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Research Article

Investigating the allelopathic interference of chenopodium album l. leaves on maize and mung bean and its implications for sustainable agribusinesses

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ABSTRACT

The present study elaborates on the Allelopathic effect of Chenopodium album L. on seed germination and seedling growth of Maize and mung bean. The experiment was done in the Department of Agronomy, Bahauddin Zakariya Multan, Pakistan. The experiment used the Petri dish method, which had six different concentrations with three replications. Results are precise that the leaf powder extract of C. album has a varying impact on the seed germination of maize and mung bean, while seedling growth showed an inhibitory effect for both test species. Similarly, both test species affected radicle length more than the plumule length. Moreover, allelopathy, producing allelochemicals, empowers agribusiness sustainability by reducing environmental damage, enhancing soil health, introducing agribusiness product development, sustaining agribusiness practices, and, above all, achieving food security. This existing study suggested that this weed exhibited a strong allelopathic potential, promoting seed germination and plant growth. Along with this, the findings of this weed underline its potential to enhance agribusiness sustainability through various organic applications.

Keywords: Seedling, Growth Germination, Allelopathic effect, Chenopodium album L., Agribusiness, Sustainable

INTRODUCTION

The process in which an organism's development, growth, reproduction, and survival are influenced by another organism, which produces certain biochemicals. These biochemicals are called allelochemicals. When one organism produces these chemicals, it may be harmful or beneficial for other organisms nearby (Kocacë Aliskan & Terzi, 2015). The potential of allelopathic chemicals can be synthesized in any plant part (Farooq, Khawar Jabran, Cheema, Wahidb, & Siddique, 2011) leaves, roots, stems, flowers, seeds, buds, and bark (Weston & Duke, 2003). In Agriculture, the potential impact of allelopathy has been discussed and described in detail (Weston & Duke, 2003). Theophrastus and Democritus, in the third and fifth century BC, respectively, recognized the ability of allelopathy to influence Agriculture (Putnam & Duke, 1978).

In the Agricultural site, Duke and Putnam (1974) were the first to describe the utilization of allelopathic crops to suppress weed growth (Weston & Duke, 2003). In the Agricultural site, Duke and Putnam (1974) were the first to describe the utilization of allelopathic crops to suppress weed growth (Weston & Duke, 2003). Allelopathy has been related to crop production and its problems in certain soil types (Schreiner & Reed, 2014). The effect of allelopathy on crop production is due to the release of toxic material from ground cover into the soil. This toxic material can remain after harvest, on and under the surface; it can also be released due to the decomposition of microorganism microorganisms and rain (Putnam & Duke, 1978). If the plant releases different amounts of the toxicant, the allelopathic effect will also differ (Guenzi et al., 1967). Different amounts of toxicants may be released from the different types of cultivars of the same crop (Putnam & Duke, 1978). These aspects of allelopathy should be considered in the development of new cultivars. Toxicity may be an essential factor that can inhibit plant growth.

The need of the hour is to develop a cropping system that can inhibit the growth of weeds for exploiting allelopathy in agriculture. The agriculture losses due to allelopathy can be minimized by removing toxic material from the soil. For example, charcoal can inactive the pesticide present in the soil (Putnam & Duke, 1978). Terzi, Kocaçalişkan, BenliogĞlu, and Solak (2003) reported that leaf extract (LE) of walnuts inhibited the seed germination and seedling growth of cucumber, tomato, garden cress, and alfalfa. In the root extract, the seed germination was less affected than the shoot's (Kocacë et al., 2015). Samad, Rahman, Hossain, Rahman, & Rahman (2008) reported that by using the aqueous extracts of five selected weeds (Polygonum hydropiper L., Amaranthus spinosus L., Chenopodium album L. Cyperus rotundus L. and Imperata cylindrical L.) the seedling growth and development of corn was inhibited due to allelopathic potential effect of these weeds. The root and shoot length of chickpeas and peas was significantly decreased using the Chenopodium mural's residue (Alam & Shaikh, 2007). Naseem et al., 2009 revealed in their experiment that water extract from sunflowers increased wheat yield significantly except in the pre-emergence stage and 35 days after sowing (Naseem et al., 2009).

