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RESPONSE OF CUMIN (*CUMINUM CYMINUM* L.) TO PLANTING TIMES AND FOLIAR APPLICATION OF LICORICE EXTRACT

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SUMMARY

The field study was commenced during the winter of 2020–2021 to study the effects of planting times and licorice extract foliar application on the growth, yield, and quality traits of cumin (*Cuminum cyminum* L.), conducted at the city of Karma, Anbar Governorate, Iraq. The experiment layout had randomized complete block design (RCBD) with a split-plot arrangement, with two factors. The planting dates November 1 and 20 and December 10, 2020 were the first consideration; the second was the licorice extract with three concentrations 0, 20, and 40 g L^{-1}. The results revealed early planting (first of November) of cumin led to a significant increase in all the studied traits compared with the medium- and late-planting dates. Licorice extract concentration (40 g L^{-1}) effectively improved growth and production characters and enhanced the oil and protein content in cumin fruits (2.62% and 18.52%, respectively). In the interaction of early planting date (November 1) and licorice extract (40 g L^{-1}), the highest yield (1.95 g $plant^{-1}$) appeared compared with the late planting with the control treatment, which revealed the lowest yield (0.98 g $plant^{-1}$). The results concluded increasing cumin fruit yield with improved proportions of oil and protein can result from the early planting and foliar application of licorice extract (40 g L^{-1}).

Keywords: Cumin (*C. cyminum* L.), planting times, licorice extract concentrations, photoperiods, fruits' oil and protein content

Key findings: Results revealed by adopting early planting with licorice concentration (40 g L^{-1}), the cumin (*C. cyminum* L.) growth and yield traits and fruits' oil and protein content can be considerably improved.

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INTRODUCTION

In the present era, the medicinal plants occupy an important position in agriculture as the main source of plant drugs and effective substances included in preparing medicines as extracts. They also served as raw materials in the production of some chemical compounds as primary ingredients to develop essential drugs. In addition to their uses in medicines, cosmetics and food industries also play an influential economic role in some countries (Naser and Mheidi, 2021, Hashim and Mheidi, 2023).

Cumin (*C. cyminum* L) is one of the vital medicinal plants belonging to the family Apiaceae. Naturally, it has an imperative role in treating various pathological conditions because its fruits contain very effective substances. Traditionally, it is beneficial in treating digestive disorders, such as, diarrhea, a good analgesic for colic, a gas repellant, an appetizer, and as organs' stimulator. It helps in the reproduction and in producing milk during breastfeeding, and its oil contains antibacterial and antifungal substances. Additionally, it also serves in foods as spices and flavorings and various other uses in cosmetics and perfume industries (Dave et al., 2021).

The planting time is one of the determining factors for the success or failure of the crop. Likewise, the identification of appropriate planting time can result from the length of the lighting period, the intensity of radiation, temperatures, and other environmental factors prevailing in the area (Shenawa and Alfalahi, 2023). Therefore, it is necessary to develop a scientific base to determine the appropriate time of planting in each region based on the prevailing climatic conditions in that region. Moreover, the factors of the geographical and environmental locations vary from other environmental sites (Moosavi et al., 2014, Hashem and Al-Issawi, 2023).

Past studies detailed sweet beans' planting can have three different times (early, medium, and late) for two seasons, with the first and second planting times provided the highest plant height compared with the late planting in both seasons (Selim et al., 2013). Sequentially, their findings also showed early planting had an apparent and positive impact on enhancing the number of branches compared with medium and late plantings. Wafaa et al. (2017) also confirmed the early planting of sweet beans provided the highest fruit yield in both seasons (540.54 and 570.20 kg ha^{-1}, respectively).

In order to decrease the usage of pesticides with negative residual effects on crop plants and surrounding ecosystems, the researchers tended to adopt modern methods. Among these several techniques, foliar application of plant extracts can also improve the plant's nutritional value (Al-Falahi et al*.,* 2023). Among these extracts is the licorice (*Glycyrrhiza glabra* L.) roots extract, which is part of the legume family Fabaceae with several nutritional value. Glycyrrhizin, which has the same action as the growth regulator and accelerates the rate of protein synthesis in the plant and enhances development characteristics, is the most important ingredient in licorices. Moreover, licorice extract improved vegetative and blooming development since it has vitamins, minerals, and carbohydrates (AlKaisy et al*.,* 2014).

