

Allelopathic Effects of *Lantana camara* Leaf Extracts on the Germination and Growth of Wheat (*Triticum aestivum* L.) and Selected Weed Species.

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Abstract

This study investigated the allelopathic effects of *Lantana camara* leaf aqueous extracts on the germination and early seedling growth of wheat (*Triticum aestivum* L.) and two common weed species: wild barley (*Hordeum spontaneum*) and milk thistle (*Silybum marianum*). Aqueous extracts of *Lantana camara* leaves were prepared at concentrations of 5%, 15%, 30%, and 45%, and their effects were assessed on germination percentage and seedling growth parameters under controlled laboratory conditions. Results revealed that the extracts significantly inhibited germination and seedling growth in a concentration-dependent manner across all species. Wheat exhibited the highest tolerance, maintaining a 70% germination rate at 45% extract concentration, while wild barley was the most sensitive (48.88%). Milk thistle showed a non-linear response, with increased germination at higher concentrations. Radicle and plumule length, seedling biomass, and vigor index were significantly reduced in all species, especially at 30% and 45% concentrations. Notably, lower concentrations (5–15%) occasionally stimulated root or shoot growth, suggesting a possible hormetic effect. These findings highlight the potential of *Lantana camara* as a natural bio-herbicide, offering an eco-friendly alternative for weed management in sustainable agriculture. However, its phytotoxic effects also warrant caution due to possible risks to non-target crops.

Keywords: Allelopathy, *Lantana camara*, Germination, Wheat, Seedling growth.

1.Introduction

The worldwide issue of weed infestation can be a major restriction on the yield of agricultural crops. The most common approach to dealing with weeds is to use chemical herbicides which can be useful. However, they sometimes create related issues such as crop damage, the development of resistant weed strains, and potential hazards to humans and livestock.

Allelopathy provides a sustainable aspect to weed management that is preferable to chemical methods (Pukclai & Kato-Noguchi ., 2011).

Allelopathy is a distinct type of plant interaction that can be an important component of natural ecosystems, and agricultural systems (Michelangelo et al., 2016). It is the result of the secondary metabolites referred to as allelochemicals

which are produced as a result of the primary metabolic within a plant (Anwar et al., 2013). Allelochemicals can affect plants by altering the uptake of nutrients and activity in the cell membrane, disturbing enzyme activity and could induce genetic mutation or hinder photosynthesis (Hussain et al., 2011). Like many other naturally-derived compounds, these chemicals have a wide variety of biological activities that could be useful for weed management and sustainable systems in agriculture. (Zhou et al., 2004).

It is widely accepted that the volatile compounds produced by the Verbenaceae family *Lantana camara* are a common invasive species categorized as one of the top ten invasive plants in the world (Sharma et al., 2005). Though this invasive species poses a major ecological threat, new studies are beginning to show potential usefulness in weed management for sustainability. *Lantana camara* also has ability to inhibit the germination and early growth of nearby plants. As stated by Dobhal et al. (2010) this inhibitory component occurs when the plant has to compete for soil nutrients as well as altering the ecosystem with its dense and vigorous growth. The objective of this study is to assess the suitability of *Lantana camara* leaf extracts as a natural herbicide in agricultural systems by examining their effects on seed germination and early growth parameters of wheat and specific weed species.

2. Material and Methods

2.1 Plant Material Collection

In October, *Lantana camara* L. leaves were gathered in the Erbil area (Kurdistan region -Iraq).

After being cleaned with running water to get rid of dust and other impurities, identical leaves were kept in the shade at room temperature (20–25 °C) for 14 days and dried in blotting paper. The dried leaves were then ground into a fine powder using with an electric, sieved through a 2 mm mesh screen, and stored in airtight plastic zip-lock bags at 4 °C (Anwar et al. 2013).

2.2 Preparation of Aqueous Extract of *Lantana camara* L.

To prepare the aqueous extract of *Lantana camara* L. 50 grams of dried plant powder were mixed with 500 milliliters of distilled water. The mixture was subjected to continuous mechanical stirring at room temperature for 24 hours. After the extraction period, the solution was filtered using Whatman filter paper to remove solid residues. The resulting filtrate was designated as the stock solution (100% concentration). From this stock, a series of diluted extracts were prepared at concentrations of 5%, 15%, 30%, and 45%. Distilled water served as the control in the experiment.

2.3 Methods

This study was conducted in the Laboratory of the Field Crop and Medicinal Plant Department at the College of Agricultural Engineering Sciences, Salahaddin University. The Agriculture Research Center at Ankawa provided the wheat seeds and seeds of a number of common weed species used in this project.

