Allelopathic Effects of Lantana (*Lantana camara* L.) Leaf Extracts on Germination and Early Growth of three Agricultural Crops in Ethiopia

Desalegn Tadele
Biology Department, P. O. Box 1817, Bahir Dar University, Bahir Dar, Ethiopia (*desalegn64@yahoo.com)

ABSTRACT
Allelopathic potential of aqueous extracts of lantana (*Lantana camara* L.) leaf on germination and growth of three agricultural crops: Maize, Finger millet and Tef, commonly cultivated in Ethiopia were studied under laboratory condition. The aqueous extracts were assayed at 5, 10, 25, 50 and 75% and their allelopathic effects were compared with distilled water (control). All the aqueous extracts did not significantly influence germination of the agricultural crops except 75% extract which significantly reduced germination of tef. All the leaf extracts stimulated root growth of maize and finger millet plants with the effect being declined with rise of concentration. In contrast, tef plants had reduced root growth in various leaf extracts with the highest reduction occurring at higher concentrations (25, 50 and 75%). The shoots of maize plants were also stimulated by all extract concentrations; whereas shoot growth of both tef and finger millet were not significantly affected by the leaf extracts. The results generally showed that lantana leaf extracts had stimulatory effects on early growth of maize and finger millet and inhibitory effects on tef growth.

Keywords: Finger millet, Maize, Root growth, Shoot growth, Tef.

1. INTRODUCTION

Lantana camara L. (Verbenaceae), a fast-growing woody thicket-forming shrub, is native to tropical and sub-tropical South and Central America and currently widely distributed in many countries including Ethiopia (Binggeli and Dessissa, 2002; Zalucki et al., 2007). It is among the top ten invasive weeds on earth (Sharma et al., 2005). The species may reach 3 m in height within 3 to 4 years and often forms dense thicket. It can aggressively establish in open forest lands, plantations, farmlands and wastelands. *Lantana camara* (hereafter referred to as lantana) grows under a wide range of climate conditions and occurs on a variety of soil types reflecting its wide ecological tolerance (Baars and Neser, 1999; Day et al., 2003).

The different parts of lantana contain allelochemicals mainly aromatic alkaloids and phenolic compounds (Ambika et al., 2003) which can interfere with seed germination and early growth of many plant species (Sahid and Sugau, 1993; Gentle and Duggin, 1997; Sharma et al., 2005; Ahmed et al., 2007). Lantana can also interfere growth of nearby plants by outcompeting for soil nutrients (Dobhal, et al., 2010) and altering microenvironment (e.g. light, temperature) by forming dense thickets (Sharma and Raghubanshi, 2007). Despite its recognition as among the worst invasive alien species in the world (Baars and Neser, 1999; Sharma et al., 2005; Zalucki et al., 2007), information on the ecological interference of lantana on the growth and establishment of native plants, especially on agronomic crops, is scanty in Ethiopia. In the present study, the allelopathic potential of lantana was therefore evaluated on three agricultural crops commonly grown in Ethiopia to identify whether lantana invasion in agricultural lands might interfere with agricultural crop production by reducing crop growth and establishment. The agricultural crops were maize (*Zea mays*), tef (*Eragrostis tef*) and finger millet (*Eleusine coracana*). Aqueous extracts of lantana leaf were used for testing the allelopathic potential of lantana on the agricultural crops. It is hypothesized that germination and early growth of the three agricultural crops is lower under the various concentrations of lantana leaf extracts.

2. MATERIALS AND METHODS

2.1. Extract Preparation

Mature leaves were collected from shrubs of lantana established in Abay Millennium Park, northwestern Ethiopia, where the species has aggressively invaded forest edges and grasslands of the park and adjacent farmlands and grazing lands (Solomon, 2010). Aqueous leaf extracts were prepared by soaking 100g fresh leaves of lantana with 500 ml distilled water using 1000 ml container. Each container was shaken and kept at room temperature for 24 hours. The resulting aqueous extracts were filtered through two layers of Whatman No. 1 filter paper and then some extracts were diluted to generate concentrations of 5, 10, 25, 50 and 75% and stored in conical flasks until required.

