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Research Article

Allelopathic activity of *Zea mays* extracts on some physiological and anatomical features of corn and wheat cultivars

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Abstract
Wheat is often planted directly after maize in fields following the maize harvest, and maize residues decompose in the soil by various biological factors, releasing phenolic compounds that affect the germination and growth of some crops planted with or after it. This research aimed to identify the effect of *Zea mays* leaf extract on seed germination physiological and anatomical features of *Z. mays* var. (Drachma, Mahali) and *Triticum aestivum* var. (Baraka, Abu Ghraib) . The results showed *Z. mays* leaf extract stimulated some traits germination (100%) in Drachama at control, plumule length (7.8cm) in Abu-Graib, radicle length (11.6cm) in Baraka at 2%, fresh weight of plumule and radical (0.0113, 0.0148gm) respectively in Drachama at control. There was highest reduction germination (60%) in Drachama at 6% extract [plumule length (1.0)cm, radicle length (4.2cm), fresh weight of plumule (0.0052cm) in Mahali at 4%], fresh weight of radical (0.00026gm) in Abu-Graib at 6%. There was a difference in response in greenhouse experiments. Anatomical traits of the two corn cultivars differed at 2% and 4% concentrations. The highest increase in germination (96.7%) was in Baraka at 4%, shoot length (22.1cm) in Drachama at 4%, fresh weight of root (0.254gm) in Abu-Graib at 4%, [root length (44cm), fresh weight of root (0.052 gm) in Abu-Graib at 4%], the highest reduction in germination (80%) in Abu-Graib, dry weight of root (23gm) in Abu-Graib at 2%. Using HPLC, compounds tannic acid, gallic acid, benzoic acid, and salicylic acid were identified from *Z. mays* L. extracts. The study will help to develop sustainable agricultural practices, such as crop rotation, to increase crop productivity and reduce reliance on chemicals.

Keywords: Allelopathy, Corn, Extracts, Germination, Response physiological, Wheat, Zea mays

INTRODUCTION

Zea mays L., a widely spaced crop, is cultivated more extensively than any other grain each year The total global production in 2021 was 1.2 billion tonnes (International Grains Council, 2013). In many regions of the world, it has evolved into an important dish, allowing for economically intercropping vegetables in the intercrops and being directly consumed by people. Intercropping has been around for a while and has become more popular due to its good yields (Choudhary *et al*., 2014). Allelopathic activation is brought on by accumulating physiologically active substances with beneficial effects (Cipollini *et al*., 2012).

Allelopathic potential, also called allelochemical impacts on inter- or intraspecific species, was investigated by) Deng *et al*., 2020). When the leaves of allelopathic plants fall to the ground, they decompose and emit unpleasant chemicals that inhibit the growth of other plants nearby. Plants emit substances that affect soil microorganisms and ultimately alter the makeup of plant communities (Kalisz *et al*., 2021). Results showed significant inhibitory effects of aqueous extracts on seed germination, growth and dry biomass reduced plumule and radical growth were recorded under dry aqueous leaf extracts when compared to control (Muhammad and Majeed, 2014). In fields with sunflower residues (Pannacci *et al*., 2013), decreased growth and yield were observed in *Sorghum vulgare* and *Zea mays*. Sunflower leaf extracts applied to mustard (*Sinapis alba* L.) at various dosages negatively affected seed germination and seedling growth (Bogatek *et al*., 2006).

Aqueous extracts of maize root and shoot significantly impacted seed germination and other parameters when compared to similar controls. Both the roots and shoot aqueous extracts included a variety of phytochemicals, including tannins, phlobatannins, flavonoids, terpenoids, and alkaloids, according to preliminary phytochemical screening (Ahmed, 2018). (Ming *et al*., 2020) examined the effects of *Castanea henryi* litter aqueous extracts on *Z. mays* and *Brassica pekinensis* growth and physiological responses. After applying leaf extract at high concentrations (0.05 g/ml for *B. pekinensis* and 0.10 g/ml for *Z. mays*), the amount of malonaldehyde was significantly increased, while seed germination and seedling growth were both significantly reduced while extract concentration often increased these effects of the sunflower varieties'. The results of *Helianthus annuus* residues potential against the growth characteristics of the suggested succeeding crops were assessed to some soil qualities, Broad bean *Vicia faba* L., flax *Linum ustatissim* L., and wheat *Triticum aestivum* L. After receiving seeds, sunflower plants were broken up and mixed with the field dirt before being used to cultivate subsequent crops. The sunflower residues have fortified the soil with the macronutrients thought to be necessary for the germination of any crop. It was shown that broad bean and flax harvests significantly suppressed wheat growth (Flayyih and Almarie, 2022).

The present study aimed to investigate the allelopathic effect of aqueous extract of *Z. mays* L. on germination and growth of two cultivars of wheat (Baraka, Abu-Graib) and corn (Mahali, Drachama). Further, some anatomical features of stems of two cultivars of corn and phenolic compounds of *Z. mays* L. were also identified using (HPLC) technique.

MATERIALS AND METHODS

An experiment was conducted to test the allelopathic activity of *Z. mays* leaves on the seeds germination and the growth of seedlings of two species of corn (Drachma, Mahali) and wheat (Baraka, Abu Ghraib) plants. The plants were harvested and brought to the Biology Department, Mosul University lab, to prepare residues and extracts. *Z. mays* and *T. aestivum* seeds were evenly scattered on the bottom of two layer s of filter paper in disposable Petri dishes with a 9 cm dia meter. The distilled water was used to wet the filter sheets. Each Petri dish's lid's center was bonded with the filter paper. The extracts were put into the filter paper pieces at various concentrations (0, 2, 4, 6%) / Petri dishes) (Iman *et al*., 2023). Each Petri dish's lid was then sealed with Para film; Petri dishes were incubated for one week at an average temperature of (22 ± 2(°C. Germination rates, radical lengths, and plumule lengths of the test plants were measured after the incubation period.

In the greenhouse experiment, extracts of *Z. mays* at (0,2,4) % w: w were prepared, and 10 seeds were placed in plastic pots, each measuring about 20 cm in diameter and 0.5 cm deeper from the earth's surface. Next, distilled water served as the control and was placed in a grow room with a temperature of (22 ± 2) ° C. After the seedlings had grown for 10 days, the germination % was assessed using an entirely random block design with three rates in each pot.

Studied characteristics

The following important characteristics of corn (Drachama , Mahali) and wheat (Baraka, Abu Ghraib) in laboratory experiment were screened for germination percentage (%), plumule length (cm), radical length (cm), plumule and radical dry weight(gm).

In the greenhouse experiment, germination (%), shoot length (cm), root length (cm), fresh weight of shoot (gm), and fresh weight of root (gm) were determined.

