Araştırma Makalesi / Research Article

Effects of Fennel and Cumin Extracts on Flax Seed Germination Parameters and Mitotic Activity in the Root Tip Cells

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Abstract
This study was carried out to determine the effects of cumin and fennel seeds extracts, on the germination, seedling development and mitotic activity in root end meristem cells of flax seed. The experiment was established in laboratory according to randomized plot factorial experiment design with three replications in incubator having 23 ℃ temperature. At the end of 14 days of germination period some germination parameters were measured. According to the control, it was observed that fennel extract applications positively affected the germination and seedling development of flax seed except 100 g/l dose. While germination is seen at 100 g/l, seedling growth is completely prevented. It was observed that all cumin extract applications had a negative effect on the germination and seedling development of flax seed compared to the control. This negativity has shown more effect in increasing doses. While the germination rate is gradually decreasing in increasing doses, it is observed that the growth of seedlings is completely prevented except 12.5 and 25 g/l cumin extract. Increased doses at doses other than 100 g/l increased the mitotic index in fennel extract application and decreased the dose increase in cumin extract application. The percentage of chromosomal abnormality decreased in parallel with the increase in doses other than 100 g/l in fennel, but percentage of chromosomal abnormality increase with increasing doses in cumin extract. During mitotic examinations; mitotic abnormalities such as failure to collect the metaphase plate, bridge in anaphase and telophase were observed and their pictures were recorded.

Keywords: Cumin, Fennel, Germination, Mitotic activity, Plant extract.

Rezene ve Kimyon Ekstraktlarının Keten Tohumunun Çimlenme Parametreleri ve Kök Ucu Hücrelerinde Mitotik Aktivite Üzerine Etkisi

Öz
Bu çalışma kimyon ve rezene tohum ekstraktlarının keten tohumunun çimlenme, fide gelişimi ve kök ucu meristem hücreleri üzerindeki mitotik aktivitelerini belirlemek amacıyla yapılmıştır. Araştırma, laboratuvar koşullarında 23 °C'deki inkübatörde tesadüf parsellerinde faktöriyel deneme desenine göre üç tekerrürlü olarak yürütülmüştür. İki farklı öğütülmüş tohum türünden 4 farklı çözelti hazırlanmıştır. 14 günlük çimlenme süresinin sonunda, bazı çimlenme parametreleri ölçülmüştür. Kontrol uygulamasına göre, rezene ekstraktı uygulamalarının 100 g/l dozu hariç keten tohumunun çimlenmeyi teşvik ettiği ve fide gelişimini olumlu yönde etkilediği görülmüştür. 100 g/l dozunda çimlenme görülürken, fide büyümesi tamamen engellenmiştir. Tüm kimyon ekstraktı uygulamalarının, kontrol uygulamasına kıyasla keten tohumunun çimlenme ve fide gelişimi üzerinde olumsuz bir etkisi olduğu belirlenmiştir. Bu olumsuzluk artan dozlarda daha fazla etki göstermiştir. Çimlenme oranı artan dozlarda kademeli olarak düşerken, 12.5 ve 25 g/l kimyon ekstraktı uygulamaları haricinde fide büyümesinin tamamen önlendiği görülmüştür. 100 g/l dışındaki dozlar, rezene ekstraktı uygulamasında mitotik indeksi artırırken kimyon ekstraktı uygulamasında doz artışı mitotik indeksi azaltmıştır. Kromozomal anormallik yüzdesi, rezenelerde 100 g/l dışındaki dozlardaki artışa paralel olarak azalmış, ancak kimyon ekstraktında artan dozlarla kromozomal anormallik yüzdesi artmıştır. Mitotik incelemelerde; metafaz plağında toplanamama, anafazda ve telofazda köprü gibi mitotik anormallikler gözlenmiş ve resimleri kaydedilmiştir.

Anahtar kelimeler: Kimyon, Rezene, Çimlenme, Mitotik aktivite, Bitki ekstraktı.

1. Introduction

Some plants contain a number of substances that inhibit the metabolism of other plants. The presence of these substances has been known for centuries [1, 2]. The term, allelopathy, is an important evidence

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of the interaction between plant species or microorganisms. These interactions between species may be negative or positive [3]. Allelopathic substances may inhibit germination and growth of the same plant variety, as well as other plants. It may also prevent the development of alternation plants [4]. Research has shown that allelochemicals prevent or inhibit seed germination and plant growth [5]. According to Fateh et al. [4] the beneficial and harmful chemical interactions of plants and microorganisms were first described by Molisch [6] as allelopathy. Most of the allelochemicals that the plants have are secreted from leaves, stalks, roots, fruits and seeds. They affect the growth of other plants; especially phytotoxic dissociation caused a wide range of harmful effects on growth and development. Various secondary plant products are among allelopathic compounds. As the most common allelopathic substances; phenolic compounds including phenols, phenolic acids, cinnamic acid derivatives, coumarins, flavonoids, quinines and tannins are counted [4]. Plants such as roots, stems and leaves, or the chemicals that arise from the decomposition of these organs have allelopathic effects that often lead to production losses in varying proportions [7]. When previous studies on allelopathy are examined; Kim [8] reported that allelopathic substances secreted by the tomato plant prevent germination and seedling growth in lettuce, grown in the same location. In a study carried out by Uygur et al. [9] in Cukurova, it was revealed that Antep radish (*Raphanus sativus*) could be used successfully in the natural struggle with Johnson grass (*Sorghum halepense*) [10]. Hesabi [11], in order to determine the effects of yarrow herbal extract on germination of canola and yellow flax seeds, used the shoot and root portion of yarrow, prepared 5 different doses of solution and found that these extracts increased the percentage of germination, root and shoot length in increasing doses. A higher germination rate was obtained in yellow flax and canola seeds compared to the control (pure water) application. The aim of this study was to determine the allelopathic effect of extracts obtained from fennel and cumin seeds on seed germination and mitotic stages in stem tip meristem cells of flax.

