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Vicia faba overcomes drought stress by spraying with Xerophytic *Anabasis setifera* extract

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Abstract: Drought stress is a prevalent environmental factor significantly impacting the faba bean (Vicia faba L.) crop. Anabasis setifera, a plant extract (ASE), has been found to potentially regulate plant responses to drought stress for the first time. The study examined the effects of applying an exogenous ASE on the physiological, biochemical, and yield responses of faba bean plants under three soil water regimes: well-watered (8-day irrigation intervals), moderate drought stress (12-day irrigation intervals), and severe drought stress (16-day irrigation intervals). The HPLC analysis of ASE revealed that it contains major phenolic compounds such as rutin, chlorogenic acid, gallic acid, ferulic acid, and coumaric acid. The extract also contains catechin, quercetin, syringic acid, pyro catechol, and methyl gallate. The study found that faba bean plants showed enhanced drought resistance after treatment with ASE. This treatment improved growth parameters like shoot and root length, fresh and dry weight, leaf and flower number, and reduced the negative impacts of drought stress on chlorophyll levels and metabolic activities. The study indicates that plants treated with ASE, including catalase, peroxidase, and polyphenol oxidase, can significantly mitigate drought stress effects, improve yield trials, and enhance seed components, making it cost-effective and ecologically beneficial.

Keywords: *Anabasis setifera, Drought stress, Faba bean, Plant extract, Plant growth, Secondary metabolites.*

1. Introduction

Legumes are the second most important crop in the world after cereals, and they are a valuable source of necessary nutrients for human diets since they include carbohydrates, proteins, and minerals (Anwar, Borbi and Rakha, 2024). Among other legumes, faba beans are unique because of their substantial protein content (26.1%) and dietary fiber (25.0%). It has been proposed that diets derived from faba beans may be advantageous for those with diabetes and high blood pressure (Agrawal, Panigrahi and Eri, 2024). According to available data, the faba bean ranks fourth among food legumes for the cold season, with 4.84 million tons of dry grain produced worldwide in 2017 (Maalouf, Ahmed and Bishaw, 2021). In Egypt, 58120 feds were farmed in 2020, yielding 88109 tons of dry seed with an average of 1.52 tons fed^{-1}(Morsy and Mehanna, 2022).

A drought stress is one of the most common environmental stressors that affects the development and growth of plants and contributes to a significant global drop in agricultural yields (Junaid and Gokce, 2024). Eser *et al.*, (2024) demonstrated how the plant's development, growth, and yield components are impacted by drought, resulting in a notable decrease in output. Several investigations on the faba bean have shown that drought stress reduces plant height, leaf area, number of leaves per

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plant, number of branches per plant, number of pods per plant, the yielded seeds, and the protein levels in faba bean seeds (Alza *et al*., 2024; Abid *et al*., 2024 and E Maaty *et al*., 2024). Furthermore, drought was shown to impede photosynthesis and disrupt a number of enzymatic pathways, according to Kabbadj *et al*., (2017). Apart from conventional breeding techniques, some novel approaches have been suggested recently to enhance plant resilience against external stressors. The most effective of these tactics may be the induction of resistance in plants to stimulate their natural defenses. Utilizing plant extracts as natural sources of vitamins, antioxidants, osmoprotectant substances, and etc. are some of these techniques. According to earlier research, treatment with plant extract can improve the drought resistance of plants as rice (Farooq *et al*., 2009), jute mallow (Nowwar *et al*., 2022), common bean (Nowwar *et al*., 2023), sunflower (Mohamed A Al Abboud *et al*., 2024) and maize (Han *et al*., 2024). Within the family Chenopoodiaceae, *Anabasis setifera* is halophytic and xerophytic plant species that are found worldwide in arid regions. Hydroethanolic *Anabasis setifera* extracts effectively inhibited several important bacterial and fungal pathogens (Dehghani Kazemi, *et al*., 2023). *Anabasis setifera* has been long employed as a medicinal herb, mostly for the treatment of cardiovascular disease, kidney failure, lung inflammation, and as a preventative measure against atherosclerosis and arthritis. Phenolic compounds, saponins, flavonoids, and alkaloids isolated from *Anabasis setifera* (Shegebayev, *et al*., 2023).

Even so, no research has been done to date on the effects of *Anabasis setifera* extract on plants faba bean drought stress resistance, so this study aimed to determine the phenolic compound of *Anabasis setifera* extract (ASE) and the effects of exogenous application of it on the growth, biochemical analysis and yield traits of faba bean (*Vicia faba* L.) plant response to drought stress.