Leaf area

The leaf area was calculated according to the following equation:

Leaf area (cm2) = maximum leaf width × .0.75 (Salimpour *et al*., 2010)

Anatomical study

For the study of the effect of mays leaf extracts at 2 and 4% concentrations on anatomical features of corn cultivars, stems were cut at 1 cm from the base 15 days after planting for three replicates of each cultivar The stems were cut using sharp blades, stained with safranin which prepared by melting 1 gm of safranin in 99 ml of ethanol 70%, washed with distilled water to get rid of excess dye. Slides were screened using an optical microscope (Olympus) at (4 and 10 X.) The stems' dimensions were examined using an Ocular micrometer, which included stem diameter, vascular bundle length and width (Saeed and Ibraheem, 2008; Abbas *et al*., 2020).

Identification of phenolic compound of *Zea mays* L.

The quantification level of phenolic compounds was determined in mays using (HPLC) technique (Radovanović *et al*., 2015). The plants were dried at (40) ^{0}C to ensure no volatilization of phenolic compounds. HPLC analysis was performed using gradient elution with low pressure, gradient using methanol and water 80:20 as mobile phase with a 1 ml/min flow rate for tannic acid and gallic acid. The separation was done using the C18 column as stationary phase and the detection wavelength at 280 nm. For benzoic acid and salcylic acid, acetonitrile (CAN) and water 40:60 were used as mobile phases with a flow rate of 1ml /min, and the detection wavelength was 275 nm.

Analytical statistics

The research study was carried out using the Random Complete Design (R.C.D.) plan, and SAS was used to analyze the data statistically. At a 5% chance of differentiation between the average of transactions (Kannah and Shihab, 2017).

RESULTS

Allelopathic activity of *Zea mays* extract

The results in Table 1 indicate the effect of the aqueous extract of *Z. mays* leaves at concentrations of 2, 4 and 6% on the germination percentage of two cultivars of wheat, Abu Ghraib and Baraka. From the interaction between the two cultivars and the three concentrations of the aqueous extract, it was found that the highest decrease in the germination percentage was 66.6% in the Abu Ghraib cultivar at 6% conc. From the comparison of the mean concentrations, the effect increased with the increase in concentration, and there were significant differences between the three concentrations. From the overlap between the two cultivars and concentrations, the results in Table 1 indicated a significant increase in the length of plumule for the two cultivars at the three concentrations. The highest increase was recorded in the Abu Ghraib cultivar at 2% conc; when observing the average effect of the concentrations, the results showed that the effect increased with the increase in the concentration of the extract. Significant differences were observed between the average concentrations used.

The results in Table 1 indicated significant differences when comparing the mean effect of the two cultivars and the superiority of the Baraka cultivar over the Abu Ghraib cultivar. When comparing the overlap between the two cultivars and concentrations, it was found that there was a significant decrease in the root length. Significant differences, and the concentration exceeded 6% in the effect.

The effect of the aqueous extract of *Z. mays* on both cultivars' dry weights of plumule and root. From the interaction between cultivars and concentrations in Table 1, a significant increase was observed in the dry weights of the root, reaching the highest in the Baraka cultivar at 6% conc., while the effect of the three concentrations on the decrease in the dry weights of the root reached the highest in the Abu Ghraib cultivar at 6%.

In Table 2, the results indicated a significant decrease in the percentage of germination of seeds of Mahali and Drachama cultivars by the effect of the aqueous extract of corn 2, 4, and 6% conc. A significant difference was observed between the concentrations and the germination percentage decreased for both cultivars with increasing concentration.

The effect of the aqueous extract of *Z. mays* with the three concentrations on the stalk and root lengths of two corn cultivars is shown in Table 2. A significant difference between the control and the concentrations. By comparing the average of the two cultivars, it was noted that the Mahali cultivar was superior to the Baraka cultivar. The average effect of the concentrations indicates significant differences for both cultivars, and the concentration exceeds 2% in the impact.

Table 1. Effect of *Zea mays* on seed germination and growth of two wheat cultivars

Wheat cultivars	Treatments	Seed germination %	Plumule length (cm)	Radical length (cm)	Plumule dry weight (gm)	Radicle dry weight (gm)
Baraka	0	96.6a	5.9c	11.2a	0.0066c	0.0056a
	2%	96.7a	7.6a	11.6a	0.0091b	0.0058a
	4%	90b	7.3a	8.6b	0.0089ab	0.0041b
	6%	90b	6.2b	8.7b	0.0101a	0.0037c
Cultivar mean		93.3a	6.8a	10.02a	0.0086a	0.0048a
Abu – Ghraib	0	93.3a	6.0c	11.05a	0.0055c	0.0049a
	2%	93.3a	7.8a	10.17b	0.007a	0.0030b
	4%	83.3b	6.6b	9.06c	0.0077a	0.0032b
	6%	66.6c	5.9c	5.5d	0.0068b	0.0026c
Cultivar mean		84.1b	6.6a	8.9b	0.0068b	0.0034b
Mean of concentrations	0	95a	5.95c	11.1a	0.0061b	0,0051a
	2%	95a	7.70a	10.9a	0.0081a	0.0044b
	4%	86.7b	6.95b	8.9b	0.0083a	0.0037c
	6%	78.3c	6.05b	7.1c	0.0085a	0.0032d

*Similar letters indicate no significant differences at the 5% level, considering Duncan's Multiple Range Selection.

Table 2. Effect of *Zea mays* on seed germination and growth of two corn cultivars

Corn cultivars	Treatments	Seed germination %	Plumule length (cm)	Radical length (cm)	plumule dry weight (gm)	Radicle dry weight (gm)
Mahali	0	93.3a	2.23a	6.7a	0.0092a	0.0111a
	2%	86.7c	2.27a	6.9a	0.0081b	0.0098b
	4%	90b	1.5c	4.2b	0.0052d	0.0045d
	6%	80d	2.0b	4.5b	0.0077c	0.0060c
Cultivar mean		87.5a	2.0b	5.58b	0.0076b	0.0076b
Drachama	0	100a	4.3b	7.5c	0.0113a	0.0148a
	2%	65c	6.6a	9.5a	0.0068b	0.0031d
	4%	86.7b	4.6b	8.5b	0.0069b	0.0082b
	6%	60c	4.7b	6.5d	0.0065c	0.0058c
Cultivar mean		78.0b	5.1a	8.0a	0.0079a	0.080a
Mean of concentrations	0	96.6a	3.3b	7.1b	0.0103a	0.0130a
	2%	75.8c	4.4a	8.2a	0.0075b	0.0065b
	4%	88.5b	3.1b	6.4c	0.0061c	0.0064b
	6%	70.0d	3.0b	5.5d	0.0071b	0.0059c

*Similar letters indicate no significant differences at the 5% level, considering Duncan's Multiple Range Selection

Table 3. Effect of *Zea mays* on seed germination and growth of two wheat cultivars