2.2. Germination Test

Seeds of maize, finger millet and tef, after washed with distilled water, were surface sterilized with 15% sodium hypochlorite for 20 min (Tinnin and Kirkpatrick, 1985). The seeds were then rinsed with distilled water. Three replicates in a completely randomized design, each containing 25 seeds of maize, 50 seeds finger millet and 50 seeds of tef, were prepared for each extract concentration using sterile petri dishes (9 cm diameter) lined with sterile Whatman No. 1 filter paper. Seeds were evenly distributed on the filter paper and 5 ml of each extract solution was added to each petri dish. The seeds used as controls were treated with only distilled water of same amount. Moisture in the petri dishes was maintained by adding 2 ml of aqueous extract or distilled water every 2 days. The experiment was carried out for two weeks. The seeds were considered germinated upon the emergence of the radicle. Germinated seeds were counted daily and the lengths of the roots and shoots were measured at the end of the experiment.

2.3. Data Analyses

The results were quantified as germination capacity, root or shoot growth in length. Germination capacity (GC) and relative elongation ratio (RER) of root and shoot were calculated following Bewley and Black (1994); and Saxena et al. (1996) as:

GC(%) = (No. of germinated seeds / total No. of seeds sown) x 100;

RER of shoot = (Mean shoot length of tested plant/Mean shoot length of control) x 100;

RER of root = (Mean root length of tested plant/ Mean root length of control) x 100;

All statistical analyses were done using SPSS Version 16. Differences among the treatment means were assessed by ANOVA according to general linear model (GLM) procedure. Significant differences among the means were found through Tukey's Honestly Significant Difference Test at $P < 0.05$.

3. RESULTS

3.1. Seed Germination of the Agricultural Crops

The effects of aqueous extracts of lantana leaf on seed germination of the three agricultural crops are shown in Figure 1. As compared to the control, lantana leaf extracts had no significant effects ($P > 0.07$) on seed germination of the agricultural crops except at 75% extract concentration where seed germination of tef was significantly reduced ($P < 0.01$) by 13.5%.

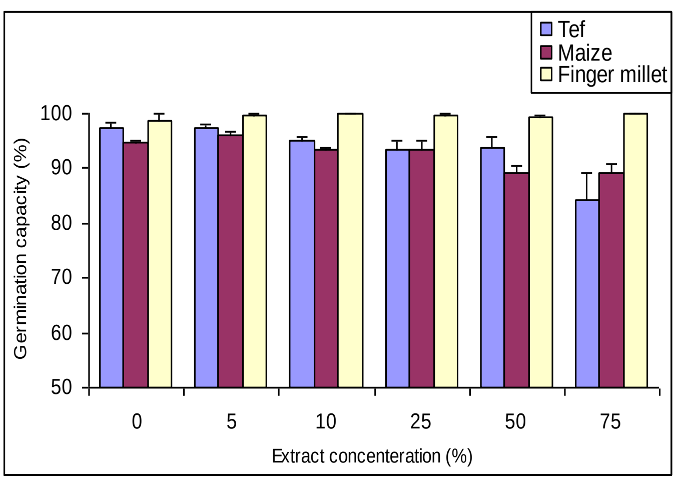

Figure 1. Germination capacity (%) of three agricultural crops in response to different concentrations of lantana leaf extracts. Bars indicate ± SE.

3.2. Root and Shoot Growth of the Agricultural Crops

Root and shoot growths of the agricultural crops grown under various concentrations of aqueous extracts of lantana leaf are presented in table 1. Both maize and finger millet plants developed significantly longer roots ($P < 0.001$) at all extract concentrations as compared to the control, with the stimulatory effect being decreased at higher concentrations. In tef plants, however, the various leaf extracts generally reduced root growth, with the highest reduction ($P < 0.001$) occurring at higher concentrations (25, 50 and 75%). The shoots of maize plants were also longer at all extract concentrations as compared to those treated with water alone; whereas shoot growth of both tef and finger millet were not significantly affected by lantana leaf extracts ($P > 0.06$).

Table 1. Root and shoot elongation (mm) of three agricultural crops in response to different concentrations of lantana leaf extracts (mean ± SE).