2. Materials and Methods

The research was carried out in February 2017 at Kahramanmaras Sutcu Imam University, Faculty of Agriculture, Field Crops Department and Medicinal Plants Laboratory. The study was established according to the factorial arrangement in randomized complete block design with 3 replications. 50 grams of ground cumin and fennel seeds were collected and placed in 1000 ml volumetric flask. These samples were added to 500 ml of distilled water and extracted for 3 hours in the Neo-Clevenger apparatus. As a result of the extraction, 100 g/l dose was formed. This dose was diluted and other doses (12.5, 25 and 50 g/l) were obtained. All of the solutions were prepared using pure water. The base of each Petri dish (110 mm) is covered with two layers of Whatman filter paper. Then, 10 ml of the solutions were taken and the drying papers were wetted and 25 pieces of flax seed were planted. Seeds placed in Petri dishes were allowed to germinate for 14 days in an incubator with a temperature of 23 ± 1°C. The germination rate, radicle length, plumule length, seedling length, seedling fresh weight, seedling dry weight and vigor index values were measured. Seed germination was divided into total number of seeds and then multiplied by 100 and the germination rate was found. The radicle and plumule lengths were measured separately with the help of the ruler, and then both were collected and the seedling length was calculated. Radicle and plumula were weighed freshly and the fresh weight of the seedling was measured and then it was kept at 78 °C for 24 hours and the seedlings were weighed dry again. To find the vigor index, the seedling length was multiplied by the germination rate [3]. For the mitotic analysis, 10 germinated seeds with a root length of 2 mm were taken and fixed in glacial acetic acid-ethanol solution (1:3) in refrigerator for 24 hours. After fixation, they were stored in 70% alcohol. In order to examine the mitotic activities in root tip cells, the root tips were hydrolysed in 1 N HCl. In the dark one hour is stained with Feulgen. At the end of the dyeing process, at least five slides of these root tips were prepared and mitotic stages were examined and the phases of the cells counted under the microscope were taken [12]. The data in the study were subjected to variance analysis using SAS 9.4 statistical program (SAS, 2014). Averages compared to Least Significant Differences (LSD) test (Steel and Torrie, 1980).

3. Results and Discussion

3.1. Germination and seedling development results

3.1.1. Germination rate (%)

As a result of the application of fennel extracts as shown in Table 1, the highest germination rate in flax seeds was obtained as 93% in fennel extracts of 25 and 50 g/l, while the lowest germination rate was 87% in control application. In the application of cumin extracts, the highest germination rate was obtained in control application with 84%, while the lowest germination rate was 4% in 50 g/l of cumin extract. As seen in Table 1, the difference between the average germination rate of fennel and cumin extracts was statistically significant. The average germination rate of fennel extract was obtained as 91%. This value was found to be 29% in cumin application. Application of fennel extract promotes germination, while cumin extract applications have decelerated germination.

3.1.2. Radicle length (cm)

According to Table 1, the highest radicle length in flax seeds was obtained as 4.22 cm from 12.5 g/l fennel extract. In addition, the lowest radicle length was obtained as 2.91 cm from 25 g/l fennel application. In the application of 100 g/l fennel extract, the elongation is completely prevented. In the application of cumin extracts, the highest radicle length was found as 3.09 cm in the control application, followed by 12.5 g/l and 25 g/l applications as 0.76 cm and 0.02 cm respectively. In 50 g/l and 100 g/l cumin extract applications, radicle growth was completely stopped. As seen in Table 1, the difference between the radicle length averages obtained from fennel and cumin extracts was statistically significant. While the average of radicle length was 2.75 cm in fennel extract application, this value was found to be 0.77 cm in cumin application. Applications of cumin extract halted the development of radicle while fennel extract application promotes radicle development.

