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Allelopathic Effects of Lantana (*Lantana camara*) on Blackjack (*Bidens pilosa*) and Pearl Millet (*Pennisetum glaucum*)

Kwembeya, A., Rugare, J. T., Mabasa, S.
Crop Science Department, Faculty of Agriculture, University of Zimbabwe, Mt Pleasant, Harare, Zimbabwe

Abstract

Lantana camara L. (Verbanaceae) is an invasive plant widely distributed in Zimbabwe and is toxic to livestock and humans. Greenhouse and laboratory experiments were done at the Crop Science Department, University of Zimbabwe to assess the allelopathic effects of *L. camara* on *Bidens pilosa* and pearl millet. First, *L. camara* biomass was evaluated for its impact on the emergence and growth of *B. pilosa* and pearl millet, after the addition of 0, 10, 30, 40 and 50 g per pot (18 cm diameter x 17 cm depth each), under glasshouse conditions and adequate moisture conditions. Second, *L. camara* leaf extracts at 0, 10, 20, 30, 40 and 50 % concentrations were screened for their effects on the germination of *B. pilosa* and pearl millet under laboratory conditions. Randomized complete block designs, with 6 treatments replicated 4 times were used in both experiments. *Lantana camara* leaf biomass significantly ($p<0.05$) reduced the emergence and growth of *B. pilosa*, when it was added to the soil under glasshouse conditions. In contrast, pearl millet emergence and growth was not affected by *L. camara*. However, *L. camara* leaf extracts reduced the germination percentage, radicle length and plumule length of pearl millet under laboratory conditions.

Keywords: *Lantana camara*, Allelopathic effects, *Bidens pilosa*, Pearl millet, Seed germination

Introduction

Lantana camara L. (lantana or cherry pie) (Verbinaceae), is a perennial shrub which was introduced in Zimbabwe as an ornamental plant. It is known in the local Shona and Ndebele languages as Mbarati and Besikihwa, respectively (Maroyi, 2012) and is one of the worlds' worst non arable weeds. It is used as a hedge around houses in urban areas and homesteads in rural areas. Lantana has a stem with four sides, which almost describes a square cross section and is covered with hooked prickles. It produces flowers of different colours namely white, red and yellow. The fruits are green berries which turn black when they are ripe. These berries are eaten by birds and human beings and this aid in the dispersal of lantana seeds. This plant has been reported to produce allelochemicals, which are toxic to other plants growing near it (Achhireddy and Singh, 1984). Lantana is able to colonise large areas, because seed dispersal is via birds and due to its ability to produce allelochemicals which causes it to out compete other plants. It grows mainly in non arable terrestrial habitats and farmers are reluctant to control it because it is not a threat to crop production. However, it has been reported that the leaves and unripe berries of lantana can produce high levels of poisonous alkaloids which are toxic to livestock and humans. Some of the allelochemicals which have been found in lantana leaves are p-OH-benzoic acid, p-coumaric acid, caffeic acid, vallic acid, syringic

Corresponding author's details:
Name: Mabasa, S.
Email address: smabasa@googlemail.com

acid and gentisic acid (Hussein *et al*., 2011). Rakesh *et al*. (1989) reported the presence of at least 14 phenolic compounds, which included p-hydrobenzoic acid, p-coumaric acid and salicycic acid. It was concluded that pentacyclic tripernoides, lantadene A and lantadene B were the allelochemicals responsible for the herbicidal effects on *Eichhornia crassipes* and *Microcystis aeruginosa* (Kong *et al*., 2006).