Due to the Allelopathic effect, the germination decreases and delays the germination time (Rezaie & Yarnia, 2009). The root and shoot length of wheat has been reduced due to the Allelopathic effect of C. album (Majeed, Chaudhry, and Muhammad, 2012). Seed germination of corn and sugar beet has decreased by about 53.4% and 60.8%, respectively, due to the extract of Chenopodium album (Yarnia, 2009). Keeping in view the reviews mentioned above about allelopathy and allelopathic potential of C. album, a lab bioassay was planned to utilize the different concentrations of LE of C. album L. for their efficacy against the seedling growth and germination of Maize and Mung bean in petri dish culture

MATERIAL AND METHOD

Preparation of Plant Extract

Outdoor cultivated bath (Chenopodium album L.) leaves were collected from the Agronomy Research Area, Bahauddin Zakariya University Multan, Pakistan. Leaves were sun-dried for 72 hours and then dried in an oven at 720 C for 24 hours. The dried leaf samples were ground in a Wiley mill to pass through a 20-mesh screen (Alam & Shaikh, 2007). To get the leaf extract, 10 grams of leaf powder was added to 100 mL pure ethanol (1:10) and mixed for 24 hours by placing it on a magnetic stirrer to get a homogenous mixture. This mixture was centrifuged for 15 minutes at 4000 rpm (Model Dynac II Centrifuge, Clay Adams) (Siddique & Ismail, 2013). The supernatant was taken after the centrifuge. The extract was stored in sealed plastic bottles for further use.

Experimental Treatment

A stock solution (SS) is a concentrated solution that will be diluted to lower concentrations for actual use. To fulfill the 100 mL of stock solution requirement, we will take 1 mL of pure leaf extract and add 99 mL of distilled water. The experiment consisted of the following treatments: T1 = Distilled water, T2 = 0.01% of SS, T3 = 0.05% of SS, T4 = 0.10% of SS, T5 = 0.50% of SS, and T6 = 1% that is the stock solution.

Methodology

The germination process of wheat and mung bean seeds was investigated using the Petri dish method. In each Petri dish lined with double-layered Whatman No two filter paper, five seeds of each test crop were placed and treated with leaf powder extracts in six different concentrations. Subsequently, these Petri dishes were maintained at room temperature for five days for wheat and mung bean seeds, ensuring they remained consistently moist with the solutions. Following this incubation period, the seed germination and seedling growth were evaluated across various treatments. The germination percentage was then determined by dividing the number of germinated seeds by the total number of days taken.

RESULTS

Germination of Maize and Mung bean

Data regarding germination of maize showed that leaf powder extract of C. album has a varying impact on both the test species (Table No. 1). Maximum mean germination was recorded in the case of treatments T3, T5, and T6, where we applied 0.05%, 0.50% and 1% of C. album LE respectively. Whereas in comparison to the control treatment (T1), where we applied distilled water, T2 and T4 treatment (0.01% and 0.10% of C. album LE respectively) showed low mean germination of maize seeds (Table No 1).

In the case of mung bean, data for mean germination again showed a varying impact for all concentrations (Table No.2). Highest seed germination was noted in the case of T5 (0.5% C. album LE) and T6 (1% C. album LE) in comparison to control (T1, Distilled water). The lowest seed germination was noted in treatment T4 (0.1% C. album LE), where mean germination was lower even than in the control treatment (Table No. 1)

Radicle and Plumule length of Maize and Mung bean

The maximum radicle length of maize (2.57 cm) was observed in T5 (0.5% C. album LE) as compared to T1 (distilled water). While all other treatments, where we applied different concentrations of C. album LE, were significantly lower in comparison to the control treatment (Graph No. 1). Data regarding plumule length of maize also showed the same trend, i.e., the highest value for plumule length of maize seedling was recorded when we applied 0.5% C. album LE. Whereas all other treatments of different concentrations of C. album LE have an inhibitory effect on the plumule length of maize compared with control treatment T1 (see Graph No, 2).

Table 1. Effect of C. album leaves extract on the seed germination of Maize (cm)

	T1	T2	T3	T4	T5	T6
R1	3.67	3.67	3.00	3.67	3.67	4.00
R2	3.34	3.00	4.00	2.67	3.33	3.00
R3	3.00	3.00	3.34	3.00	3.34	3.34
MEAN	3.34	3.22	3.45	3.11	3.45	3.45