Wheat cultivars	Treatments	Seed germination%	Shoot length(cm)	shoot dry weight(gm)	Root length (cm)	Root dry weight (gm)
Baraka	0	80.0c	16.0b	0.146b	30b	0.007c
	2%	85.0b	16.9a	0.159b	32a	0.009b
	4%	96.7a	17.2a	0.188a	43a	0.013a
Cultivar mean		87.2b	17.07b	0.164b	35a	0.0097b
Abo – Ghraib	0	96.a	19.2b	0.163c	23c	0.014c
	2%	90.0b	19.7b	0.166b	29b	0.020b
	4%	80.0c	20.8a	0.254a	44a	0.025a
Cultivar mean		88.7a	19.9a	0.193a	32b	0.0197a
Mean of concentrations	0	88.0a	17. 6c	0.155c	26.5c	0.011b
	2%	87.5b	18.3b	0.174b	30.5b	0.012b
	4%	88.4a	19.0a	0.221a	43.5a	0.019a

*Similar letters indicate no significant differences at the 5% level, considering Duncan's Multiple Range Selection

The results in Table 2 indicated a significant decrease in the dry weights of the plumule and root by the effect of the three concentrations of the aqueous extract. The highest decrease in the dry weight of the root was in the cultivar Drachama with the effect of 6% concentration, while the highest decrease in the dry weight of the root was in the Mahali cultivar with the effect of the same concentration. From the comparison of the average of the two cultivars, it was noted that the Mahali cultivar was superior to the Drachama cultivar. The comparison of the arithmetic average of the effect of concentrations showed that the significant decrease increased with the increase in concentration.

Z. mays extracts significantly increased wheat cultivars' germination percentage at (2, 4) % , as shown in (Table 3). In Baraka cultivar, the maximum decline in germination percentage was recorded 96.7%, whereas inhibition was recorded in Abu Ghraib cultivar, which showed maximum decrease in seed germination at 4% concentration.The average effect of the two cultivars indicates the sensitivity of the Abu Ghraib to the response to the effect of the water extract more than the cultivar Baraka, and the concentration of 2% is more significant in affecting the percentage of germination of the seeds of the two cultivars . The aqueous extract of *Z. mays* significantly reduced the shoot length and dry weight of

Table 4. Effect of *Zea mays* on seed germination and growth of two corn cultivars

Corn cultivars	Treatments	Seed germination%	Shoot length(cm)	Shoot dry weight(gm)	Root length (cm)	Rroot dry weight(gm)
Mahali	0	86.7a	25.0b	0.27c	71c	0.18
	2%	80.0b	26.4b	0.30b	83b	0.23a
	4%	80.0b	28.5a	0.35a	85a	0.25a
Cultivar mean		82.2b	26.6a	0.31b	79.7a	0.22b
Drachma	0	86.7b	18.7b	0.39b	47c	0.16c
	2%	80.0c	19.5b	0.40b	60b	0.28b
	4%	90.0a	22.1a	0.41a	64a	0.30a
Cultivar mean		85.6a	21.9b	0.40a	57b	0.25a
Mean of concentrations	0	86.7a	21.85c	0.33c	59c	0.17c
	2%	80.0c	22.95b	0.35b	71.5b	0.26b
	4%	85.0b	25.3a	0.38a	74.5a	0.28a

*Similar letters indicate that there are no significant differences at the 5% level, considering Duncan's Multiple Range Selection

Table 5. Phenolic compounds and retention time for standards and phenolic extracts identified by HPLC

Phenolic compounds	Rt of standards	Rt of phenolic extracts
Tannic acid	2.9	2.9
Gallic acid	3.8	-----
Benzoic acid	4.38	4.33
Salcylic acid	2.40	2.0

two wheat cultivars.

The average effect of the two cultivars indicated the sensitivity of the Abu Ghraib to the response to the effect of the water extract more than the cultivar Baraka.The overlap between the two cultivars and concentrations indicates significant differences in the shoot length and dry weight. By comparing the average effects of the concentrations, it is evident that the effect grew as the concentration increased. There were notable differences at 2, 4 % conc., and the concentration increased along with the length and dry weight of the roots, indicating the superiority of the Abu Ghraib cultivar. The impact of *Z. mays* aqueous extract on the two characteristics mentioned above.

The germination percentage of Mahali cultivars significantly decreased with the use of *Z. mays* extracts. The results showed that the maximum decline in germination percentage of Mahali cultivar was recorded at 80%. The extract of *Z. mays* enhanced the germination percentage of drachma at 4% conc. The mean of the two cultivars' effects on this trait shows the superiority of the Drachama cultivar over the Mahali cultivar of *Z. mays* The interaction between the two cultivars and concentrations shows an increase in shoot length and dry weight with increasing concentration compared to the average of the two cultivars. Drachama was superior in shoot length and cultivar, and significant differences between concentrations. The highest increase in shoot length and dry weight of the other shoot at 4% concentration. The interaction between the two cultivars and concentrations shows an increase in shoot length and dry weight with increasing concentration compared to the average of the two cultivars. Drachama was superior in root length and dry weights. The highest increase in shoot length and dry weight at 4% concentration. Mahali cultivar was superior in shoot and root dry weight, with significant differences between concentrations.

Identification and characterization of the quantitative level of phenolic compounds in maize extracts

Table 5 shows the values of Rt of phenolic compounds identified in maize extracts. The results showed the presence of several phenolic compounds known to have allelopathic potential. It seems clear from Table 6 that the highest concentration was of benzoic acid, reaching 2.97 ppm, while gallic acid was absent.

The results of separating a standard sample of benzoic acid from Fig. 4 prepared with a concentration of 100mg /ml. It was noted through the standard curve that the highest absorption peak had a retention time of 4.3 minutes and the area under the curve (84.830) was multi-voltage.

Fig. 5 represents the absorption peak curve of benzoic acid; when passing mays extract on the separating column, the presence of benzoic acid by comparing the

