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Study of Allelopathic Effects of *Argemone mexicana* L. Root Extract on Seed Germination and Growth of *Triticum aestivum* L. Under *in vitro* Condition

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Abstract

The present study was conducted in Department of Botany, Institute of Science, Nagpur, to investigate the allelopathic effects of Mexican poppy (*Argemone mexicana* L.) on wheat. Wheat is the most important edible cereal crop. Wheat can grow in a wide variety of soils and temperatures, but thrives in humid regions with 30-90 cm of precipitation. *Argemone mexicana* L. is a rapidly expanding weed and an important competitor of wheat (in terms of allelochemicals). Weed is one of major cause of crop production loss. The entire plants of *Argemone mexicana* L. were harvested, rinse with tap water to remove soil debris, roots are dried in shade which kept at 25 degrees celcius (±2) for 72 hours. To demonstrate the germination of seeds of two locally grown wheat varieties (Sharabati and Lokwan), five concentrations of different ratios of root aqueous extract were obtained. A bioassay of a petri dish was carried out to assess the allelopathic potential of *Argemone mexicana* L. on the germination of *Triticum aestivum* L. seeds. The water based root extracts of weeds were used for treatment. The differential inhibitory effect of *Argemone mexicana* L. on Sharbati and Lokwan variety of wheat was observed.

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Allelochemicals; *Argemone mexicana* L.; Petri Dish Bioassay; Seed Germination.

Introduction

Allelopathy refers to biochemical interactions between plants, including those mediated by microorganisms.[1] Allelopathy is defined as the inhibitory or stimulating effect of plants or microorganisms on other plants by releasing chemical compounds into the environment, called allelochemicals.[2] Most allelelochemicals or plant toxic substances that are suspected to inhibit the growth of plants and chemicals released by weeds in soils are secondary metabolites that are not present in all organisms, but occur occasionally.[3]

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Allelopathy is an organic peculiarity in which a plant suppresses the development of different plants through the creation of allelochemicals.[4] In terms of rehearsals, Allelopathy can be considered to be an obstacle between the crops and between the yields and weeds that finally affect the crops production.[5]

Weeds are considered as undesirable plants that compete with growing crops for water, supplementation and sunlight and affect the rate of development and regeneration of crops.[6] Consequently, weeds have a significant impact on crop production due to their detrimental effects on crops. Allelopathy is a kind of obstruction in which the recipient plant by the arrival of the naturally produced inhibitor from the living or decayed tissues has a suppressive effect on the other plant.[7] Various pieces of weeds show allopathic effects by delivering water-soluble allelochemicals that mainly affect plants at the levels of seed and seedling development.[8] Allelochemicals could have a significant impact on the target plants. Allelochemicals are substances that come from the stems, leaves, roots, flowers, and leaf of plants and are produced by them as final components or metabolites. However, the roots and leaves had all the characteristics of being the most reliable Allelochemical manufacturers.[9] These gatherings of naturally produced compounds can be delivered together and can trigger harmful effects in an additional substance or then in a synergistic manner. Allelochemical release from different parts of plants has an immediate impact (inhibitory or stimulative) on seed germination and seedling development of crop plants receiving treatment. The Sharbati and Lokwan wheat varieties (*Triticum aestivum* L., family Poaceae) are grown as winter wheat varieties and are ideal for agro climate conditions in Maharashtra and Madhya Pradesh. Wheat is most common commercial crop, and the main food source for humans.[10] *Triticum aestivum* L. is a Rabi season cereal crop that grows in winter. The harvest is primarily focused on seeds with extremely high contents of carbohydrates. Crop yields are predominantly occupied in the tropical and subtropical regions of the world.

