Zimbabwe Journal of Science & Technology pp 77 – 84 Vol.12 [2017]
e-ISSN 2409-0360
Zimbabwej.sci.technol

Multi-herbicidal effects of *Lanta camara* extracts on *Eleucine indica* and *Amaranthus hybridus*: implications to weed control in organic gardens

[1]Mabasa Chiedza, [1]Rugare Joyful, [1]Mabasa Stanford and [2]Mandumbu Ronald

[1]Crop science Department, University of Zimbabwe, P.O. Box MP167, Mount Pleasant, Harare, Zimbabwe

[2]Crop Science Department, Bindura University of Science Education, P. Bag 1020, Bindura, Zimbabwe

Email: rmandumbu@gmail.com

Abstract

Lantana camara has been reported to cause allelopathy on a number of plants and therefore can be exploited in weed management without adversely affecting the environment. Laboratory and greenhouse experiments were carried out to determine the allelopathic effects of *L camara* extracts and mulch on the germination and early growth of *Amaranthus hybridus* and *Eleucine indica.* Results indicated that both weeds were reduced in their germination by both the *L camara* extracts and biomass. The results indicate that *L camara* leaves can be incoporated into organic gardens and suppresses the growth of weeds. Therefore in mulch based systems, *L camara* can be used to ecologically manage the two weeds.

Received21.04.17. Accepted:07.02.18

1. INTRODUCTION

Lantana camara is an invasive weed that was introduced to Zimbabwe as an ornamental plant and is invading the country at an uncontrollable rate (Kwembeya et al., 2013). The noxious weed grows wildly and colonises large parts of arable lands. The weed is a huge threat to agricultural production due to allelopathy effects and replaces natural vegetation with consequent loss of agricultural production. Moreover, the weed is poisonous to people and livestock. It is a prolific seed producer and that enables it to thrive and invade large areas of non arable lands. According to Eldershaw (2003), the weed grows well in road sides, fence lines, cultivated pastures and edges of forests.

Putnam (1988) reported that the weed produces a toxic substance known as lantadene A as well as cynogenic compounds, alkaloids, benzoxazinones and acid derivatives. With these allelochemcals, *L camara* has potential to be used for cultural weed management practices in organic gardens and plots. The quest to develop environmentally friendly weed management technologies has motivated a number of studies in allelopathic interactions between crops and weeds (Om et al., 2004, Sangaeetha and Baskar, 2015)

Eleucine indica is the worst grass weed in Zimbabwe whilst *Amaranthus hybridus* is ranked fourth worst broad leaved weed (Mandumbu et al., 2013). The weeds are very competitive in agrosystems and the communal sector has not adopted the herbicide technology to manage the weeds. With the widespread promotion of mulch tillage in sub Saharan Africa (Mandumbu et al., 2012), there is need to determine the mulches that can prevent or hinder germination and early establishment of these weeds both through physical effects and also allelopathy. In a related study by Mandumbu et al., (2016) sorghum and wheat mulches and extracts were found to inhibit the germination and early establishment of both *Rottboellia cochinchinensis* and *Amaranthus hybridus*. Weed germination is a key event in the success of weeds in the agrosystems, therefore we set out to determine the allelopathic effects of *L camara* on the germination and early establishment of *E indica* and *A hybridus*.

2. MATERIALS AND METHODS

2.1 Experimental Site

The study was done in the laboratory and green house at the University of Zimbabwe's (U.Z) Crop Science Department in Harare, Zimbabwe (17.780S, 31.050E, 1523 meters above sea level). The U.Z is in Natural Region II with an annual rainfall of 600-1000mm and average temperature of 20-30 ^{0} C.

