Asian Journal of Agricultural Science 7(1): 4-10, 2015
ISSN: 2041-3882; e-ISSN: 2041-3890

Submitted: November 3, 2014 Accepted: December 18, 2014 Published: January 15, 2015

Allelopathic Effect of *Lantana camara* L. Leaf Powder on Germination and Growth Behaviour of Maize, *Zea mays* Linn. and Wheat, *Triticum turgidum* Linn. Cultivars

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Abstract: Aim of the present study was to evaluate allelopathic effect of *Lantana camara* leaf powder on germination and growth behaviour of *Zea mays* and *Triticum turgidum.* The pot culture experiments were conducted at Botany laboratory, Tewodros campus, University of Gondar, Ethiopia from November 2012 to April 2013. The experimental design was Completely Randomized Block Design (CRBD) with three treatments and one control. The soil without adding *L. camara* leaf powder was considered as control (T_0) and T_1, T_2 and T_3 were mixed with 25, 50 and 75 g of *L. camara* leaf powder, respectively. The percentage of germination, root and shoot length, stem thickness and biomass were recorded from three replicates. Maximum germination percentage of wheat (96.60%) and maize (53.33%) was recorded at T_1 and it was minimum (70%) in wheat and maize (43.33%) at T_3 compared to control (100%). The germination index of wheat and maize was 5 cm and 1.9 cm, respectively at T_1. The shoot and root length variation observed in wheat and maize was statistically significant ($p<0.05$) compared to control. The percentage root inhibition of wheat and maize was 62.1 and 39.4%, respectively at T_3 compared to control. The stem thickness variation among the treatment and control was statistically significant ($p<0.05$) in both the experimental plants. Maximum fresh weight and dry weight of wheat was 1.3 g and 0.4 g, respectively at T_0 and minimum was 0.8 and 0.1 g, respectively at T_3. In maize, maximum fresh weight and dry weight was 8.5 g and 1.5 g, respectively at T_0 and minimum 3.9 and 0.4 g, respectively at T_3. The biomass variation of wheat and maize results were statistically significant ($p<0.05$). In conclusion, *L. camara* leaf powder significantly inhibits seed germination, speed of germination, shoot and root length, stem thickness and biomass of wheat and maize. By keeping the *L. camara* plants around agricultural field may affect growth parameter of wheat and maize. Further studies on characterization of phytochemicals and their specific role in different agricultural crops is important.

Keywords: Allelopathy, biomass, germination, growth, *Lantana camara, Triticum turgidum, Zea mays*

INTRODUCTION

Allelopathy is a biological phenomenon in which plants can produce certain secondary metabolites that inhibit the growth, reproduction and survival of other plants to avoid competition in their surroundings. Some of the plant secondary metabolites have phytotoxic effects (Stamp, 2003). Allelopathic nature of the plants help them to be highly competitor for space, light and nutrients with the nearby plants (Syed and Imran, 2001). The distribution of plant species and abundance in a particular place is determined by allelopathic interactions, especially in the success of invasive plants.

Lantana camara belongs to the family Verbenaceae is one of the known allelopathic weed plants in many parts of the world (Binggel and Desalegn, 2002). This plant contains variety of phenolic acids and toxic substances which hinders seedling growth and development of nearby floras (Achhireddy and Singh, 1984). The hindering mechanism involves aggressive competition for surface-soil nutrients and water (Gentle and Duggin, 1998). Allelopathic effects of *L. camara* on germination and growth of chickpea, sonalika seeds and rice was reported by Singh *et al*. (1989) and Prasad and Srivastava (1991).

