Comparative Evaluation of the Allelopathic Effects of Eucalyptus Leaf, Sunflower Seed Coat, and Rice Husk Extracts on Germination and Seedling Growth of Cereal Crops and Weeds

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Abstract:

Allelopathy is crucial biological phenomenon through which certain plants release compounds that can affect the germination and early growth of neighboring plant species. The experiment was carried out in a laboratory in the College of Agricultural Engineering Sciences, University of Sulaimani, Sulaymaniyah City, Kurdistan Region of Iraq, in autumn 2025. The study was designed to evaluate the effect of some aqueous plant extracts such as eucalyptus leaves (*Eucalyptus camaldulensis*), sunflower seed coats (*Helianthus annuus*) and rice husks (*Oryza sativa*) on seed germination such as germination percentage (G%), mean germination time (MGT, days), and coefficient of variation of germination velocity (CVG%) and radical and coleoptile length (cm) of seedling properties of cereal crops (*Triticum aestivum* and *Hordeum vulgare*) and weed plants (*Lolium rigidum* and *Cephalaria syriaca*) at concentration of 10% and 25 % plus to control. The experiment was conducted using a factorial-completely randomized design (CRD) using two-way ANOVA. Comparisons among means of the parameters were carried out using were carried out by Duncan's multiple range test at $P \leq 0.05$. The results showed that the extract of eucalyptus leaf extract had the strongest activity, particularly at 25%, where germination was completely inhibited in all tested species, followed by sunflower seed coat extract. Thus, the results concluded that plant derived extracts offer the more and effective environmental compatibility on inhibiting seed germination and seedlings properties can be used as alternative of conventional synthetic herbicides.

Keywords: Inhibitory effect, Seed germination, Eucalyptus Leaves, Sunflower Seed Coats, Rice Husks, weeds, cereal crops and GC-MS.

Introduction:

Weed plants are one of the most obstruction factors in agricultural lands due to their effect on losing yields in field and horticultural crops [28]. Common methods for weed control is depending on synthetic herbicides. Unfortunately, prolonged and more using of these chemicals has cause contamination of environment, side effects on non-target living things and appear of herbicides resistant weed genotype [18].In

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spite of that, bio herbicide is alternative methods for weed control in the way of allelophathy.

Some plants naturally produce chemical substances that interfere with the establishment of nearby vegetation. These compounds are released into the surrounding environment as plant residues decompose or through substances secreted by roots and washed out by water. The chemicals originate from different plant tissues, such as leaves, stems, roots, fruits, and seeds, and may disrupt normal germination processes and early plant development, resulting in adverse effects on neighboring plants [2, 30]. Certain allelochemicals can significantly inhibit crop growth and development, even when present at very low concentrations [1]. In agricultural environments, allelopathic substances may disrupt normal crop establishment by slowing seed emergence, increasing the loss of young seedlings, and limiting plant growth, which ultimately leads to reduced crop performance and yield [19]. Wheat and barley are among the crops that possess strong allelopathic activity on weeds or other crops [21]. These two species have been selected according to their wide diffusion and economic importance by Iraqi farmers.

[29] Demonstrated that extracts from the roots, stems, leaves, and fruits of some plant species negatively influence wheat growth by reduce seedling vigor, limit root and shoot elongation, and decrease both root dry weight and total biomass of the seedlings.

Eucalyptus trees take up farmland that could be utilized for growing food crops and adversely impact indigenous plant species, including crops [12] the leaves of many Eucalyptus species are rich in secondary metabolites with potent allelopathic activity. These bioactive compounds can be released into the surrounding environment and influence the germination, growth, and competitive interactions of neighboring plants. As a result, Eucalyptus species are capable of modifying plant community structure and exerting significant ecological effects in the ecosystems they colonize [20]. [22] found that extracts of *Eucalyptus* leaves inhibit wheat growth, causing reductions in germination, root and shoot lengths, and both fresh and dry weights of the seedlings. Sunflower (*Helianthus annuus* L.) is well known for its strong allelopathic activity [25], and use of sunflower seed coat is considered as an alternative strategy for weed management especially in organic farming. [15, 16] High allelopathic-inhibitory effectiveness of sunflower against most common weeds as reported in previous studies [24, 8]. in laboratory study we observed that, wheat germination is almost unaffected by sunflower allelopathics [9], while in the field substantial reduction in wheat germination and seeding establishment took place when covered by sunflower seed coat[15,16]. [27] reported that approximately 3.5% of the global rice germplasm exhibits allelopathic traits, with phenolic acids identified as the most prominent allelopathic compounds in rice.