The experimental design was done using sterile Petri dishes (12 cm diameter) filled with moistened Whatman No. 3 filter paper to ensure suitable seed germination. Twenty viable wheat seeds, fifteen wild barley seeds, and fifteen milk thistle seeds were placed in each dish as appropriate, and treated with multiple levels of *Lantana camara* aqueous extract. The control samples were treated with distilled water only. All Petri dishes were incubated in the laboratory with closely monitored environmental conditions for ten days. Each treatment, including the controls, was repeated three times for statistical value. Germination (defined as the emergence of the radicle) was recorded on a daily schedule, and assessments of different parameters of the response were taken.

2.4 Germination Percentage (%)

Germination percentage was calculated using the formula described by De-Oliveira et al. (2013):

Germination percentage

$$= \frac{\text{no of germinated seeds}}{\text{no of total tested seeds}} \times 100$$

2.5. Germination speed (seed/ day):

$$SG \left(\frac{\text{seed}}{\text{day}} \right) = \left(\frac{N1}{1} + \frac{N2}{2} + \frac{N3}{3} + \frac{N}{n} \right)$$

Where SG = speed of germination, N1, N2, N3 N= number of seed which germinate on days 1, 2, 3n. The observations began three days after incubation, and germination was recorded daily based on the emergence of healthy radicles.

2.6. Plumule length (cm): The plumule length was measured in centimeters from germinated seeds in each Petri dish.

2.7. Radicle length (cm): Radicle length was also recorded in centimeters for each germinated seed in the Petri dishes.

2.8. Seedling length (cm): Seedling length was determined by summing the lengths of the radicle and the plumule, as outlined by De-Oliveira et al. (2013).

2.9. Plumule and radicle dry weight (mg): Dry weights were determined after drying the plant parts in an oven at 40°C for 72 hours (or until constant weight was achieved). Samples were also counted using an electronic balance.

2.10. Seedling dry weight (mg): This was calculated as the sum of the dry weights of the radicle and plumule, according to Jiang and Lafitte (2007).

2.11. Root/ shoot ratio %: The root-to-shoot ratio was calculated using the equation described by Jiang and Lafitte (2007):

$$RSR\% = \frac{RDW}{SDW} \times 100$$

Where:

RDW= Root Dry Weight

SDW = Shoot Dry Weight

2.12. Relative Root Length (%)

Relative root length was determined using the method described by Rho (1986). The calculation is as follows:

$$Rr = \frac{M}{Mc} \times 100$$

Where:

Rr= Relative root length (%)

M = Mean root length of treated seedlings

Mc= Mean root length of control seedlings

2.13. Relative Shoot Length (%)

According to the formula established by Rho (1986), the relative shoot length was calculated using:

$$R_s = \frac{M_s}{M_c} \times 100$$

Where:

R_s= Relative shoot length (%)

M_s= Mean shoot length of treated seedlings

M_c= Mean shoot length of control seedlings

2.14. Seedling vigor index

The Seedling Vigor Index was computed using the formula provided by De-Oliveira et al. (2013):

$$SVI = (SL \times GP) / 100$$

Where:

SL = Seedling Length (cm)

GP = Germination Percentage (%)

The statistical analysis of the experiment data done using the SPSS program. Duncan's multiple rang test (DMRT) at the 0.01 probability level was applied to compare treatment means.

3.Result

The process of germination for wheat, wild barley, and milk thistle was inhibited by varying rates in the presence of increasing concentrations of *Lantana camara* leaf water extract. The aqueous extract of *Lantana camara* significantly inhibited germination of all plant species, as determined by statistical analysis. In the control treatment, wheat showed the highest germination percentage of 93.33% and wild oat had a germination percentage of 90.55% while milk thistle showed the lowest germination percentage of 77.33%. At the highest concentration level (45%), wheat had maintained a germination percentage of 70%, wild barley's germination dropped drastically to 48.88%, and milk thistle germinated at a somewhat moderate level at 62.22%. Wheat exhibited higher tolerance, while wild barley was the most sensitive. Milk thistle germination increased at a 45% concentration but was inhibited otherwise. Wheat and wild barley had the highest germination speeds (8.64 and 7.21 seeds/day, respectively), while milk thistle had the lowest (4.41 seeds/day). The lowest values for wheat and wild barley were 5.16 and 3.69 seeds/day, respectively. Milk thistle germination speed was 2.19 seeds/day at a 30% concentration of *Lantana camara* leaves extract (Fig 1&2).