2. Materials and Methods

2.1. Seeds, Growth Conditions and Treatments

Faba bean (*Vicia faba* L.) seeds (Cv. *Nubaria* 2) were received from the Agricultural Research Centre of the Ministry of Agriculture in Giza, Egypt. Seeds were surface sterilized with 3.5% sodium hypochlorite for 20 minutes. After that, they were repeatedly cleaned with distilled water. Six seeds per pot, thinning occurred after seedling advent, and four plants were maintained per pot were used for the seed planting. The pots held 6.0 kg of clay soil. The following treatments were represented by the six sets of pots (each group having five duplicates).

i- 8 days irrigation intervals (8D), (well-watered)
ii- 8 days irrigation intervals + *Anabasis setifera* extract (8D+ASE)
iii- 12 days irrigation intervals (12D), (moderate drought stress)
iv- 12 days irrigation intervals + *Anabasis setifera* extract (12D+ASE)
v- 16 days irrigation intervals (16D), (severe drought stress)
vi- 16 days irrigation intervals + *Anabasis setifera* extract (16D+ASE)

The experiment was conducted in a completely randomized design. After the plants were planted, at 55 (Stage I) and 70 (Stage II) days, plant samples were taken for analysis. A yield analysis was performed at the end of the growing season (165 days) comparing the various treatments to the control.

2.2. Preparation of Anabasis Setifera Extract for Foliar Application

Plant powder (leaves) is heated for 45 minutes at 60 ℃ in sterile distilled water. After filtering with filter paper, The extracts were stored at 4℃ for future experimentation (Anisimov *et al*., 2013). Four grams of powdered extract were applied topically for every liter of fluid. These doses were used in an initial trial that produced the optimum faba bean plant development.

2.3. Conditions for HPLC analysis of Anabasis Setifera Extract

The Agilent 1260 series HPLC was employed in the investigation. The separation was performed using an Eclipse C18 column (4.6 mm x 250 mm i.d., 5 µm). The mobile phase was made up of trifluoroacetic acid (0.05%) in acetonitrile (B) flowing at 0.9 ml/min and water (A). The mobile phase was programmed using the following linear gradient in order: 8-12 min (60% A), 0-5 min (80% A), 12-15 min (82% A), 15-16 min (82% A), and 16-20 min. The multiwavelength detector was monitored at

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280 nm. Each sample solution had a 5 µl injection volume. There was no variation from the 40°C column temperature.

2.4. Analysis of Treatment Plants

2.4.1. Morphological Analysis

Eight distinct individual plants' shoot and root lengths were measured in centimeters, and the leaves of the same group of plants were also counted. After clipping, the fresh weight of the roots and shoots (estimated at g/plant) of each of the treatments' plants was measured by weighing them. Plant substances were dried at 65 ℃ until their dry weight remained constant. Subsequently, the dry weights of shoot and root were noted as the ultimate weights (Nowwar *et al*., 2020).

2.4.2. Pigments Of Photosynthetic Concentrations

One gram of freshly picked leaves was thoroughly pulverized and dissolved in 100 ml of 80% acetone. The liquid was then filtered via Whatman filter paper (No. 1). The extract's efficacy was assessed by measuring optical densities at wavelengths of 470 nm, 649 nm, and 665 nm (Vernon and Seely, 2014). The concentrations of chlorophyll ***a*** and ***b***, total chlorophyll (***a*** + ***b***), and carotenoids were calculated using Smith (2013).

2.4.3. Carbohydrates, Protein and Free Proline Contents

The methods of Umbreit, Burris and Stauffer (1957), Lowry *et al*., (1951) and Bates, Waldren and Teare, (1973) were used to measure the total soluble carbohydrates, proteins and free proline, respectively.

2.4.4. Antioxidant Enzymes Activities

The enzymes peroxidase, catalase, and polyphenol oxidase were extracted according to Mukherjee and Choudhuri (1983), and estimated in the following:

The method described by Mueller, Riedel and Stremmel (1997) was used to determined catalase (CAT), whereas (Castillo, Penel and Greppin, 1984) determined peroxidase (POX), and (Matta and Diamoned, 1963) evaluated polyphenol oxidase (PPO) enzymes.

2.4.5. Statistical Analysis

SPSS version 25 was used for statistical computations with a 0.05 probability threshold (Wiedermann et al., 2020; Nowwar et al., 2023). One-way ANOVA and Tukey's post hoc test were used to analyze the variance of quantitative parametric data.

3. Results

3.1. Detection of Phenolic Compounds of Anabasis Setifera by Using HPLC

In our investigation, we employed eight phenolic acids, four phenolics, and seven flavonoid standards to identify and quantify phenolic components in *Anabasis setifera.* The results in table 1 and figure 1 showed that rutin, chlorogenic acid, gallic acid, coumaric acid, and ferulic acid are the primary phenolic chemicals found in plants. On the other hand, ellagic acid, coffeic acid and hesperetin have not appeared in phenolic profile of plant. vanillin and cinnamic acid are the lowest values of phenolic compounds in plants by 4.99 and 12.89 (µg/g). Also, HPLC analysis of *Anabasis* ***setifera*** Extract appeared that, contents of catechin (1634.61µg/g), quercetin (359.09 µg/g), syringic acid (767.03 µg/g), pyro catechol (1845.46 µg/g) and methyl gallate (510.67 µg/g) of *Anabasis setifera* extract.