Table 1. Effects of cumin and fennel extracts on germination and seedling development of flax seed

		GR (%)	RL (cm)	PL (cm)	SL (cm)	SFW (g)	SDW (g)	VI
		**	**	**	**	**	**	**
Extracts	Fennel	91 a	2.75 a	7.65 a	10.41 a	0.629 a	0.041 a	953 a
	Cumin	29 b	0.77 b	2.42 b	3.19 b	0.178 b	0.010 b	249 b
	LSD	7.15	0.62	0.65	1.06	0.062	0.014	100.7
		**	**	**	**	**	*	**
Control	0	86 a	3.00 abc	9.38 ab	12.39 ab	0.701 ab	0.041 b	1057 ab
	100	88 a	no	no	no	no	no	no
Fennel (g/l)	50	93 a	3.72 ab	9.51 ab	13.24 ab	0.790 ab	0.042 b	1239 c
	25	93 a	2.91 abc	8.47 ab	11.38 ab	0.798 ab	0.044 b	1062 ab
	12.5	92 a	4.22 a	11.12 a	15.35 a	0.865 a	0.077 a	1414 a
	100	9 b	no	no	no	no	no	no
Cumin (g/l)	50	4 b	no	no	no	no	no	no
	25	7 b	0.02 c	0.03 c	0.05 c	0.006 c	0.001c	0.33 c
	12.5	43 ab	0.76 bc	2.49 bc	3.26 bc	0.178 bc	0.015c	177 bc
	LSD	55.93	2.96	7.648	10.57	0.6469	0.02437	1005
	CV (%)	15.54	45.86	16.84	20.25	20.07	66.93	21.85

**Significant at P<0.01; * Significant at P<0.05; no: no observation; GR: Germination Rate; RL: Radicle Length; PL: Plumula Length; SL: Seedling Length, SFW: Seedling Fresh Weight; SDW: Seedling Dry Weight; VI: Vigour Index

3.1.3. Plumule length (cm)

As shown in Table 1, the highest plumule length in flax seeds was obtained as 11.12 cm in 12.5 g/l fennel extracts, while the lowest plumula length was obtained as 8.47 cm in 25 g/l fennel extracts. In

the application of 100 g/l fennel extract, the elongation is completely prevented. In the application of cumin extracts, the highest plumule length was 9.58 cm in the control application, followed by 12.5 g/l and 25 g/l applications as 2.49 cm and 0.03 cm, respectively. Plumule growth was completely prevented in 50 g/l and 100 g/l cumin extract applications. As seen in Table 1, the difference between plumule length averages obtained from fennel and cumin extracts was statistically significant. While the average length of the plumule was obtained as 7.65 cm in fennel extract application, this value was 2.42 cm in cumin application. Applications of cumin extract halted the development of plumule while fennel extract application promotes the development of plumule.

3.1.4. Seedling length (cm)

As a result of the application of fennel extracts, the highest seedling length in flax seeds was obtained from 12.5 g/l fennel extracts as 15.35 cm, while the lowest seedling length was obtained as 11.38 cm in 25 g/l fennel application. In the application of 100 g/l fennel extract, the elongation is completely prevented. In the application of cumin extract, the highest seedling length was obtained with 12.67 cm in the control application, followed by 12.5 g/l and 25 g/l as 3.26 cm and 0.05 cm respectively. Plumule growth was completely prevented in 50 g/l and 100 g/l cumin extract applications. The difference between seedling length averages obtained from fennel and cumin extracts was statistically significant. The average length of the seedling was obtained as 10.41 cm in fennel extract, while this value was 3.19 cm in cumin application (Table 1). Applications of cumin extract prevented the growth of seedlings while fennel extract application promotes the growth of seedlings.

3.1.5. Seedling fresh weight (g)

According to Table 1, the highest seedling fresh weight in flax seeds was obtained from 12.5 g/l fennel extracts as 0.865 g, while the lowest seedling fresh weight was obtained as 0.692 g in the control application. In the application of cumin extracts, the highest seedling fresh weight was obtained in the control application as 0.71 g, while the lowest seedling fresh weight was obtained as 0.006 g in 25 g/l cumin extract. In 50 g/l and 100 g/l cumin extract applications, seedling development is completely prevented. As seen in Table 1, the difference between the average seedling fresh weight obtained from fennel and cumin extract applications was statistically significant. In the fennel extract application, the average seedling fresh weight was obtained as 0.629 g, in the cumin extract application this value was obtained as 0.178 g. Fennel extract application increased seedling fresh weight value while cumin extract applications lowered this value due to stagnation in seedling development.

3.1.6. Seedling dry weight (g)

The highest seedling dry weight in flax seeds was obtained as 0.077 g in 12.5 g/l fennel extracts application while the lowest seedling dry weight was obtained as 0.042 g in 50 g/l application. Seedling development was completely prevented in 100 g/l application (Table 1). In the application of cumin extracts, the highest seedling dry weight was obtained as 0.037 g in control application while the lowest seedling dry weight was obtained as 0.001g in 25 g/l cumin extract. In 50 g/l and 100 g/l cumin extract applications, seedling development is completely prevented. As seen in Table 1, the difference between seedling dry weight averages obtained from fennel and cumin extract applications was statistically significant. In the fennel extract application, seedling dry weight averages were obtained as 0.041 g, while in cumin application this value was found as 0.010 g. Fennel extract application increased seedling dry weight value while cumin extract applications decreased this value due to stagnation in seedling development.

