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Allelopathic effect of the aqueous extract of *Lantana camara* L. on the germination and development of four vegetable species

Fahima TALHI[1]*, Ali Kalla [2], Noureddine GHERRAF[1] and Amar ZELLAGUI[3]

[1]Laboratory of Natural Resources and Management of Sensitive Environments, university of Larbi ben M'hidi, Oum El bouaghi, Algeria [2] MS department. Larbi tebessi university, tebessa, Algeria, and [3] Laboratory of Biomolecules and Plant Breeding, University of Larbi ben M'hidi Oum El Bouaghi, Algeria

Abstract

The present study was carried out to assess the allelopathic effect of the aqueous extract of *Lantana camara* on the germination and growth of four plant species namely: durum wheat (*Triticum turgidum* ssp. durum), barley (*Hordeum vulgare*), chickpea (*Cicer arietinum*) and lentil (*Lens culinaris*). The suppressive effect of the different concentrations of the aqueous extract of *Lantana camara* was recorded and compared with the control treatment (distilled water). The results obtained showed that the concentrations (10 %, 25 % and 50 %) have a significant inhibitory effect on the germination of seeds, the speed of germination, the index of germination and the length of shoots and roots. The results also showed that the inhibitory effect was proportional to the concentration of extract, and that the highest concentrations (75% and 100%) have an inhibitory capacity of the order of 100 %. The inhibitory effect of the aqueous extract may be due to the presence of alkaloids and phenolic compounds. Our results suggest the use of *Lantana camara* as a source of allelochemicals to control weeds.

Keywords: *Lantana camara*, allelopathic potential, germination rate, germination index, speed of germination

Full length article **Corresponding Author*, e-mail: fahima.talhi@yahoo.com

1. Introduction

Allelopathy is a means of biological control in which plants can influence other plants growing in their vicinity by the release of certain toxic products into the environment [1]. This influence is the direct or indirect chemical effect of these plants on the germination, growth or development of neighboring plants in order to avoid competition in their environment. *Lantana camara* L. is a medicinal plant from the verbinaceae family. It encompasses 650 varieties dispersed in more than 60 countries; it is considered one of the ten most spread weeds in the world [2]. It is native to tropical and subtropical America; but introduced in Algeria as an ornamental plant during the colonization period. This plant is considered to be one of the most widely distributed allelopathic species in the world [3]. The different parts of *Lantana camara* L. contain allelochemicals which have the ability to interfere with the germination and growth of many plant species [4]. In the present work, some laboratory bioassays were conducted to study the allelopathic effects of the aqueous extract of the leaves of *Lantana camara* L. on the germination and growth of four plant species: durum wheat (*Triticum turgidum ssp. durum*), barley (*Hordeum vulgare*), chickpea (*Cicer arietinum*) and lentil (*Lens culinaris*).

2. Material and methods

2.1. Collection of plant material

The leaves of *Lantana camara* L. were collected in October in the Ferdjioua region (Mila province, Algeria). They were washed with running water to remove dust and contaminants, and then dried at room temperature for a few days. After drying, the leaves were ground to powder using an electric grinder.

2.2. Preparation of the aqueous extract of Lantana camara L.

The aqueous extract of *Lantana camara* L. was prepared by soaking 50 g of the plant powder in 500 ml of distilled water under mechanical stirring at room temperature for 24 hours. The obtained mixture was filtered using Whatman paper. The obtained extract was considered to be 100 %, then a series of dilutions were prepared (10 %, 25 %, 50 % and 75 %). Distilled water was used as a control treatment.

2.3. Methods

The experiment was carried out in sterile 12 cm diameter petri dishes, in which the moistened Whatman No 3 paper was used as a germination support. Before being used; the tested grains were chosen healthy and then disinfected with bleach / distilled water (1v / 1v). Afterwards, 10 grains were placed in each Petri dish before being treated with a sufficient amount of various concentrations of the aqueous extract, while the control was only treated with distilled water. The experiment was carried out under laboratory conditions for a period of ten days and with three repetitions for each treatment. A grain was considered germinated when the radicle appeared. Germination was recorded daily and the results were determined by measuring different parameters:

1. Germination rate (GR): The germination rate was calculated according to the formula given by Come (1970): [5].

$$GR = (Ng/Ns)100$$

- Ng: Number of germinated seeds.
- Ns: Number of seeds sown.