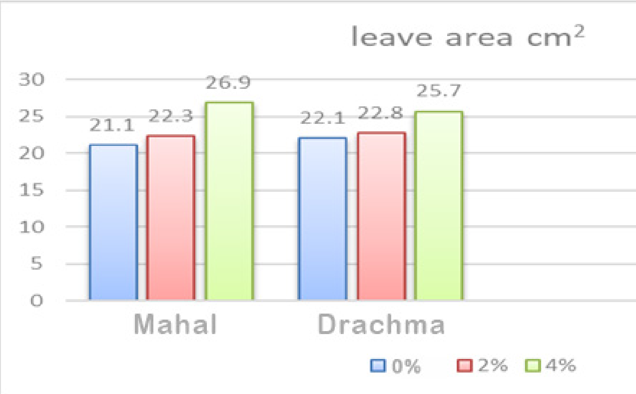


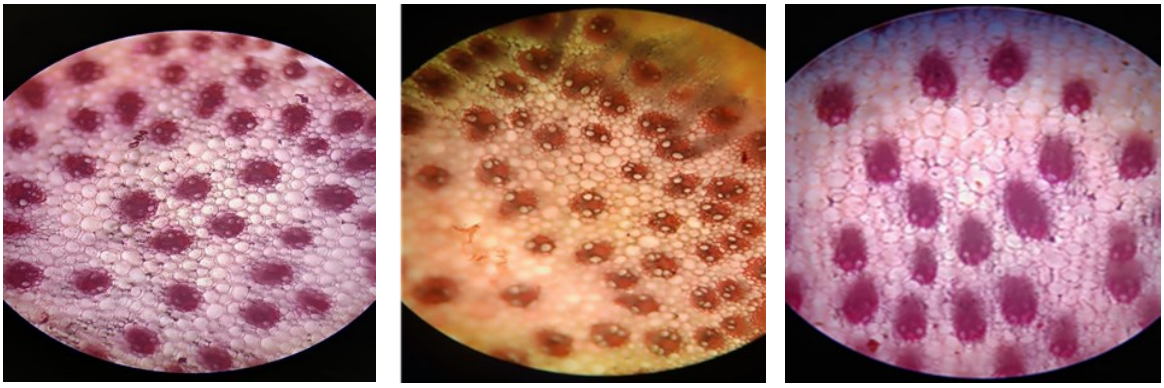
Fig. 1. *Effect of Zea mays on leaf area of two corn cultivars*

retention time of the standard compound (4.3) unit with an area under the curve (8.339) multi-voltage. The results of separation of the standard sample salicylic acid prepared at 100 mg/ml concentration, the highest absorption peak was 2.4 and area under the peak (98.95) multi-voltage (Fig. 6).

As for *Z. mays* extracts, the results of separation indicated the presence of salcylic acid with a retention time of 2.02 minutes and the area under the curve (0.268) multi-voltage (Fig. 7). As shown by the results of separation for a standard sample of gallic acid, the highest absorption peak was with a retention time of 3.8 minutes, while for mays extract, separation results showed the absence of gallic and showed other absorption peaks could not identified because standards were not available (Fig . 8,9). Figure 10 shows a curve of the absorption peak of tannic acid prepared at a concentration of 100 mg /ml .It was the highest absorption peak at retention time of 2.9 minutes of the area under the peak (62.406). Separation results for mays extract (Fig.11) revealed the presence of an absorbance peak with a retention time (2.9), which is identical to a standard tannic acid and the area under the curve (34.433).

Anatomical features:

As shown in Fig. 2 and 3, results of anatomical traits indicate that aqueous extracts of *Z. mays* caused an increase in the anatomical traits in the stem cross-section of two corn cultivars, represented by stem diameter, vascular bundle length and vascular bundle width. It was observed (Fig.2 A and B) that a 4% concentration caused an increase in stem diameter (0.705)



(a) **(b)** **(c)**

Fig. 2. A. *Effect of Zea mays extracts at (0,2,4)% in stem cross section of corn (Mahali). (a) Control showing stem diameter, vascular bundle length and width; (b) Effect of Zea mays 2% showing increase in stem diameter;(c) - Effect of Zea mays 4% showing higher increase in stem diameter and vascular bundle length*

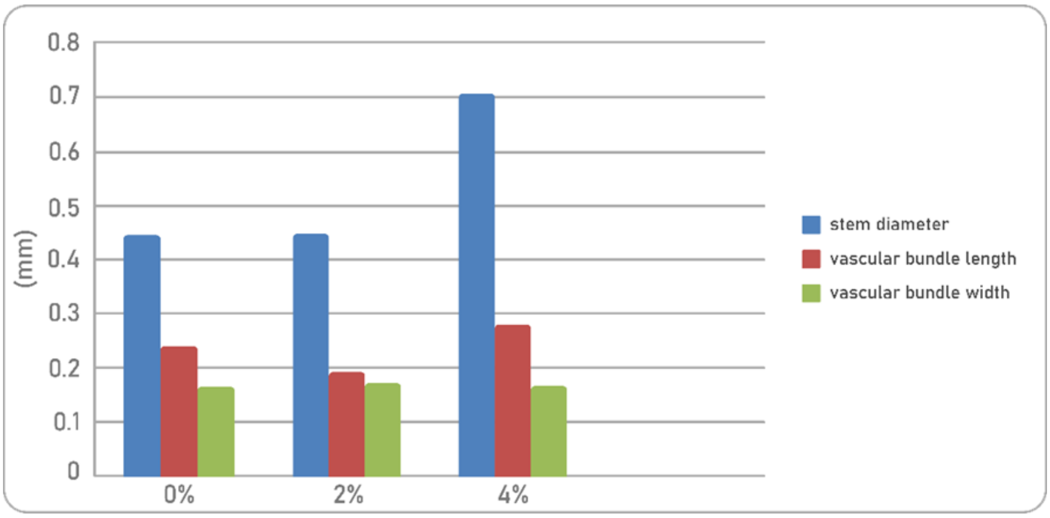
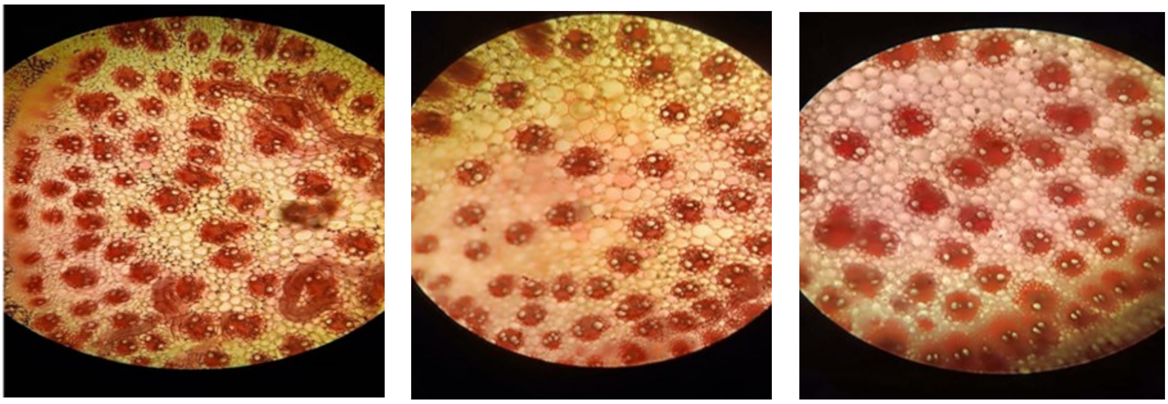


Fig. 2 B. *Effect of Zea mays extracts (0,2,4)% on stem anatomical feature on Mahali cultivar*



(a) **(b)** **(c)**

Fig. 3 A. Effect of *Zea mays* extracts at (0,2,4)% in stem cross section of corn (Drachma); *(a) Control showing stem diameter, vascular bundle length and width; (b)- Effect of Zea mays 2% showing increase in stem diameter;*