Chatanga (2007) and Sithole *et al*. (2012) reported the presence and spread of lantana in the Gonarezhou National Park in the South Eastern part of Zimbabwe. It has also been reported to be threatening biodiversity at Victoria Falls (Nang'alelwa, 2010) and in Masvingo province (Masocha, 2009). Lantana appears to be associated with wet areas (Nang'alelwa, 2010) and high rainfall increases its spread. It has been noted that lantana is wide spread across all the agroecological regions of Zimbabwe. Although lantana is listed as an invasive weed in Zimbabwe (Zimbabwe Environmental Management Act, 2002) no action is being taken to curb the spread of this fast spreading weed. Identification of alternative uses of lantana biomass could motivate farmers to control this weed. In some countries it is used for medicinal purposes (Kalita *et al*., 2012). Svotwa *et al*. (2009) reported the use of a mixture of lantana and camfy leaf extracts for the control of sucking pests in organic vegetable farming. There could therefore be merit in studying the allelopathic potential of this weed on other weeds and crops with the hope of identifying ways in exploiting the use of allelochemicals that are produced by lantana in integrated weed management programs. There is a possibility of using lantana biomass as composted manure or through the use of lantana biomass as mulch in conservation agriculture and organic systems. The use of lantana biomass for weed control is likely to be adopted by farmers because it is cheap and safe both to human beings and the environment. This would increase the adoption of new and emerging environmentally friendly ways of crop production such as Conservation Agriculture and organic farming, because the uptake of these emerging technologies has been slow due to increased weed problems that are associated with these technologies. Weeds are the most serious biotic factor limiting crop production in the smallholder farming sector in Zimbabwe (Chivinge, 1984). Achhireddy and Singh (1984) and Kong *et al*. (2006) reported that lantana biomass was able to control weeds when incorporated into the soil. These researchers also observed that lantana leaf extracts were efficacious in reducing germination, radical and plumule length of weeds under laboratory conditions. However, the allelochemicals from lantana have also been observed to be phytotoxic to some crops (Sahid and Sugau, 1993; Ahmed *et al*., 2007).

There is need to investigate the effect of lantana on some important arable weeds and crops in Zimbabwe. Chivinge (1988) reported that blackjack (*Bidens pilosa* L.) is an important weed in Zimbabwe. It is a dicotyledonous annual arable weed that grows in all the different agroecological zones and is responsible for huge yield losses due to competition with crops for resources. One of the crops that has been affected by blackjack is pearl millet (*Pennisatum glaucum*) which is a drought tolerant cereal mainly grown in marginal areas in Zimbawe. Pearl millet is an important food security crop not only in Zimbabwe but also in other Southern African countries where its grain is used as a source of carbohydrate in place of maize (*Zea mays* L.)

In this study it was hypothesised that lantana has phytotoxic effects on *B. pilosa* and is likely to be useful for controlling this weed. However, there is a possibility that it could also have negative effects on crops, for example, pearl millet. The objectives of this study were therefore to (1) to determine the effect of soil incorporated lantana leaf biomass on the emergence and growth of *B. pilosa* and pearl millet and (2) determine the effect of lantana leaf extracts on the germination of *B. pilosa* and pearl millet.

Materials and Methods

Soil assays

Fresh leaves of lantana with white flowers were collected from the Faculty of Agriculture cropping field, University of Zimbabwe (17.78°S, 31.05°E, 1523 meters above sea level) in January 2013. Collections were done in January 2013. Lantana leaves were washed thoroughly with tap water to remove any dirty

and dust. Seeds of the receptor plants were collected from the field Crop Science Department, University of Zimbabwe field. The lantana leaves were air dried in a shade at room temperature 25-30^0 C for two weeks in the Weed Science laboratory. The leaves were grounded into a fine powder using the hummer grinder with 0.5 mm sieve size.

Pots, each measuring 18 cm diameter x 17 cm depth, were three quarter filled with red clay soil which contained 30 % clay and 1 % organic matter. Then lantana leaf biomass was added to the soil in pots at 0, 10, 20, 30, 40, and 50 g per pot. These treatments were replicated four times and arranged in a Randomized Complete Block Design. The leaf biomass was mixed with the top 2 cm soil. *B. pilosa* seeds with a mass of 0.25 g and 10 seeds of pearl millet were sown in each pot. The pots were often watered to allow the germination and growth of *B. pilosa* and pearl millet.

The number of emerged *B. pilosa* and pearl millet was recorded from 3 to 15 days from planting. The mass of dry matter of *B. pilosa* and pearl millet were determined after 15 days from planting. The phytotoxic symptoms caused by lantana biomass addition to *B. pilosa* were noted. Analysis of variance was done on the final emergence counts of *B. pilosa* and pearl millet. Regression analysis was done to relate lantana biomass rates (g / pot) to *B. pilosa* and pearl millet parameters (emergence counts and dry matter), using the Sigma Plot Statistical Software.