Argemone mexicana L. is a branching herb plant that has been widely naturalized in many tropical and subtropical regions, although it is native to tropical America.[11] It is a widespread annual weed, mainly associated with agricultural crops and wetlands. It is a major weed in a number of crops in the tropics and warm temperate regions and persists as it produces a seed bank. *Argemone mexicana* L. is among the invasive weeds which was believed to released allelochemicals that affected some other species around it, especially crops on agricultural fields. *Argemone Mexicana* L. extracts of seeds, roots and shoot inhibit the growth of pearl lime, mustard, wheat, carrots, corn and turnip, caused by allelopathic compounds dissolved in extracts.[12] Allelopathy mainly affects plants by reducing seed germination and seedling development.[13] Afterwards, allelopathy plays an essential role in many agricultural ecosystems.[14] The types and convergences of allelochemicals, the species of beneficial plants and environmental fsactors are all associated with the allelopathic effects on seed germination.[15] Use of allelolochemicals are a climate-friendly approach which considered as a potential method of controlling weeds.[16] The provided information clearly shows that allelochemicals contained in the above-mentioned weeds may inhibit seed germination. The specific objectives of this study are therefore to evaluate the allelopathic effects of several local weeds on the germination and seedling development of wheat.

Fig. 1: Argemone mexican L. in Wheat field

Materials and Methods

Collection of Weed Plants

Argemone mexicana L. was collected from an agricultural wheat field in village Ridhora near

Warora Tahsil, Chandrapur district of Maharashtra. The roots of weed plants were separated, the roots were washed several times with water, cut into pieces and allowed to dry in shade. The dried plant material was separately sheared in a grinder and, after sieving, stored in air-tight glass bottles.

Preparation of Aqueous Root Extract

The water extract is a combination of filtration by mixing 10 grams of powder root material with 100 ml of distilled water, and the final volume was adjusted to 100 ml, with a 10% water extract. Various strengths (10, 20, 30, 40 and 50%) of dilutions were prepared from the root aqueous extract and used as stock solutions.[17] The powdered parts were processed into a water extract of the root and then placed in bottles. For two days, the bottle is shaken once every 24 hours. The extracts were carefully marked and stored in black bottles after filtering with Muslin linen. In this research, water extraction method was chosen because water serves as a natural solvent extraction medium.

Procurement of Seeds

Certified wheat varieties such as Sharbati and Lokvan, which are mostly cultivated in the district of Chandrapur, were purchased from the Department of Agriculture, office of the District Council, Chandrapur, Maharashtra. The seeds were surface sterilized for 15 minutes with 1% Mercuric chloride and used for Petri dish bioassay of wheat seed germination and seedling growth experiment.

Seed Germination and Growth Study

The study was carried out by the Petri Dish Bioassay Experiment.[18] Total twenty-five healthy, even, surface sterilized seeds were retained for the germination study in the sterilized petri dishes covered with double-blotting paper and moistened with 10 ml different concentrations of the aquatic root extract (10%, 20%, 30%, 40% & 50%). Each treatment had five repeats of control distilled water. Petri dishes were stored in laboratory conditions for a week (room temperature of 25°C for day and night). After a week, the percentage of seed germination was recorded by counting germinated seeds. On the 15th day, various parameters such as length of radical and Plumule were measured with the help of a slide caliper; observations were made five times, with a break of two days.[19]

Data Analysis

Collected data of allelopathic effects of *Argemone mexicana* L. on germination and growth of seedlings (shoot and root length) of *Triticum aestivum* L. were compared with one-way ANOVA.

In order to investigate the significant differences between group averages, Fishers LSD test was used. All tests were carried out with statistical software with an importance threshold of 5%.

Results

The experimental results showed that seed germination percentage and seedling growth were reduced by *Argemone mexicana* L. root extracts compared to control sets of both wheat crop recipient varieties. A higher inhibition was observed in 50% concentration of aqueous root extracts. The results showed that the aqueous root extracts of *Argemone mexicana* L. significantly affected seed germination, root length, stem length as compared to control. One-way ANOVA were used to calculate F test value statistically. The statistical software used in all tests was the IBM SPSS 28.0.1.0 version with a significance value of 5%

Effect on Germination of Seed (in Percentage)