3.1.7. Vigor index

As a result of the application of fennel, the highest vigor index in flax seeds was obtained in 12.5 g/l fennel extract application as 1414, while the lowest vigor index was obtained from control application as 1048. This value could not be calculated since seedling development was completely prevented in 100 g/l application. In the application of cumin extracts, the highest vigor index was obtained in the

control application as 1066 while the lowest vigor index was obtained from 12.5 g/l cumin extract application as 177. In 50 g/l and 100 g/l cumin extract applications, vigor index value could not be calculated since seedling development was prevented completely (Table 1). As seen in Table 1, the difference between vigor index means obtained from fennel and cumin extracts were statistically significant. While the average vigor index value of fennel extract was obtained as 953. This value was found to be 249 in cumin application. Fennel extract application increased mean vigor index value while cumin extract applications decreased this value due to germination and stagnation in seedling development.

According to Özbay [10], in order to determine the allelopathic effects of some weeds, medicinal and aromatic plants on germination and seedling growth of pepper (*Capsicum annuum* L.), the study was carried out with laboratory and greenhouse experiments. The water extracts were obtain from fennel (*Foeniculum vulgare*), hibiscus (*Malva sylvestris*), red clover (*Trifolium pratense* L), mustard (*Brassica nigra*), dill (*Anethum graveolens*), mother of pearl (*Ruta graveolens* L.), cumin (*Cuminum cyminum* L.) and liquorice (*Glycyrrhiza glabra* L.). According to this study, inhibition effect and rate varies depending on the plants tested and concentration and applications. Especially fennel (10%), hibiscus (10%), pearl grass (10%), liquorice (10%) and mustard (10%) on pepper seedlings other inhibitory effects was found to be more than the others applications. In a study conducted on five indigenous and five nonindigenous invasive plant species commonly grown in China. The different concentrations of extracts obtained from leaves and roots of *Chromolaena odorata* (control, 1%, 5% and 10%) were investigated for allelopathic effect of invasive plant species on seed germination. Extracts prepared from *C. odorata* leaves and roots limited seed germination, root and stem length development in identified species. This inhibitory effect is generally increased with an increase in extract concentration and has been reported to be more pronounced in leaf extract than in root extract [15]. According to Kadioglu and Yanar's [16] study on 22 different plant extracts on the germination of nine different wild plant seeds, it was found that all weed extracts, except *Lolium temulentum* L., stimulated seed germination of *Descurania sophia* at different levels. Germination of *Lolium perenne* L. was most strongly inhibited by the extracts of *Salvia officinalis* L., *Laurus nobilis* L. and *Artemisia vulgaris* L. According to Horoz [17], extracts obtained from leaf, stem and roots of flowering and pre-flowering periods of Andyba (*Inula viscosa* (L.) Aiton) and coke tree (*Ailanthus altissima* (Mill.) Swing); *Amaranthus albus* L., *Amaranthus hybridus* L., *Amaranthus retroflexus* L., *Avena sterilis* L., *Echinochloa cruss-galli* (L.) P. Beauv., *Echinochloa colonum* (L.) Link., *Hirchfeldia incana* (L.) Lagr. Foss., *Lolium multiflorum* (L.) Lam., *Portulaca oleracea* L., *Setaria verticillata* (L.) P. Beauv., *Sinapis arvensis* L. and some cultivated plants; allelopathic activity of *Capsicum annuum* L., *Lycopersicon esculentum* L., *Triticum* durum L., *Triticum aestivum* L. and *Zea mays* L. were investigated. According to the results, allelopathic activity of plant extracts increased in parallel with increasing doses (1%, 2%, 4%, 8% and 16%), weeds significantly prevent seed germination. As stated in Horoz [17], according to Sözeri and Ayhan [18], the root and leaf-water extract concentrations of *Taraxacum officinale* in 1/4, 1/8, 1/12, 1/16 ratios, *Festuca arundinacea* (fine lawn), *F. avina* (crystal), *F. rubra var. rubra* (franklin), *F. rubra var. commutata* (tamara), *F. rubra var. trichophylla*, *F. perene* (peramo) varieties have been investigated for allelopathic effects on germination and root development, *T. officinale*`s leaf-water extracts *F. rubra var. rubra* and *F. rubra var. trichophylla* has been reported to promote seed germination, but seedling deaths have been reported after emergence. Burgos and Talbert [19], rye (*Secale cereale*) in the water extract allelochemicals *Cucumis melo, Cucumis sativus* and *Cucurbita pepo* was found to have the ability to inhibit shoot development. Turk and Tawaha [20] found that *Brassica nigra* L. (black mustard) contains water-soluble substances that prevent the growth of seedlings and seed germination of *Avena fatua* L. (wild oats). They found that the aqueous extracts of shredded *B. nigra* affected germination, seedling length and weight of *Avena fatua* in parallel with the increase in concentration. *Melissa officinalis*'s ground plant parts of young plants of 30 days; *Amaranthus caudatus* L. inhibited germination and shoot growth of *Digitaria sanguinalis* (L.) Scop and *Lactuca sativa* L. seeds. [21]. Kordali et al. [22], *Achillea biebersteinii* and *A. gypsicola* in the study of the effects of essential oils and extracts, it was found that *A. gypsicola*, especially *Amaranthus retroflexus*, *Cirsium arvense* and *Lactuca serriola* completely had prevented germination and seedling development. According to Kitis et al. [23], water extracts of 25%, 50% and 100% of the common vetch were kept in water for 1, 3 and 7 days. The extracts were carried out on the seeds of *Avena sterilis, Amaranthus retroflexus, Chenopodium album, Corchorus olitorus, Echinochloa colonum, Lepidium sativum, Portulaca oleracea, Setaria verticillata,*

Sinapis arvensis. At the end of the study, it was determined that allelopathic potential of common vetch on seed germination was influential in suppressing weeds.