Agricultural crops	*Extract conc. (%)*	*Root length*	*Shoot length*
Tef	0	33.4 ± 5.48	16.1 ± 0.57
	5	33.5 ± 5.48	16.1 ± 0.61
	10	32.3 ± 5.48	16.0 ± 0.47
	25	27.7 ± 5.31*	16.4 ± 0.45
	50	24.5 ± 4.91*	15.9 ± 0.47
	75	20.8 ± 4.42*	16.2 ± 0.57
Maize	0	72.5 ± 2.57	40.9 ± 1.61
	5	109 ± 5.17*	47.4 ± 2.00*
	10	122 ± 5.22*	57.6 ± 2.04*
	25	110.9 ± 4.25*	57.1 ± 2.36*
	50	102.2 ± 3.04*	56.9 ± 1.87*
	75	95.3 ± 2.70*	53.3 ± 1.89*
Finger millet	0	33 ± 1.91	22.4 ± 0.54
	5	45 ± 2.63*	23.6 ± 0.61
	10	52.1 ± 1.07*	23.8 ± 0.54
	25	49.1 ± 1.89*	25 ± 0.46
	50	41.8 ± 1.75*	23.3 ± 0.72
	75	41.3 ± 1.71*	22.1 ± 0.72

*Significantly different from the control at $P < 0.05$ according to Tukey's HSD Test.

Figure 2 shows root and shoot elongation ratio of the agricultural crops grown in various lantana leaf extracts with respect to those grown in the control (treated by water only). Maximum relative elongation ratio (RER) of roots of maize (168%) and finger millet (158%) were found at

10% while tef had its maximum root elongation ratio (100%) at 5% extract concentration. Similarly, both finger millet (112%) and tef (102%) had their maximum shoot elongation ratios at 25 %, with maize (141%) achieving this ratio at 10% extract concentration. Interestingly, all of the agricultural crops had their minimum root elongation ratios at the highest extract concentration, 75%. Minimum shoot elongation ratios for maize, finger millet and tef were found at 5, 75 and 50% extract concentration, respectively.

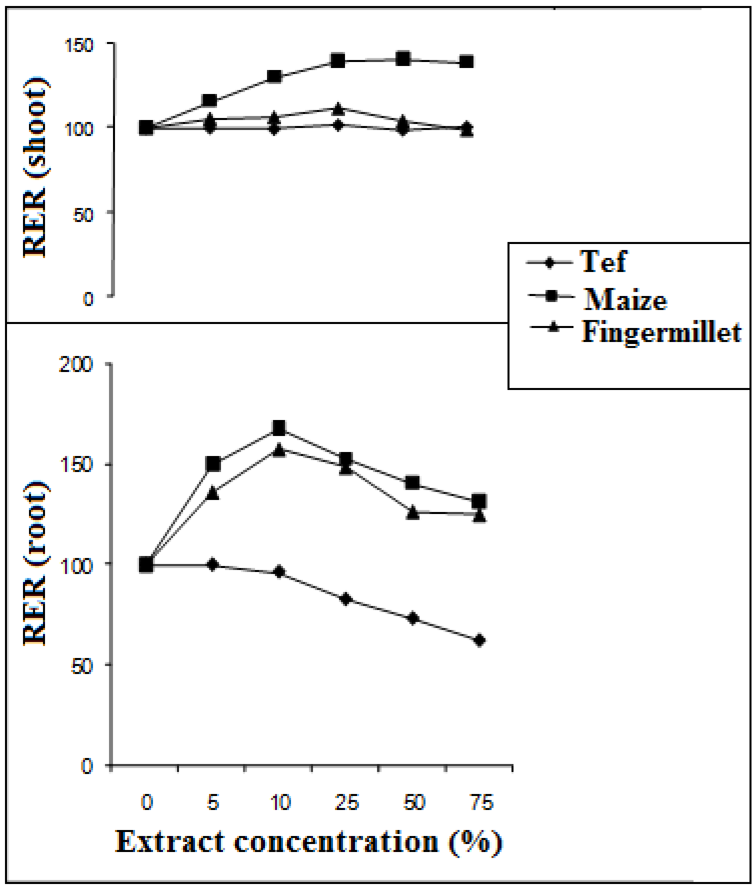

Figure 2. Relative elongation ratio (RER) of root and shoot (percent of control) of three agricultural crops in response to different concentrations of lantana leaf extracts.