In Ethiopia, *L. camara* is an exotic species and it has wide ecological tolerance and growing successfully in various soil types (Day *et al*., 2003). The wide spread nature of this plant is facilitated by moving of seeds through running water, dispersal by birds and animals after eating and excreting undigested seeds (IBC, 2009). Some of the hotspot areas of *Lantana* in Ethiopia include Debre Zeit, Dire Dawa, Harerge and Somali region. Allelopathic effects of *L. camara* on some agricultural crops are given worldwide emphasis, but such scientific investigations are limited in Ethiopia. The agrarian society of Ethiopia is growing many agricultural food crops in order to fulfill the demands of growing population. The dominated agricultural crops in the country are maize, *Zea mays* and wheat, *Triticum*

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turgidum. Therefore, allelopathic effects of *L. camara* leaf powder on germination and growth of *Zea mays* and *Triticum turgidum* was evaluated using pot culture experiment and reported.

MATERIALS AND METHODS

Preparation of plant materials and soil: Leaves of *L. camara* was collected from the vicinity of University of Gondar, Ethiopia and washed with tap water to remove the adherent dust particles and allowed to dry at room temperature in Botany laboratory. The dried leaves were powdered by using electric blender. The leaf powder was measured to 25, 50 and 75 g, respectively using digital balancer. The loamy soil (pH of 7.4) was collected within the University of Gondar campus and quantified in to 1000 g and kept in plastic containers for subsequent experiments. The allelopathic effect of plant powder was evaluated by mixing of pre-quantified leaf powder in to 1000 g of soil in plastic containers. The seeds of *Zea mays* and *Triticum turgidum* were procured from North Gondar Zone of Tsehay Hulegeb Farmers Union, Ethiopia.

Experimental design: The experiment was conducted in Completely Randomized Block Design (CRBD) which includes three treatments and one control for each crop seeds. The three treatments were considered as T_1, T_2 and T_3 and control group denotes T_0. The control group plants were grown in soil without mixing the *L. camara* leaf powder whereas T_1, T_2 and T_3 plants were grown in soil mixed with 25, 50 and 75 g, of *L. camara* leaf powder, respectively. For each experiment, ten seeds were sown and allowed for germination to all the treated plastic containers. The experiment was replicated at three times and performed from November 2012 to April 2013.

Measurement of seed germination and growth: The experimental pots were kept outside the botany laboratory and regular water was given to keep the seed moist enough to get favorable condition for germination and growth. The seed germination was monitored continuously for twenty one days or allowed the last seed to germinate. The shoot growth development was recorded on daily basis after seed germination. The root length was measured at the end of experimental period. The following parameters such as germination percentage, speed of germination, stem thickness, roots and shoots elongation were recorded and calculated before the maturity of plants.

Percentage and speed of germination: The numbers of germinated seeds were counted daily until the completion of experiment. Percentage of germination and speed of germination index (S) were calculated using the following formula recommended by Khandakar and Bradbear (1983):

$$S = \left(\frac{N_1}{1} + \frac{N_2}{2} + \frac{N_3}{3} + \ldots \frac{N_n}{n}\right) \times 100\%$$

where, N_1, N_2, N_3…. N, are proportions of seed which germinate on days 1, 2, 3… N following set up of the experiment. If all the seeds sown were germinated at a time was considered as 100% whereas if none of the seeds germinated were considered as 0.

Measurement of growth parameters: After the completion of seed germination, shoot length was measured using ruler with different days of developmental period. The stem thickness of the plants were measured by using Caliper meter. The root length and inhibition percentage of the root length for each seeds of maize and wheat was calculated. The following formula was used to calculate percentage root length inhibition:

$$\%\ \text{inhibition of the root length} = \frac{\text{RLC - RLT}}{\text{RLC}} \times 100$$

where, RLC is root length in control and RLT is root length in treatment

Measurement of biomass: After the completion of experiment, plants were harvested and the biomass of shoots and roots was measured. The fresh weight of the sample was calculated immediately after harvest and dry weight was calculated by keeping the plants in oven at 80°C for 72 h.

Data analysis: The data collected from the experiments were subjected to descriptive statistics to calculate mean, standard deviation, germination index and percentage by using Ms-Excel spreadsheet version 2010. The statistical significant difference on shoot and root length elongation, stem thickness and biomass was confirmed by one way ANOVA using SPSS version 20.