3.2. Mitotic activity results

As seen in Table 2, average 3000 cells were counted in the preparations for observing mitotic activity in the root tip cells of flax seeds. The most obvious indication of the negative effects of the germinated flax seeds on the root tip meristems is the changes in the mitotic index.

As shown in Table 2, mitotic index and chromosomal abnormalities percentage varies in different doses of fennel and cumin extract. The lowest mitotic index was found in 100 g/l application and the highest mitotic index was in the control group. The highest chromosomal abnormality was observed at a dose of 12.5 g/l and the lowest at 50 g/l at the concentrations obtained from cumin extracts. Since germination stopped at 50 g/l and 100 g/l cumin applications, the root could not be obtained from mitotic examination. In the fennel control group, division was observed in 142 of 3000 cells counted at the root tip. In relation to abnormalities in this concentration and their distribution to phases; in 5 cells, the metaphase plate could not be collected, and bridge in anaphase in 4 cells was observed (Table 2, Fig. 1-3). In the 12.5 g/l fennel application, the division in 83 of the 3000 cells counted at the root tip was observed. The abnormalities in this concentration and their distribution to phases; bridge in anaphase was observed in 7 cells (Table 2, Fig. 3). In the 25 g/l fennel application, the division in 111 of the 3000 cells counted at the root tips were observed. The abnormalities in this concentration and their distribution to phases; bridge in anaphase in 2 cells and bridge in telophase in 3 cells were observed (Table 2, Fig. 3, 4). In the 50 g/l fennel application, the division in 113 of 3000 cells counted at the root tips were observed. The abnormalities in this concentration and their distribution to phases; bridge in anaphase was observed in 2 cells (Table 2, Fig. 3). In the 100 g/l fennel application, the division in 79 of 3000 cells counted at the root tips were observed. The abnormalities in this concentration and their distribution to phases; in 1 cell the metaphase plate could not be collected and bridge in anaphase in 4 cells was observed (Table 2, Fig.2, 3). In the cumin control application, the division in 108 of 3000 cells counted at the root tips were observed. The abnormalities in this concentration and their distribution to phases; bridge in anaphase in 7 cells was observed (Table 2, Fig. 3). In the 12.5 g/l cumin application, the division in 107 of 3000 cells counted at the root tips was observed. The abnormalities in this concentration and their distribution to phases; the bridge in anaphase in 5 cells was observed (Table 2, Fig. 3). In the 25 g/l fennel application, the division in 90 of 3000 cells counted at the root tips were observed. The abnormalities in this concentration and their distribution to phases; in 4 cells the metaphase plate could not be collected and bridge in anaphase in 7 cells was observed (Table 2, Fig. 2, 3). Since 50 g/l and 100 g/l cumin doses completely stopped germination, the root tip could not be obtained from mitotic examinations.

Table 2. Effects of cumin and fennel extracts on mitosis in flax seed root tip cells

		Doses (g/l)				
		Control	12.5	25	50	100
Fennel	Number of average counted cells	3000	3000	3000	3000	3000
	Mitotic index (%)	4.73	2.76	3.70	3.73	2.63
	Chromosome abnormalities (%)	6.76	9.21	4.71	1.80	6.75
	Normal split cell number	133	76	106	111	74
	Inability to collect in metaphase	5	-	-	-	1
	Bridge in anaphase	4	7	2	2	4
	Bridge in telophase	-	-	3	-	-
Cumin	Number of average counted cells	3000	3000	3000	3000	3000
	Mitotic index (%)	3.6	3.56	3.00	-	-
	Chromosome abnormalities (%)	6.93	4.67	13.92	-	-
	Normal split cell number	101	102	79	-	-
	Inability to collect in metaphase	-	-	4	-	-
	Bridge in anaphase	7	5	7	-	-