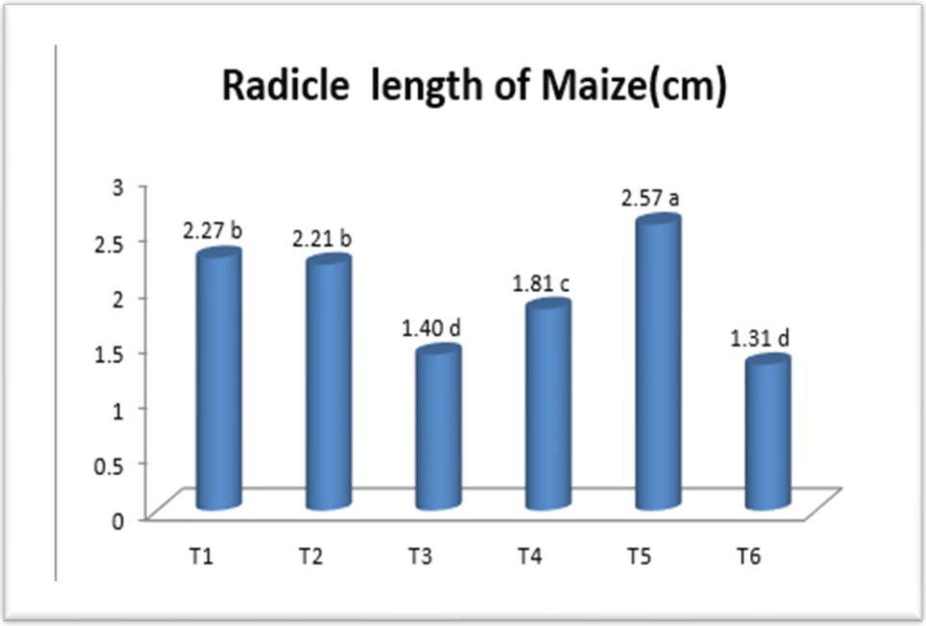
In the case of 2nd test species, the maximum radicle length of mung bean (3.38cm) was noted in T6 (1% C. album LE) as compared to T1 (distilled water). While all other treatments, where we applied different concentrations of C. album LE, were significantly lower in comparison to the control treatment (Graph No. 3). Result regarding plumule length of mung bean showed that all other treatments of different concentrations of C. album LE have an inhibitory effect on the plumule length of mung bean when compared with control treatment T1. (Graph No. 4).

T1= Distilled Water, T2= 0.01% C. album LE, T3= 0.05% C. album LE, T4= 0.1% C. album LE, T5= 0.5% C. album LE, T6= 1% C. album LE

Table 2. Effect of C. album leaves extract on the seed germination of Mung bean (cm)

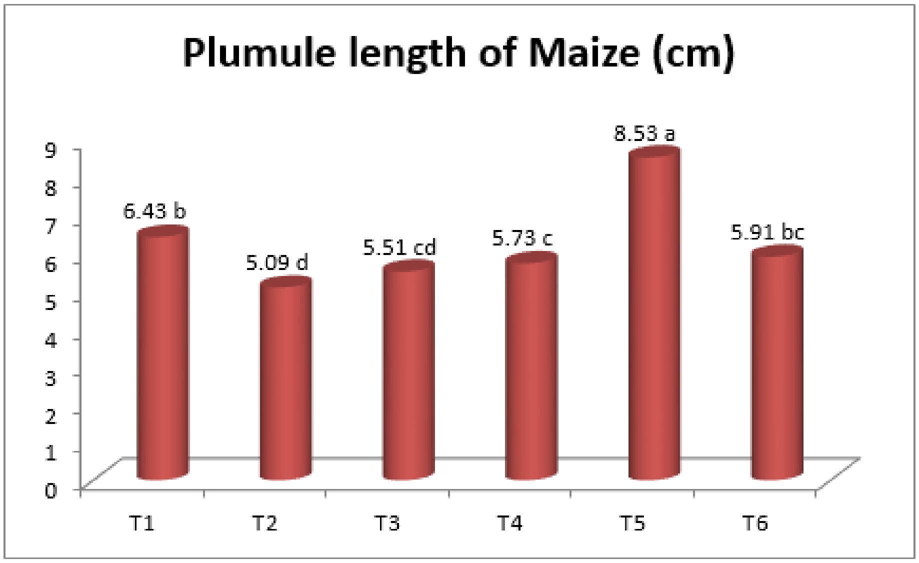
	T1	T2	T3	T4	T5	T6
R1	4.00	3.00	4.00	4.50	4.25	3.25
R2	3.50	4.00	4.00	3.75	4.00	4.25
R3	4.25	4.25	3.75	2.50	3.75	4.50
MEAN	3.92	3.75	3.92	3.58	4.00	4.00

T1= Distilled Water, T2= 0.01% C. album LE, T3= 0.05% C. album LE, T4= 0.1% C. album LE, T5= 0.5% C. album LE, T6= 1% C. album LE