Past studies indicated licorice extract foliar application at the level of 5 mg L^{-1} emerged with the highest rate of total weight and 100-seed weight in broad beans compared with the control treatment (Hamza and Abbas, 2020). Early studies revealed the use of licorice extract concentration of 10 g L^{-1} gave the topmost plant height and other growth traits in broad bean (Abotlasha et al., 2021; Almehemdi et al., 2021). In another study conducted on the fenugreek plant, it was evident that the addition of licorice extract (30 g L^{-1}) increased the plant height, the number of branches, and 1000-seed weight (Ahmed and Mheidi, 2023). Based on the above mentioned arguments, this research aimed to determine the effects of licorice extract foliar application and planting timings on the growth, yield, and quality characteristics of cumin (*C. cyminum* L.).

MATERIALS AND METHODS

The experiment was conducted during winter season of 2020–2021 to study the effects of planting times and licorice (Glycyrrhiza glabra L.) extract foliar application on the growth, yield, and quality traits of cumin (C. cyminum L.), conducted at the city of Karma, Anbar Governorate, Iraq. For foliar application, dissolving the licorice root powder prepared the required concentrations (20 and 40 g L^{-1}) by weighing the required quantity separately in a liter of distilled water for 24 hours. The process ensured that the extract was prepared for spraying through dissolving the largest quantity of powder into the water and filtering it with a cotton cloth. The cumin plants were sprayed with each concentrate in two batches, in along with the standard treatment (spray with distilled water only). The first, at the branching stage, while the second dose application was at the beginning of flowering.

The experiment layout consisted of a split-plot arrangement with a randomized complete block design (RCBD) and two factors. The main plots were inhabited by the planting dates of November 1 and 20 and December 10, 2020. Meanwhile, the second factor was the licorice extract with three concentrations (0, 20, and 40 g L^{-1}), which comprised the subplots. Cumin (C. cyminum L.) seeds proceeded planting in 2 cm deep holes, with a distance of 20 cm between the holes. The irrigation and hoeing practices ensued whenever needed. Plants' harvesting at maturity occurred when the fruits turned olive and before reaching the stage of complete dryness.

Data collection

The data recording for all the parameters continued on 10 randomly selected plants of cumin (*C. cyminum* L.), and then averaged. A tape measure was used to measure the plant's height in centimeters. Estimating the number of main branches on the main stem and the dry weight of the shoots (g/plant) also progressed. After the physiological maturity, recording the data on the 1000-fruit weight (g) and the total fruit yield per plant (g) continued. For the quality characteristics of fruits, the extraction of volatile oil used the hydro-distillation method and the Clevenger apparatus, saving the oil. The cumin fruits' extract storing in the dark consisted of sealed bottles at 4 °C temperature. The volatile oil percentage estimation employed the following equation (Chen et al., 1993).

$$\text{Cumin oil (\%)} = \frac{\text{weight of the oil produced in grams}}{\text{weight of the sample in grams}} \times 100$$

Fruit protein (%) = weight of Protein / Protein intake for growth.

RESULTS AND DISCUSSION

The planting times, licorice (G. glabra L.) concentrations individually, and their interactions revealed significant differences for most studied traits in cumin (C. cyminum L.) (Table 1). However, the planting times and licorice extract interactions proved nonsignificant for growth traits.

Planting time and licorice effects on growth traits

Planting dates demonstrated a considerable effect on the vegetative growth traits, i.e., plant height, number of branches, and dry plant weight, with the early planting (November 1) recording the highest mean (32.00 cm, 6.47 branches $plant^{-1}$, and 30.82 g, respectively) (Table 2). The early planting appeared superior to the other dates, wherein the third date (December 10) emerged with the lowest rates for the above traits. Like other crop plants, the cumin plants depend mainly upon the stages of its growth with the appropriate environmental conditions, which are the most important determinants of the success in its cultivation. The daily variations in the intensity of lighting and the maximum and minimum temperatures directly affect its development. Its plant height, number of branches, and plant dry weight were in accordance with the appropriate environmental conditions, leading to increased plant activities

Table 1. Analysis of variance for various traits in cumin.