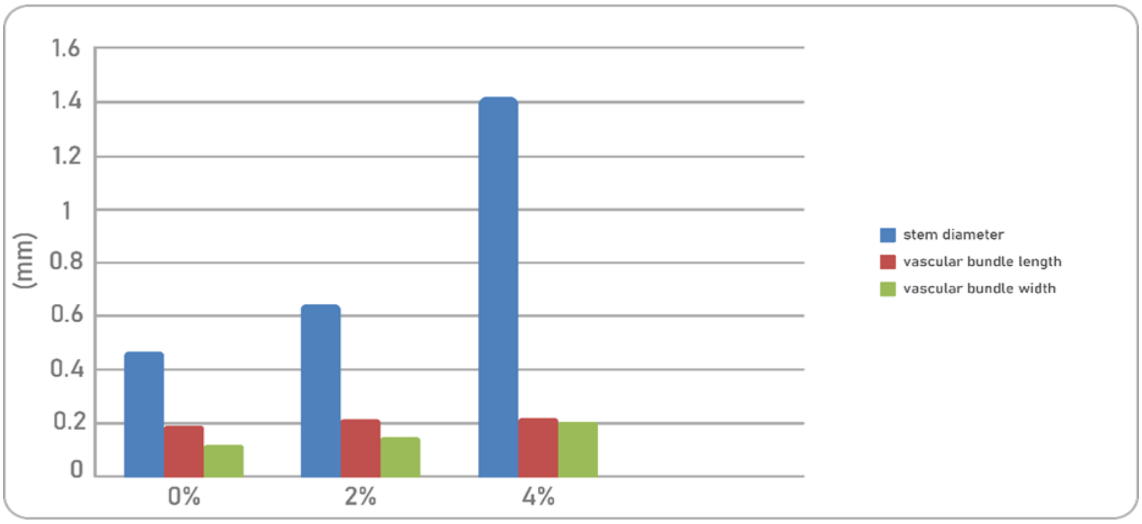
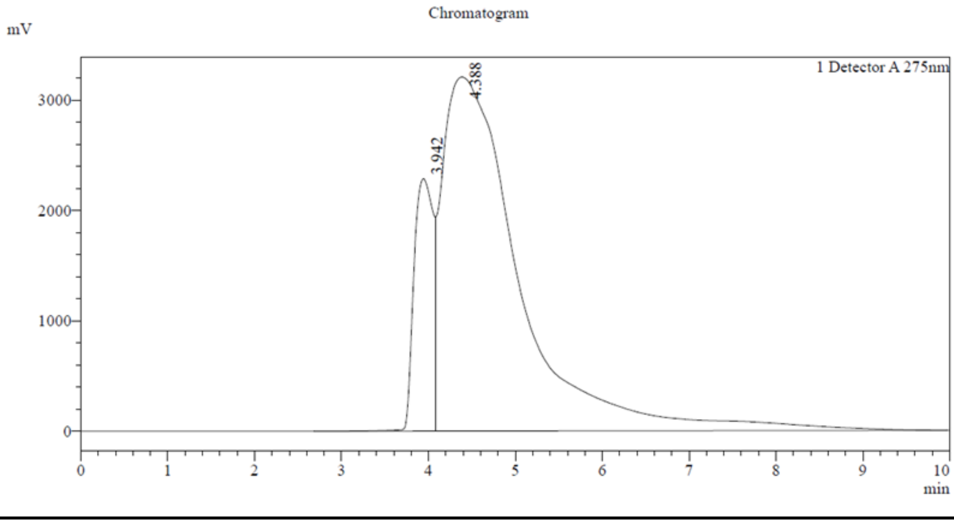


Fig. 3 B. *Effect of Zea mays extracts (0,2,4)% on stem anatomical feature on Drachma cultivar*



Peak#	Ret. Time	Area	Height	Area%
1	3.942	35676565	2287801	15.170
2	4.388	199498401	3207476	84.830
Total		235174966	5495277	100.000

Fig. 4. *Absorbance peaks of the standard sample benzoic acid*

Table 6. Concentration of phenolic compounds (ppm) of *Z. mays* extracts identified by (HPLC).

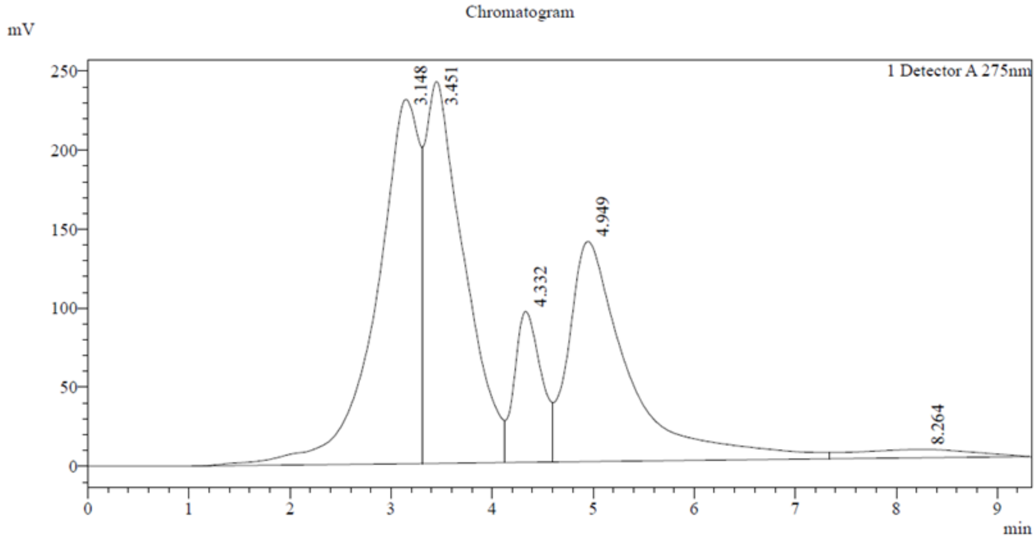
Phenolic compounds	Concentration (PPm)
Tannic acid	1.94
Gallic acid	---------
Benzoic acid	2.97
Salcylic acid	2.27

mm and an increase in vascular bundle length (0.278) mm in Mahali cultivar. For Drachma cultivar, it was found (Fig.3 A and B) that aqueous extracts caused a significant increase in stem diameter at 4% concentration, reaching (1.419)mm, with the highest vascular bundle length (0.238)mm observed under the influence of 2% concentration.