Germination is the period between the hydration and the beginning of the seedling growth related activity, when the physiological processes of seeds begin, causing cell extension, new cells, tissues, and organs.[20] data analysis showed that the germination percentage of Sharbati and Lokwan wheat (*Triticum aestivum* L.) were considerably affected ($P < 0.001$) by various plant water extracts of *Argemone mexicana* L. The maximum seed germination(100±SE00) is seen in control and 10% concentration for both wheat varieties, while the minimum seed germination(76.8±SE1.446) and (77.6±SE0.979) are seen in 50% concentration for Sharbati and Lokwan wheat varieties. It was considerably lower ($P < 0.001$) than all other treatment concentrations. The mean percentages of germination were 97.6±SE0.979, 94.2±SE0.916, 88±SE1.264 and 98.4±SE0.8, 95.8±SE1.8, 88.4±SE1.435 respectively for Sharbati and Lokwan variety, in the concentration range between 20 and 40 per cent.

Table 1: Mean percentage germination (±SE) after one week

Sr.No.	Treatments (%)	Wheat Variety	
		Sharbati	Lokwan
1	Control	100 (±0)	100 (±0)
2	10	100 (±0)	100 (±0)
3	20	97.6(±0.979)	98.4(±0.979)
4	30	94.2(±0.916)	95.8(±1.8)
5	40	88(±1.264)	88.4(±1.435)
6	50	76.8(±1.496)	77.6(±0.979)
F Statistic at p = 0.05, P < 0.001.		35	26

Effect on Root Length

Root aqueous extracts of *Argemone mexicana* L. (P<0.001) affected the root length of wheat (*Triticum aestivum* L.) varieties Sharbati and Lokwan. 50% concentration showed the maximum inhibition percentage in root length (4.8±0.374 cm and 4.4±0.4 cm) followed by 40% (7.2±0.374 cm and 7±0.316 cm), 30% (8.2±0.2 cm and 9±0.316 cm), 20% (11.2±0.489 cm and 10.6±0.4 cm), 10% (14.8±0.374 cm and 14±0.447cm) over control (15.2±0.589 cm and 14.4±0.244cm). Statistical comparison between groups also showed that there was a statistically non-significant difference in between treatment groups when compared with each other. Hence it can be concluded that on variation of concentration of test sample significantly variable changes in root length was observed (P<0.001).

Table 2: Mean root length (±SE) after 15 days

Sr. No.	Concentration	Root Length in cm.	
		Sharbati	Lokwan
1	Control	15.2(±0.089)	14.4(± 0.244)
2	10	14.8(±0.374)	14(± 0.447)
3	20	11.2(±0.489)	10.6(± 0.4)
4	30	8.2(±0.2)	9(± 0.316)
5	40	7.2(± 0.374)	7(± 0.316)
6	50	4.8(± 0.374)	4.4(± 0.4)
F Statistic at p = 0.05, P < 0.001.		60	66

Effect on Shoot Length

Statistical analysis of the data revealed that the different aqueous root extracts of *Argemone mexicana* L. (P< 0.001) affected the length of wheat stems (*Triticum aestivum* L.) Sharbati and Lokwan varieties. The maximum shoot length (12.6±0.244cm and 12.8±0.2 cm) was recorded for control seeds receiving distilled water and was significantly higher (P< 0.001)

than all other treatments. While the minimum (5.4±0.4cm and 4.8±0.2 cm) shoot length in 50%

concentrations was observed for the wheat variants Sharbati and Lokwan respectively. The length of the shoots in concentrations ranging from10% to 40% was (12±0.316 cm and 12.4±0.244cm), (11±0.316cm and 11.6±0.4cm), (10.6±0.4 cm and 9.4±0.244 cm) and (7.2±0.374 cm and 7±0.447 cm) respectively. Multiple comparisons between groups showed that there was a statistically not significant difference between treatment groups (control to 50%) compared to each other.

Table 3: Mean shoot length (±SE) after 15 days.