2.2 Laboratory Experiments

2.2.1 Effects of *L. camara* leaf extracts on the germination of *E. indica* and *A. hybridus*

Fresh leaves of *L.camara* were collected from the Faculty of Agriculture cropping field, University of Zimbabwe. The leaves were collected in December 2013.These leaves were washed under running tap water to remove all dust particles. The leaves were then air-dried under room temperature of 25-30 ^{0} C for three weeks in the Weed Science Laboratory. After drying, the leaves were ground into a fine powder using the hammer grinder with 0.5 mm sieve size. *L.camara* powder extracts of 10 g, 20 g, 30 g, 40 g and 50 g were soaked in 1000 ml distilled water for 24 hours at room temperature. These produced 1%, 2%, 3%, 4%, and 5% leaf extract concentrations. The extracts were filtered using a 12.5 cm filter paper and sieve until particles were removed. The filtrate was stored in a refrigerator to prevent occurrence of biochemical changes. Filter papers were fitted inside each 9 cm diameter petri dish. The seeds of *E. indica* and *A. hybridus* were added to each petri dish. Forty five weed seeds were planted in each petri dish. Lantana filtrate of two millimetres was added to each respective treatment. The filtrate was regularly added when required.

2.2.2 Experimental Design

The experiment was arranged in a Randomised Complete Block Design (R.C.B.D).A total of six treatments were replicated six times and repeated twice over time. The treatments were 0 %, 2 %, 3 %, 4 % and 6 % *Lantana camara* leaf extracts.

2..2.3 Data collection

Germination refers to the emergence of the radicle from the seed coat. The numbers of emerged seeds were counted. The obtained number was expressed as a percentage with the total number of seeds planted per petri dish. The germination percentage was determined after seven days when the experiment was terminated. Root and plumule lengths were measured using a 30cm ruler at the termination of the experiment. Dry matter of the seedlings was also determined. The dry matter weights of the seedlings were determined using a weighing balance.

2.3 Glasshouse Experiments

2.3.1 Effects of *L. camara* leaf biomass on the emergence and growth of *E. indica* and *A. Hybridus.*

Fresh leaves of Lantana were collected from the University of Zimbabwe Agriculture fields. They were collected in December 2013. The leaves were washed under running tap water to remove all dust particles. They were air-dried under room temperature of 25-30 ^{0} C for three weeks in the Weed Science Laboratory. After drying, the leaves were ground into a fine powder using a hammer grinder with 0.5mm sieve size. Pots measuring 18 cm diameter x 17 cm depth, were used. These were three quarter filled with soil which contained 30 % clay and 1 % organic matter. The leaf biomass was mixed with the top two centimetres of the soil. Forty five seeds were sown in each pot. Lantana leaf biomass was then added to soil in pots at 0 g, 10 g, 20 g, 30 g, 40 g and 50 g respectively per pot. Adequate water was provided to ensure germination of the weed seeds. The treatments were replicated six times in a Randomised Complete Block Design. Blocking factor was sunlight.

2.3.2 Experimental Design

The experiment was arranged in a Randomised Complete Block Design (R C B D) with six blocks. A total of six treatments were replicated six times. The treatments were 0, 10, 20, 30, 40 and 50g *L camara* biomass.

2.3.3 Data collection

The number of emerged *E.indica* and *A. hybridus* seedlings was recorded. After the experiment, the dry matter of *E. indica* and *A. hybridus* was weighed. The experiment was terminated after twenty one days. The phytotoxic symptoms caused by *Lantana* biomass addition to *E.indica and A.hybridus* were noted.

2.3.4 Data Analysis

Analysis of variance was done on the final emergence counts of *E.indica* and *A.hybridus*. Regression analysis was done to relate lantana biomass rates (g / pot) to *E.indica and A.hybridus* parameters (emergence counts and dry matter), using the Sigma Plot Statistical Software.The regression analysis was done to determine the relationship of *L. camara* concentrations and the parameters of *E.indica* and *A. hybridus* (seed germination, radicle length, plumule length and dry matter.The Sigma Plot Stastical Software was used.

3. Results

3.1 Laboratory Experiments

3.1.1 Effects of *L camara* leaf extracts on the emergence of *A hybridus* and *E indica*

The relationship of *A. hybridus* germination counts and *L. camara* concentrations was significantly (p<0.0001) linear. The r^2 value was high as shown by Fig 1.This means that *A. hybridus* was sensitive to *L. camara* concentrations. *A. hybridus* germination decreased as *L. camara* concentrations were
increased.