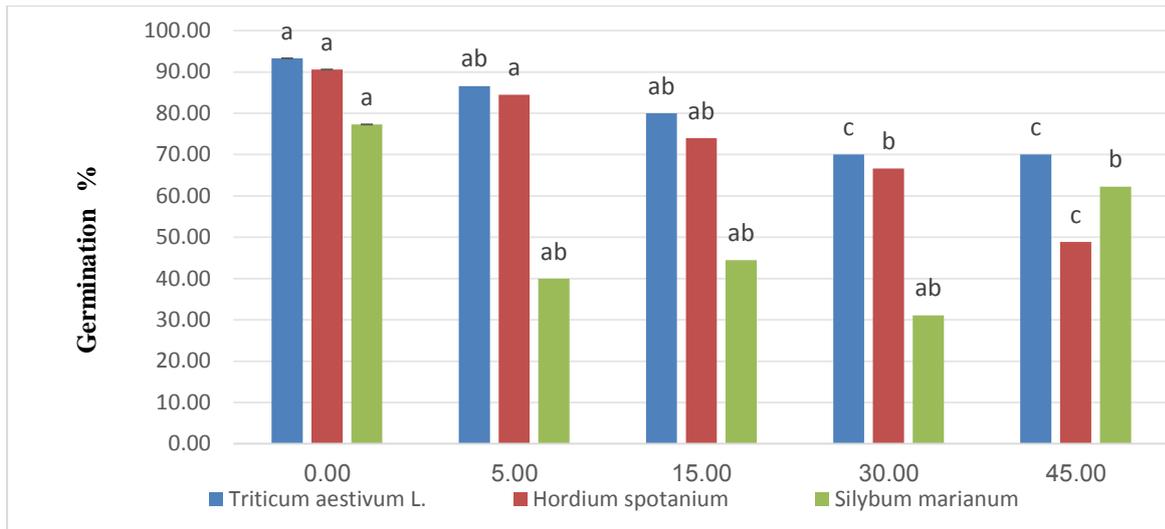


Fig 1. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on germination (%).

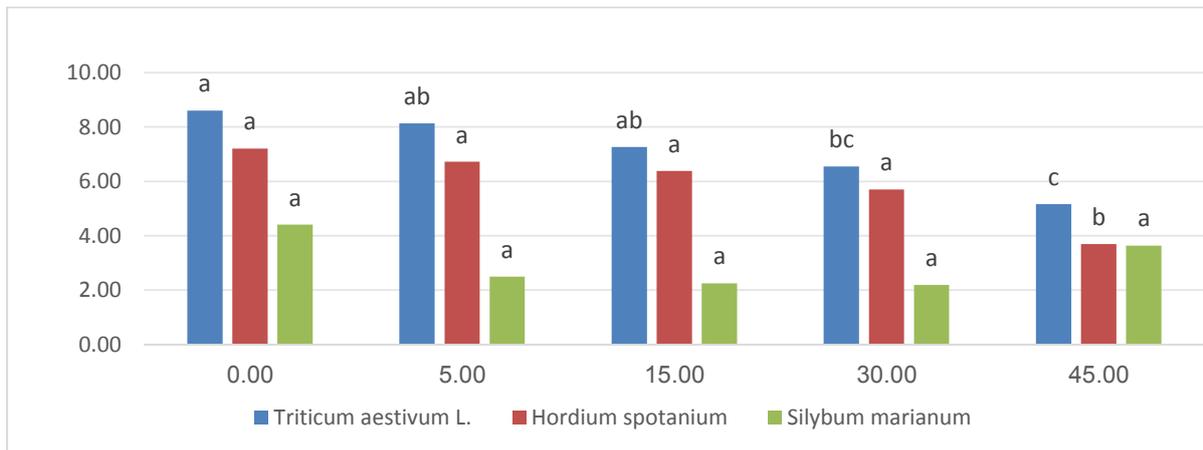


Fig 2. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on speed germination.

The aqueous extract of *Lantana camara* inhibited plumule and radicle growth in all tested species. In wheat seedlings, at 45% concentration of the extract reduced plumule length from 14.92 cm (control) to 5.75 cm and radicle length from 14.41 cm to 4.76 cm. Wild barley showed a similar

trend, with radicle growth experiencing more significant inhibition (decreasing from 10.20 cm to 4.08 cm). Milk thistle was most affected, with plumule length decreasing to 1.93 cm at the 45% concentration, indicating high sensitivity in shoot elongation (Fig 3&4)