Sr.No.	Concentration	Shoot Length in cm.	
		Sharbati	Lokwan
1	Control	12.6(±0.244)	12.8(± 0.2)
2	10	12(± 0.316)	12.4(±0.244)
3	20	11(± 0.316)	11.6(± 0.4)
4	30	10.6(±0.4)	9.4(± 0.244)
5	40	7.2(± 0.374)	7(± 0.447)
6	50	5.4(± 0.4)	4.8(± 0.2)
F Statistic at p = 0.05, P < 0.001.		27	45

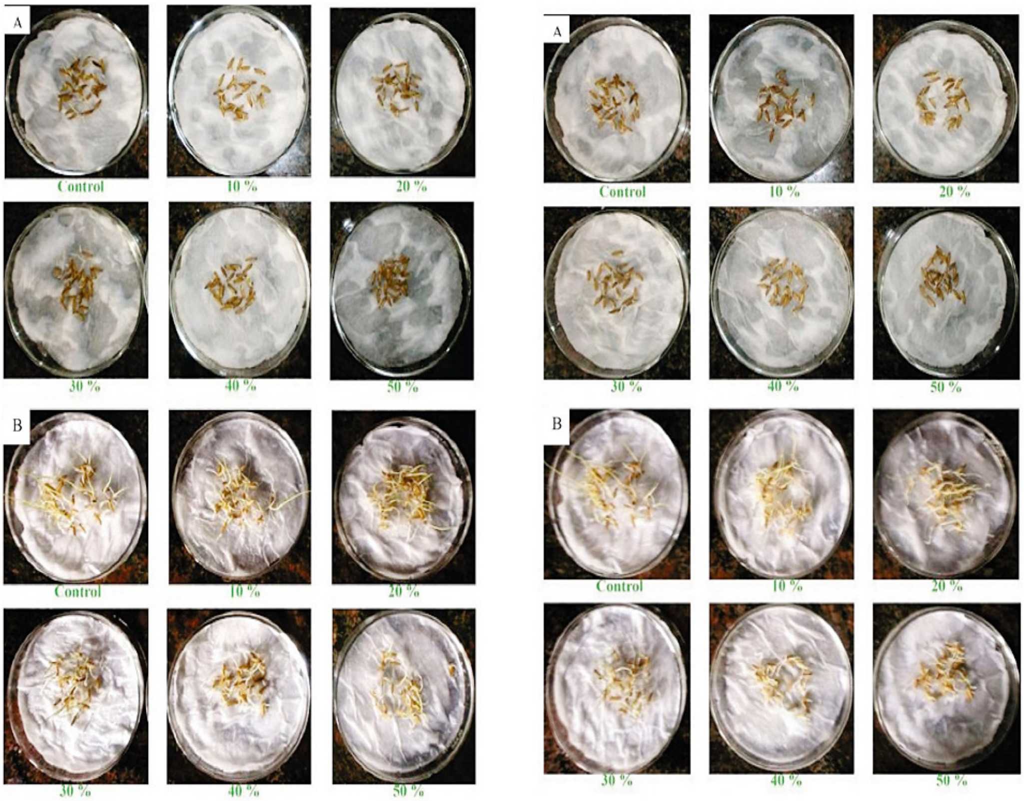

Fig. 2: Left:Seed germination Var.Sharbati, Right: Var. Lokwan A: After 2 Day, B: After 7 day A: After 2 Day, B: After 7 day