RESULTS

Germination percentage: The mean germination percentage of maize and wheat grown on the pot (Fig. 1) was recorded and explained in Fig. 2. The experimental results demonstrate that leaf powder of *L. camara* exhibit profound inhibitory effects on germination. Among the three treatments, germination percentage of wheat was maximum (96.60%) in T_1 and it was decreased in T_3 (70%) compared to control (100%). In maize, maximum percentage of germination was recorded in T_1 (53.33%) and it was minimum in T_3 (43.33%) compared to control (73.33%).

Speed of germination: The speed of germination or germination index was calculated for maize and wheat and depicted in Fig. 3. Results revealed that after 12

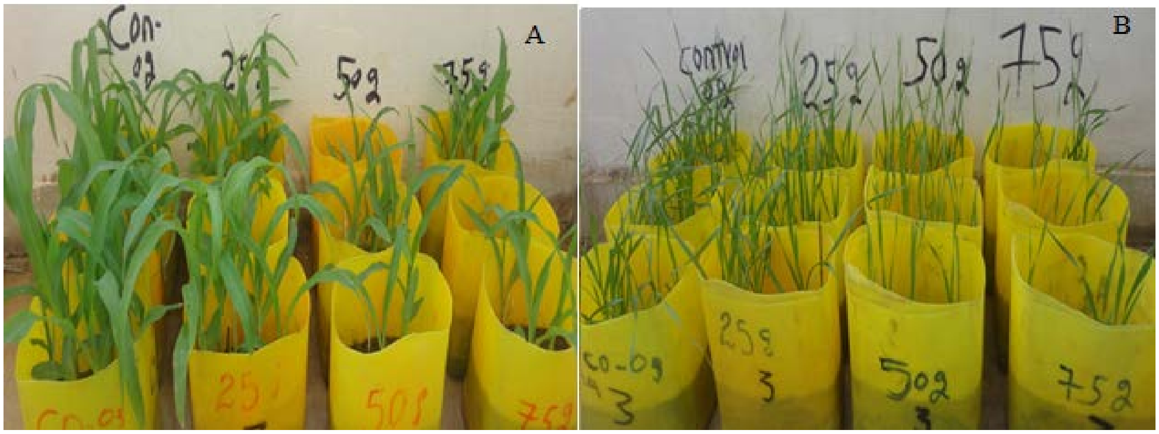
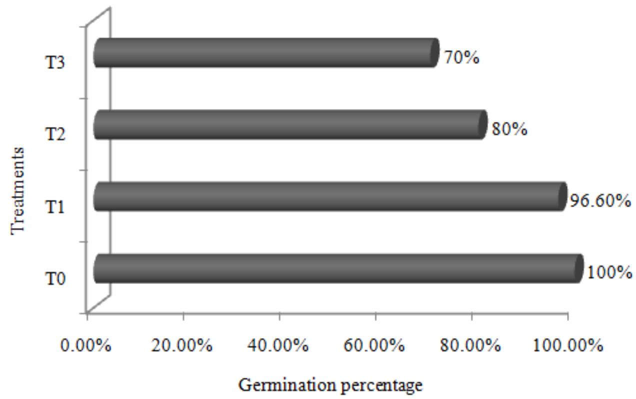
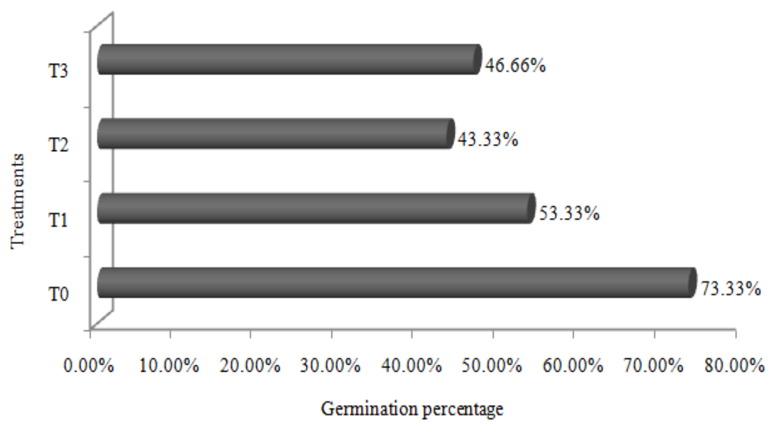