DISCUSSION

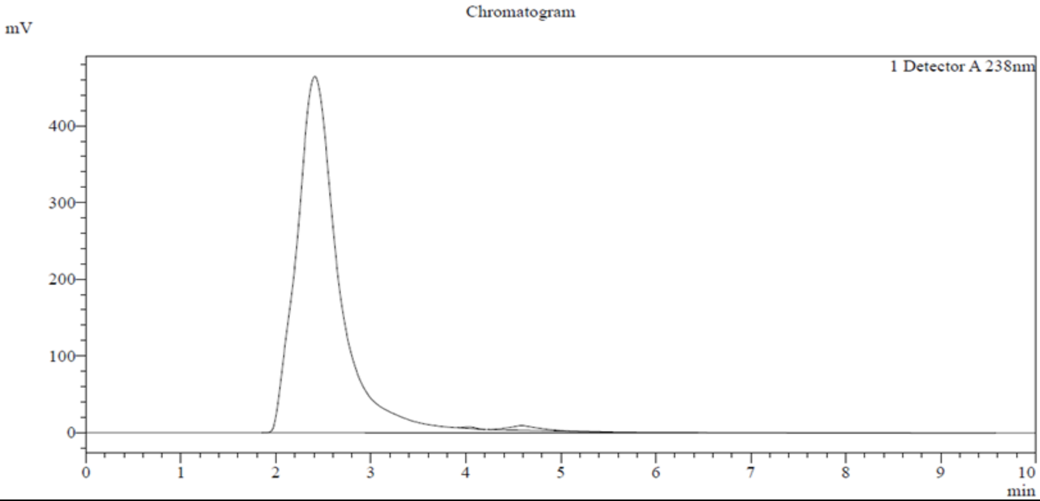
The current study's result indicated a decrease in the germination rate, radical and plumule growth, and dry matter of wheat and corn. By comparing the two species, results in laboratory experiments (Table 1 and 2) showed the highest value of decrease in germination percentage (60%) in Drachama at 6%, Shoot length (1.0) cm , radicle length (4.2) cm, fresh weight of plumule (0.0052) gm in Mahali at 4%, and fresh weight of radical (0.00026) gm in Abu-Graib at 6% of *Z. mays*. In the greenhouse, when comparing the two species (Table 3 and 4), showed the highest reduction (80)% in germination percentage in Abu-Graib , dry weight of root (23) gm in Abu-Graib at 2% may be linked to allelochemicals present in *Z. mays'* suppressive effects, which may have altered the target plants' seedlings' cell division, physiological processes, and absorption capacity. Possible allelochemicals in *Z. mays* may have changed the cell membrane permeability of wheat and maize seeds in this study, resulting in decreased accumulation of germination energy reserves and distortion of receptors essential for germination, which in turn resulted in reduced germination (Muhammad and Majeed, 2014).

These findings are consistent with data on sunflower allelopathy against wheat and maize (Anjum and Bajwa, 2010; Nikneshan *et al*., 2011). Allopathic potentials of sunflowers on weeds and other crops have been documented by researchers (Abdul Khaliq *et al*., 2013) and these findings are generally consistent with those findings. According to Aulya *et al*. (2018), numerous plant species have the potential to have allelopathic effects. The type and concentration of allelochemicals in various plant organs may be associated with the distinct allelopathic activity of various sunflower components (root, shoot, and leaf) on wheat and maize seedlings. Generally speaking, plant leaves are more phytotoxic than other portions because they contain more allelochemicals. It is reported that 2 weeks after germination, tomato leaves could be treated with a crude extract from *Moringa oleifera* leaves to boost growth



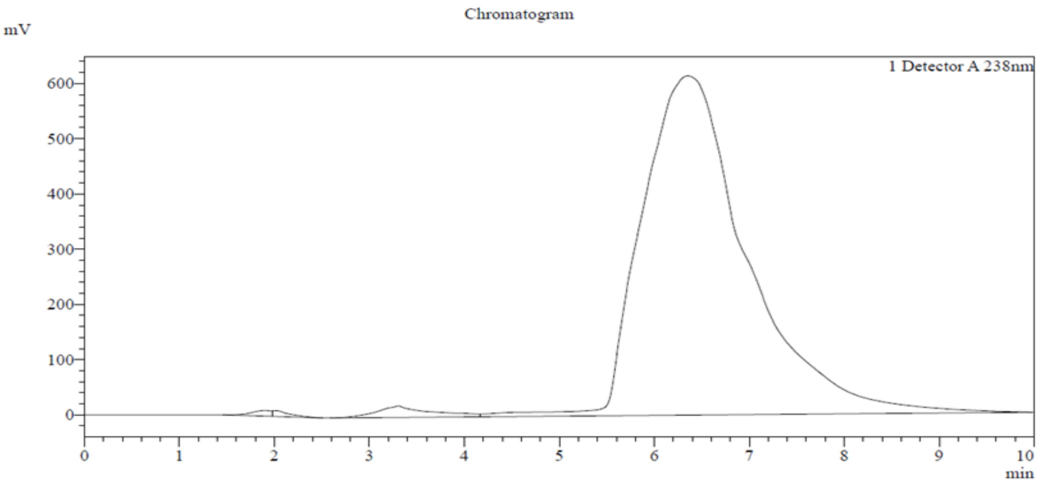
Peak#	Ret. Time	Area	Height	Area%
1	3.148	6863932	230576	32.099
2	3.451	6487942	241612	30.340
3	4.332	178320a3	95501	8.339
4	4.949	5810908	139336	27.174
5	8.264	437895	5218	2.048
Total		21383880	712242	100.000

Fig. 5. *Absorbance peaks of Benzoic acid in phenolic extract of Zea mays*



Peak#	Ret. Time	Area	Height	Area%
1	2.409	14654957	464565	98.959
2	4.028	17052	2065	0.115
3	4.586	137045	6093	0.925
Total		14809053	472723	100.000

Fig. 6. *Absorbance peaks of the standard sample salcylic acid*

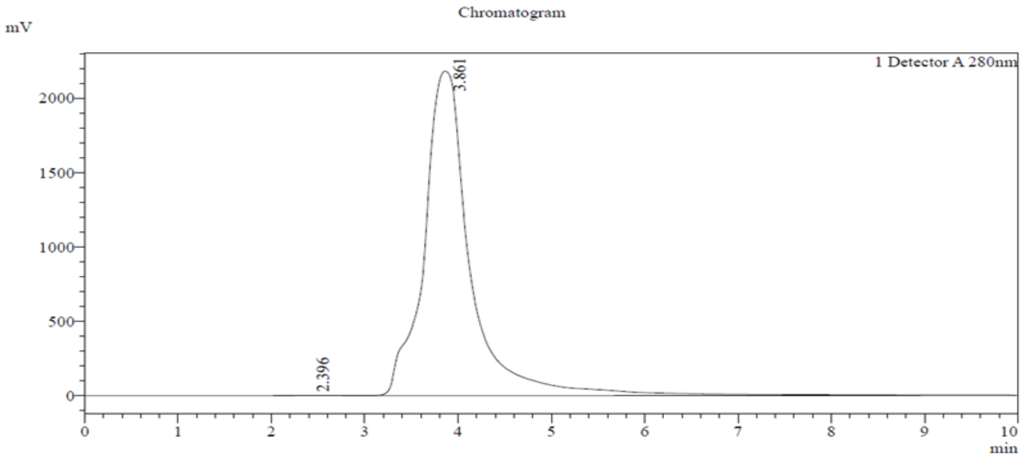


Peak#	Ret. Time	Area	Height	Area%
1	1.901	151849	10282	0.315
2	2.024	129167	10585	0.268
3	3.303	829940	20814	1.721
4	6.352	47111345	613951	97.696
Total		48222301	655633	100.000

