}±2.14	123.40^{d}±3.88
Leaf area (cm^2)	224.68^{c}±1.52	326.36^{a}±4.22	283.04^{b}±4.72	259.54^{b}±10.3	189.95^{d}±4.7
Mean fruit length per vine (cm)	21.44^{b} ±0.89	27.38^{a} ±0.68	24.92^{a} ±0.81	21.64^{b}±0.19	20.66^{b} ±0.68
Total sterile seeds per vine	35.6^{b}±4.3	72^{a} ±6.29	70.8^{a}±3.5	59.8^{ab}±10.9	32.4^{b} ±5.64
Number of fruits per vine	13.2^{c}±0.8	20.2^{a}±0.58	17.8^{ab}±0.37	16.6^{b}±0.24	13^{c}±1.05
Length of the vine (cm)	154.8^{ab}±14.2	204.6^{a}±6.8	194.14^{ab}±7.47	172.82^{ab}±3.99	146.0^{b}±21.28

Values are means of five replicates ± SE. Different superscripts in each row mentions significantly different (P<0.05) of growth parameters at different concentrations of aqueous leaf extracts

Conclusions and Recommendations

Although the leaf extracts of *C. hirta* have allelopathic effects on seed germination and seedling growth of Bushita (BS1) and Okra (Haritha), they increased growth and yield performance of the same crops when apply as a liquid organic fertilizer after seed germination. Although *C. hirta* has low impacts on growth and yield performance of Okra, 50 gL^{-1} concentrated treatment can be used to enhance the growth and yield performance of Bushita. As the aqueous extracts of *Clidemia hirta* have shown an allelopathic effect on seed germination and seedling growth of crop seeds, this phenomenon can be employed in organic agriculture to suppress the weed species. However, their potential of use as an organic liquid fertilizer to increase growth and yield performance of crop is also of great significance.

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