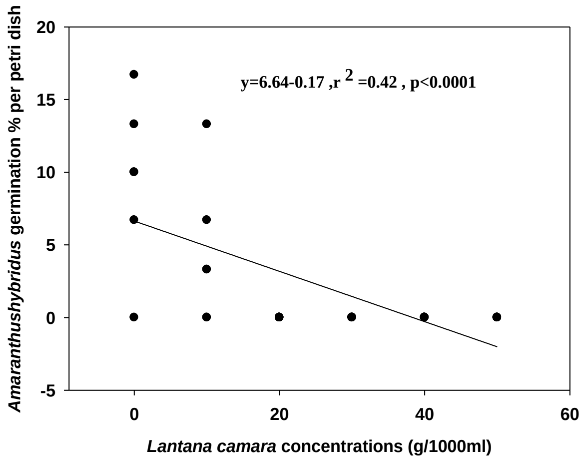

Figure1: The relationship of *A hybridus* germination percentage and *L camara* concentrations *Amaranthus hybridus* radicle length

The relationship of A *hybridus* radicle length and lantana concentrations was significantly linear (p < 0.001) (Figure 2). *A hybridus* radicle length decreased with an increase in *Lantana* concentration.The r^2 value was high meaning *A.hybridus* was sensitive to *Lantana* ext

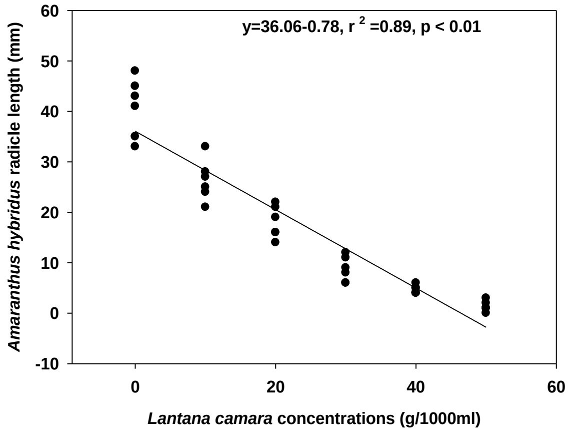

Figure 2: The relationship of *A hybridus* radicle length and *L camara* concentrations

3.1.2 Amaranthus hybridus Plumule Length

The relationship of *A hybridus* plumule length and *Lantana camara* was significantly linear (p< 0.001) as shown by Figure 4.3. It means that *L.camara* concentrations inhibited germination of *A.hybridus* seeds. An increase in *L camara* concentrations resulted in decreased *A hybridus* plumule length.The r^2 was high meaning that *A.hybridus* was sensitive to addition of *L.camara* concentrations.

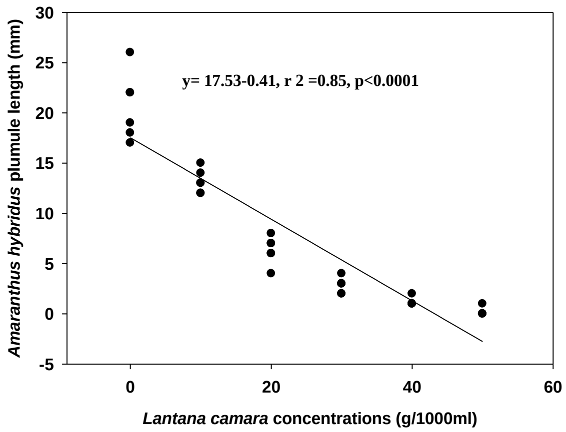

Figure 3: The relationship of *A hybridus* plumule length and *L camara* concentrations

The regression line shown by Figure 4 was significant (p<0.001).The r^2 value was very low meaning that *Eleusine indica* germination was very sensitive to *Lantana camara* concentrations. The control treatment had high E.indica counts compared to the other treatments. Lantana suppressed germination of *E.indica*.