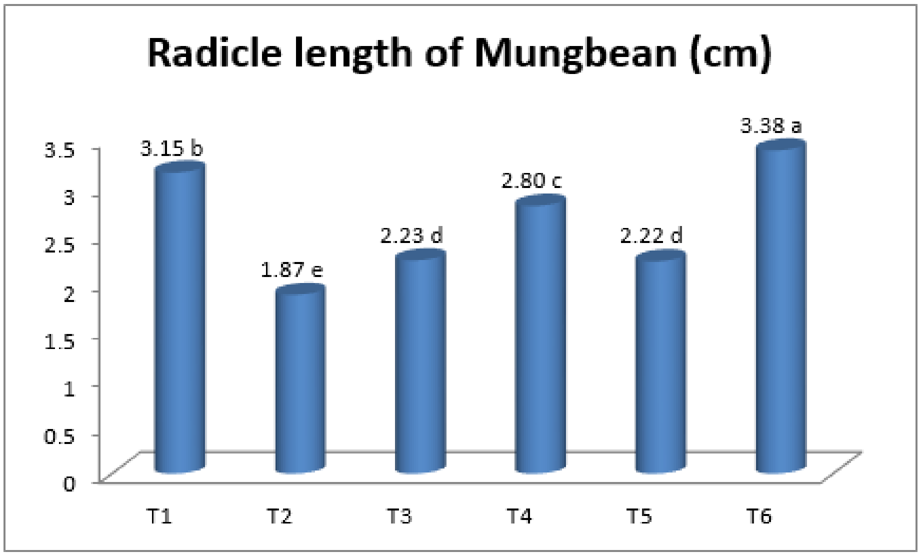
Graph 1. Radicle Length of Maize

T1= Distilled Water, T2= 0.01% C. album LE, T3= 0.05% C. album LE, T4= 0.1% C. album LE, T5= 0.5% C. album LE, T6= 1% C. album LE, LSD= 0.19



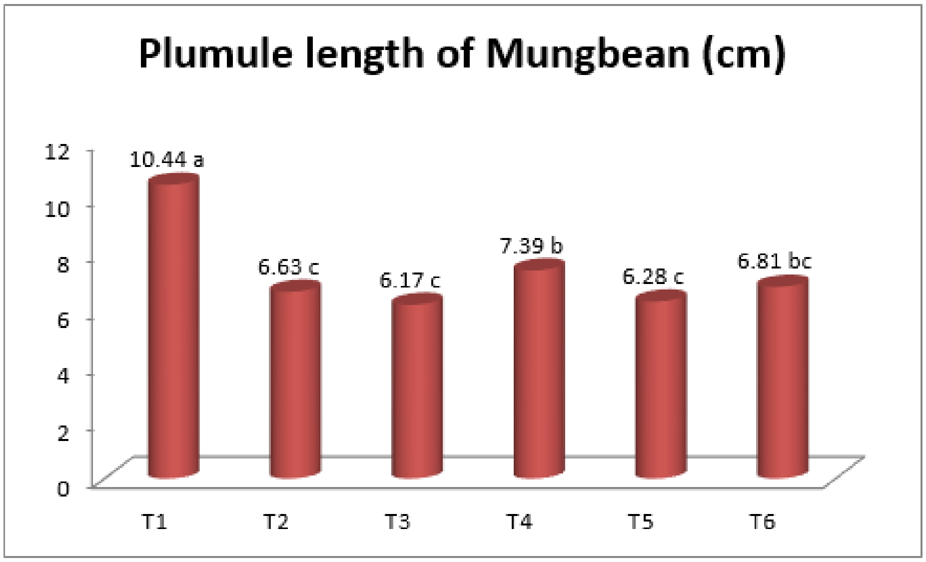
Graph 2. Plumule length of Maize

T1= Distilled Water, T2= 0.01% C. album LE, T3= 0.05% C. album LE, T4= 0.1% C. album LE, T5= 0.5% C. album LE, T6= 1% C. album LE, LSD= 0.53



Graph 3. Radicle length of Mungbean

T1= Distilled Water, T2= 0.01% C. album LE, T3= 0.05% C. album LE, T4= 0.1% C. album LE, T5= 0.5% C. album LE, T6= 1% C. album LE, LSD= 0.53



Graph 4. Plumule length of Mungbean

T1= Distilled Water, T2= 0.01% C. album LE, T3= 0.05% C. album LE, T4= 0.1% C. album LE, T5= 0.5% C. album LE, T6= 1% C. album LE, LSD= 0.53

DISCUSSION

The present study shows both the stimulatory (at lower concentrations) and inhibitory (at higher concentrations) effects of LEs of C. album L. on seedling growth seed germination and maize and mung bean. The allelopathic activity of C. album is related to the presence of phenolics and alkaloid compounds in the leaves (Majeed, Chaudhry, and Muhammad, 2012). Malik et al., 1994 studied the inhibited growth and germination of radish and wheat under air-dried extract of C. album. They isolated seven plant phenolics from shoots and identified chlorogenic acid as a toxic material (Mallik, Puchala, & Grosz, 1994). Reducing mitochondrial respiration may decrease ATP production due to phenolic compounds. It could be due to some physiological effects that can reduce growth. Respiration disorder terminates the ATP energy, reducing seedling growth and germination (Rezaie & Yarnia, 2009).