3.2. Morphological Parameters of Faba Bean Under Drought Stress

Table 2 shows that fresh and dry weights of both shoot and root, the shoot and root lengths, leaves number per plant, branch number per plant, and flowers number per plant of faba bean plant under drought stress appeared to decrease at stages I and II, when compared to other treatments. However, foliar spraying of *Anabasis setifera* extract (ASE) significantly decreased the deleterious effects of drought stress on all morphological parameters investigated in the faba bean plant. In comparison to the

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untreated plants, the highest values of shoot and root lengths, fresh and dry weights of both shoot and root, number of branches per plant, number of leaves per plant, and number of flowers per plant were noted when *Anabasis setifera extract* was applied at 8-day irrigation intervals throughout the two stages of the plant growth.

3.3. Photosynthetic Pigments of Faba Bean Under Drought Stress

The information shown in Table 3 makes it abundantly evident that drought stress significantly reduced the amount of chlorophylls (a, b, and a+b) and carotenoids in faba bean plants throughout the plant stages (I and II). On the other hand, data from this study also shows that, after spraying an *Anabasis setifera* extract solution, faba bean plants' levels of chlorophyll and carotenoid pigments generally increased significantly at stages I and II.

3.4. Metabolic Contents of Faba Bean Under Drought Stress

The results (Figure 2) showed that the metabolic components of faba bean plants appeared to be significantly affected by water deficit stress at stages I and II. In case of 16days irrigation intervals (16D), the plant's protein and carbohydrate levels were at their lowest, while the free proline significantly increased. On the other hand, treatment with *Anabasis setifera* extract significantly enhance the amount of protein and carbohydrates. Whereas, the contents of free proline decreased significantly compared to untreated plants, throughout the two stages of the plant growth.

3.5. Antioxidant Enzymes of Faba Bean Under Drought Stress

The antioxidant enzymes (CAT, POX, and PPO) activities were evaluated (Figure 3). In general, drought stress and exogenous *Anabasis setifera* extract administration cause modifications in the activities of antioxidant enzymes. Drought stress results in a significant increase in CAT, POX, and PPO activities in faba bean plant to reach its maximum after 16 days of drought stress at stages I and II. In contrast, exogenous application of *Anabasis setifera* extract greatly decreased the deleterious effects of drought stress on plants. As a result, the activity of all antioxidant enzymes investigated were dramatically reduced at both stages I and II.

3.6. Yield Characters

In comparison to the treated plant, the data shown in Table 4 show that all yield attributes of the *Vicia faba* plants were reduced as a result of drought stress. After 16 days of drought stress, the most significant drop in pod number per plant, seed number per plant, seed weight per plant, weight of 100 seeds, and total soluble carbohydrate and protein contents in seeds was observed. On the other hand, foliar application of *Anabasis setifera* extract significantly increases all yield trials. In addition, the total soluble carbohydrate and protein contents in seeds were enhanced markedly as compared to that of untreated plant.

4. Discussion

Applying natural metabolites exogenously can help lessen the negative impacts of stress on crops. Our data showed that, rutin, chlorogenic acid, gallic acid, ferulic acid and coumaric acid are the major phenolic compounds plants by 7513.20, 4409.19, 3554.74, 3547.39 and 3184.48 (µg/g). In this concept (El Ashry, et al 2023) found accumulation of ferulic acid of Gardenia jasmonide Variegata callus cultures plants under drought stress. Also, (Lini´c, et al., 2021) found that ferulic acid had a more effective ameliorative impact on salt stress of Chinese cabbage plants than salicylic acid. Fascinatingly, phenolic compounds' antioxidant properties have been thoroughly researched. These properties aid in shielding plants from oxidative stress and harm from things like UV rays, infections, and environmental stresses. Phenolic chemicals are involved in defensive processes in plants, but they also give fruits, vegetables, and drinks like tea, coffee, and wine their unique color, flavor, and aroma. The potential advantages of phenolic compounds for human health have also garnered attention. Certain chemicals, such as the antioxidants and flavonoids present in fruits, vegetables, and seeds, may be advantageous to human health. Additionally, they may aid in the prevention of some types of cancer and heart disease, among

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other chronic illnesses. Consequently, the Anabasis setifera plant's high concentration of these phenolic chemicals has significant economic implications. There appears to be a lack of literature discussing the role of phenolic compounds of halophytic and xerophytic plant species to alleviate the harmful effect of drought stress on economic plants.

One of the main environmental factors that can significantly restrict the growth and productivity of faba bean (*Vicia faba* L.) plants is drought. According to a number of studies, exogenous application of plant extract, e.g. *Anabasis setifera* extract, may be crucial for controlling a plant's ability to withstand both biotic and abiotic stresses and for regulating growth and development (Nowwar *et al*., 2022, Nowwar *et al*., 2023 and Shalaby, 2024). Drought tolerance is induced by plant extract, which is an effective method for reducing drought damage in plants such as *Zea mays* (Bhowmick *et al*., 2024 and Shaw *et al*., 2016), rice (Park, Win and Kuk, 2024 and Pandey *et al*., 2016), and *Ocimum basilicum* (Taha *et al*., 2020). These results collectively provide credence to the theory that plant extract functions as a form of protection against drought stress. A significant decrease in the morphological characteristics and biochemical constituents under water deficit stress had been previously documented in the other crops, such as wheat plant (Nyaupane *et al*., 2024). These may be explained by drought stress, which reduces photosynthetic capacity and increases reactive oxygen species (ROS), which in turn causes oxidative damage to proteins, lipids, and DNA and consequently lower chlorophyll pigments (Garcia-Caparros *et al*., 2021). Drought stress also directly affects photosynthetic rates because stomatal closure reduces CO_2 availability (Pirasteh-Anosheh *et al*., 2016).