Sources of Variation	Replications	Planting times	Experimental error	Licorice extract	Interactions	Experimental error
Degrees of freedom (d.f.)	2	2	4	2	4	12
Plant height	4.266	69.981*	1.188	102.362*	1.553$^{N.S}$	2.453
Branches plant^{-1}	0.1416	3.3834*	0.1448	10.0981*	0.0994 $^{N.S}$	0.4742
Dry plant weight	2.137	156.103*	0.822	240.534*	2.712 $^{N.S}$	3.253
1000-fruit weight	0.2325	16.4697*	0.2645	19.2290*	0.1943 $^{N.S}$	0.3204
Fruit yield plant^{-1}	0.002048	0.278337*	0.012243	0.900115*	0.009826*	0.002750
Fruit oil (%)	0.010626	0.409881*	0.001215	0.220893*	0.034231*	0.002274
Fruit protein (%)	0.5204	84.7794*	2.4001	16.1818*	0.2418*	0.3245

Table 2. Effect of planting times, licorice extract concentrations, and their interaction on the vegetative growth traits in cumin.

Planting dates	Licorice concentrations (g L^{-1})	Plant height (cm)	Branches per plant	Dry plant weight (g)
November 1	0	29.52	5.33	24.91
	20	30.81	6.70	31.23
	40	35.68	7.37	36.31
November 20	0	24.25	4.67	21.33
	20	28.19	5.63	24.27
	40	31.56	6.99	31.39
December 10	0	23.92	4.25	17.83
	20	25.61	5.24	22.55
	40	30.38	6.25	27.34
$LSD_{0.05}$		N.S	N.S	N.S
Planting dates	November 1	32.00	6.47	30.82
	November 20	28.00	5.76	25.67
	December 10	26.64	5.25	22.57
$LSD_{0.05}$		1.426	0.498	1.186
Licorice concentrations (g L^{-1})	0	25.90	4.75	21.36
	20	28.20	5.86	26.02
	40	32.54	6.87	31.68
$LSD_{0.05}$		1.609	0.707	1.853

to carry out vital processes. The most crucial, of which, was photosynthesis, encouraging the formation of vegetative branches, increasing their numbers, and accumulating the resulting material in them.

Clearly, from the same table, licorice (G. glabra L.) extract concentrations also significantly influenced the vegetative growth characteristics. The highest concentration (40 g L^{-1}) gave maximum values for plant height, the number of branches, and dry plant weight (32.54 cm, 6.87 branch plant^{-1}, and 31.68 g, respectively) versus comparison plants, which recorded the lowest rates for the above traits. Licorice extract contains several nutrients and amino acids, including Tryptophan, considered the basic material in the process of indole-3-acetic acid (IAA), found necessary in cell division and increasing their elongation. These vital processes also reflected positively in increasing the plant height and the number of branches in cumin plants sprayed with licorice extract, eventually enhancing the plant dry weight (Abdulkafoor et al., 2019). The increased activities of the cumin plants to carry out vital processes, including photosynthesis, also boost the dry weight of the plants. However, the interactions between the planting times and licorice extraction concentration showed a nonsignificant effect on the vegetative growth characteristics of cumin plants (Table 1).

Planting time and licorice effects on yield traits

The results suggested the cumin plants grown earlier (November 1) were significantly superior compared with the medium and later plantings (November 20 and December 10) for 1000-fruit weight and the fruit yield per plant (Table 3). With early planting (November 1), the highest values appeared for the 1000-fruit weight and the fruit yield per plant (7.49 and 1.64 g, respectively), compared with the late planting (December 10), providing the lowest values for the above two traits (1.30 and 4.82 g, respectively). The superiority of the cumin's early plantation in 1000-fruit weight and the yield per plant was due to the length of the photoperiod, as well as, the appropriate environmental conditions required for the plants' vegetative growth and development. This boosted seed filling and eventually enhanced the fruit weight (Table 3). The early planting encouraged the manufacturing of nutrients with increased quantity and their accumulation inside the fruits compared with the late planting in Ammi visnaga (Al-Doghachi and Matroad, 2016).