Petri dish assays

Lantana powder extract of 10 g, 20 g, 30 g, 40 g and 50 g was soaked in 300 ml of distilled water for 24 hours at room temperature, to give 0, 10, 20, 30, 40, and 50 % concentration of extract, respectively. The extracts were filtered using cotton and filter paper until, solid particles were removed. The filtrate was stored at 5^o C to avoid other biochemical changes.

The seeds of pearl millet and *B. pilosa* were sterilized with sodium hypocloride for 5 minutes and followed by rinsing with distilled water to remove any excess chemical. The sterilized seeds were sun dried. Twenty seeds of each receptor plant (pearl millet, and *B. pilosa*) were placed on filter papers, fitted inside 9 cm diameter petri dishes. Lantana filtrate (2 ml) was added to each treatment. The addition of the filtrate was regularly done when the filtrate decreased. The petri dishes were placed in incubators which maintained temperature at 30° C in continuous darkness. The lantana concentrations (0, 10, 20, 30, 40 and 50 %) were replicated four times in a Randomized Complete Block Design. The blocking factor was the shelves of the incubator.

The seed germination which was defined as the emergence of the radicle from the seed coat, was recorded daily. The germination percentage was determined after seven days. The radicle and shoot length of five seedlings chosen at random per treatment was measured using a ruler and recorded after seven days. The dry matter weights of the seedlings were determined using a weighing balance. The regression analysis was done to determine the relationship of lantana concentrations and the parameters of pearl millet (seed germination, radicle length, plumule length and dry matter).

Results

Soil assay

Emergence of *B. pilosa*.

B. pilosa emergence occurred in all the concentrations. Weed seedling emergence in all treatments started after 3 days from planting as shown in Fig. 1. There was no significant difference ($p > 0.05$) in *B. pilosa* emergence at 3 days from planting. After 15 days from planting there were significant treatment differences ($p < 0.001$). The emergence of *B. pilosa* in the control rose with a steep gradient from 3 to 6 days after planting and stabilization occurred from day 6 onwards. In the other treatments i.e.10 g, 20 g, 30 g, 40 g, and 50 g of lantana biomass per pot, the emergence was low. Weed emergence continued until the termination of the experiment at 15 days from planting. The control treatment had high emergence counts and growth rate, while the other treatments had inhibited emergence. From day 12 and onwards some curling of leaves and yellowing were observed in the two treatments with highest lantana biomass of 40 g and 50 g per pot, on the *B. pilosa* seedlings. Generally *B. pilosa*

emergence decreased as concentration of lantana increased.

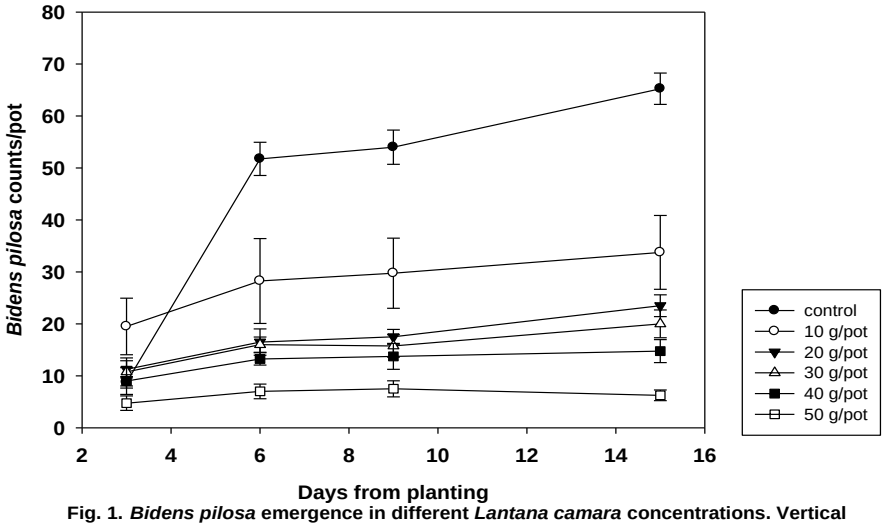

Fig. 1. *Bidens pilosa* emergence in different *Lantana camara* concentrations. Vertical bars show standard errors ± SE

***Bidens pilosa* counts**

The regression line shown by Fig. 2. was highly significant ($p < 0.001$) and the r^2 value was high. The inhibition of *B. pilosa* emergence increased with the increased application rates of lantana biomass. The control treatment had high *B. pilosa* counts compared to the other treatments. Lantana suppressed the emergence of *B. pilosa*. The results show that the extent of inhibition is related to the quantity of lantana biomass addition. *B. pilosa* emergence counts decreased as the lantana biomass increases from 0 g / pot to 50 g / pot.