2. Germination inhibition rate: according to Ben khettou [6], the inhibition rate (GIR) is calculated by the following formula:

$$GIR = ((Ns-Ng)/Ns)100$$

- Ns: Number of seeds sown.
- Ng: Number of germinated seeds.

3. Kinetics of germination: according to Come, it is the variation of germination rate of seeds as a function of time [5].

4. Germination speed: the germination speed is calculated by the following formula proposed by Come [5]:

$$V = (N1+N2+N3+\ldots+Nn)/(N1T1+N2T2+N3T3+\ldots+NnTn)$$

- V: Speed of germination
- N1: The number of seeds germinated at time T1

5. Germination index: the germination index (GI) is a quantitative expression of germination which relates to the daily germination rate at the maximum value of noted germination [7], it is calculated by the following equation:

$$GI = N1+N2-N1/2+N3-N2/3+\ldots+Nn-Nn-1/n$$

- Nn: Percentage of germination in nth day

6. Relative length of roots: the relative length of roots was calculated according to the formula given by Rho and Kil (1986): [8]

$$Rr = M/Mc.100$$

- Rr: Relative length of roots
- M: Average length of roots of treated plants
- Mc: Average length of roots of control plants

7. Relative shoot length: according to Rho and Kil [8] this parameter was calculated by the following formula:

$$Rs = Ms/Mc.100$$

- Rs: Relative length of shoots
- Ms: Average length of shoots of treated plants
- Mc: Average length of shoots of control plants

8. The inhibition Rate and / or growth stimulation: this parameter is calculated according to formula given by Abiyu. E and Nagappan. R in 2015[9]:

$$IR = (RLT-RLC)/RLC.100$$

- IR: Growth inhibition rate of stems or roots
- RLC: Length of stems or roots of control plants
- RLT: length of stems or roots of treated plants

Statistical analyzes: The mean data obtained from the three replicates were subjected to an analysis of variance using the SPSS at a probability level of 0.05.

3. Results and discussions

3.1. Rate of germination and inhibition of germination

The maximum germination rate of the four plant species is shown in Fig.1 which depicts the effect of the aqueous extract of *Lantana camara* at different concentrations on the maximum germination rate of the four studied species. The results obtained show that in all cases, the variation in the germination rate is proportional to the concentration of extract and no germination was observed at the 75 % and 100 % concentrations. Consequently, the germination inhibition rate is maximum for these two concentrations as shown in figure 2 which displays the effect of the extract at different concentrations on the maximum germination inhibition rate of the studied species.

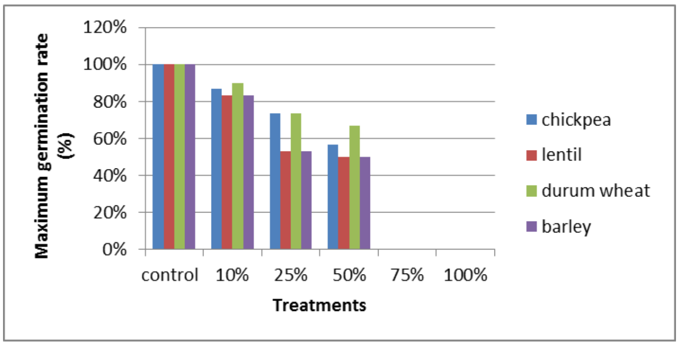

Figure 1: Effect of the aqueous extract of *Lantana camara* at different concentrations on the maximum germination rate of the four studied species