Therefore, the aim of the present study was to determine the allelochemical-induced effects of the leaf water extract of eucalyptus leaves, sunflower seed coats and rice husks upon seed germination and seedling growth in two important crops in Kurdistan-Iraq, wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), plus two weed species *Lolium rigidum* and *Cephalaria syriaca*.

Materials and Methods

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A laboratory experiment was conducted in germinator conditions in the College of Agricultural Engineering Sciences, University of Sulaimani, Sulaymaniyah City, Kurdistan Region of Iraq, in autumn 2025. The studies were designed to investigate the effect of some aqueous plant extracts such as eucalyptus leaves (*Eucalyptus camaldulensis*), sunflower seed coats (*Helianthus annuus*) and rice husks (*Oryza sativa*) on seed germination and seedling properties of cereal crops (*Triticum aestivum* and *Hordeum vulgare*) and weed plants (*Lolium rigidum* and *Cephalaria syriaca*), which kindly provided by the Agricultural Research Station in Bakrajo-Sulaymaniyah.

Plant sampling and preparation of extracts

In order to prepare aqueous plant extracts, samples of eucalyptus leave, sunflower seed coat and rice husks were collected from several field in Sulaymaniyah in autumn 2025, at the end of growing season. The phenolic compound by high performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS) of chemical constituent's essential oil components of these plant extracts are shown in Table 1 and 2, respectively. The collected samples were dried in open air, then ground into powder form. In a next stage the ground plant material was dissolved in distilled water in the ratio of 1:50 (w/v) and the mixture was left in a water bath at 40°C for two hours and then stored in a cool, dark place for 24 hours. The suspension was then filtered using sterile cotton cloth [3]. The filtrate was designated as stock solution of 50% concentration, this stock solution was diluted by using distilled water as the diluent to prepare concentrations of 10 and 25% and the control contained only distilled water, [17].

Table 1. Constituents of phenolic compound (mg/g) in three plant extracts using HPLC

Compound	Plant part		
	Eucalyptus leaves	Sunflower seed coat	Rice husk
Caffeic acid	13.58	ND	3.68
Catechin	57.84	ND	1.22
Ferulic acid	ND	52.9	164.6
Gallic acid	913.5	ND	ND
Ellagic acid	148.9	ND	ND
Quercetin	50.04	ND	ND
Chlorogenic acid	52.13	ND	ND
Vanillic acid	12.37	ND	ND
Kaempferol	8.56	ND	ND
Rutin	7.78	ND	ND
Proanthocyanidins	ND	168	ND
Caffeoylquinic acid	ND	48.3	ND
Extractable phenolics	ND	27.6	ND
p-Coumaric acid	ND	ND	278.4
p-Hydroxybenzoic acid	ND	ND	12.51
Epicatechin	ND	ND	1.91

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ND: not detected

Table 2. Chemical contents of three plant extracts essential oil using GC-MS

No	Eucalyptus leaves		Sunflower seed coat		Rice husk	
	Compound Names	**Conc. (%)**	**Compound Names**	**Conc. (%)**	**Compound Names**	**Conc. (%)**
1	9-Octadecenoic acid	35.43	Hexadecanoic acid (Palmitic acid)	19.82	Hexanal	1.12
2	Octadecenoic acid	19.89	9,12-Octadecadienoic acid (Linoleic acid)	23.26	Nonanal	1.48
3	Eucalyptol	14.85	Oleic acid	18.91	4-Hydroxybenzoic acid	2.81
4	n-Hexadecanoic acid	4.51	Stearic acid	5.14	Vanillic acid	3.94
5	Octadecanoic acid	5.08	Phytol	6.27	*trans*-p-Coumaric acid	6.16
6	Hexadecanoic acid, methyl ester	3.28	β-Sitosterol	8.17	Oxiranylmethyl ester of 9-octadecenoic acid	3.49
7	9,12-Octadecadienoic acid	8.21	γ-Tocopherol	3.46	Ferulic acid	8.02
8	Methyl stearate	1.92	Squalene	2.81	Phytol	5.01
9	Cyclohexanecarboxylic acid	1.51	Campesterol	2.89	Momilactone B	4.62
10	Globulol	1.05	Other minor compounds	9.27	Heptamethoxyflavone	3.43
11	Aromandendrene	1.14			n-Hexadecanoic acid (Palmitic acid)	20.54
12	Cyclopropaneoctanal	0.84			Hexamethoxyflavone	7.15
13	9-Octadecyne	0.66			2-Methoxyphenol (Guaiacol)	1.69
14	Cyclopropaneoctanal, 2-octyl-	0.61			9,12-Octadecadienoic acid (Linoleic acid)	18.31
15	Cycloprop	0.5			*n*-Hexadecanoic acid (Palmitic acid)	12.23
16	Alloaromadendrene	0.52				