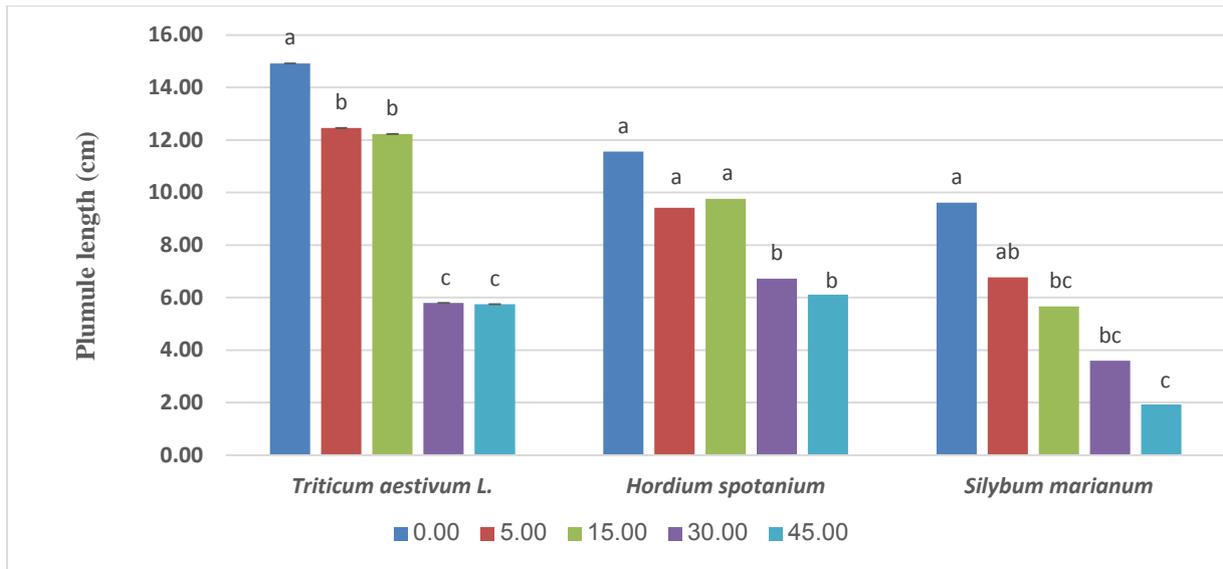


Fig 3. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on plumule length (cm).

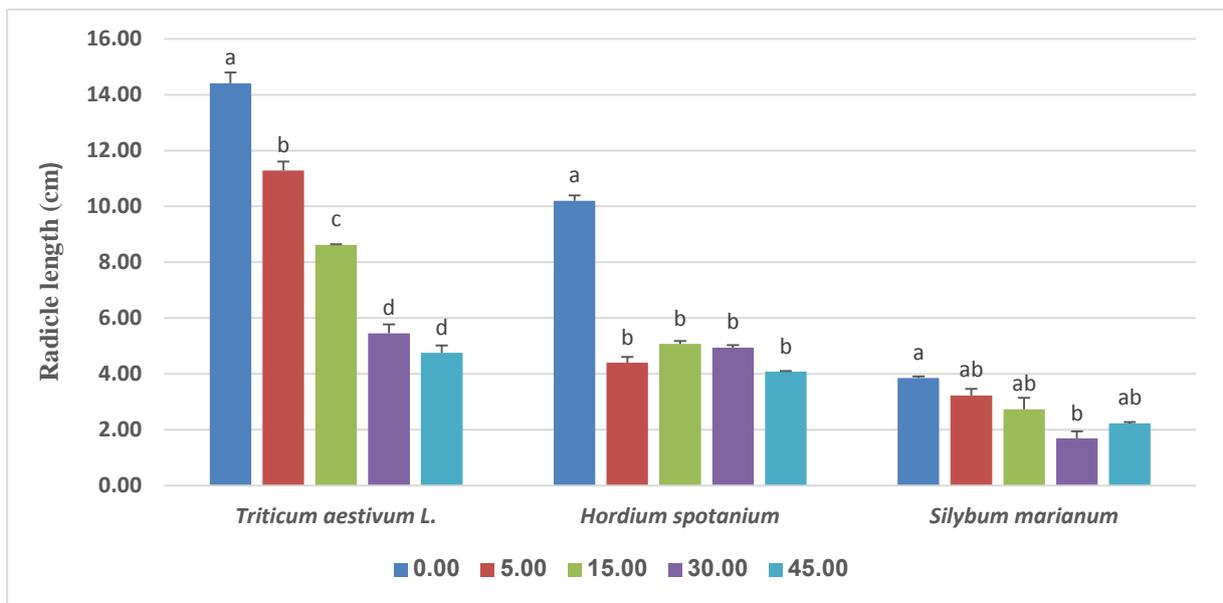


Fig 4. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on radical length (cm)

The parameter for seedling growth showed the highest measurements in the control, which were (29.33, 21.77, and 13.47) cm respectively for wheat, wild barley, and milk thistle. Likewise, the previously mentioned parameters of plumule and

radicle length were noted at 45% concentration the lowest recorded values were (10.57 and 10.20 cm) respectively for wheat and wild barley, while for milk thistle, the minimum value was found at 30% concentration (fig 5).