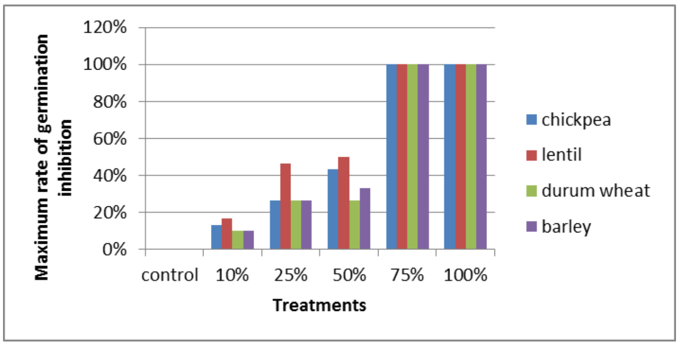

Figure 2: Effect of the aqueous extract of *Lantana camara* at different concentrations on the maximum germination inhibition rate of the four studied species

It is obvious to point out that for cereal species, the aqueous extract had a greater inhibitory effect on barley than on durum wheat, and that this effect was more important on lentils than on chickpeas for legumes. It was observed that the aqueous extract of *Lantana camara* significantly reduced the germination percentage of the four species compared to the control.

3.2. Kinetics of germination

The germination kinetics is the variation of the germination rate as a function of time. Figures 3, 4, 5 and 6 show the variation in the germination rate of the seeds of the four species as a function of the time of the experiment.

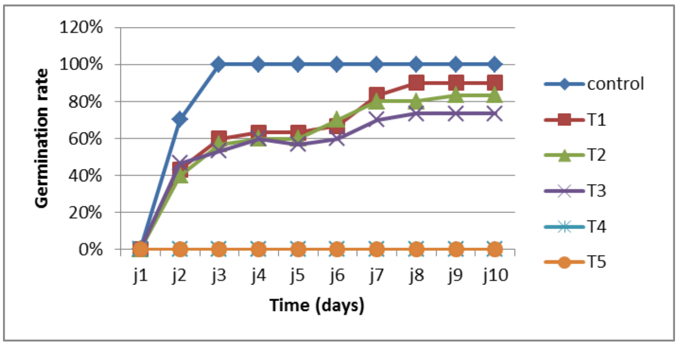

Figure 3: Effect of the aqueous extract of *Lantana camara* at various concentrations on the kinetics of durum wheat germination

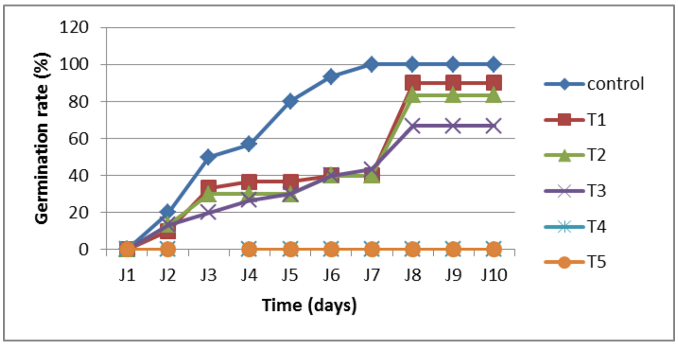

Figure 4: Effect of the aqueous extract of *Lantana camara* at various concentrations on the kinetics of germination of the barley

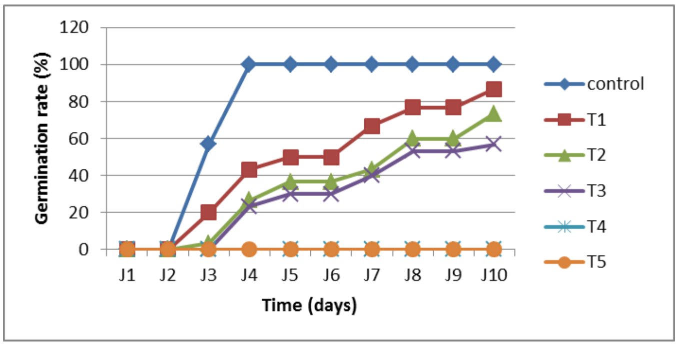

Figure 5: Effect of the aqueous extract of *Lantana camara* at various concentrations on the kinetics of germination of lens