On the other hand, exogenous plant extract application improved sunflower growth parameters by improving shoot and root lengths, fresh and dry weights of both shoot and root, chlorophyll contents and photosynthetic rate (Mohamed A Al Abboud *et al*., 2024). In the present study, drought stress significantly decreased the shoot and root lengths, fresh and dry weights of both shoot and root, branch number per plant, leaves number per plant, flowers number per plant and chlorophyll and carotenoid contents. However, the negative consequences of the drought on all morphological characteristics and photosynthetic pigments of faba bean were lessened by the application of *Anabasis setifera* extract. This improvement may be due to the impact that plant extracts are mainly contains amino acids, vitamins, minerals, hormones, and other bioactive and biostimulant compounds which can enhance plant growth, photosynthetic rate, phytohormones activity, plant-water relationship and other plant processes (Zhang *et al*., 2024). In this way, Bonea and Urechean, (2018) investigated the effects of sweet marjoram extract on maize plant. They found that treatment with 1% and 2% concentrations of sweet marjoram extracts significantly improve all growth performance of *Zea mays* plant.

In the current investigation, plant under drought stress has the lowest values of protein and carbohydrate contents. Conversely, the water deficit stress greatly increased the levels of free proline. These outcomes agree with previous research of Mafakheri *et al*., (2011). In contrast, *Anabasis setifera* extract (ASE) applied topically greatly increases the amounts of protein and carbohydrates. On the other hand, our treatments significantly decreased the amount of free proline present in comparison to the untreated plants. The collected results demonstrated how these treatments helped the investigated plant recover from the negative effects of drought stress and return to its normal state. Our results are in complete harmony with the previous studies of Mohamed A. Al Abboud *et al*., (2024) they found that foliar application of *Curcurma longa*, *Nigella sativa* and *Origanum majorana* plant extract mitigated the negative effects of drought stress in sunflower plant and the contents of protein and carbohydrates significantly increased. While the free proline contents significantly decreased at stages I and II.

Drought stress causes oxidative damage and may even result in cell death because of its detrimental impact on plant growth (Shu *et al*., 2024). Plants' antioxidant system, in particular enzyme antioxidants like SOD, CAT, PPO, and POX, serves as the first line of defense in the plant's ability to withstand these adverse conditions. This is due to the fact that the ROS will kill the plant if they are not eliminated right away (Biswas and Pal, 2024). In the current investigation, drought stress stimulated antioxidant enzymes activities in faba bean plants in compared to control. Our results corroborated those published recently by Al-Shammari *et al*., (2024) showed that drought stress significantly increased the activity of CAT, POX, SOD enzymes in *Glycine max* (L.) plants. Also, Mohamed A. Al Abboud *et al*., (2024) investigated the impact of drought stress on sunflower plant antioxidant enzyme

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activities. They found that the activities of the catalases, peroxidase, and superoxide dismutase enzymes significantly enhanced under stress conditions. On the other hand, antioxidant enzyme activities were markedly decreased by exogenous application of *Anabasis setifera* extract in comparison to untreated (stress) plant. These treatments assisted *Vicia faba* plants in recovering from the oxidative damage caused by drought stress, as evidenced by the reductions in SOD, CAT, POX, and PPO activities. Within this concept, Ibrahim *et al*., (2023) reported that extract from moringa leaves applied externally helps wheat plants resist the negative effects of water stress. Therefore, there was a considerable drop in proline levels and antioxidant enzyme activities. Recently, Mohamed and Akladious, (2014) examined the effects of exogenous application of natural plant extract (garlic extract) in two cultivars (Giza 22 and 111) of soybean (*Glycine max*) plants under drought stress. They found that, enzymatic antioxidants (ascorbate peroxidase, superoxide dismutase, and glutathione reductase) were significantly decreased in the shoots of the soybean plants cultivars in response to treatment with plant extract.

The culmination of growth, physiological, and yield-related characteristics that are impacted by water scarcity is the seeds' yield (Raza *et al*., 2024). Lack of irrigation significantly decreased the output of seeds and its constituent parts, including the weight of each plant's seeds, the weight of one hundred seeds, and the amount of protein and soluble carbohydrates overall. Our results were harmony with those reported by Maswada *et al*., (2018) they found that drought stress resulted in a considerable drop in all investigated yield parameters (number of grains per row, 100 grain weight, aboveground biomass, grain yield and harvest index) and yield components (carbohydrate and protein) of maize plant. Conversely, a positive effect on all yield parameters yield components were reported when treated with *Anabasis setifera* extract. The same trends were observed by the previous studies of (Yasmeen *et al*., 2013) in wheat, (Maswada *et al*., 2018) in maize, and (Mohamed A Al Abboud *et al*., 2024) in sunflower plants.