Fig. 7. *Absorbance peaks of salicylic acid in phenolic extract of Zea mays*

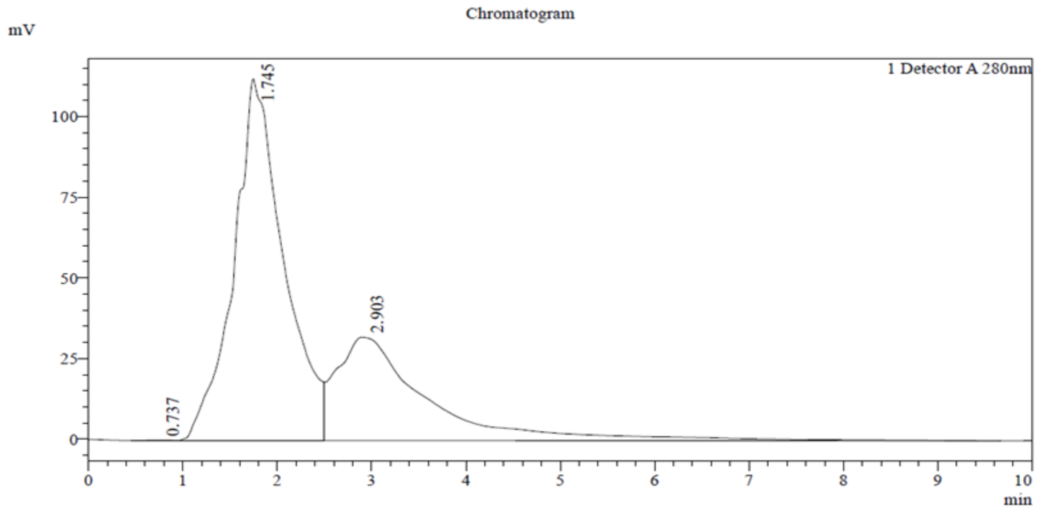
and yield, dry root weight, and tomato height (Ibrahim *et al*., 2013).

According to the results, Muhammad and Majeed (2014) reported that the effects of aqueous extracts on seed germination, growth, and dry biomass of wheat and maize seedlings were highly inhibitive. When compared to controls, wheat seedlings exposed to aqueous leaf extracts showed lower plumule and radical development. Leaf extracts reduced plumule and radical lengths, impaired maize germination percentage, and were more phytotoxic than fresh aqueous leaf extracts (FAE); for both of the examined plants, the inhibitory effects of aqueous extracts of various sunflower components were seen in the order of leaf, shoot and root. Ming *et al.* (2020) examined the allelopathic effects of aqueous extracts of *Castanea henryi* litter on *Brassica pekinensis* and *Z. mays* growth and physiological responses. Malonaldehyde levels considerably rose after treatment with leaf extract at high concentrations, and these effects generally became more pronounced with increasing extract concentrations. Low extract concentrations, however, really encouraged seed germination,



Peak#	Ret. Time	Area	Height	Conc.	Unit	Mark	Name
1	2.396	27379	1119	0.000			
2	3.861	75632376	2180937	0.000		V	
Total		75659755	2182056				

Fig. 8. *Absorbance peak of a standard sample of gallic acid.*



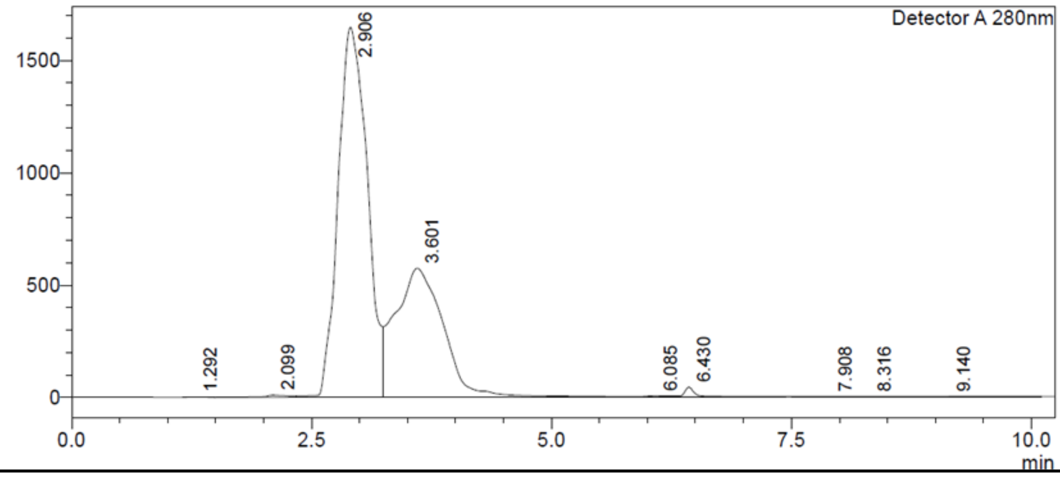
Peak#	Ret. Time	Area	Height	Area%
1	0.737	1160	62	0.018
2	1.745	4142716	112010	65.549
3	2.903	2176147	32008	34.433
Total		6320024	144079	100.000

Fig. 9. *Absorbance peaks of gallic acid in the phenolic extract of Zea mays*

shoot growth, and chlorophyll content in *Z. mays*.