Fig. 1: Maize (a) and wheat (b) seeds grown at various treatments



(a)



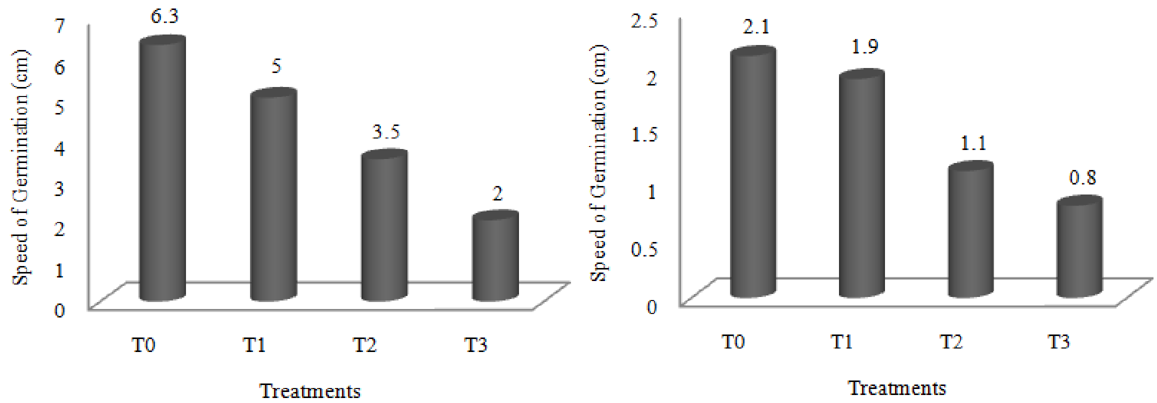
(b)

Fig. 2: Germination percentage of wheat (a) and maize (b) at different treatments

days of seed sowing, germination index of wheat was observed 5, 3.5 and 2 cm in T_1, T_2 and T_3, respectively. The maximum speed of germination (6.3 cm) was calculated from T_0. In maize, germination speed was 1.9, 1.1 and 0.8 cm in T_1, T_2 and T_3, respectively. The maximum speed of germination (2.1 cm) was recorded in T_0.

Growth parameters of wheat and maize:

Shoot length: The average shoot length (cm) recorded from the germinated seedlings (Fig. 4) after 21 days are presented in Table 1. Results indicate that shoot development of wheat was maximum (27.8 cm) in control (T_0). The application of *L. camara* leaf power at 75 g (T_3) is significantly reduced shoot development (F



(a) (b)

Fig. 3: Germination index of wheat (a) and maize (b)