Through the correlation analysis of samples, it was found that the chlorophyll a, b, a+b and carotenoids contents in leaves were positively associated with yield traits (weight of seeds /plant, weight of 100 seeds, carbohydrates and protein of seeds). Also, shows that proline content and enzyme activities (catalase, peroxidase and poly phenol oxidase) were negatively associated with yield traits (weight of seeds /plant, weight of 100 seeds, carbohydrates and protein of seeds). Additionally, oxidative burst and the obvious build-up of free radicals are brought on by drought stress in plant cells. To get rid of the ROS, the non- enzymatic and enzymatic antioxidants activities are also triggered simultaneously. Our findings indicated a substantial positive correlation between the water deficit stress and the free proline, SOD, CAT, and POD contents. such these findings were corroborating to that observed by (Bistgani *et al*., 2024).

5. Conclusions

It is clear from the data that drought stress negatively impacted the faba bean plant's growth characteristics, metabolic makeup, and yield trials. HPLC appeared that rutin, chlorogenic acid, gallic acid, ferulic acid and coumaric acid are the major phenolic compounds of *Anabasis setifera* extract by 7513.20, 4409.19, 3554.74, 3547.39 and 3184.48 (µg/g), so when drought stressed plants were combined with a naturally occurring growth regulator (*Anabasis setifera* extract), all growth factors, yield parameters, and seed components rose, and drought resistance was enhanced. Ultimately, the detrimental impacts of drought stress can be successfully avoided by faba bean plants by using these natural plant extract.

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Table 1.
Assessment of phenolic compounds in Anabasis setifera extract.

Phenolic compounds	Area	Conc. (µg/ml=20mg/ml)	Conc. (µg/g)
Gallic acid	823.32	71.09	3554.74
Chlorogenic acid	643.95	88.18	4409.19
Catechin	132.01	32.69	1634.61
Methyl gallate	187.12	10.21	510.67
Coffeic acid	0.00	0.00	0.00
Syringic acid	226.23	15.34	767.03
Pyro catecho	117.51	16.91	845.46
Rutin	1294.00	150.26	7513.20
Ellagic acid	0.00	0.00	0.00
Coumaric acid	2018.78	63.69	3184.48
Vanillin	2.28	0.10	4.99
Ferulic acid	1038.45	70.95	3547.39
Naringenin	129.39	15.60	780.13
Daidzein	30.38	1.88	93.83
Querectin	52.14	7.18	359.09
Cinnamic acid	14.00	0.26	12.89
Apigenin	39.55	3.01	150.51
Kaempferol	32.07	2.49	124.34
Hesperetin	0.00	0.00	0.00

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Table 2.
Morphological parameters of Vicia faba plant due to treatment with Anabasis *setifera* extract under drought stress.

Parameters	Plant growth stages	Irrigation intervals						HSD
		8D	8D+ASE	12D	12D+ASE	16D	16D+ASE	
Shoot length (cm)	Stage I	25.00±2.00ab	29.33±3.51a	16.00±2.02c	18.67±2.52bc	13.67±2.50c	15.33±1.53c	3.05
	Stage II	37.33±2.08ab	42.67±2.52a	25.00±3.00c	34.00±5.00b	18.00±2.00c	21.00±3.00c	3.90
Root length (cm)	Stage I	11.67±2.08ab	13.00±2.00a	8.00±1.00bc	10.00±1.73abc	5.33±1.53c	7.00±1.73bc	2.16
	Stage II	13.67±1.16ab	15.00±2.00a	10.33±1.16abc	11.67±1.16abc	8.00±2.65c	10.00±1.73bc	2.18
Shoot fresh weight (gm)	Stage I	27.00±3.46ab	29.33±3.51a	22.67±3.06abc	26.00±1.73ab	17.00±2.00c	20.00±3.61bc	3.76
	Stage II	33.33±3.51ab	37.00±3.00a	30.00±3.03ab	32.67±3.06ab	21.00±4.00c	26.00±2.00bc	3.97
Shoot dry weight (gm)	Stage I	3.11±0.08a	3.25±0.04a	2.98±0.12ab	3.09±0.03a	2.50±0.12c	2.74±0.15bc	0.13
	Stage II	3.61±0.04b	3.87±0.07a	3.25±0.03c	3.50±0.05b	3.06±0.02d	3.13±0.06cd	0.07
Branch number/plant	Stage I	1.00±0.50a	1.67±0.58a	0.67±0.59a	1.33±0.55a	0.33±0.52a	1.00±0,56a	0.94
	Stage II	2.00±0.96a	3.00±0.95a	1.33±0.58a	2.33±0.56a	0.67±0.66a	2.00±0.91a	1.26
Leaves number/plant	Stage I	12.33±2.31a	15.00±1.00a	11.67±1.16a	13.00±1.73a	11.00±2.65a	12.00±1.73a	2.34
	Stage II	15.00±1.73ab	18.00±1.70a	13.00±1.00ab	15.33±1.16ab	12.00±3.00b	12.67±2.52ab	2.50
Flowers number/plant	Stage II	14.00±1.00ab	16.33±1.53a	11.67±1.16bcd	13.00±1.73abc	8.33±1.53d	9.00±1.73cd	1.85

Note: Data represents means ± standard error (n=5).