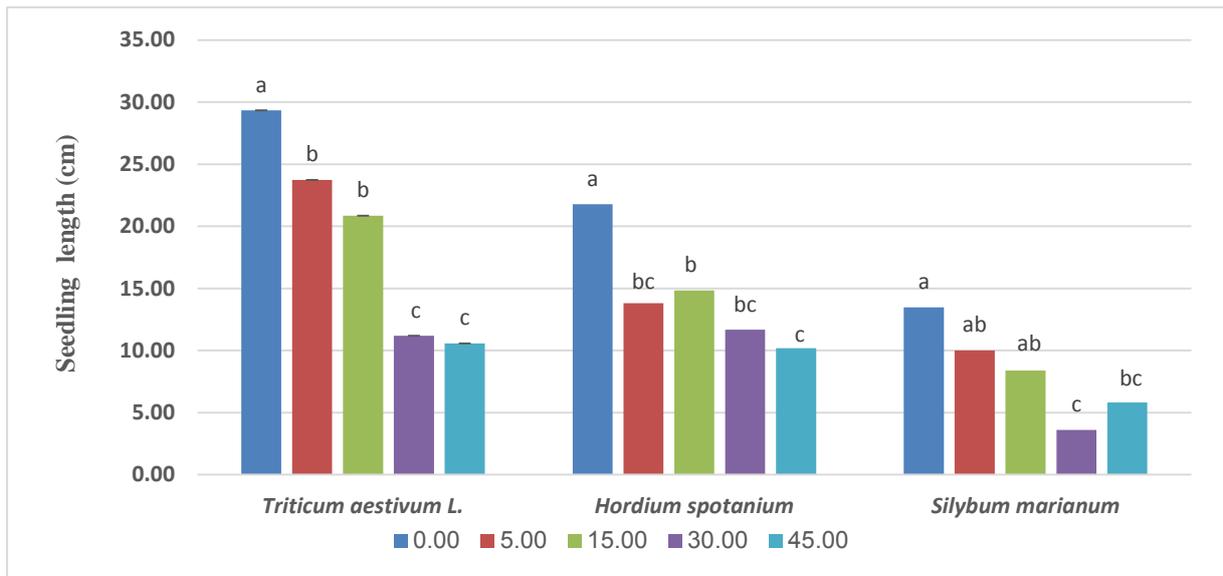


Fig 5. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on seedling length (cm).

The treatment negatively affected plumule and radicle elongation in all species, with measurements lower than the control values for wheat (1.49 and 1.44 cm), wild oat (1.15 and 1.02 cm), and milk thistle (0.98 and 0.38 cm). At 45% extract

concentration resulted in the lowest measurements for wheat (0.58 and 0.49 cm) and wild oat (0.61 and 0.40 cm), while milk thistle's minimum values (0.19 and 0.16 cm) occurred at 30% concentration (fig. 6).

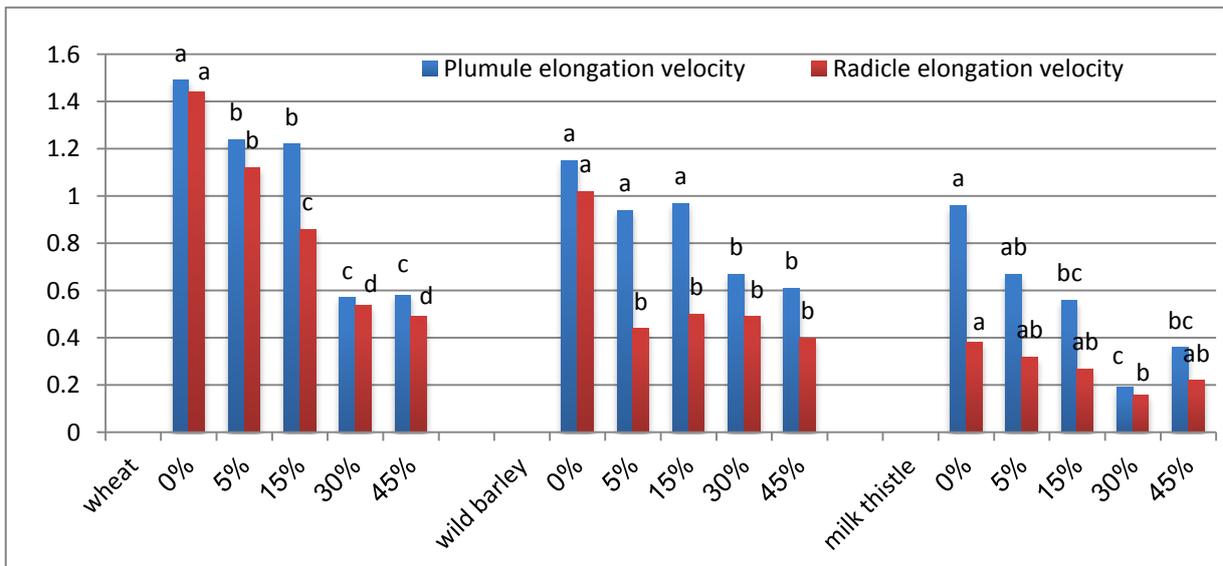


Fig 6. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on plumule and radical elongation velocity.