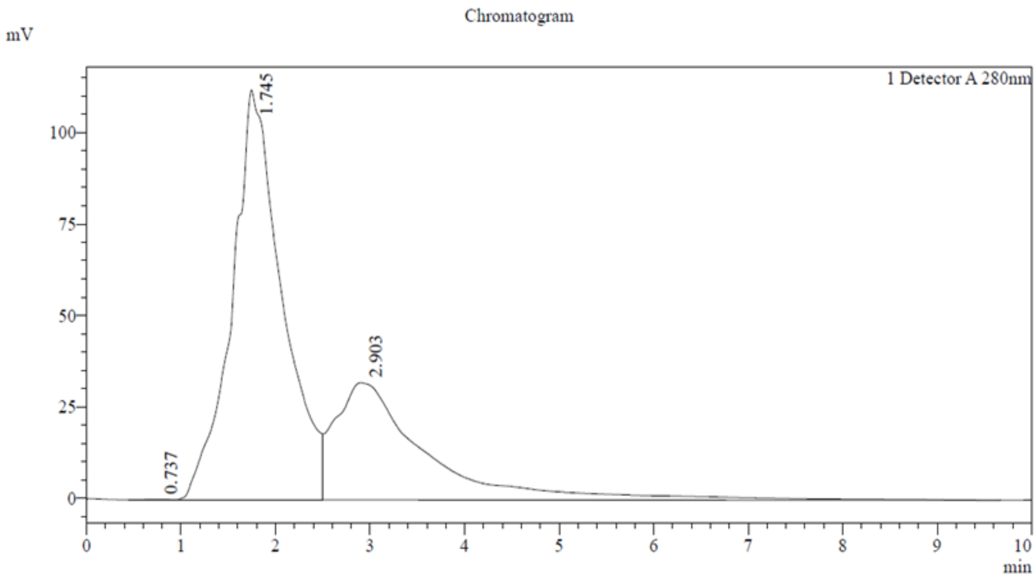
The proline level of GM maize leaf extracts was dramatically reduced, although wheat plants' protein and sugar content were unaffected (Ahmed, 2018). Flayyih and Almarie (2022) noticed saponins were only found in the shoot aqueous extract, while only terpenoids and alkaloids were found in the shoot ethanol extracts; using an ultraviolet-visible spectrometer, the total polyphenolic (TPC) content of maize root and shoot water extracts and corn shot ethanol extracts was also measured, results showed that the corn had TPC content.

On the other hand, low extract concentrations of *Z. mays* encouraged the germination and growth of *Z. mays* and *T.aestivum* cultivars in the present study. Laboratory experiments (Table 1 and 2) showed that *Z. mays* leaf extract stimulated some traits germination percentage (100)% in Drachaama at control, plumule length (7.8) cm in Abu-Graib, radicle length (11.6)cm in Baraka at 2%, fresh weight of plumule (0.0113) gm in Drachama at control, and fresh weight of radical (0.0148) gm in Drachama at control and highest reduction germination (60%) in Drachama at 6% , [plumule



Peak#	Ret. Time	Area	Height	Peak End	Area%
1	1.292	1221	193	1.475	0.002
2	2.099	174261	9740	2.342	0.315
3	2.906	34574409	1647392	3.242	62.406
4	3.601	20239899	574200	10.108	36.533
5	6.085	53332	3179	6.317	0.096
6	6.430	294863	41923	7.442	0.532
7	7.908	3434	227	8.000	0.006
8	8.316	46440	1026	9.050	0.084
9	9.140	14241	531	10.092	0.026
Total		55402100	2278411		100.000

Fig. 10. *Absorbance peaks of a standard sample of tannic acid*



Peak#	Ret. Time	Area	Height	Area%
1	0.737	1160	62	0.018
2	1.745	4142716	112010	65.549
3	2.903	2176147	32008	34.433
Total		6320024	144079	100.000

Fig. 11. *Absorbance peak of tannic acid in phenolic extract of Zea mays*

length (1.0) cm , radicle length (4.2) cm, fresh weight of plumule (0.0052)cm in Mahali at 4%], and fresh weight of radical (0.00026) gm in Abu-Graib at 6%. In greenhouse experiments, it was found that the anatomical traits of the two corn cultivars differed at concentrations of 2 and 4% compared to comparison, Aqueous extracts of *Z. mays* caused an increase in the anatomical traits in the stem cross-section of two corn cultivars, represented by (stem diameter, vascular bundle length, and vascular bundle width). It was observed (Fig. 2) that the 4% concentration caused an increase in the stem diameter (0.705)mm and an increase in the vascular bundle length (0.278mm) in *Mahali cultivar.* As for *Drachma*, it was found (Fig. 3 A, B) that the aqueous extracts caused a significant increase in the stem diameter at the 4% concentration, reaching (1.419)mm, the highest vascular bundle length was (0.238)mm under the influence of 2% concentration, These results disagreed with Al-Hafith (2020) study, which found that aqueous extracts of plant residues from crops such as *Cucurbita pepo*, *Cucumis sativus*, and *Cucumis melo* had an inhibitory effect on anatomical characteristics of stem in five varieties of soft wheat, including stem thickness, vascular bundle length, diameter of large xylem vessels, phloem width, and epidermal cell thickness. While agreed with Shah *et al.* (2023) that low leaf extract concentration of *Averrhoa carambola L.* increased growth and promoted anatomical structure of stem and root of three cultivars of wheat as stem cellular region thickness and epidermal thickness increased at low leaf extract concentration but decreased at high concentration.

The highest increase of germination (96.7)% in Baraka at 4%, shoot length (22.1 cm) in Drachama at 4%, fresh weight of root (0.254 gm) in Abu-Graib at 4% [root length (44 cm), fresh weight of root (0.052 gm) in Abu-Graib at 4%], These agree with the sunflower residues that fortified the soil with the macronutrients thought to be necessary for the germination of any crop. While it was shown that broad bean and flax harvests significantly suppressed wheat growth (Flayyih and Almarie, 2022). The results of the present study agree with the following decreases that occurred in the allelopathic effects of the various *C. henryi* extracts from leaves, twigs, and shells, which are in order. Rutin, quercetin, luteolin, procyanidin A2, kaempferol, allantoin, propionic acid, salicylic acid, and jasmonic acid were among the eleven probable allelochemicals (Ming *et al*., 2020). Present study findings indicate the presence of phenolic compounds (Tannic acid, Benzoic acid, Salcylic acid) in Table 5, but Gallic acid was not detected in corn extracts. This may be due to the genetic factors of the cultivar used in the study. Hussein *et al.* (2018) study revealed the presence of several phenolic compounds (vanillin, rutin, resorcinol, hydroquinone, caffiec acid) in corn residues. The present study revealed the presence of phenolic compounds in corn extracts, known for their allelopathic activities. These compounds of tannic acid, benzoic acid, salcylic acid were identified using the HPLC technique, and the variation in the quantity, quality, and concentration of the identified compounds can be due to genetic variation and environmental factors affecting the plant.

Conclusion

The allelopathic substances play a positive or negative role in the subsequent crops. The present results showed that *Z. mays* leaf extracts at different concentrations significantly inhibited and stimulated the germination and growth of corn and wheat cultivars. These effects varied among species (corn and wheat), cultivars (Mahali, Drachama , Baraka, Abu-Graib) and concentrations. Also, increased anatomical traits of the stem are represented by stem diameter, vascular bundle length and width. Drachma's largest stem diameter reached (1.419mm) at 4%. *Z. mays* extract included a variety of phytochemicals (Tannic acid, benzoic acid, salcylic acid) and the highest value of benzoic acid was 2.97 ppm. Most previous studies have focused on understanding the inhibitory effects of plants, whereas the present study highlights both inhibitory and stimulatory effects. Additionally, identifying specific plant compounds responsible for these effects and using certain concentrations provides an understanding of these processes. This knowledge can be utilized to develop sustainable agricultural practices, such as crop rotation, to increase crop productivity and reduce reliance on chemicals.

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Conflict of interest

The authors declare that they have no conflict of interest.

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