Germination and Seedlings Growth

Wheat Germination and Seedlings Growth: Ten seeds of each of cereal crops such as wheat and barley, and weed species like rigid ryegrass and Syrian cephalaria were grown in petri dishes of 9 cm diameter. Whatman No. 42 filter paper was used as medium of germination. In total, 4 cm^3 of

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solution was applied, half (2 cm^3) of which was used as moisture for filter paper receiving seeds in the dishes and remaining half was applied to the covering filter paper. The control treatment received 4 cm^3 of distilled water in the same fashion. Both control and treated petri dishes were kept moist by applying distilled water whenever needed. The dishes for cereal and weed seeds were placed separately in germinator set at 20±2°C for cereals seeds and 25±3°C for weed seeds with relative humidity 90-95% and a 16 *hr.* light /8 *hr.* dark photoperiod for cereal and weeds' seed, and germination counts were recorded daily for a period of fourteen days to calculate these parameters, according to [26,30];

- Germination rate (G, %): is total number of seeds that germinated divided by total number of seed sown multiply 100.
- Mean germination time (MGT, day): $\text{MGT (day)} = \frac{\sum(Ni \times Ti)}{\sum Ni}$

Where: Ni = Number of seeds germinated on day i, and Ti= time from the 1st day to day i

- Coefficient of velocity of germination (CVG, %): $\text{CVG (\%)} = \frac{\sum Ni}{\sum(Ni \times Ti)} \times 100$

After 14 days, radical and coleoptile length (cm) were measured.

All treatments were replicated three times in a factorial-completely randomized design (CRD) using two-way ANOVA. The treatments were analyzed using Statistical

Package for Social Sciences (IBM SPSS Statistics for windows, Version 24.0). Furthermore, the comparisons among means were carried out by Duncan's multiple range test at P≤0.05 (Bender, 2020).

Result and Discussion

Table 3 shows the effect of plant extracts on germination rate (G, %), mean germination time (MGT, day), and coefficient of velocity of germination (CVG, %). All plant extract at both concentrations significantly affect the germination parameters compared to control. In germination rate, at both concentrations, the extract of eucalyptus leaves has the strongest inhibitory impact (40.833%) for 10% and completely inhibited germination (0.00%) for 25%, followed by sunflower seed coat (57.500% and 39.167%) and rice husk (64.167% and 45.833%) for %10 and %25, respectively.

In mean germination time (MGT, day), the extracts of leaves of eucalyptus and sunflower seed coat significantly accelerate germination relative to the control. In contrast, the extract of rice husk at 10% did not significantly alter MGT compared to control (5.579 and 5.291days, respectively), whereas at 25% it reduced (4.105 days).

The coefficient of velocity of germination (CVG) followed a pattern with germination rate and mean germination time. Eucalyptus leaves and sunflower seed coat extracts at both concentrations significantly decreased CVG, while rice husk showed intermediate effect, with CVG values remaining statistically comparable to the control at 10% but decreased significantly at 25%.