The findings indicated that the highest dry weights for the wheat plumule and radical were found to be 0.067 and 0.054 gm, respectively, in the control group. At 30% concentration, the lowest dry weight for the plumule was recorded at 0.30 gm, whereas the dry weight of the radical was noted at 0.31 gm at 45% concentration. In comparison, wild barley demonstrated the highest dry weights of 0.51 gm for plumule and 0.40 grams for radical at the control

level. The minimal values identified for wild barley included a radical dry weight of 0.029 gm and a plumule dry weight of 0.036 gm, both observed at a 30% concentration, with the plumule weight also measured at 15% concentration. At the same time, the dry weights of the milk thistle plumule and radical varied with different concentrations of leaf extract as

Table 1. Effect of *Lantana camara*. aqueous leaf extract concentrations (%) on radicle, plumule, and total dry weight (gm) of *Triticum aestivum* L., *Hordeum spontaneum* and *Silybum marianum*

	Concentration	Radical dry weight (gm)	Plumule dry weight (gm)	Seedling dry weight (gm)	Radicle/Plumule ratio
<i>Triticum aestivum</i> L.	Con. 0%	0.054 a	0.067 a	0.121 a	79.19 a
	Con. 5 %	0.029 a	0.056 ab	0.085 ab	52.04 a
	Con. 15 %	0.040 a	0.061 a	0.10 ab	67.04 a
	Con. 30 %	0.031 a	0.040 b	0.071 b	76.52 a
	Con. 45 %	0.032 a	0.030 b	0.070 b	86.50 a
<i>Hordeum spontaneum</i>	Con. 0%	0.040 a	0.0516 a	0.091 a	77.63 a
	Con. 5 %	0.033 b	0.046 a	0.079 ab	73.19 a
	Con. 15 %	0.032 b	0.036 a	0.069 b	86.35 a
	Con. 30 %	0.029 b	0.045 a	0.074 ab	65.28 a
	Con. 45 %	0.033 b	0.044 a	0.078 ab	75.68 a
<i>Silybum marianum</i>	Con. 0%	0.023 a	0.042 a	0.063 a	58.62 a
	Con. 5 %	0.026 a	0.038 a	0.065 a	68.88 a
	Con. 15 %	0.016 a	0.046 a	0.063 a	34.44 a
	Con. 30 %	0.015 a	0.030 a	0.045 a	48.07 a
	Con. 45 %	0.010 a	0.042 a	0.045 a	25.26 a

compared to the control. Nonetheless, the variance analysis revealed that the various concentrations of leaf extract and the control did not exhibit significant differences

Wheat seedlings had a maximum dry weight of 0.121 gm (control) and a minimum of 0.070 gm. Wild barley seedling dry weight peaked at 0.91 gm (control) and reached a minimum of 0.061 gm at 15% concentration. Milk thistle seedling dry weight showed no significant differences. While the radicle to plumule ratio varied with leaf extract concentration compared to the control, ANOVA revealed no significant differences between leaves extract concentrations and the control for wheat, wild barley, and milk thistle (Table 1).

*At p ≤0.01 sharing the same letters does not result in significant differences.

The relative lengths of the roots were assessed after ten days of growth in the seedlings. The findings illustrated in Fig.8 depict the relative root lengths of three plant species that were exposed to different concentrations of the aqueous extract from *Lantana camara*. The roots' relative lengths exhibited a dependence on the concentration applied. The highest measurements were noted in the groups treated with a 5% dilution of the aqueous extract for both wheat and milk thistle, whereas wild barley demonstrated maximum growth when treated with a 15% concentration of the extract.

The changes in shoot lengths for the three species exposed to varying concentrations of the aqueous extract from *Lantana camara* are documented in Fig. 7. The data indicate that the length of the shoots increases progressively with higher

concentrations. The peak shoot elongation recorded was 83.97 for wheat and 76.37 for milk thistle at the 5% concentration, while wild barley reached a maximum of 86.76 at a 10% concentration. Conversely, the control group for both wheat and milk thistle recorded the lowest measurements of 0.00 for all instances.