The outcomes further revealed substantial variations among the licorice extract concentrations for 1000-fruit weight and the fruit yield per plant (Table 3). The licorice highest concentration (40 g L^{-1}) was evident with the highest values for 1000-fruit weight and the fruit yield per plant (7.51 and 1.80 g) versus the control treatment. It recorded with the lowest values for the said traits (4.58 and 1.17 g), respectively. The positive effect of licorice extract on yield characteristics may refer to its hormonal nature, which stimulates the vegetative growth of plants, represented by increased plant's height and the number of branches (Table 2). Improvement in those growth traits helped to form an efficient source of light interception, leading to an increase in the process of carbon metabolism and food processing, which contributes to an upsurge in yield in watermelon hybrids (Abdel-Mawgoud et al., 2010).

Furthermore, the interaction of planting times and licorice extract concentrations had a significant effect on the 1000-fruit weight and fruit yield per yield in cumin plants. The cumin plants grown early (November 1) with licorice foliar application of 40 g L^{-1} emerged with the maximum 1000-fruit weight and fruit yield per plant (8.98 and 1.95 g, respectively) compared with the rest of the interaction treatments. The cumin plant with late planting (December 10) and the control treatment of licorice extract gave the lowest 1000-fruit weight and fruit yield per plant (3.59 and 0.98 g).

Planting time and licorice effects on quality traits

The planting times, licorice concentrations, and their interaction notably affected the percentage of oil and protein in the cumin fruits (Table 4). The cumin early planting (November 1) with licorice foliar application (40 g L^{-1}) proved significantly superior over the two other planting dates and control treatment of the licorice. The early planting (November 1) sprayed with licorice concentration of 40 g L^{-1} excelled over the other two concentrations by recording the highest percentages of oil and protein (2.97% and 21.72%, respectively) versus the lowest percentages (2.20% and 13.32%, respectively) from the late planting (December 10) and the control treatment of licorice.

The superiority of the cumin plants grown earlier in the ratios of oil and protein refers to the effect of environmental conditions on increasing the outputs of photosynthesis as a result of increasing vegetative traits (Table 2). Given the formation of oil and protein requires energy, the carbon compounds produced from the breakdown of carbohydrates converted into amino acids and fatty acids, and thus, forming the protein and oil. In addition to the positive role of licorice extract in providing the plant with essential nutrients, it also contributed in building protein molecules (Marhoon, 2024; Zubair et al., 2024).

Table 3. Effect of planting times, licorice extract concentrations, and their interactions on fruit yield traits in cumin.

Planting dates	Licorice concentrations (g L^{-1})	Weight of 1000-fruit (g)	Total fruits per plant (g)
November 1	0	6.13	1.31
	20	7.37	1.66
	40	8.98	1.95
November 20	0	4.03	1.22
	20	6.02	1.60
	40	7.36	1.79
December 10	0	3.59	0.98
	20	4.69	1.25
	40	6.17	1.66
$LSD_{0.05}$		N.S	0.1452
Planting dates	November 1	7.49	1.64
	November 20	5.81	1.53
	December 10	4.82	1.30
$LSD_{0.05}$		0.673	0.1448
Licorice concentrations (g L^{-1})	0	4.58	1.17
	20	6.03	1.50
	40	7.51	1.80
$LSD_{0.05}$		0.581	0.0539

Table 4. Effect of planting times, licorice extract concentrations, and their interactions on oil and protein percentage in cumin.

Planting dates	Licorice concentrations (g L^{-1})	Fruit oil (%)	Fruit protein (%)
November 1	0	2.47	19.55
	20	2.59	20.19
	40	2.97	21.72
November 20	0	2.25	14.72
	20	2.48	16.30
	40	2.54	17.81
December 10	0	2.20	13.32
	20	2.22	14.19
	40	2.34	16.04
$LSD_{0.05}$		0.07591	1.991
Planting dates	November 1	2.68	20.49
	November 20	2.42	16.28
	December 10	2.25	14.51
$LSD_{0.05}$		0.04562	2.028
Licorice concentrations (g L^{-1})	0	2.31	18.52
	20	2.43	16.89
	40	2.62	15.86
$LSD_{0.05}$		0.04898	0.585

CONCLUSIONS

The results revealed early planting of cumin with licorice foliar application were more effective in obtaining the optimum growth and highest fruit yield of the best quality.

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