Table 3. Effect of plant extracts on germination rate (G, %), mean germination time (MGT, day), and coefficient of velocity of germination (CVG, %)

Plant Extracts	G	MGT	CVG
Control	88.333 a	5.291 a	22.836 a
Eucalyptus leaves 10%	40.833 d	2.051 b	13.184 c

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Sunflower seed coat 10%	57.500 c	4.683 a	22.055 ab
Rice husks 10%	64.167 b	5.579 a	21.909 ab
Eucalyptus leaves 25%	0.000 e	0.000 c	0.000 d
Sunflower seed coat 25%	39.167 d	2.341 b	13.909 c
Rice husks 25%	45.833 d	4.105 a	19.241 b

Means with the same letter within each column are not significantly different at the 5% level based on Duncan's Multiple Range Test

The data in table 4 illustrate the effect of plant extracts on the length of hypocotyl and radicle of seedlings (cm). all plant extracts reduced seedling growth compared to control also concentration 25% was more affected in decreasing length of hypocotyl and radicle than 10%. Eucalyptus leaf extract was the most powerful inhibitor in reducing the length of hypocotyl and radicle at both concentrations, at 25% reached to 0.00 cm, whereas at 10% recorded 2.423 and 1.988 cm for hypocotyl and radicle respectively. meanwhile, the extract of rice husk was least inhibitory at 10% hypocotyl length (6.686 cm) was statistically comparable to the control, while, in 25% reduced hypocotyl length to (3.498 cm). Sunflower seed coat extract exhibited moderate inhibition at both concentrations for both parameters.

Table 4. Effect of plant extracts on the length of hypocotyl and radicle of seedlings (cm)

Plant Extracts	Length of Hypocotyl (cm)	Length of Radicle (cm)
Control	7.254 a	4.407 a
Eucalyptus leaves 10%	2.423 d	1.988 c
Sunflower seed coat 10%	4.981 b	3.824 b
Rice husks 10%	6.686 a	3.900 ab
Eucalyptus leaves 25%	0.000 e	0.000 e
Sunflower seed coat 25%	1.981 d	0.933 d
Rice husks 25%	3.498 c	2.208 c

Means with the same letter within each column are not significantly different at the 5% level based on Duncan's Multiple Range Test

Results in table 5 demonstrate interaction effect of plant extracts and seeds of cereal crops; wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*) and weeds species; rigid ryegrass (*Lolium rigidum*) and Syrian cephalaria (*Cephalaria syriaca*) on germination rate G (%). In control treatment, both cereal and weed seeds get high germination rate with (100%) for both cereal seeds, and weed seeds recorded 86.667% and 66.667% for rigid ryegrass and Syrian sepahlaria, respectively. Eucalyptus leaf extract caused serve inhibition for both species of cereals and weed seeds at concentration 25% which reached to non-germination (0.000%) while at concentration 10% exerting only mildest phytotoxicity on cereal seeds (70.000% for T. *aestivum* and

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93.333% for *H. vulgare*). Whereas sunflower seed coat and rice husk were showed lower inhibitory effects on cereal germination than on weed germination under the tested condition.

Table 5. Interaction effect of plant extracts and seeds of cereal crops and weeds on Germination rate G (%)

Plant Extracts	Cereal seeds		Weed seeds	
	Triticum aestivum	*Hordeum vulgare*	*Lolium rigidum*	*Cephalaria syriaca*
Control	100.000 a	100.000 a	86.667 abc	66.667 e
Eucalyptus leaves 10%	70.000 de	93.333 ab	0.000 h	0.000 h
Sunflower seed coat 10%	96.667 ab	93.333 ab	6.667 h	33.333 fg
Rice husks 10%	100.000 a	90.000 abc	23.333 g	43.333 f
Eucalyptus leaves 25%	0.000 h	0.000 h	0.000 h	0.000 h
Sunflower seed coat 25%	70.000 de	83.333 bcd	0.000 h	3.333 h
Rice husks 25%	93.333 ab	76.667 cde	6.667 h	6.667 h

Means with the same letter are not significantly different at the 5% level based on Duncan's Multiple Range Test

The results in table 6 imply that the interaction between aqueous plant extracts and cereal and weed seed species had a varied significant effect on the mean germination time MGT (days). Eucalyptus leaf extract at 10% intermediate delayed cereal MGT (4.238 days for T. *aestivum* and 3.967 days for *H. vulgare*) but for weed species (*L. rigidum* and *C. syriaca*) it eliminated germination, while at 25% completely preventing seed germination across all species. Meanwhile, the extracts of sunflower seed coat and rice husk maintained near normal for cereal MGT (2.750 – 3.785 days) while decreasing weed MGT to (0.000 – 5.667 days).