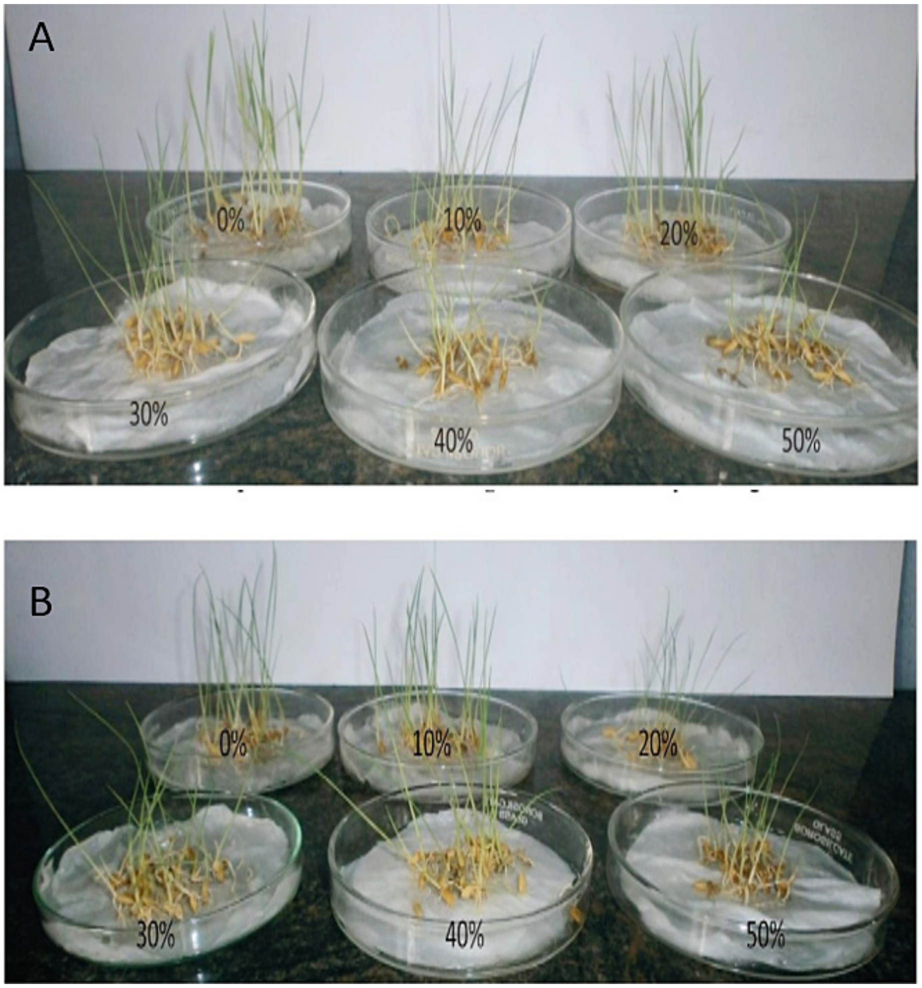

Fig. 3: Seed germination after 12 day, A: Sharbati Var., B:Lokwan Var.

Discussion

This experiment showed that *Triticum aestivum* L. seed germination was dramatically reduced by the aqueous root extract of *Argemone mexicana* L., suggesting that the plant may contain water-soluble allelochemicals that have inhibitory effects on the wheat crop. These results are consistent with a study on the allelopathic effects of *Argemone mexicana* L. on seed germination of *Brachiaria dictyoneura* L. and *Clitoria ternatea* L. where germination was reduced to 7.5% and 65%, respectively.[21] Furthermore, the *Argemone Mexicana* L. aqueous root extracts showed maximum inhibition in the germination of *Triticum aestivum* L. at higher concentrations (30%, 40% and 50%). Allelopathic effect are due to different aqueous root extract concentrations resulting from various abnormalities in metabolic processes caused by the allelochemicals may have inhibited the seed germination of *Triticum aestivum* L. The results of this study also showed that the *Argemone mexicana* L. aqueous root extracts considerably shortened the root and shoot lengths of the *Triticum aestivum* L. Sharabati and Lokwan varieties. Although the effects varied between the two varieties of wheat (Sharbati and Lokwan), they were concentration dependent. In comparison to Sharbati, the roots and shoots of the Lokwan variety were found to be more sensitive to the applied allelopathic stress; at high concentrations (50%) of *Argemone mexicana* L. aqueous root extracts, root and shoot length was significantly reduced. *Argemone mexicana* L. weed extracts from leaves had potent inhibitory effects and decreased Sorghum root and stem 29% to 40%, respectively, and seed germination ranges between 18% to 76%.[22] The reduced root and shoot lengths seen in this study may adversely affect crop production, especially in smallholder farming systems. Root and shoot lengths are very important parameters that determine plants' growth and health because they are important in nutrient uptakes and physical support of the plant.[23] Shorter roots are associated with plants' inability to compete and look for water and minerals from the ground.[24] On the contrary, shorter shoot have been linked to a plant's vulnerability to environmental pressures like drought.[25] Additionally, shorter shoots make it more difficult for plants to compete for the light, air, and space that are necessary for photosynthesis which may lead to poor plant growth.[26]