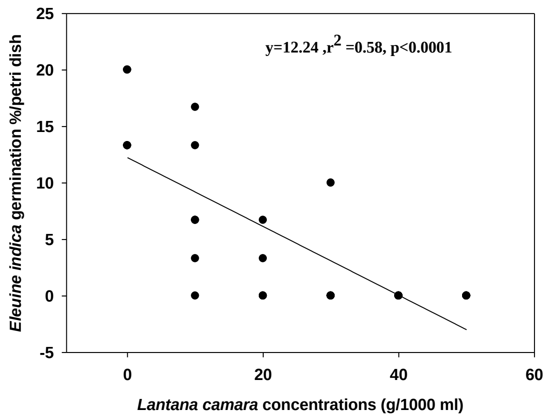

Figure 4: The relationship of *E indica* germination %age and *L camara* concentrations

The relationship of *Eleusine indica* radicle length and *Lantana camara* concentrations was significantly linear (p <0.001) as shown by Figure 4.3. *Eleusine indica* radicle length decreased with an increase in *Lantana camara* concentrations.

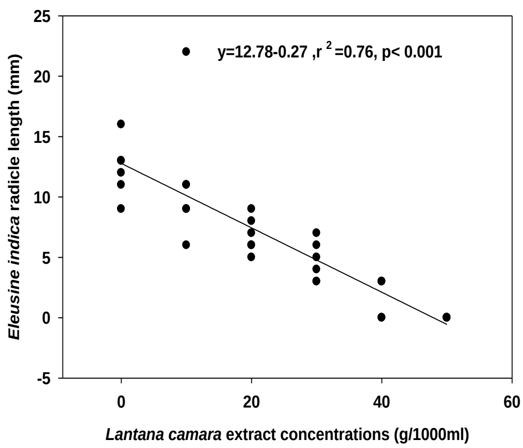

Figure 5: The relationship of *Eleusine indica* radicle length and *Lantana camara* concentrations

The relationship of *Eleusine indica* plumule length and *Lantana camara* was significantly linear (p< 0.001) as shown by Figure 4.4.It means that *L.camara* concentrations inhibited germination of *E.indica* seeds.An increase in *L. camara* concentrations resulted in decreased *E. indica* radicle length.

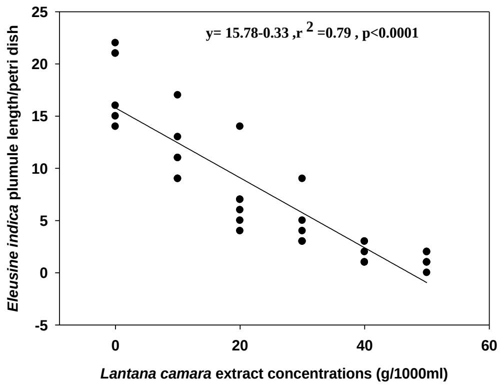

Figure 6: The relationship of *Eleusine indica* plumule length and *L camara* concentrations

3.1.3 Effect of *L.camara* leaf biomass on *E.indica* germination

The regression line shown in Figure 7 was highly significant ($p < 0.0001$).The r^2 value was high showing that *E. indica* was sensitive to *L camara* biomass. The inhibition of *E indica* emergence increased with the increased application rates of Lantana biomass. The control treatment had high *E.indica* counts compared to the other treatments. *E indica* emergence counts decreased as the lantana biomass increased from 0 g to 50 g / pot.