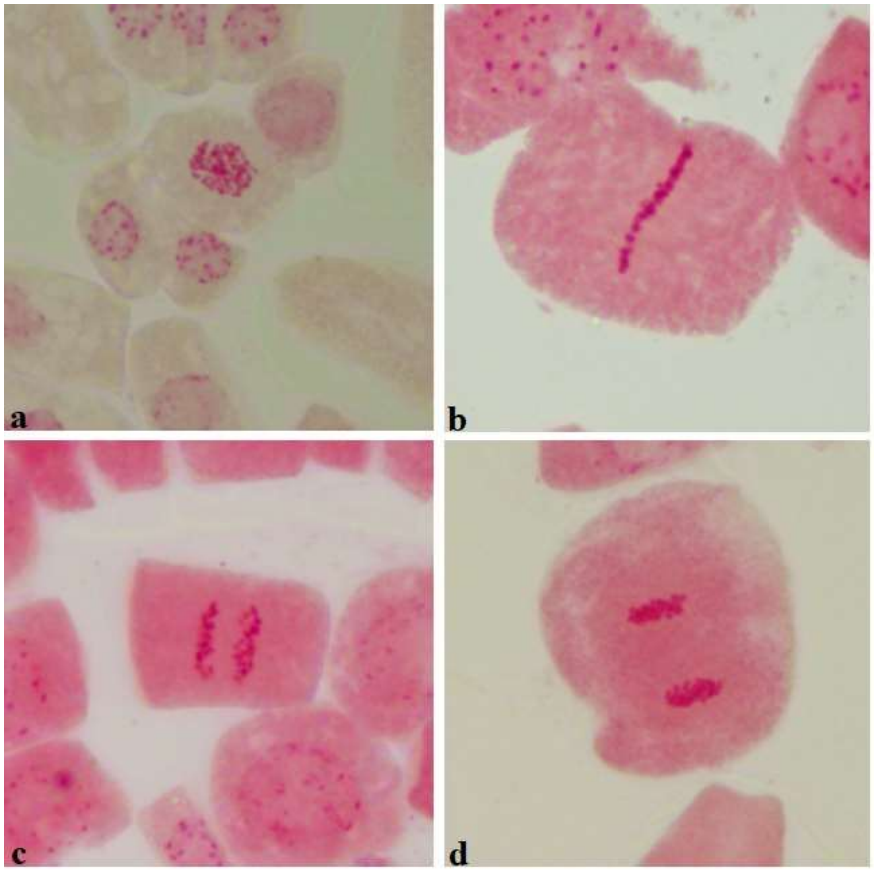

Figure 1. Normal and abnormal mitotic phase images of flax species:
a- Prophase, b- Metaphase, c- Anaphase, d- Telophase