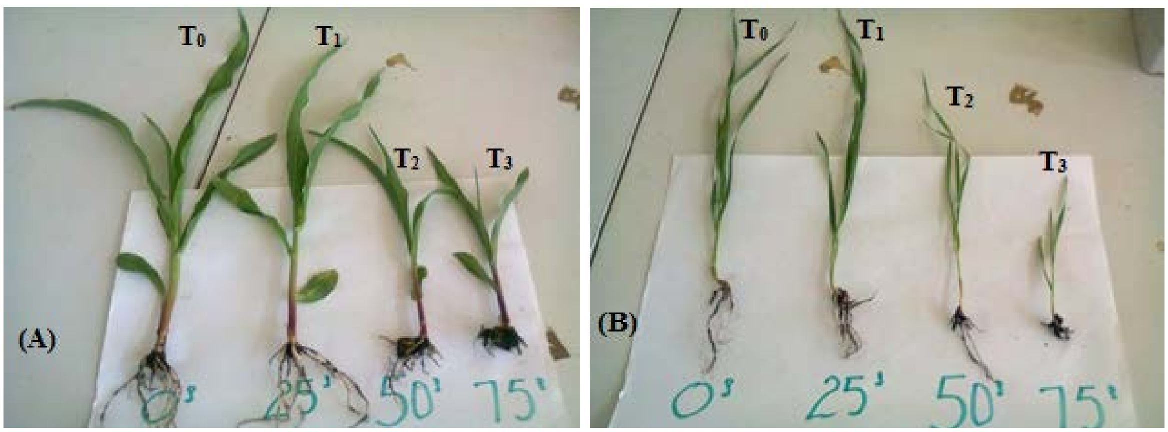


Fig. 4: Variation in shoot elongation of maize (A) and wheat (B) at various treatments

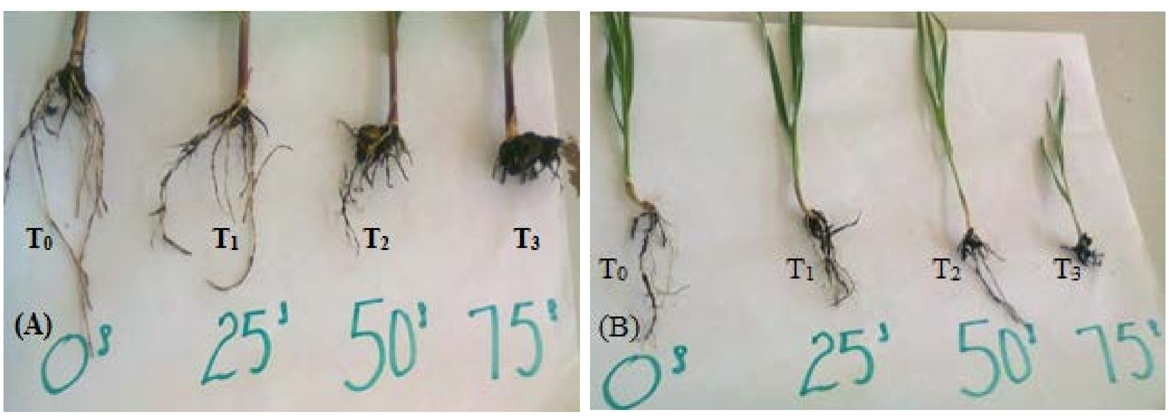


Fig. 5: Variation in root elongation of maize (A) and wheat (B) at various treatments

Table 1: Growth parameters of wheat and maize after 21 days of seed sowing

	Shoot length (cm)		Root length (cm)		% inhibition of the root length	
Treatments	Wheat	Maize	Wheat	Maize	Wheat	Maize
T_0	27.8±0.72	32.9±0.10	12.4±0.55	9.3±0.44		
T_1	26.3±0.32	26.6±0.21	9.0±0.45	7.2±0.31	25.0%	22.5%
T_2	22.1±0.45	19.7±0.44	6.6±0.11	6.0±0.10	46.7%	35.5%
T_3	19.6±0.05	19.4±0.05	4.7±0.26	5.6±0.44	62.1%	39.4%

Values are mean±standard deviation of three replicates

Table 2: Mean stem thickness of wheat and maize

Treatments	Mean of stem thickness (mm) Wheat	Maize
T_0	2.5±0.20	4.7±0.15
T_1	2.1±0.12	4.0±0.30
T_2	1.7±2.27	3.6±0.21
T_3	1.4±0.02	3.3±0.31