Table 6. Interaction effect of plant extracts and seeds of cereal crops and weeds on mean germination time MGT (day)

Plant Extracts	Cereal seeds		Weed seeds	
	Triticum aestivum	*Hordeum vulgare*	*Lolium rigidum*	*Cephalaria syriaca*
Control	3.067 cde	3.200 cde	6.343 bc	8.556 ab
Eucalyptus leaves 10%	4.238 cd	3.967 cd	0.000 e	0.000 e
Sunflower seed coat 10%	3.000 cde	2.900 de	3.333 cde	9.500 a
Rice husks 10%	3.467 cd	3.048 cde	7.333 ab	8.467 ab
Eucalyptus leaves 25%	0.000 e	0.000 e	0.000 e	0.000 e
Sunflower seed coat 25%	2.750 de	3.282 cde	0.000 e	3.333 cde

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Rice husks 25%	3.785 cd	3.300 cde	3.667 cd	5.667 bcd

Means with the same letter are not significantly different at the 5% level based on Duncan's Multiple Range Test

Interaction effect of plant extracts and seeds of cereal crops and weeds on coefficient of velocity of germination (CVG, %) is explained in table 7. In control treatment, cereals showed big CVG scores (32.616 and 31.270% for T. *aestivum* and *H. vulgare*, respectively), whereas weeds scored significant synchronization (15.769 and 11.690% for *L. rigidum* and *C. syriaca*, respectively). Under extract of eucalyptus leaf condition at 25%, the CVG get the lowest value which it is phytotoxic for across all species (0. 000%).while sunflower seed coat and rice husk extracts recorded high cereal CVG (21.193 – 31.111%) while drastically decreasing weed CVG (14.021 – 0.000%).

Table 7. Interaction effect of plant extracts and seeds of cereal crops and weeds on coefficient of velocity of germination (CVG, %)

Plant Extracts	Cereal seeds		Weed seeds	
	Triticum aestivum	*Hordeum vulgare*	*Lolium rigidum*	*Cephalaria syriaca*
Control	32.616 a	31.270 a	15.769 cd	11.690 de
Eucalyptus leaves 10%	25.858 ab	26.880 ab	0.000 g	0.000 g
Sunflower seed coat 10%	31.332 a	32.323 a	13.889 de	10.675 de
Rice husks 10%	28.867 a	32.828 a	14.021 de	11.918 de
Eucalyptus leaves 25%	0.000 g	0.000 g	0.000 g	0.000 g
Sunflower seed coat 25%	31.111 a	21.193 bc	0.000 g	3.333 fg
Rice husks 25%	26.434 ab	30.439 a	12.222 de	7.870 ef

Means with the same letter are not significantly different at the 5% level based on Duncan's Multiple Range Test

Table 8 shows the interaction effect of plant extracts and seeds of cereal crops and weeds on the length of hypocotyl of seedlings (cm**).** The hypocotyl value exhibits the selectivity of phytotoxicity observed in germination characteristics. Leaves of eucalyptus extract non selectively stopped hypocotyl elongation among all species at 25%. In contrast, the extract of sunflower seed coat and rice husk maintained close to normal cereal hypocotyl development get through hard restricting weed shoot growth.

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Table 8. Interaction effect of plant extracts and seeds of cereal crops and weeds on the length of hypocotyl of seedlings (cm)

Plant Extracts	Cereal seeds		Weed seeds	
	Triticum aestivum	*Hordeum vulgare*	*Lolium rigidum*	*Cephalaria syriaca*
Control	8.783 bc	10.967 a	6.287 de	2.980 hi
Eucalyptus leaves 10%	3.886 gh	5.806 ef	0.000 l	0.000 l
Sunflower seed coat 10%	7.707 cd	8.430 bc	1.787 ijkl	2.000 ijk
Rice husks 10%	9.617 ab	10.502 a	4.590 efgh	2.037 ijk
Eucalyptus leaves 25%	0.000 l	0.000 l	0.000 l	0.000 l
Sunflower seed coat 25%	3.406 ghi	4.181 fgh	0.000 l	0.337 kl
Rice husks 25%	4.994 efg	5.913 e	2.207 ij	0.880 jkl

Means with the same letter are not significantly different at the 5% level based on Duncan's Multiple Range Test

The interaction effect of plant extracts and seeds of cereal crops and weeds on the length of radicle of seedlings (cm) is shown in table 9. The length of radicle exhibited more sensitivity to all studied extracts than the length of hypocotyl, especially in both weed seeds. Under control conditions, the establishment of cereal taller radicle than weed species (7.500 cm for *H. vulgare* and 1.053 cm for *C. syriaca*). Eucalyptus leaf extract at 25% arrested root development across all species (0.000cm). the extracts of sunflower seed coat and rice husk at 10% exerted cereal radicle lengths near control score (7.693 - 6.133 cm) but drastically inhibited weed roots (0.000 – 0.947cm). at 25%, these plant extracts kept partial radicle growth (1.225-4.384 cm) whereas essentially reducing establishment of weed roots, affirming that root system is the basal target area of allelopathic inhibition.