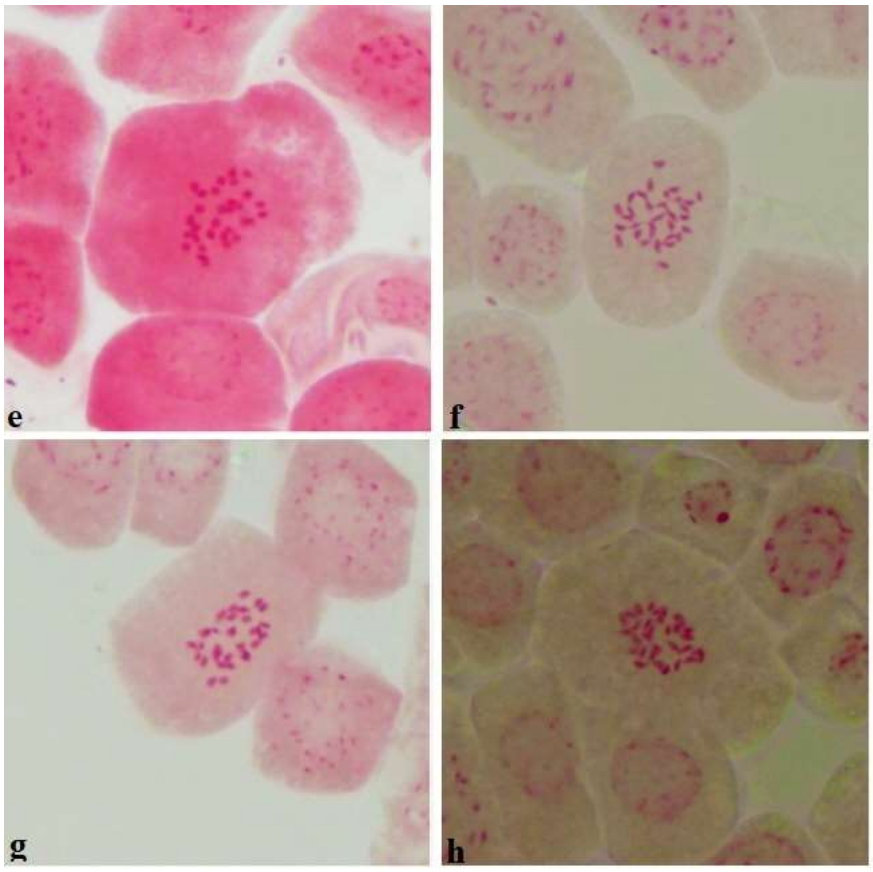

Figure 2. e-f-g-h: Do not gather on metaphase plate in different cells

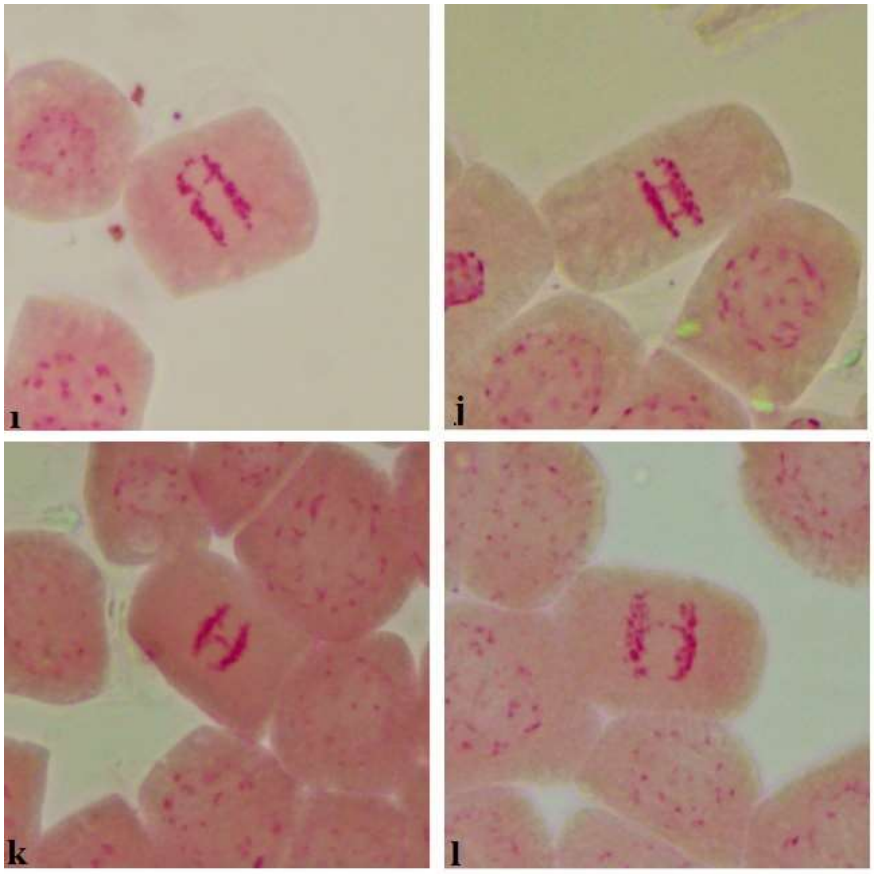

Figure 3. ı-j-k-l: Chromosome bridge in anaphase in different cells

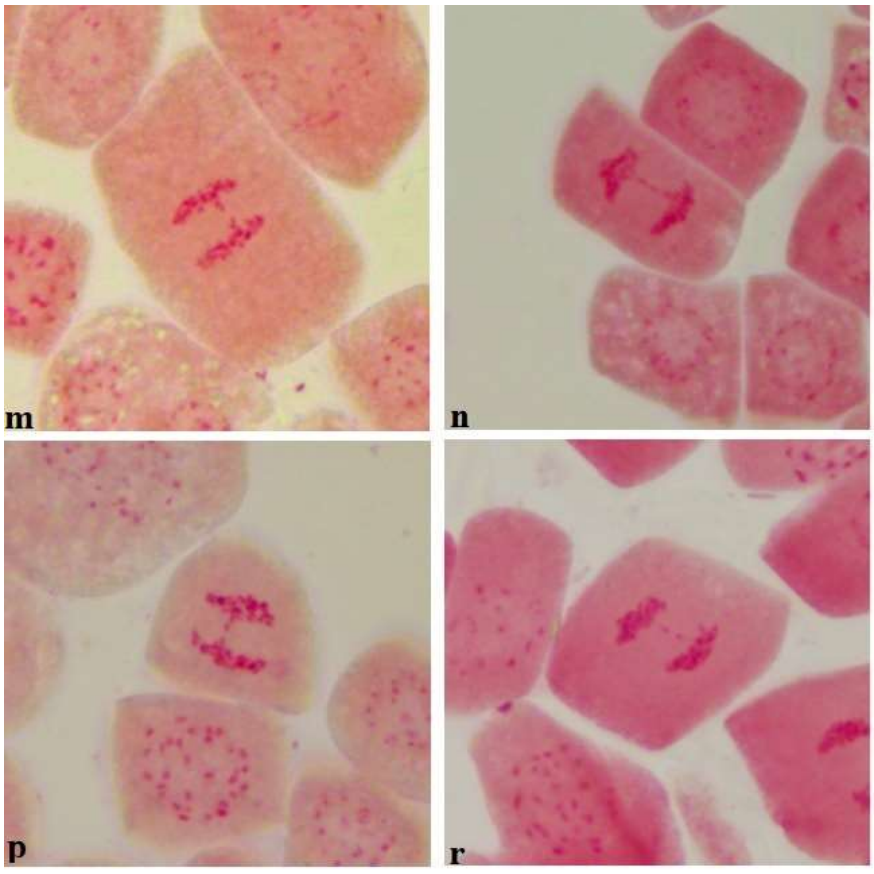

Figure 4. m-n-p-r: Chromosome bridge in telophase in different cells

4. Conclusion

In the light of all information, in this study, fennel extract appears to promote flax germination. It is thought that this effect can be used to break dormancy in different seeds, thanks to more detailed studies. It was seen that fennel extract increased mitotic index of flax seeds, while cumin extract decreased. In addition, it is considered that cumin extract can be used in some seeds to prevent germination. Further research is needed to investigate its effects against various species.