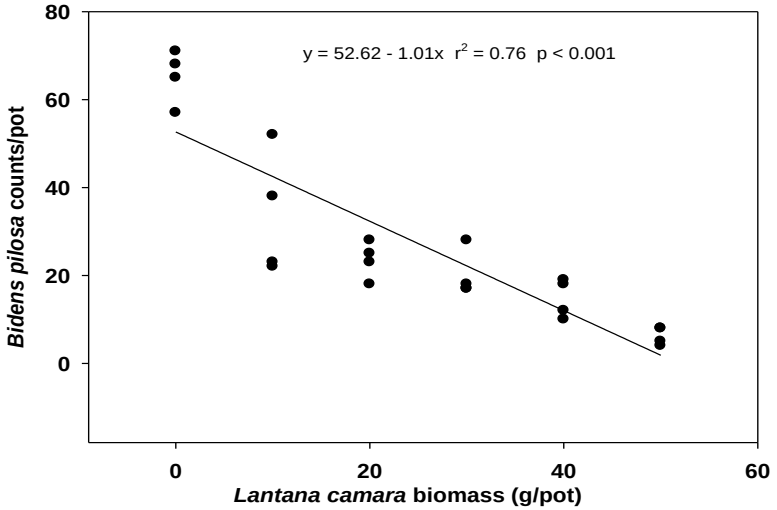

Fig. 2. The relationship of *Bidens pilosa* counts with different *Lantana camara* biomass.

Bidens pilosa dry matter

Although the regression which related *B. pilosa* dry matter and lantana biomass was significantly linear ($p < 0.001$), the r^2 value was low (Fig. 3). The dry matter of *B. pilosa* decreased as the lantana concentration increased.

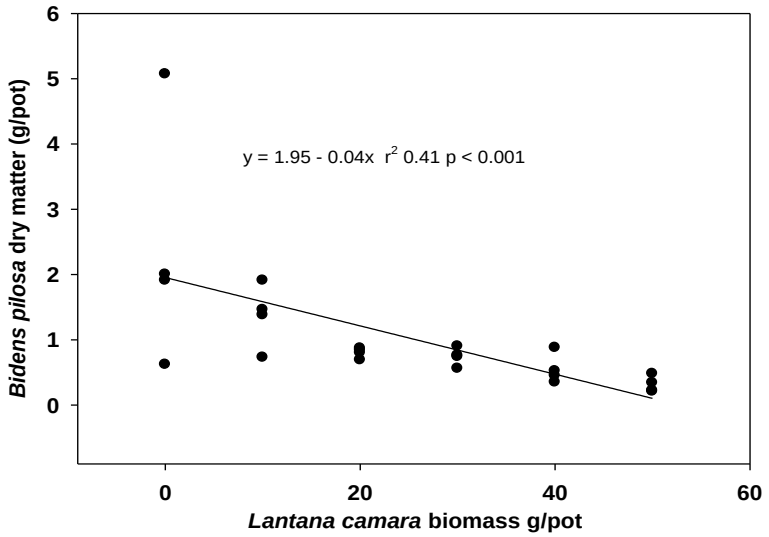

Fig. 3. The relationship of *Bidens pilosa* dry matter in different *Lantana camara* biomass.

Emergence of pearl millet (local landrace)

Fig. 4 shows that the different lantana concentrations had no significant ($p > 0.05$) effect on the emergence of pearl millet after 15 days from planting. This implies that pearl millet emergence in the pots was not affected by the addition of lantana biomass. The emergence of pearl millet was not related to lantana biomass application rates. Therefore, lantana did not have inhibitory effects on pearl millet.