Table 9. Interaction effect of plant extracts and seeds of cereal crops and weeds on the length of radicle of seedlings (cm)

Plant Extracts	Cereal seeds		Weed seeds	
	Triticum aestivum	*Hordeum vulgare*	*Lolium rigidum*	*Cephalaria syriaca*
Control	7.183 ab	7.500 a	1.890 fg	1.053 gh
Eucalyptus leaves 10%	3.276 de	4.678 c	0.000 h	0.000 h
Sunflower seed coat 10%	7.693 a	6.133 b	0.470 h	1.000 gh
Rice husks 10%	7.200 ab	6.525 ab	0.927 gh	0.947 gh
Eucalyptus leaves 25%	0.000 h	0.000 h	0.000 h	0.000 h
Sunflower seed coat 25%	1.225 fgh	2.267 ef	0.000 h	0.240 h
Rice husks 25%	3.694 cd	4.384 cd	0.407 h	0.347 h

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Means with the same letter are not significantly different at the 5% level based on Duncan's Multiple Range Test

Table 10 illustrate the Pearson correlation among Germination rate (G), mean germination time (MGT), and coefficient of velocity of germination (CVG). The Pearson analysis revealed strong positive connection among G, MGT and CVG. Germination rate G was highly correlated with CVG (r=0.89). In contrast, MGT showed weak positive correlations with G (r=0.30) and CVG (r=0.31), indicating that germination timing is more independent of germination rate success and velocity across treatments.

Table 10. Pearson correlation among Germination rate (G), mean germination time (MGT), and coefficient of velocity of germination (CVG)

Variables	G	MGT	CVG
G	1	0.30	0.89
MGT	0.30	1	0.31
CVG	0.89	0.31	1

Figure 1 illustrates the germination rate (G, %), mean germination time (MGT, day), and coefficient of velocity of germination (CVG, %) of *Triticum aestivum, Hordeum vulgare, Lolium rigidum, and Cephalaria syriaca*. Cereal and weed species have differential response to aqueous plant extract treatments all over three germination parameters. In germination rate panel, cereal crops had highly germination percentage under all plant extracts except extract of eucalyptus 25%, while weed species were hardly affected particularly by extracts of eucalyptus leaf and sunflower seed coat. In panel of MGT, cereals had shortest mean germination time, whereas weed plants delayed emergence under germination stress. The CVG panel confirmed that CVG was systematically high in cereals but drastically decreased in weeds, the extract of eucalyptus leaves causing complete loss of germination synchrony, these results agree with [10].