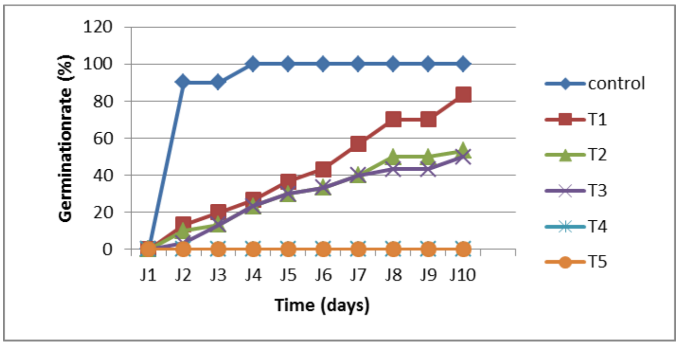

Figure 6: Effect of the aqueous extract of *Lantana camara* at various concentrations on the kinetics of chickpea germination

After 48 hours of experimentation, the control batches of the four species gave germination rates of 20 %, 70 % and 90 % for barley, durum wheat and for lentil, respectively, while the chickpea showed no germination activity. The maximum germination rate was reached on the fourth day for legume species, the fourth day for durum wheat and the seventh day for barley. For the batches treated with the concentrations 10 %, 25 % and 50 % of the aqueous extract. Germination started from the second day (except for the chickpea where it started from the third day). On the other hand, no germination was observed in batches treated with pure aqueous extract or diluted to 75 % during the experimental period.

3.3. Germination speed

The speed of seed germination was calculated for the four species and the results are shown in Figure 7 which highlights the germination speed of seeds for the species treated with different concentrations of the aqueous extract of *Lantana camara*. According to the results, it is clear that the batches treated with the mother solution (100 %) of the aqueous extract and the concentration of 75 %, show no germination. The control batches show a significant germination rate as follows: 14.35 seeds/day for barley, 14.29 seeds/day for chickpeas, 16.22 seeds/day for durum wheat and 16.44 seeds/day for lentils. The batches treated with the aqueous extracts diluted to 10 %, 25 % and 50 % exhibited slower germination rates than the control batches of the same species.

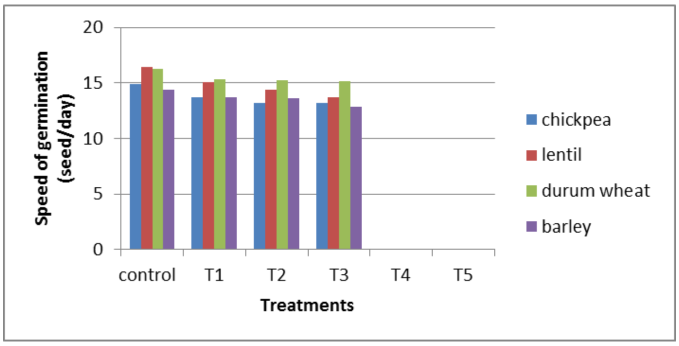

Figure 7: Germination Speed of seeds for the four species treated with different concentrations of the aqueous extract of *Lantana camara* and compared with the control

3.4. Germination index

The results of the quantitative expression of daily germination Index with respect to the maximum germination value are represented in Figure 8 which illustrates the germination of the four vegetable species treated with various concentrations of the aqueous extract of *Lantana camara* and compared with the control. These results revealed no germination for the batches treated with the pure (100 %) and 75 % diluted extracts. The batches treated with the other extracts at lower concentrations (10 %, 25 % and 50 %) showed an increase depending on the concentration. These values are always less important than the values recorded in the control batches.