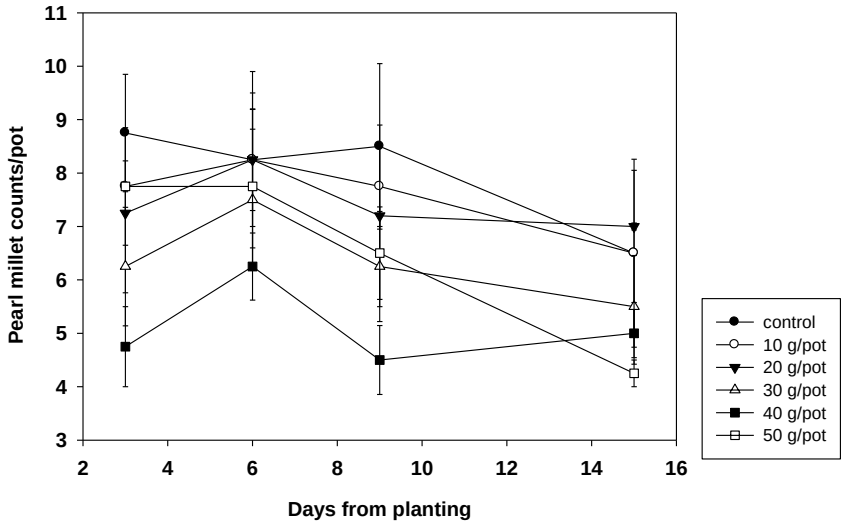

Fig. 4. Pearl millet emergence in different *Lantana camara* concentrations. Vertical bars show standard errors ± se

Pearl millet counts

The emergence of pearl millet was not related to lantana biomass application rates as shown in Fig. 5. It appeared that lantana did not have inhibitory effects on pearl millet emergence.

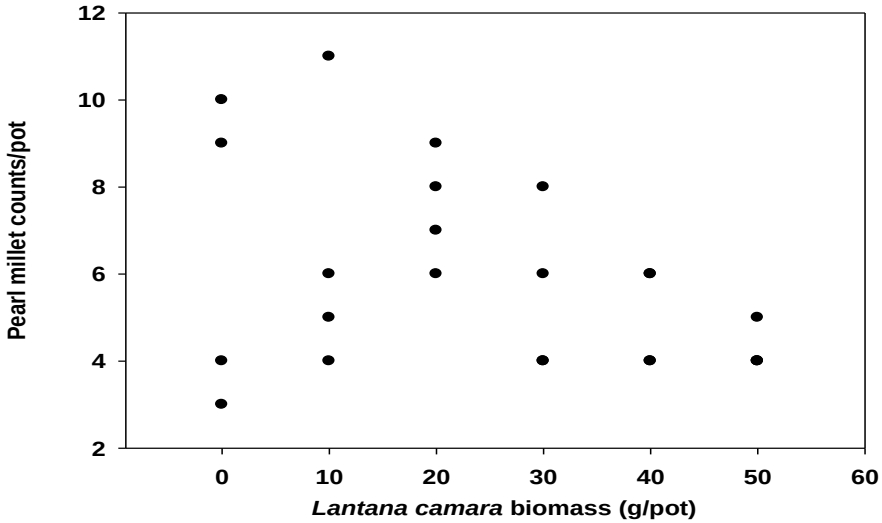

Fig. 5. The relationship of pearl millet counts and *Lantana camara* biomass

Pearl millet dry matter

Lantana concentration had no impact on pearl millet dry matter as shown by Fig. 6. The results more or less followed those of pearl millet counts.

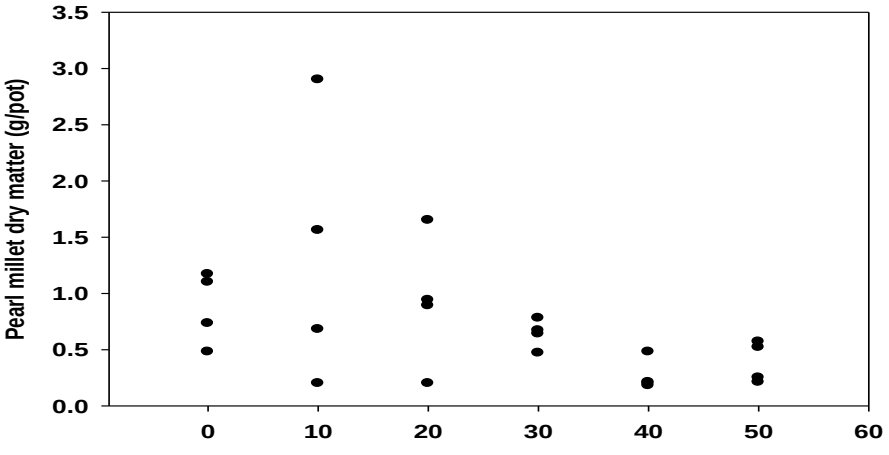

Fig. 6. The relationship of pearl millet dry matter and *Lantana camara* biomass.