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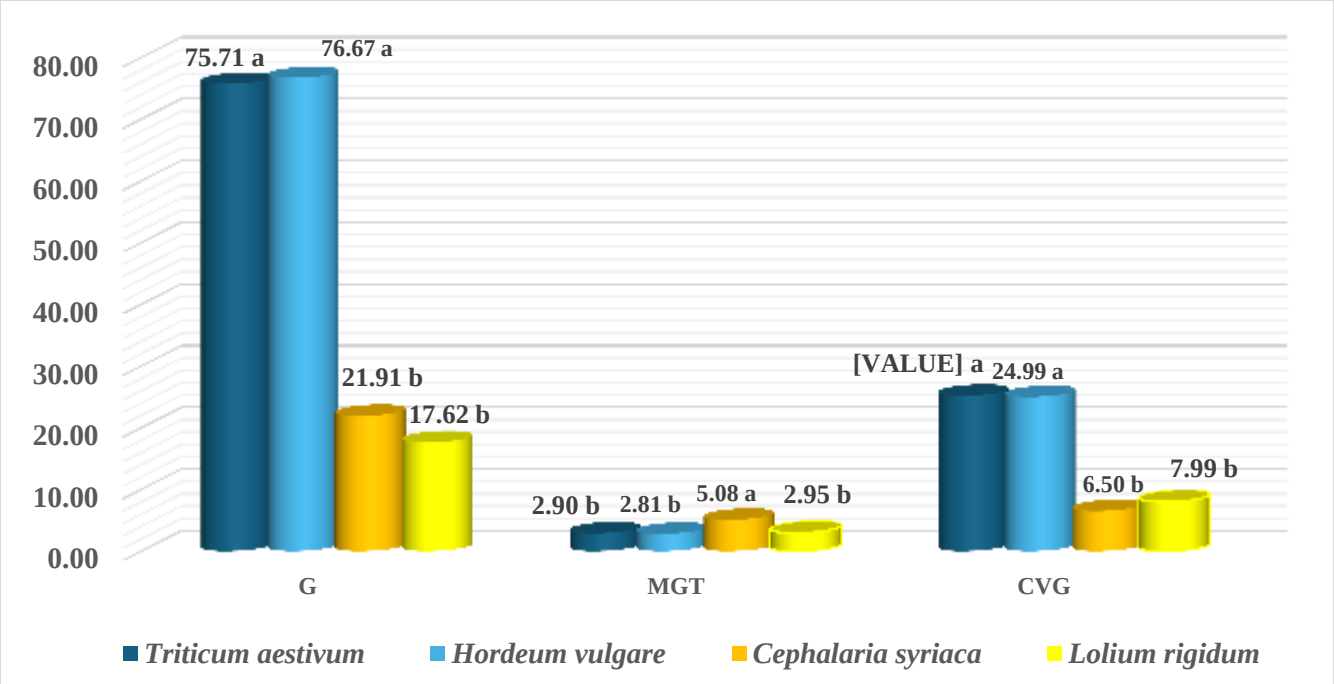


Figure 1. The germination rate (G, %), mean germination time (MGT, day), and coefficient of velocity of germination (CVG, %) of *Triticum aestivum, Hordeum vulgare, Lolium rigidum, and Cephalaria syriaca*

Figure 2 demonstrates the response of length of hypocotyl and radicle (cm) of *Triticum aestivum, Hordeum vulgare, Lolium rigidum, and Cephalaria syriaca* seedlings under different aqueous plant extracts stress. Cereal plants (T. *aestivum* and *H. vulgare*) remained considerably longer hypocotyl and radicle growth than weed species (*L. rigidum* and *C. syriaca*). Barley (*H. vulgare*) showed the longest hypocotyl (6.54cm), whilst radicle obviously discerned cereals (4.33 – 4.50cm) from weed species (0.51 - 0.53 cm), pointing that root systems are more sensitive to allelopathic stress than shoot systems.

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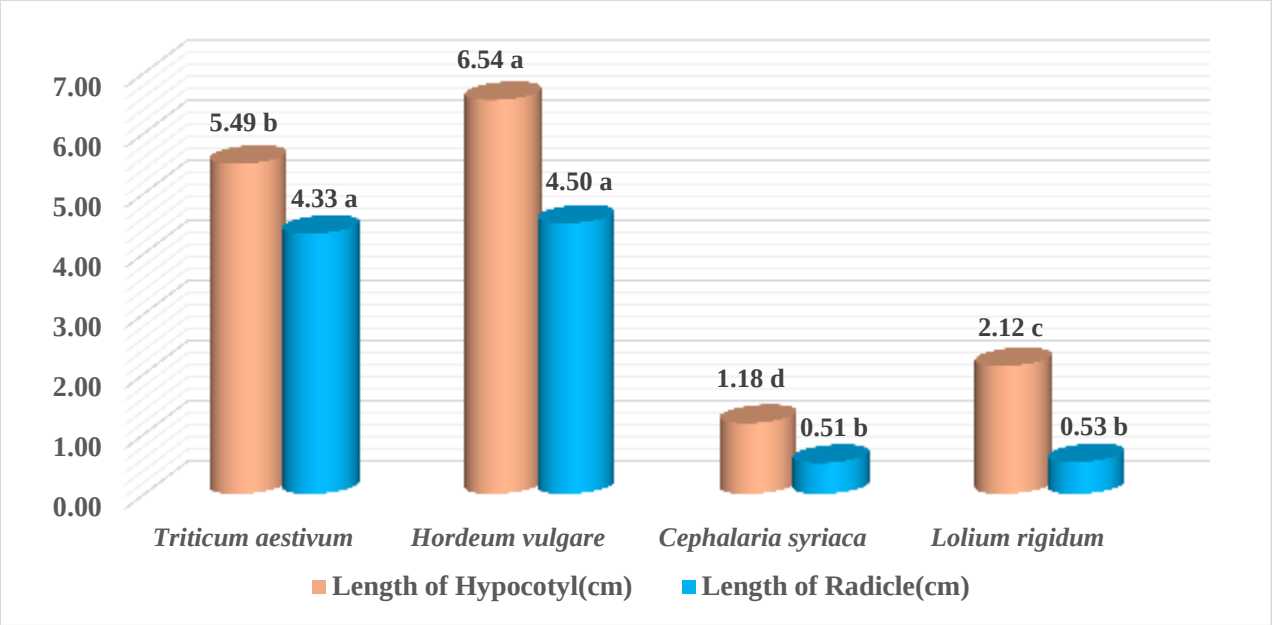