4. DISCUSSION

Growth of both shoots and roots of maize and roots of finger millet were stimulated by all extract concentrations with magnitude of stimulation become lowered at higher concentrations. In contrast, the various leaf extracts generally had inhibitory effects on root growth of tef with increasing reduction towards higher extract concentrations. In all agricultural crops, shoot growth was less affected by the leaf extracts than root growth. The results indicated that the effects of lantana leaf extracts on root and shoot growth were both species specific (stimulatory effect on maize and finger millet and suppressive effect on tef) and concentration dependent and they were generally more pronounced on the roots than shoots of the agricultural crops. Previous studies on allelopathic effects of lantana showed its potential interference with seed germination and growth of many plant species including agricultural crops (Sahid and Sugau, 1993; Gentle and Duggin, 1997; Sharma et al., 2005; Ahmed et al., 2007; Hossain and Alam, 2010). Plants containing allelochemicals can affect germination and growth of other plants on concentration dependent manner; and the effects of these chemicals are selective and can vary with different plant species (Rice, 1984; Daniel, 1999; Cruz-Ortega et al., 2002; Morita et al., 2005; Hossain and Alam, 2010). More sensitive and stronger responses of roots of the agricultural crops to lantana leaf extracts than the shoots might be due to close contact of the root with the extract solution (Qasem, 1995; Tefera, 2002).

Allelopathy is one of the important mechanisms in agro-ecosystems which affect crop performance (Rice, 1984; Kohli et al., 1998). High germination capacity and stimulated early growth of maize and finger millet indicates that lantana leaf extracts exerted a positive action affecting germination capacity of the seeds and growth of roots and shoots of these crops. The results, thus, indicate the possibility to cultivate maize and finger millet in agricultural lands invaded by lantana after its removal or growth of these crops close to lantana thickets. Growing tef, however, may not be promising in areas where lantana invasion occurs due to allelopathic interference though the allelochemicals causing reduction in growth of tef may not cause the same effect in the field since the concentration of these substances is probably greater in aqueous extracts than under natural conditions in the field (Rice, 1984) or they may be bound and made unavailable by soil particles (Dalton et al., 1983) or decay may reduce the allelopathic effects of leaf litter (May and Ash, 1990). The report from Hussain et al. (2011), for example, showed strong allelopathic effects of aqueous extracts of all parts of lantana on the test species while the soil collected underneath lantana thickets had no allelopathic effects.

5. CONCLUSION

The results of the study showed allelopathic potential of aqueous lantana leaf extracts on the growth of the agricultural crops. The leaf extracts had differential effects on the germination and growth of the crops. The roots were found more sensitive to the leaf extracts than the shoots.

Though laboratory bioassays are important to single out allelopathic effects it necessitates investigating the significance of these results under field conditions. Moreover, further investigations are required to better understand the underline causes and actual mechanisms involved in the differential effects of the leaf allelochemicals on different species.

6. ACKNOWLEDGEMENT

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7. REFERENCE

Ahmed, R., Uddin, M.B., Khan, M.A.S.A & Mukul, S.A. 2007. Allelopathic effects of *Lantana camara* on germination and growth behavior of some agricultural crops in Bangladish. *Journal of Forestry Research*, **18(4)**: 301-304.

Ambika, S.R., Poornima, S., Palaniraj, R., Sati, S.C & Narwal, S.S. 2003. Allelopathic plants: 10. *Lantana camara* L. *Allelopathy Journal*, **12**: 147–162.

Baars, J.R & Neser, S. 1999. Past and present initiatives on the biological control of Lantana camara (Verbenaceae) in South Africa. In: Olckers, T., Hill, M.P. (Eds.), Biological controls control of weeds in South Africa (1990–1999). African Entomology, Memoir No. 1. Entomological Society of Southern Africa, Johannesburg, South Africa, 182p.

Bewley, J.D & Black, M. 1994. Seeds: physiology of development and germination. Plenum Press, New York, 445p.

Binggeli, P & Desissa, D. 2002. *Lantana camara* - the invasive shrub that threatens to drive people out of their land. Newsletter of the Ethiopian Wildlife and Natural History Society, April-June 2002, pp.4-6.