Table 3.
Effects of *Anabasis setifera* extract on the chlorophyll and carotenoid contents (mg/g fresh weight) of *Vicia faba* plant under drought stress.

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Treatments	Chlorophyll (a) mg/g fresh weight		Chlorophyll (b) mg/g fresh weight		Chlorophyll (a+b) mg/g fresh weight		Carotenoids (mg/g fresh weight)	
	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II	Stage I	Stage II
8D	10.01±0.10c	14.30±0.16b	4.15±0.22abc	5.40±0.27b	14.17±0.23b	19.70±0.12b	0.83±0.14bc	2.26±0.09b
8D+ASE	12.54±0.11a	16.94±0.18a	5.55±0.24a	9.97±0.28a	18.09±0.27a	26.91±0.15a	2.21±0.10a	3.37±0.14a
12D	8.21±0.14d	11.11±0.12e	3.89±0.34bc	3.52±0.17d	12.10±0.34c	14.63±0.29d	0.76±0.17bc	3.35±0.13a
12D+ASE	11.12±0.17b	13.66±0.09c	4.33±0.15ab	5.11±0.20bc	15.45±1.02b	18.77±0.23b	1.34±0.47b	2.26±0.12b
16D	7.28±0.15e	8.58±0.05f	2.81±0.37c	3.04±0.92d	10.09±0.28d	11.61±0.91e	0.63±0.09c	2.82±0.44ab
16D+ASE	8.54±0.11d	12.59±0.08d	3.99±0.18bc	4.21±0.21cd	12.52±0.22c	16.80±0.27c	1.16±0.05bc	1.63±0.15c
HSD	0.16	0.16	0.67	0.54	0.61	0.53	0.28	0.27

Note: Data represents means ± standard error (n=5).

Table 4.
Yield characters of *Vicia faba* plant due to treatment with *Anabasis setifera* extract under drought stress.

Yield characters		Pods number/plant	Seeds number/plant	Seeds weight/plant (gm)	Weight of 100 seeds (gm)	Total soluble carbohydrate in seeds (mg/g dry weight)	Total soluble protein in seeds (mg/g dry weight)
Irrigation intervals	8D	8.00±1.73a	26.33±1.53ab	15.00±2.00ab	53.00±3.00a	11.56±0.08	32.90±0.29b
	8D+ASE	10.00±1.01a	29.67±3.06a	17.00±1.00a	56.00±2.00a	13.77±0.09	34.29±0.33a
	12D	7.00±1.73a	22.00±3.61bc	13.00±1.98ab	46.33±2.08bc	12.83±0.06	30.51±0.25c
	12D+ASE	8.33±1.16a	27.00±2.65ab	16.00±1.73ab	52.00±2.65ab	13.92±0.05	32.21±0.29b
	16D	6.67±0.58a	18.00±2.62c	11.00±2.03b	44.00±2.71c	10.78±0.09	24.12±0.22e
	16D+ASE	7.33±0.61a	21.33±2.08bc	12.00±2.65ab	46.00±2.08bc	12.21±0.07	28.67±0.23d
HSD		1.54	3.37	2.46	3.05	0.09	0.34

Note: Data represents means ± standard error (n=5).

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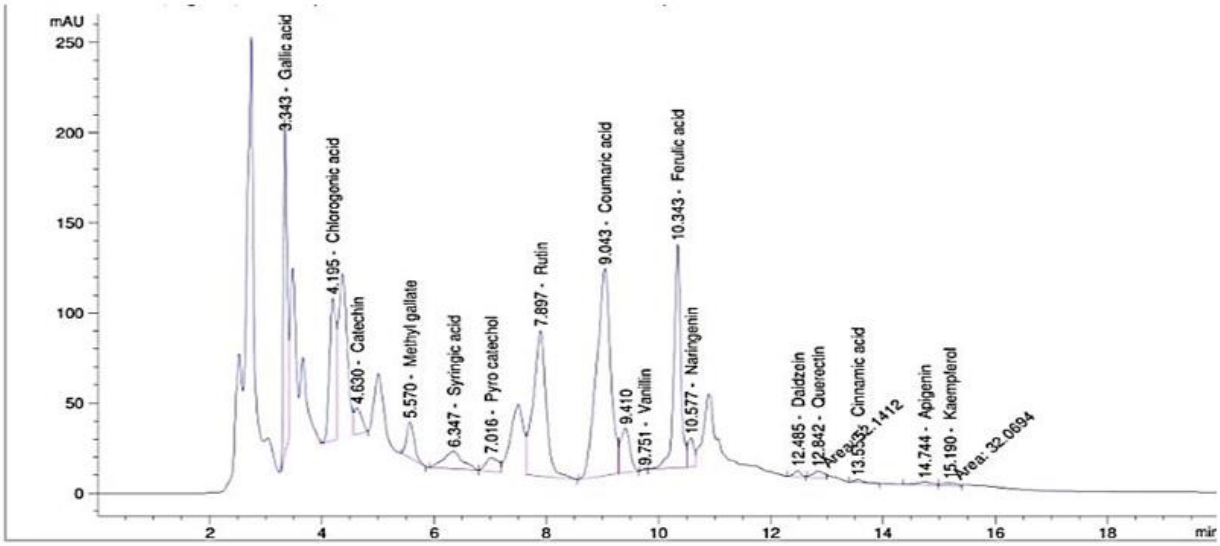