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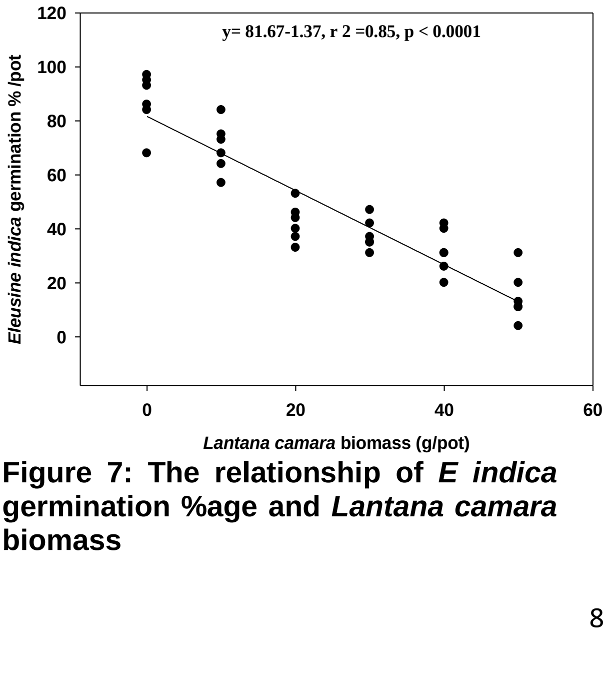

Figure 7: The relationship of *E indica* germination %age and *Lantana camara* biomass

3.1.4 Effect of Lantana dry leaf biomass on *Eleusine indica* Dry matter

The regression line which related *E indica* dry matter and lantana biomass was significantly linear ($p < 0.0001$), the r^2 value was high (Figure 8) thus *E.indica* was sensitive to *L.camara* biomass. The dry matter of *E indica* decreased as the lantana concentration increased.

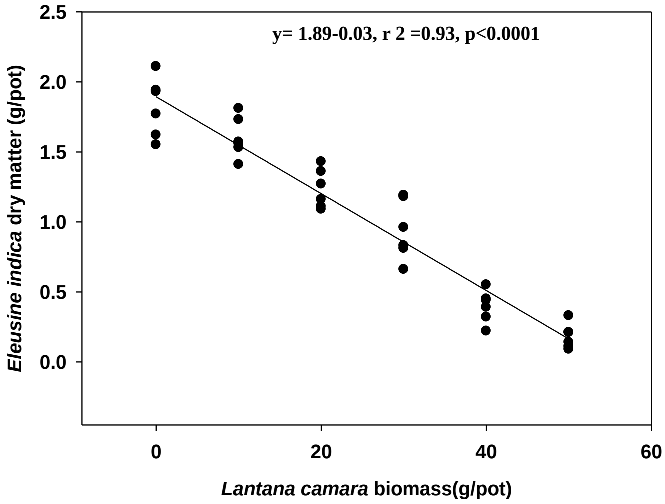

Figure 8: Relationship between *E. indica* dry matter and *L.camara* biomass

3.1.5 Effect of L. camara dry leaf biomass on *Amaranthus hybridus* germination percentage

A hybridus germination decreased as *L camara* biomass was increased. Therefore *A hybridus* seeds were sensitive to lantana biomass (Figure 9), the r^2 value was high and the regression relationship was significantly linear ($p < 0.0001$).

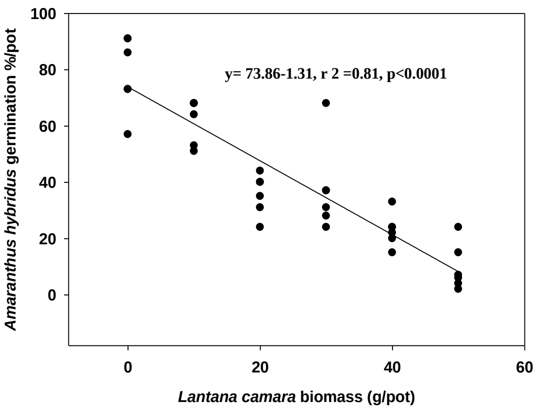

Figure 9: The relationship of *A hybridus* germination percentage and *L camara* biomass