When we increase the C. album extract concentration, germination starts to vary. Germination of mung bean also varies by the extract application. Leaf powder extract hurts the plumule and radical length of Maize and Mung bean crops. Alam et al., 1997 reported that common lambs' quarters (C. album) have a high inhibitory effect on the radicle growth of squash, beans, and corn (Alam, Azmi, Naqvi, & Khanzada, 1997). Rezaie and Yarnia 2009 reported that C. album reduces the shoot weight of corn and soybean (Rezaie & Yarnia, 2009). Adding leaf powder of C. album reduces the stem length of cucumber (Alam et al., 1997).

It has been assumed that in the soil, allelopathic compounds come in contact with the roots of test plants for water, cell division, minerals, physiological function, and cell division, which may alter its absorption capacity (Majeed, Chaudhry, and Muhammad, 2012). In our study, in maize, there was an increase in germination and radicle and plumule length at higher concentrations (T5=0.05%). The mungbean plant attains its germination at a higher concentration (T5) of C. album LE, which could be possible due to root and shoot cell elongation (Majeed, Chaudhry, and Muhammad, 2012) of maize and mungbean and better absorption of water and essential minerals because of allelochemicals supplied in dishes in the form of water-soluble LE. Alam and Sheikh (2007) used leaf extract of Chenopodium murale L. on seedling growth and germination of Rice. They found that due to direct contact with the extract of allelochemicals, the growth of the root becomes more stunted than shoot growth (Alam & Shaikh, 2007). Previous research shows that allelopathy has more effect on seeding growth, which may increase weed competition and environmental factors. Allelopathy reduces the growth of radicles and shoots (Rezaie & Yarnia, 2009). Allelopathic effects cause reduction and delay germination, strongly affecting competition between plants. Tiny seedlings might compete less with neighbors under undesirable conditions such as low soil moisture or fertilizer limitation.

Allelopathy implications for agribusiness sustainability

Weeds and pests are considered major indicators of loss in crop yield because they compete for requisite natural resources. Due to this, heavy dependency on synthetic insecticides and chemical fertilizers has increased, which led to environmental and ecosystem pollution (Fried, G., 2017 and Weldeslassie, T., 2018). Some researchers have contributed that to sustain the ecological quality and condition, it is now mandatory to replace inorganic fertilizers with organic distinctively (Lamine, C. 2011 and Geng, Y., 2019). Similarly, an overdose of synthetic input, the Nitrogen-produce leaching effect, decreases crop production rather than increases crop yield (Geng, Y., 2019). Therefore, to maintain soil nutrition health and increase soil structure, replacing synthetic input with a suitable chemical-free and natural input with an equivalent amount of Nitrogen is an appropriate approach (Geng, Y., 2019) for agribusiness sustainability. Therefore, allelopathy and its chemicals show dual effects; at higher concentrations, they reduce growth, while at lower concentrations, they stimulate growth. This characteristic makes them useful for growth boosters and herbicides (Ain, Q., 2023). For example, some allelochemicals released by rice varieties can sustain production and ecological cultivation methods (Amb, M. K., 2016). An in-depth study is required to promote the usage of allelochemicals over agrochemicals, alongside the introduction of innovative technologies for using allelopathy aqueous extracts from roots, shoots, and plants. Such initiatives can hold the potential to enhance crop production, which will lead to global food security.

CONCLUSION

The current investigation revealed that the leaf extract of C. album demonstrated effectiveness against seed germination and seedling growth of maize and mung bean. The data from this study suggests that the leaf powder extract of C. album exhibits varying impacts on the germination of maize and mung bean seeds. Additionally, it was observed that seedling growth was inhibited in both test species. Radicle length was more significantly affected than plumule length in both species. There is a pressing need for further studies to evaluate the efficacy of this weed extract under field conditions. Hence, isolating and identifying allelochemicals responsible for reducing seed germination and seedling growth of different crops is imperative. Similarly, innovative technologies that encouraging the utilization of allelopathy aqueous extracts have the potential to enhance crop production for agribusiness sustainablility.

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