Figure 1.
Chromatograms shows the peaks found in the combination made up of all 19 of *Anabasis setifera* Extract phenolic components at: λ=280 nm.

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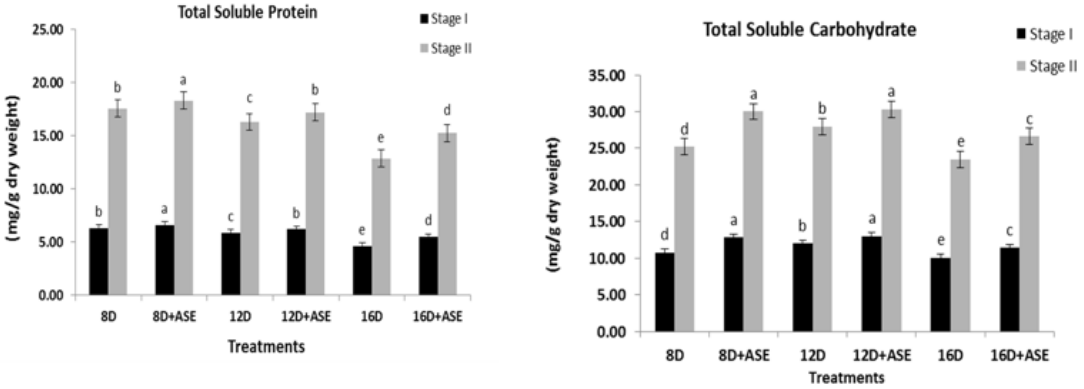

Figure 2. Effects of *Anabasis setifera* extract on the total soluble carbohydrate, protein and free proline contents (mg/g dry weight) of *Vicia faba* plant under drought stress. Each value is mean of 5 replicates ± standard error of means.. Different lower-case-letters in the same bars indicate significant differences (P≤0.05). D is Days and ASE is *Anabasis setifera* extract.

Figure 2.