Petri dish assay

Pearl millet germination

The relationship of pearl millet germination percentage and lantana was significantly ($p < 0.05$) linear. However, the r^2 value was very low as shown by Fig. 7. This means that pearl millet

was not sensitive to lantana concentrations. There was a tendency of pearl millet germination to decrease as lantana concentration was increased.

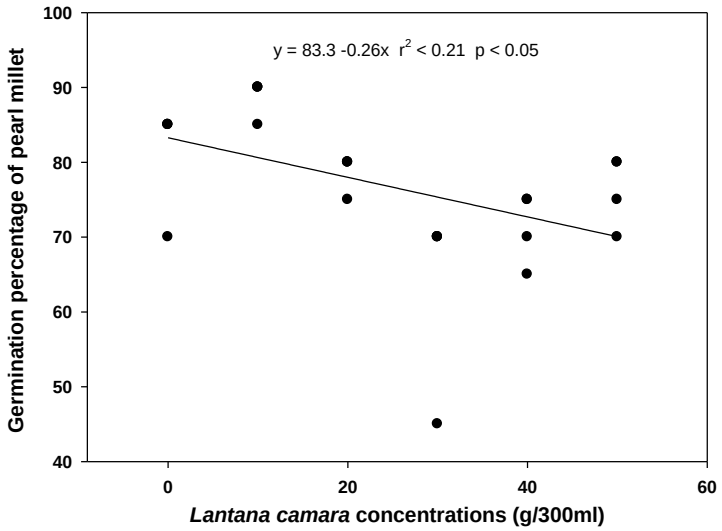

Fig. 7. The relationship of pearl millet germination percentage and *Lantana camara* concentrations.

Pearl millet radicle length

The relationship of pearl millet radicle length and lantana concentrations was significantly linear ($p < 0.001$) as shown by Fig. 8. Pearl millet radicle length decreased with increase in lantana concentration.

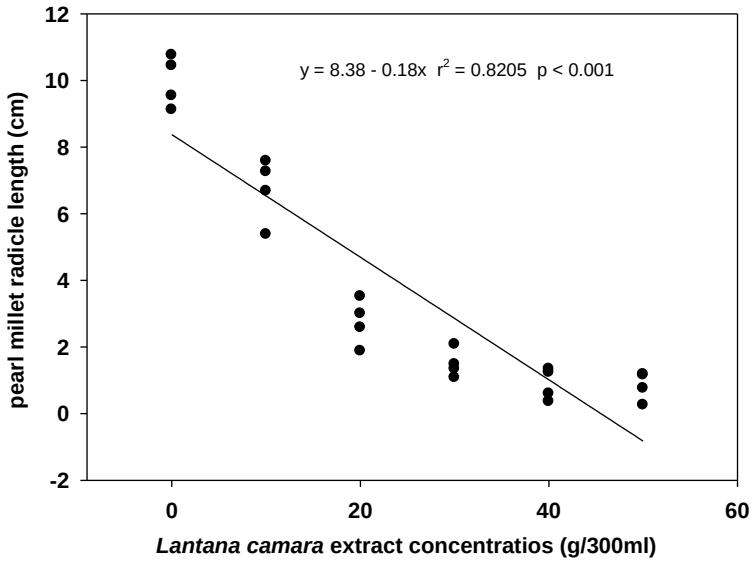

Fig. 8. The relationship of pearl millet radicle length with *Lantana camara* extract concentrations.

Pearl millet plumule length

The relationship of pearl millet plumule length and lantana concentration was significantly linear ($p < 0.001$), as shown by Fig. 9 and the r^2 value was high. The plumule length decreased with increasing lantana concentrations.