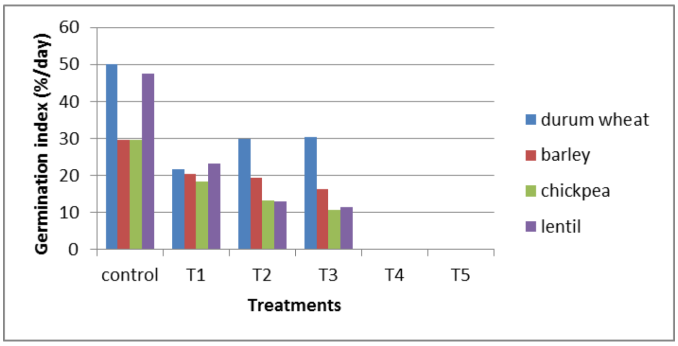

Figure 8: Germination Index of the four vegetable species treated with various concentrations of the aqueous extract of *Lantana camara* and compared with the pilot batch

3.5. Relative length of roots

The relative length of the roots was measured after ten days of seedling. The results shown in Figure 9 describe the relative length of the roots of the four vegetable species treated with various concentrations of the aqueous extract of *Lantana camara*. The relative length of the roots of the four species was concentration dependent. The maximum values were recorded in the batches treated with the aqueous extracts diluted to 10 % followed by those treated with 25 %, and finally those with 50 % extract concentration. The batches treated with 75 % and 100 % concentrations show no germination or growth activity. It is important to note that for cereal species, the aqueous extract exerted a significant inhibitory effect on barley than on durum wheat. This effect is more noticeable for lentils than for chickpeas in leguminous species.

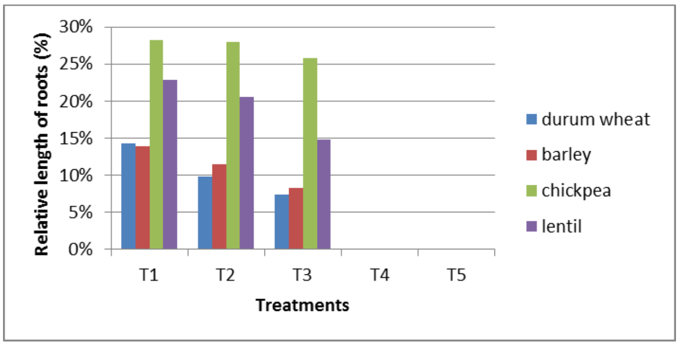

Figure 9: Relative Length of the roots of the four vegetable species treated with various concentrations of the aqueous extract of *Lantana camara*

3.6. Relative length of shoots

The variation of the relative length of the shoots of the four species treated with different concentrations of the aqueous extract of *Lantana camara* is recorded in Fig.10. The results arouse that the shoots length gradually increases with concentration. Maximum shoots elongations are recorded for treatments T1 followed by T2 and T3 respectively, and this is for all species.

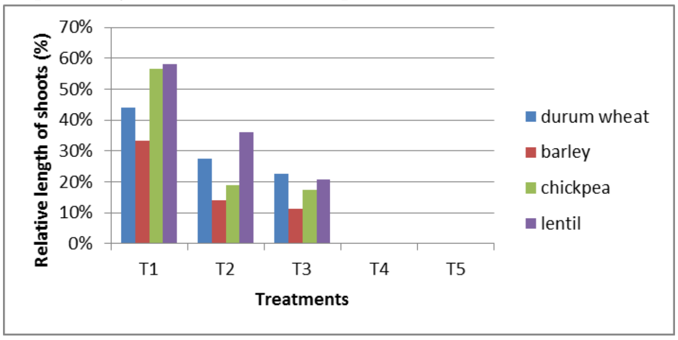

Figure 10: Relative Length of the shoots of the four species treated with different concentrations of the aqueous extract of *Lantana camara*

3.7. Percentage of inhibition and/or stimulation

The inhibition and/or the stimulation effect of the aqueous extract of the leaves *of Lantana camara* L. on the growth of the roots and shoots of the four vegetable species is illustrated in Figures11 and 12. It is noted in this study that the aqueous extract induced only an inhibitory effect on the four tested plant species. This effect is lethal with pure and 75% diluted extracts while for other concentrations it increases with increasing concentration. Growth inhibition is more pronounced for barley than for durum wheat and on chickpea than on lentil. It is also important to note that the inhibitory effect is more important on the growth of shoots than on that of roots.