Author's Contributions

In this study, both authors contributed equally.

Statement of Conflicts of Interest

No potential conflict of interest was reported by the authors.

Statement of Research and Publication Ethics

The authors declare that this study complies with Research and Publication Ethics

References

[1] Putnam A.R. 1994. Phytotoxicity of plant residues. In Managing Agricultural Residues P.W. Unger., Lewis Publishers, Boca Raton, Florida, 285-314.
[2] Zeng R.S. 2014. Allelopathy-the solution is indirect. Journal of Chemical Ecology, 40: 515-516.
[3] Uslu O.S., Gedik O., Kaya A.R., Erol A., Khan M.A., Taşsever M., Türkkaya E. 2018. Allelopathic effects of flower extract of oleander (*Nerium oleander*) on the germination of seed and seedling growth of *Lolium multiflorum.* Journal of the Institute of Science and Technology, 8 (1): 309-317.
[4] Fateh E., Sohrabi S.S., Gerami F. 2012. Evaluation the allelopathic effect of bindweed (*Convolvulus arvensis* L.) on germination and seedling growth of millet and basil. Advances in Environmental Biology, 6 (3): 940-950.
[5] Zeng R.S., Mallik A.U., Luo S.M. 2008. Allelopathy in sustainable agriculture and forestry. New York, Springer Press,1-412.
[6] Molisch H. 1937. Der einfluss einer pflanze auf die andere allelopathie. Jena, Germany: Gustav Fischer.
[7] Gürsoy M., Balkan A., Ulukan H. 2013. Allelopathy in plant production. Journal of Agricultural Faculty of Uludag University, 27 (2): 115-122.
[8] Kim Y.S. 2001. Allelopathic effects of some volatile substances from the tomato plant. Journal of Crop Production, 4 (2): 313-321.
[9] Uygur F.N., Köseli F., Cesurer L. 1991. Investigation of the use of *Raphanus sativus* L. as a bio herbicide in cotton fields. VI. Phytopathology Congress Turkey, 7-11 October Izmir. Turkey Phytopathological Society Press, 6: 167-171.
[10] Ozbay N. 2018. Allelopathic effects of some herbs and medicinal plants extracts on seed germination and seedling growth of pepper. Turkish Journal of Agricultural and Natural Sciences, 5 (1): 81-85.
[11] Hesabi S., Vazan S., Golzardi F. 2014. The effect of yellow yarrow (*Achillea santolina*) aqueous extracts as a factor in seed priming of canola and flax. International Journal of Biosciences, 5 (5): 195-202.
[12] Elci S., Sancak C. 2013. Sitogenetikte Araştırma Yöntemleri ve Gözlemler. Ankara Üniversitesi Yayınları, No: 386, 223s (In Turkish).
[13] SAS, 2014. SAS Institute. SAS 9.4 user's guide. SAS Inst., Cary, NC.
[14] Steel R.G.D, Torrie J.H. 1980. Principles and procedures of statistics. A Biometrical Approach. 2nd edition. McGraw Hill Book Co. Inc. New York, USA.

[15] Hu G., Zhang Z. 2013. Allelopathic effects of *Chromolaena odorata* on native and non-native invasive herbs. Journal of Food, Agriculture & Environment, 11 (1): 878-882.
[16] Kadıoglu I., Yanar Y. 2004. Allelopathic effects of plant extracts against seed germination of some weeds. Asian Journal of Plant Sciences, 3 (4): 472-475.
[17] Horoz H. 2019. Determination of allelopatic effects of false yellowhead (*Inula viscosa* L.) and tree of heaven (*Ailanthus altissima* (Miller) Swingle) a germination of some weed seeds. Master's Thesis, Universty of Hatay Mustafa Kemal, Institute of Science, Hatay.
[18] Sözeri S., Ayhan A. 1997. *Taraxacum officinale* Weber's root and leaf water extracts allelopathic effects on some grass types. Turkey II. Herbology Congress (1-4 September 1997, Izmir & Ayvalık), p: 313-328.
[19] Burgos N.R., Talbert R.E. 2000. Differential activity of allelochemicals from *Secale cereale* in seedling bioassays. Weed Science, 48: 302-310.
[20] Turk M.A., Tawaha A.M. 2002. Allelopathic effect of black mustard (*Brassica nigra* L.) on germination and growth of wild oat (*Avena fatua* L.). Crop Protection, 222: 673-677.
[21] Kato-Noguchi H. 2003. Assesment of allelopathic potential of shoot powder of lemon balm. Scientia Horticulture, 97: 419-423.
[22] Kordali S., Cakir A., Ozer H., Cakmakcı R., Kesdek M., Mete E. 2008. Antifungal, phytotoxic and insecticidal properties of essential oil isolated from Turkish *Origanum acuditens* and three components, carvacrol, thymol and p-cymene. Bioresource Technology, 99: 8788-8795.
[23] Kitis Y.E., Kolören O., Uygur F.N. 2016. Allelopathic effects of common vetch (*Vicia sativa* L.) on germination and development of some weed species. Journal of Central Research Institute for Field Crops, 25 (1): 100-106.