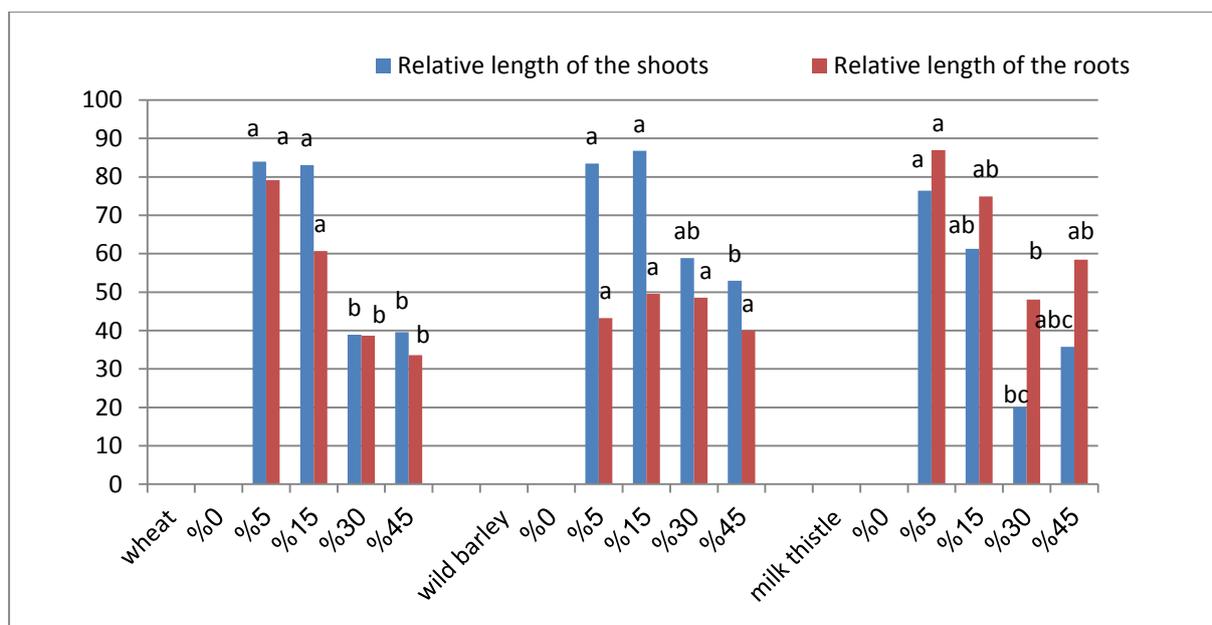


Fig 7. Effect of *Lantana camara* aqueous leaf extract concentrations (%) on Relative length of the shoot and root.

In the control group, wheat, wild barley, and milk thistle exhibited maximum seedling vigor indices of 27.51, 19.74, and 10.18, respectively. Conversely, wheat and

wild barley showed minimum vigor indices of 7.36 and 4.94 at 45% concentration, while milk thistle's minimum value occurred at 30% concentration (Fig. 8).