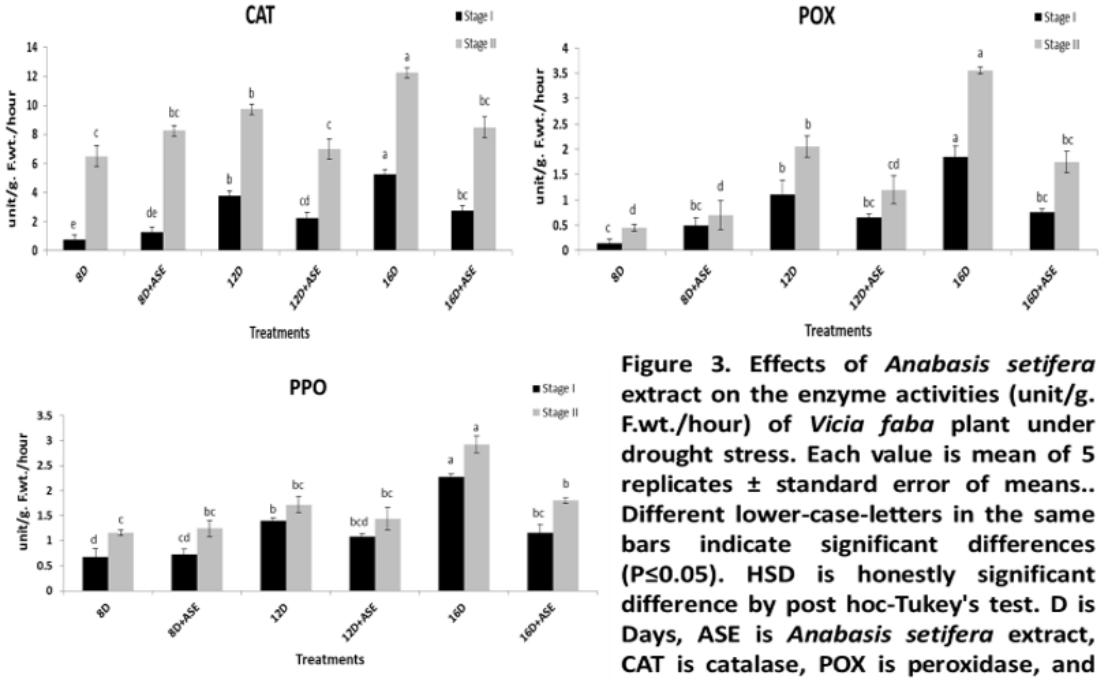

Figure 3. Effects of *Anabasis setifera* extract on the enzyme activities (unit/g. F.wt./hour) of *Vicia faba* plant under drought stress. Each value is mean of 5 replicates ± standard error of means.. Different lower-case-letters in the same bars indicate significant differences (P≤0.05). HSD is honestly significant difference by post hoc-Tukey's test. D is Days, ASE is *Anabasis setifera* extract, CAT is catalase, POX is peroxidase, and PPO is Polyphenol oxidase.

Figure 3.

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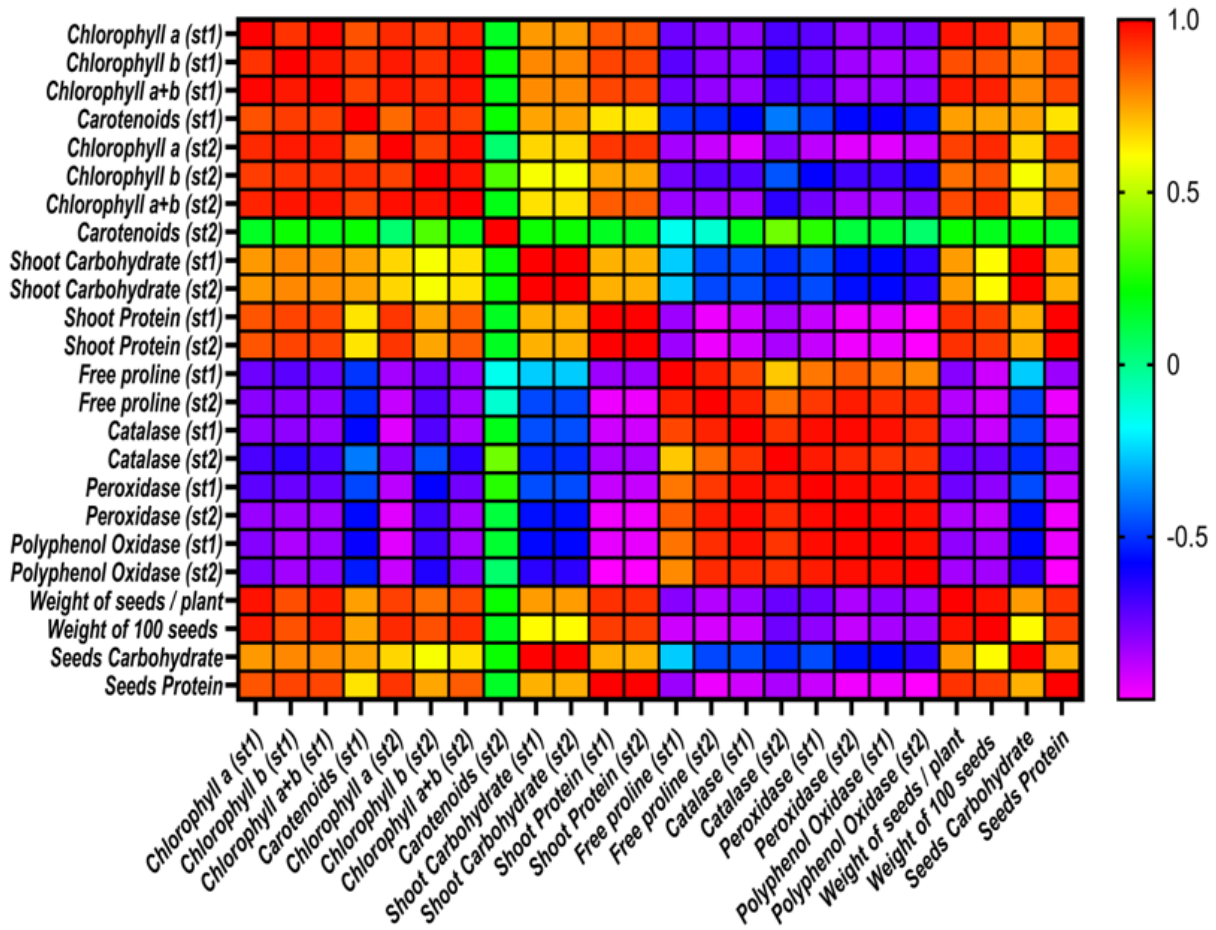

Figure 4.
Heat map correlation between some items of the biochemical constituents and yield parameters in *Vicia faba* L. plants under drought stress. Correlation coefficients were classified as weak (NS; r\0.50, n = 12), moderate (r C 0.51, P B 0.05, n = 12) and strong (r C 0.66, P B 0.01, n = 12) (St1) =stage one and (st2) stage two.

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