Values are mean±standard deviation of three replicates

Table 3: Mean biomass of wheat and maize

	Wheat Biomass (g)		Maize Biomass (g)	
Treatments	Fresh weight	Dry weight	Fresh weight	Dry weight
T_0	1.3±0.10	0.4±0.01	8.5±0.10	1.5±0.17
T_1	1.2±0.05	0.2±0.03	6.6±0.26	0.7 ±0.15
T_2	0.9±0.03	0.2±0.02	4.1±0.21	0.5±0.21
T_3	0.8 ±0.10	0.1±0.03	3.9±0.10	0.4±0.15

Values are mean±standard deviation of three replicates

= 206.97; p<0.05). In maize, maximum (32.9 cm) shoot development was observed in T_0 and it was minimum (19.4 cm) in T_3. The inhibitory effect was significantly increased (F = 207.97; p<0.05) when the application of *L. camara* leaf powder was increased.

Root length: The root length of maize and wheat plants was measured after 21 days are presented in Table 1. In the present study, development of root growth was greatly reduced with increased amount of plant powder mixed soil (Fig. 5). In wheat plant, maximum (12.4 cm) root length was observed in control (T_0) and it was minimum (4.7 cm) in T_3. The significant variation on root length development was confirmed by one way ANOVA (F = 232.62; p<0.05). In maize plant, maximum root development of 9.3cm was recorded in control (T_0) and it was minimum (5.6 cm) in T_3. The mean root development was varied significantly (F = 68.80; p<0.05) within the treatments compared to control.

Percentage of root inhibition: The percentage root inhibition of wheat was maximum (62.1%) in T_3 followed by T_2 (46.7%) and T_1 (25%). In maize, maximum of 39.4% root inhibition was noted in T_3 followed by T_2 (35.5%) and T_1 (22.5%).

Stem thickness: The mean stem thickness (mm) of wheat and maize was calculated and reported in Table 2. The mean stem thickness of wheat was maximum (2.5 mm) in T_0 and minimum (1.4 mm) in T_3. In maize, maximum mean stem thickness of 4.7 mm was recorded in T_0 and it was minimum (3.3 mm) in T_3. The variation within the treatment was statistically significant (wheat F = 23.71; maize F = 15.83; p<0.05) compared to control.

Biomass measurement: The estimated biomass of wheat and maize such as mean fresh weight and dry weight was presented in Table 3. Maximum (1.3 g) fresh weight of wheat was recorded in T_0 and it was minimum (0.8 g) in T_3. The fresh biomass variation observed from the treatments were statistically significant (F = 28.38; p<0.05). On the other hand, dry weight was maximum (0.4 g) in T_0 and minimum (0.1 g) in T_3 and the results were statistically significant (F = 68.39; p<0.05). In maize, maximum (8.5 g) fresh weight was recorded in T_0 and it was minimum (3.9 g) in T_3 and the results were statistically significant (F = 436.2; p<0.05). The dry weight was maximum (1.5 g) in T_0 and minimum (0.4 g) in T_3 and the results were statistically significant (F = 23.33; p<0.05).

DISCUSSION

Germination percentage: Allelopathic effects of *L. camara* plant result clearly indicate that increased amount of *L. camara* leaf powder have inhibitory effects on maize and wheat seeds germination. Present findings were in agreement with the report of Achhireddy *et al*. (1985) and Casado (1995), who have reported that *L. camara* is allelopathic weed and hinders the seedling recruitment and growth of other plants due to the presence of phenolic acids (Narwal, 1994) or/and phytotoxic chemicals released from the leaf litter and roots (Hossain and Alam, 2010). In other related researchers (Jabeen and Ahmed, 2009; Hossain and Alam, 2010) suggested that *L. camara* leaf extracts have allelopathic effects on germination and behavior of agricultural crops, like *Triticum aestivum* and *Cucurbita pepo*. The germination percentage of wheat and maize was not uniform in the same treatments. For example, in T_0, germination percentage of wheat and maize was 100 and 73.33%, respectively. It may be associated with the quality and nature of seeds or enzymatic and physiological activities facilitate for seed germination. Another possible reason may be related to the preference of soil type by the seeds of wheat and maize. Zuo *et al*. (2012) suggested that allelopathic plants can influence energy circulation and enzyme activity of receptor plants.