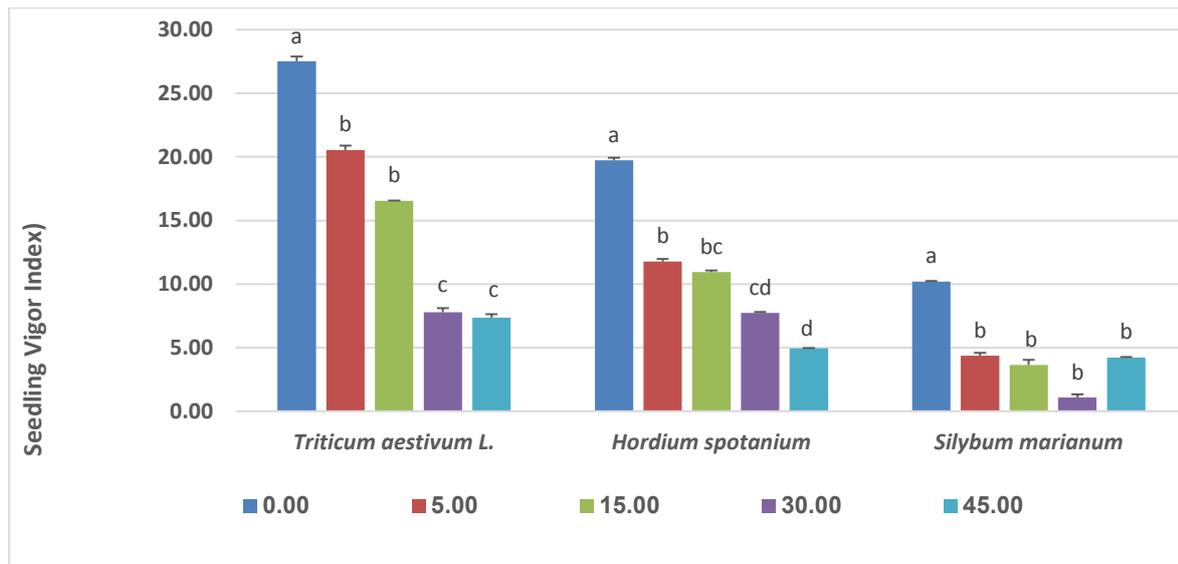


Fig 8. Effect of *Lantana camara* aqueous leaf extracts concentrations (%) on seedling vigor index

4. Discussion

Lantana camara is a well-known invasive species containing allelopathic compounds such as phenolics, alkaloids, and aromatic substances that inhibit the growth and germination of neighboring plants by altering soil nutrients and microclimatic conditions (Dobhal et al., 2010). This research evaluated the allelopathic influence of aqueous leaf extract of *L. camara* on the germination and initial growth of wheat (*Triticum aestivum*), wild barley (*Hordeum spontaneum*) and milk thistle (*Silybum marianum*). It was found that as extract concentration increased, there was a concomitant decrease in seed germination, seedling growth and biomass accumulation for all three species. Wheat had the highest germination rate (70%) at the 45% concentration, which indicated better tolerance to inhibition than milk thistle (62.22%) because the effects of these plant's allelochemicals are selective and can vary with different plant species and wild barley

(48.88%), with wild barley being the least tolerant. Allelochemicals affect seed germination by interfering with normal cellular metabolism rather than by damaging organelles (Hassan et al., 2012). Moktar Hossain et al. (2012) discovered that variations in the seed coat's selective permeability were the cause of the variation in the plants' germination percentage chemicals that prevent. This is in agreement with the previous findings of Sharma et al. (2005) and Ahmed et al. (2007) who also observed a decrease in crop seed germination due to allelopathic effects of *Lantana camara*. Hussain et al. (2011) did, similarly, report on the high phytotoxicity of *Lantana camara* leaf extracts.

Growth parameters, such as plumule and radicle elongation, were also significantly affected. At 45%, wheat and wild barley demonstrated significant reductions for both parameters while the length of milk thistle's

plumule sharply declined to 1.93 cm, indicating it was the most sensitive to inhibition in shoot growth. Interestingly, low concentrations (5–15%) stimulated root or shoot growth in some cases, indicating a possible hormetic effect. Wheat and milk thistle showed improved root growth at 5%, while wild barley peaked at 15%. Similar stimulatory effects at low doses were noted by Zhang et al. (2009) and Mishra (2012), attributed to mild stress-induced growth responses. The concentration-dependent inhibition of root and shoot growth has been described in *Vigna radiata* (Iramus et al., 2011), *Cucurbita pepo* (Jabeen and Ahmed, 2009) and *Zea mays* (Abiyu and Nagappan, 2015), and all provide support to the current basic findings.

The examined species were significantly impacted with their root and shoot lengths decreased with increasing concentrations of extract compared against the distilled water (control group). This is consistent with previous studies Zackrisson and Nilsson (1992) and Shrivastava and Jha (2016). This reduction in shoot and root length is suggested to result from a lower rate of cell division and

5. Conclusion

Lantana camara exerts strong allelopathic effects on the tested species, especially at higher concentrations. Wheat appeared most tolerant; while wild barley was the most sensitive but the high concentrations promote the germination milk thistle. These findings

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growth (Bukolova., 1971), and in addition to the proposed allelopathic effect of *Lantana camara* Sharma, et al., (1988) and Ghisalberti, (2000).

Seedling vigor index also declined at higher seedling concentration. Wheat showed the greatest vigor under control (27.51) followed by wild barley and milk thistle which had greater reductions particularly at 45% and 30% concentrations, respectively. The trends observed in both previous studies were consistent with Padhy et al. (2000) and Hussain et al. (2011), which reported *Lantana camara* extracts negatively suppressed the vigor of seedlings of various species.

Some reports indicated that these composites are substantially Lantadene A and Lantadene B.. The latter was reported to have a strong ability to inhibit the germination and growth of plants even at low concentrations Jain, et al., (1989) and Abugre, et al., (2011). They showed that the presence of polyphenols and alkaloids of compounds can prevent the embryo from growing from the seed or leading to its death.

reinforce the potential of *Lantana camara* to disrupt native or cultivated plant communities through biochemical interference and competitive dominance. Our results suggest the use of *Lantana camara* as a source of allelochemicals to control weeds.

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