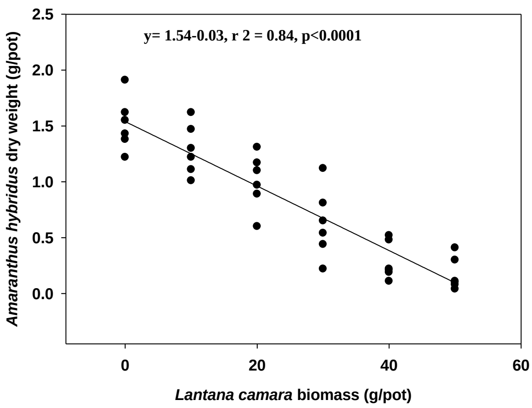

Figure 10: The relationship of *A hybridus* dry matter and *L camara* biomass

Amaranthus hybridus dry matter decreased as Lantana biomass increased. The regression relationship was significantly linear ($p < 0.0001$).The r^2 value was higher showing that *A hybridus* emergence was sensitive to *L camara* biomass(Fig 10).

DISCUSSION

Lantana camara suppressed the germination of *E. indica* and A*. hybridus* under laboratory conditions. The plumule and the radicle lengths of these weeds were reduced. Incorporating *Lantana camara* into the soil reduced the populations and biomass of E. indica and *A. hybridus*. These effects on *E. indica* and *A. hybridus* were dependent on the concentrations of *Lantana camara* extract. It was clear from this study that *Lantana camara* had phytotoxic effects on these weeds. *Lantana camara* extracts were also found to have phytotoxic effects on other plants (Kwembeya *et al*., 2013)

Germination of wheat was inhibited by *L.camara* extract due to presence of phenolic compounds (Sing *et al*., 1989). According to a research carried out, leaf extracts of *L.camara* inhibited the growth of Parthenium (Ravendra *et al.*, 2008). *L.camara* reduced the germination and growth of rice seedlings (Ravendra *et al.*, 2008).Nsolomo *et al.*, 1995 reported that *L.camara* leaf leachates produce allelochemicals.These allelochemicals were responsible for inhibiting the germination of *A. hybridus* and *E. indica* .The growth of radicle and plumule is dependent upon cell division and elongation. *L.camara* inhibits cell division and elongation (Rice, 1984).Plants grown in control treatments had longer sizes compared to those grown in test species.

Lantana camara has been reported to contain allelochemicals that interfere with germination and growth of many species (Ambika *et al*., 2003; Mersie and Singh, 1987; Shriva and Baipol, 1998). This plant contains many allelochemicals and some of them are Lantadene A and Lantadene B, Lantadene C, reduced lantadene A, lantadene D, lantanolic and lantic acid. (Bowden et al., 1999).These was responsible for the inhibitory effects inflicted on *A*. *hybridus* and *E*. *indica*.

It was noted that after a few days from germination, the seedlings started showing symptoms of chlorosis. The leaves started burning and wilting at the tips until the whole plant wilted. Visible white leaf tips were observed. Therefore it can be concluded that certain allelochemicals present in lantana disrupt chlorophyll formation thereby resulting to chlorosis. Therefore, allelochemicals inhibit chlorophyll formation and reduce the rate of photosynthesis. Allelochemicals are capable of altering a number of physiological processes. They have significant effects on photosynthesis (Singh and Thapar, 2003). Other studies have shown that allelochemicals can potentially impair the performance of three main processes of photosynthesis which include: stomatal control of carbon ndioxide, the light reaction and the dark reaction (Patterson, 1981).

This study has shown that *Lantana camara* has herbicidal properties. It has a potential to be used to control weeds in organic farming.

Conclusions

Lantana camara leaves imposed allelopathic effects on *Amaranthus hybridus* and *Eleusine indica* emergence and dry matter accumulation. Both *Amaranthus hybridus* and *Eleusine indica* germination were sensitive to allelochemicals produced by *Lantana camara*. *E*.*indica* and *A*.*hybridus* responded positively to the inhibitory effects of *L*.*camara*. As the Lantana extract concentrations were increased, the emergence of *A hybridus* and *E indica* decreased. *L camara* showed inhibitory effects on radicle and plumule lengths of *A hybridus* and *E indica*. The obtained results support the hypothesis that *Lantana camara* has allelopathic effects on *A hybridus* and *E indica*.

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