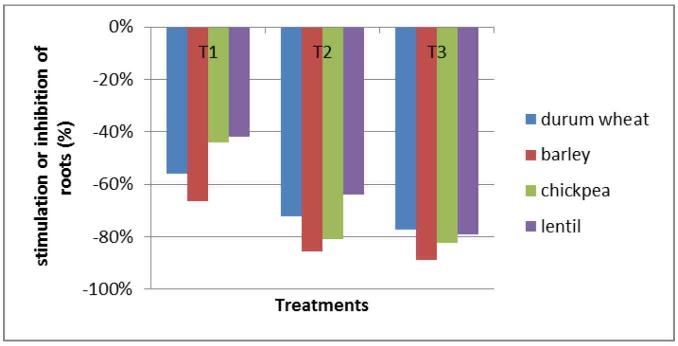

Figure 11: Inhibition effect and/or stimulation of the aqueous extract of *Lantana camara* on the growth of the roots of the four vegetable species

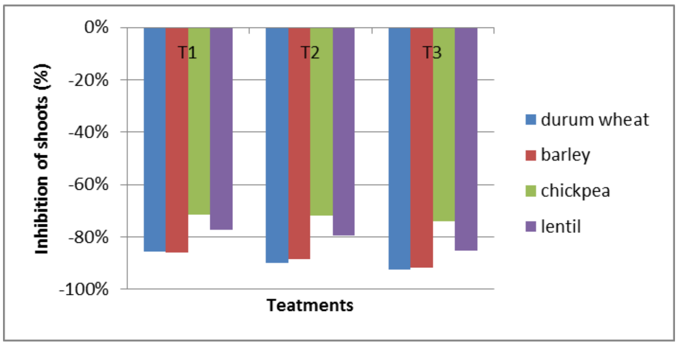

Figure 12: Inhibition effect and/or stimulation of the aqueous extract of *Lantana camara* on the growth of the shoots of the four vegetable species

The results obtained in this study clearly showed that the aqueous extract of the leaves of *Lantana camara* L. has inhibitory effects on the germination and growth of the plant species studied including wheat, barley, chickpeas, and lentils. The allelopathic effect of this extract has been widely reported [1, 10-13]. The increase in the concentration of aqueous extract caused significant inhibitory effects on the germination and growth parameters. Our results are in agreement with those obtained by Ahmed [14] who proved that the same extract with increasing concentrations causes an inhibiting effect on germination, elongation of roots and shoots, and the development of lateral roots of six agricultural species. Bansal (1998) showed that increasing the concentration of aqueous extract leads to a significant inhibition of seed germination and the development of young seedlings [2]. These same findings have been obtained by other researchers [15,16]. The length of the roots and shoots of the studied species is strongly affected. It should be noted that there was a significant reduction in the length of these two parameters in the batches treated with increasing concentrations of extracts compared to the control batch (treated with distilled water). These results are in agreement with many reports [17,18]. The reduction in the length of shoots and roots may be due to the reduction in the rate of division and elongation of cells [19] and this reduction could be due to the allelopathic effects of the phytochemicals of *Lantana camara* [20, 21]. The inhibiting or suppressing effect of the aqueous extract of *Lantana camara* on the germination and growth of other plant species could be mainly due to the presence of phytotoxins in the different parts of this plant especially in the leaves [22-24]. The allelochemical compounds of *Lantana camara* are mainly polyphenols and alkaloids [25] and the phytotoxicity of the aqueous extract was mainly due to the interaction of these compounds. Some reports indicated that these compounds are mainly 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 [26,28]. They showed that the presence of this type of compounds can prevent the embryo from growing from the seed or leading to its death.

4. Conclusions

From the results of this study, it is clear that the aqueous extract of *Lantana camara* contains allelochemicals which have the ability to suppress or inhibit the germination and growth of durum wheat, barley, lentil and Chickpea. This allelopathic potential was proportional to the concentration. The effect was significant on seed germination, the speed of seed germination, the germination index and the length of shoots and roots. Therefore, our results suggest the use of *Lantana camara* as a bioherbicide especially in the control of weeds, and hence contributing to the shrinking of the excessive use of synthetic herbicides.

Conflict of Interest

The authors declare that they do not have any conflict of interest

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