Figure 2. Length of hypocotyl and radicle of seedlings (cm) of *Triticum aestivum, Hordeum vulgare, Lolium rigidum, and Cephalaria syriaca*

The present study clarify that aqueous plant extracts of eucalyptus leaves, sun flower seed coats and rice husks maintain significant allelopathic effects on seed germination parameters (G, MGT, and CVG) and seedling growth (hypocotyl and radicle length), with phytotoxicity raising in a dose dependent manner. The extract of eucalyptus leaf was the powerful inhibitor, completely inhibiting germination and seedling development at 25% concentration across all studied species that is possibly due to the allelopathic action or the chemical phenolic compounds contained in the plant extracts may be led to disrupt plasma membrane integrity, increase electrolyte leakage, impairment of photosynthesis and uncouple mitochondrial respiratory ability by the constituent monoterpenes and essential oils (Table 1). The significant decreased MGT may be due to that membrane destroy accelerated initial water imbibition before metabolic collapse, a phenomenon usually described with phytotoxin of essential oils contained in plant extracts (Table 2) [6,26,30]. In contestability, the extracts of sunflower seed coat and rice husk illustrated mildest effect and marked selectivity. Severely limiting weed development while continuing the germination capacity and early growth of cereal crops (T. *aestivum* and *H. vulgare*). These potential for plant derived bioactive function under different responses underlines it as an environmentally sustainable alternative to chemical herbicides in integrated weed management approach [4, 5, 23].

The interaction between aqueous plant extract sources and seed species clarified a clear dichotomy in germination processes between cereals and weeds. Under control conditions, cereal crops (T. *aestivum* and *H. vulgare*) showed higher germination percentages, faster emergence, and greater seedling vigor than weed plants (*L. rigidum* and *C. syriaca*) could be related to differentiation in biological, morphological, and physiological features of seed species. According to plant extract vulnerability,

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eucalyptus leaves caused broad spectrum toxicity at 25% concentration, inhibiting germination across all species. At the same time, sunflower seed coat and rice husk extracts asserted cereal germination rates and coefficients of velocity of germination close control level even at advanced concentrations, whereas drastically suppressing weed germination. The selective disruption of time of germination and success of weed seeds may be related to the bioactive constituents in these plant extracts interpose with weed specific metabolic targets like enzyme activity of α-amylase, energy releasing, or regulator of cell cycle, whilst, cereal crops have either mechanization of anatomical barriers or detoxification that mitigate phytotoxicity [26,30]

Pearson correlation analysis discovered strong positive connections among G, MGT, and CVG, and it is confirming that these indices together display one dimension of alleolopathic stress which how it decelerates germination over time. In the other hand, MGT was only parameter that weakly correlated with G and CVG, confirmed that delay of seed germination represents the distinguishable physiological response, these impacts could be mediated through distinct mechanisms, including hormone imbalance or inhibiting of enzyme rather than lethal cell damage [14,11,13]

Conclusion

In this study, the allelochemicals present in the aqueous extracts of eucalyptus leaves strongly inhibited the seed germination and seedling growth parameters such as root length, shoot length of the winter cereal crops (*Triticum aestivum* and *Hordeum vulgare*) and weed species (*Lolium rigidum* and *Cephalaria syriaca*), These inhibitory effects increased with increasing concentration of the extracts.

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