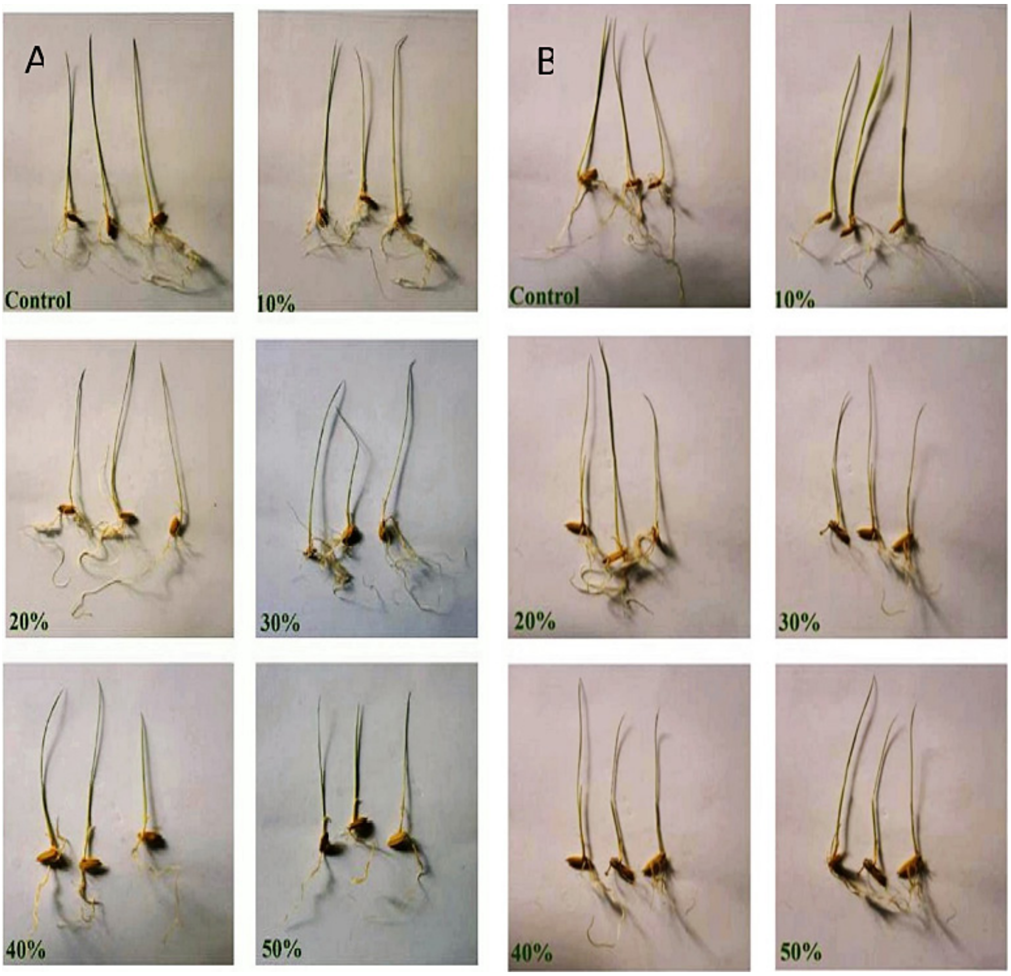

Fig. 4: Length of root and shoot, A; Sharbati Var., B: Lokwan Var.

Conclusion

Allelochemicals in aqueous extracts of the roots of *Argemone mexicana* L. plant severely reduced the germination of the Shrabati and Lokwan wheat varieties as well as seedling growth indicators such as root length, root length. The obtained results are among the first to show the effects of *Argemone mexicana* L. root extracts on the germination and seedling growth of *Triticum aestivum* L.Compared to lower doses (10%) and control (0%), the aqueous root extract of *Argemone mexicana* L. had a negative impact on seed germination and seedling growth in *Triticum aestivum* L. at higher concentrations (30%,40%,50%). These effects can be caused by water-soluble allelochemical present in the aqueous root extracts of *Argemone mexicana* L. that need to be better understood.

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Conflict of Interest
There is no known conflict of interest related to this study.

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