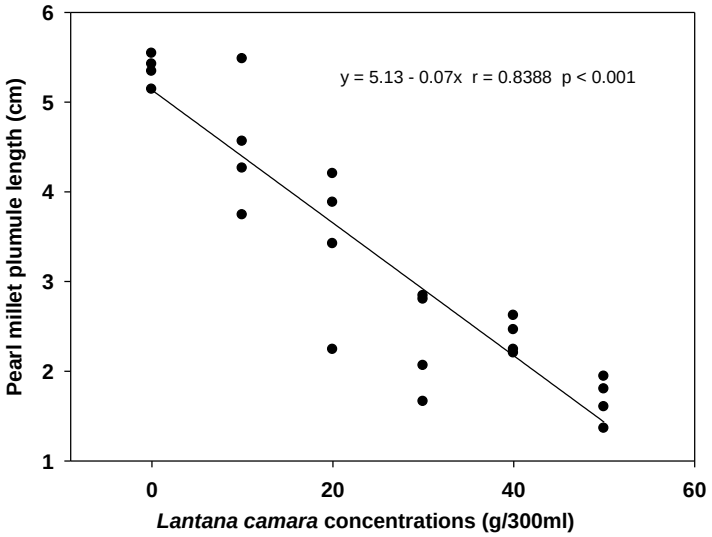

Fig. 9. The relationship of pearl millet plumule length with *Lantana camara* extract concentrations

Pearl millet dry matter

Lantana concentrations had no effect on the dry matter production. There was no relationship between the amount of lantana extracts and dry matter as shown by Fig.10. Fig.11. shows pearl millet germination in different lantana extract concentrations. The roots and shoots were inhibited as the concentration of lantana leaf extracts were increased.

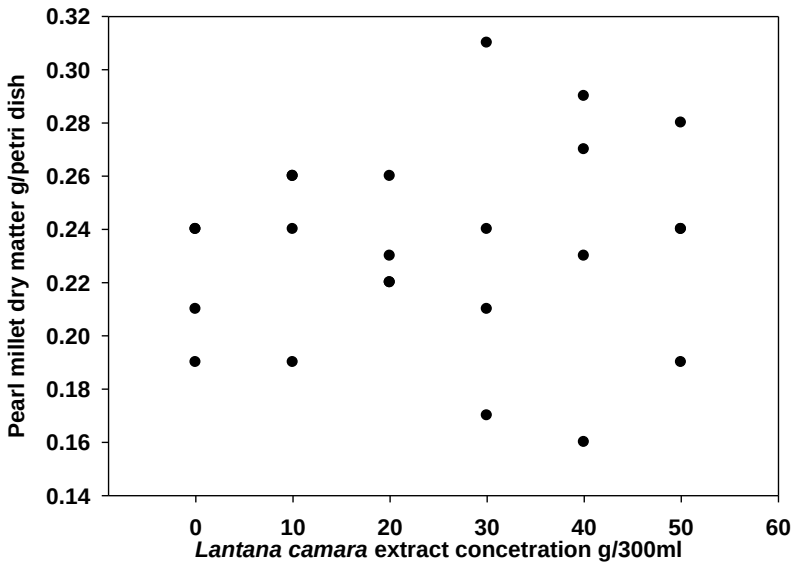

Fig.10. The relationship of pearl millet dry matter and *Lantana camara* extracts concetrations.