Germination index: The germination index has advantage over percent germination, since it is more sensitive indicator of allelophatic effects (Wardle *et al*., 1991). In the present findings calculated germination index may not be uniform in wheat and maize. The variation in germination index may be associated with the influence of various phytochemical released from the leaf powder of *L. camara*. According to Rice (1974) wide fluctuation in germination index was mainly associated with the presence of many phenolics and the leaves of *L. camara* contain 14 different phenolic compounds (Jain *et al*., 1989). It may be the reason for wide variation of germination index in wheat and maize.

Shoot length: The shoot length of wheat and maize was significantly inhibited by the *L. camara* leaf powder. The results of the present study is in agreement with the report of Hossain and Alam (2010) who have observed that increased application of *L. camara* leaf extracts completely inhibits shoot elongation of the plant *Abelmoschus exculantus.*

Root length: The root length elongation was decreased in increased amount of *L. camara* leaf powder. To support the present findings many reports suggested that root growth was more sensitive and responds more strong to an increase in percent content of *Lantana* extracts (Chou and Kuo, 1986; Alam, 1990; Zackrisson and Nilsson, 1992; Bansal, 1998) due to allelopathic effect (Leather and Einhelling, 1986; Barnes and Putnam, 1987).

Percentage root length inhibition: The percentage root length inhibition was increased in increased concentration of *L. camara* leaf powder. Iramus *et al*. (2011) was also observed significantly suppressed root elongation on mung bean due to allelopathic effect of *Lantana* weeds. Daniel (1999), Hossain and Alam (2010) was also observed inhibitory effect with increased concentration of *Lantana* and due to osmotic effects (Bell, 1974; Anderson and Loucks, 1996). In the present study root inhibition of wheat and maize may be associated with secondary metabolites released from the powder of *L. camara* affects root growth promoting tissues.

Stem thickness: The stem thickness variation of maize and wheat was greatly varied in the present study. It may be associated with the nature of the plants. Another possible reason, release of secondary metabolites from the powder of *L. camara* may alter the physicochemical properties of the soil that may influence on the stem growth. Scholes and Walker (1993) also reported that chemical and physical properties of soil influences morphological structure of plant species.

Biomass measurement: Generally, biomass was decreased in all the treatments while the increment of *L. camara* leaf powder from 25 to 75 g applied in to soil. Das *et al*. (2012) also observed reduction of dry weight of shoot and root at various concentration level of leachate. In addition, Gentle and Duggin (1997) also reported that *L. camara* had significant reduction effect on biomass and it was associated with stunted growth of the seedlings (Tripathi *et al*., 1999 and 2000). The biomass variation in increased concentration may be associated with the release of phytochemicals from the *L. camara* powder that may hinder the growth of the plant or during the decomposition process plant secondary metabolites may be alter or/and inhibit the available nutrient for plant growth.

CONCLUSION

In conclusion, experimental results clearly indicates that *L. camara* leaf powder inhibits significantly on seed germination, speed of germination, shoot and root length, stem thickness and biomass of wheat and maize. This experiment was the first to demonstrate allelopathic potentials of *L. camara* on *Zea mays* and *Triticum turgidum* in Ethiopia. In wheat and maize growing areas keeping the *L. camara* plants may affects growth parameter of wheat and maize. Further investigation on characterization of phytochemicals and their specific role in different agricultural crops need to be studied in Ethiopian context.

ACKNOWLEDGEMENT

Authors are thankful to Tsehay Hulegeb Farmers Union, Gondar, Ethiopia for providing seeds for experiment. The lab facility extended by Mengesha Asefa, Head, Department of Biology, College of Natural and Computational Sciences is gratefully acknowledged.

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