Cruz-Ortega, R., Ayala-Cordero, D & Anaya, A. L. 2002. Allelochemical stress produced by aqueous leachate of *Callicarpa acuminate*: effects on roots of bean, maize and tomato. *Physiologia Plantarum,* **116**: 20-27.

Dalton, B.R., Blum, U & Weed, S.B. 1983. Allelopathic substances in ecosystems: Effectiveness of sterile soil components in altering recovery of ferulic acid. *Journal of Chemical Ecology*, **9**: 1185-1201.

Daniel, W.G. 1999. Historical review and current models of forest succession and interference. Florida: CRC press, pp. 237-251.

Day, M.D., Wiley, C.J., Playford, J & Zalucki, M.P. 2003. Lantana: current management status and future prospects. Australian center for international agricultural research Canberra. *ACIAR Monograph*, **102**: 1-128.

Dobhal, P.K., Kohli, R.K & Batish, D.R. 2010. Evaluation of impact of *Lantana camara* L. invasion on four major woody shrubs along Nayar river of Pauri Garhwal, in Himalaya. *International Journal of Biodiversity Conservation*, **2(7)**: 166-172.

Gentle, C.B & Duggin, J.A. 1998. Allelopathy as a competitive strategy in persistent thickets of *Lantana camara* L. in three Australian forest communities. *Plant Ecology*, **132**: 85-95.

Hossain, M.K & Alam, N. 2010. Allelopathic effects of *Lantana camara* leaf extract on germination and growth behavior of some agricultural and forest crops in Bangladish. *Pakistan Journal of Weed Science*, **16(2)**: 217-226.

Hussain, F., Ghulam, S., Sher, Z & Ahmad, B. 2011. Allelopathy by *Lantana camara* L. *Pakistan Journal of Botany*, **43(5)**: 2373-2378.

Kohli, R.K. Batish, D & Singh, H.P. 1998. Allelopathy and its implications in agro-ecosystems. *Journal of Crop Prod*uction, **1**: 169-202.

May, F & Ash, J. 1990. An assessment of the allelopathic effect of *Eucalyptus*. *Australian Journal of Botany*, **38**: 245-254.

Morita, S., Ito, M & Harada. J. 2005. Screening of an allelopathic potential in arbor species. *Weed Biology and Management*, **5**: 26-30.

Qasem, J.R. 1995. The allelopathic effects of three *Amaranthus* spp. (Pigweeds) on wheat (*Triticum durum*). *Weed Res*earch, **35**: 41-49.

Rice, E.L. 1984. Allelopathy. 2nd edition. Academic Press, New York, 422p.

Sahid, I.B & Sugau, J.B. 1993. Allelopathic effects of lantana (*Lantana camara*) and siam weed (*Chromolaena odorata*) on selected crops. *Weed Sci*ence, **41(2)**: 303-308.

Saxena, A., Singh, D.V & Josh, N.L.. 1996. Autotoxic effects of pearl millet aqueous extracts on seed germination and seedling growth. *Journal of Arid Environments*, **33**: 255-260.

Sharma, G. P., Raghubanshi, A. S & Singh, J. S. 2005. Lantana invasion: an overview. *Weed Biology and Management*, **5**: 157-167.

Sharma, G.P & Raghubanshi, A.S. 2007. Effect of *Lantana camara* L. cover on local depletion of tree population in the Vindhyan tropical dry deciduous forest of India. *Applied Ecology and Environment Research*, **5(1)**:109-121.

Solomon, C. 2010. Distribution and effects of *Lantana camara* on different land- uses at Abay millennium Park, Bahir Dar, Ethiopia. M.Sc. Thesis, Bahir Dar University, 58p.

Tefera, T. 2002. Allelopathic effects of *Parthenium hysterophorus* extracts on seed germination and seedling growth *Eragrostis tef*. *Journal of Agronomy and Crop Science*, **188**: 306-310.

Tinnin, R.O & Kirkpatrick, L.A. 1985. The allelopathic influence of broadleaf trees and shrubs on seedling of Douglas fir. *Forest Science*, **31**: 945-952.

Zalucki, M.P., Day, M.D & Playford, J. 2007. Will biological control of *Lantana camara* ever succeed? Patterns, processes & prospects. *Biological Control*, **42**: 251-262.