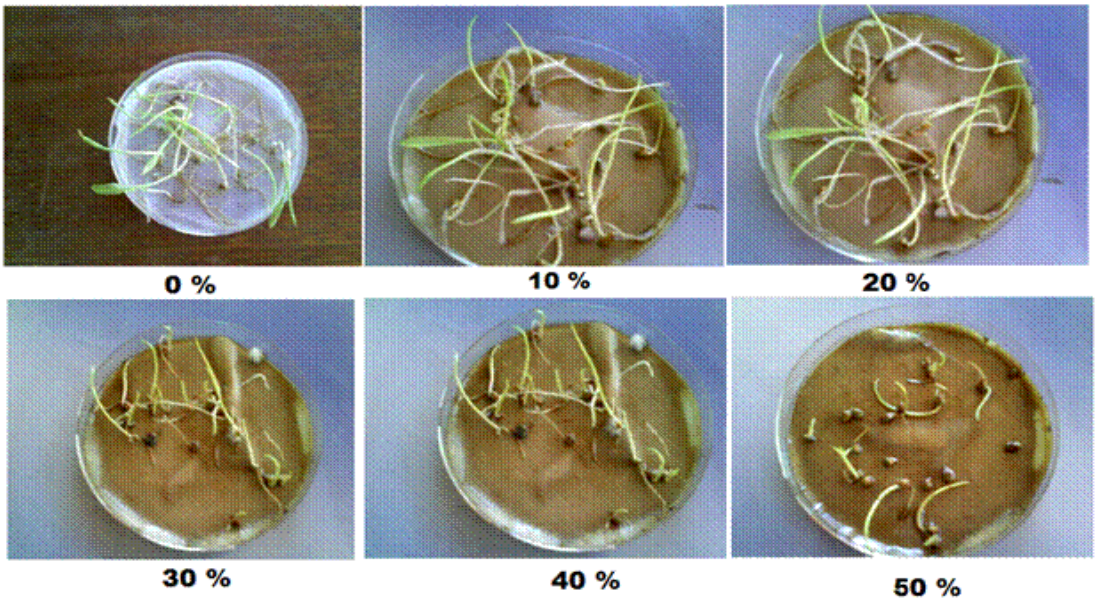

Fig. 11. Effect of *Lantana camara* leaf extracts concentrations on the germination of pearl millet.

***Bidens pilosa* germination**

Bidens pilosa failed to germinate in all the treatments.

Discussion

Lantana biomass addition to the soil suppressed the emergence and growth of *B. pilosa* under glasshouse conditions. In contrast, pearl millet emergence and growth was not suppressed under similar conditions. Probably the allelochemicals present in lantana (Hussein *et al*., 2011; Rakesh *et al*., 1989; Kong *et al*., 2006) could be responsible for reducing the emergence and growth of *B. pilosa*. The fact that leaf curling and yellowing symptoms were observed on *B. pilosa*, suggests that the allelochemicals reduce chlorophyll content. This could lead to reduced photosynthesis, followed by reduced growth of *B. pilosa*. Nashriyah *et al*. (2010) reported similar findings working with pink orchid. Salicylic acid, which is one of the allelochemicals found in lantana was reported to interfere with photosynthesis (Sharma *et al*., 2007), thereby resulting in stunted growth. Dadkhah (2012) also reported that *Ephedra major* allelopathy decreased chlorophyll and photosynthesis of *Cirsium avernse* weed. This supports the evidence that allelochemicals have negative effects on photosynthesis. Zheng *et al*. (2006) reported that lantana leaf extract sprayed to water hyacinth (*Eichhornia crassipes)* caused the overproduction of hydrogen peroxide which killed leaf cells. There is a possibility that lantana caused similar effects in *B. pilosa*, when the latter absorbed the allelochemicals via the roots.

Pearl millet emergence was not inhibited by increasing the lantana biomass per pot in the glasshouse experiment. This shows that it was not sensitive to lantana allelochemicals. Pearl millet emergence was not inhibited probably because the quantity of lantana was not sufficient to cause an inhibitory effect. Pearl millet could be tolerant to allelochemicals from lantana or the soil had some binding properties that adsorbed the allelochemicals making them unavailable for plant uptake. The soil used for this experiment contained about 30 % clay.

Although pearl millet emergence was not adversely affected by lantana biomass incorporation in the soil, its germination was inhibited by lantana leaf extracts under laboratory conditions. This difference might be caused by the fact that the pearl millet seeds in petri dishes were in direct contact with lantana extracts. El-Kenany and Darier (2013) showed that lantana leaf extracts inhibited the germination of *Sorghum bicolor* under laboratory conditions. *B. pilosa* successfully

emerged in the glasshouse conditions while in the laboratory it completely failed. It has to be noted that in the laboratory *B. pilosa* was exposed to temperatures of 30°C and continuous darkness. Its failure to germinate may be due to dormancy. Light and temperature fluctuations have effect on breaking the dormancy of seeds according to Karlsson (2008). In the glasshouse conditions temperatures were fluctuating and light was alternating with darkness. This study demonstrated the allelopathic effects of lantana and may explain why this plant is colonizing many areas in Zimbabwe. Plants which grow near lantana could be killed through allelopathy. It has also been shown that there is a potential to use lantana to control weeds, for example, *B. pilosa*. However, there is a need to evaluate the effects of lantana on a wide range of weeds and crops.

Conclusion

Lantana leaf biomass reduced the emergence and growth of *B. pilosa*, when it was added to the soil under glasshouse conditions. In contrast, pearl millet emergence and growth was not affected by lantana. However, lantana leaf extracts reduced the germination percentage, radicle length and plumule length of pearl millet under laboratory conditions.

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