***Original Research Article***

# Amino acids content in different conditions economic plants from South Sinai as affected by different habitat conditions


## ABSTRACT

The objectives of this work were to determine the amino acids contents of ecophysiologically different plants on a seasonal basis and to relationship among amino acids and soil analysis (recast). The plant species investigated were *Zilla spinosa* and *Peganum harmala* in the spring and autumn seasons during Wadi El-Arbaeen (WAR) and Wadi Ghrandal (WGH). The values of pH and electric conductivity (EC) of soil solutions at the up, mid and down streams were higher inWGH than in WAR, while unlike of mineral analysis i.e., $S^-$, $Cl^-$, $Ca^{++}$, $Mg^{++}$, $Na^+$ and $K^+$.Amino acids content in the two studied species were differed from one species to another at the spring and autumn seasons under the two locations.According to the rank method, the amino acids (proline, aspartic, glutamic, leucine, isoleucine and alanine) concentrations of the autumn season were greater than those of the spring season in *Z. spinosa*under WAR, and in *P. harmala*under WAR and WGH., while the spring season were higher than autumn season in *Z. spinosa*under WGH. While the amino acids histidine, cysteine and methionine were the least. Based on PCA, the amino acids can be classified into four groups. The amino acids i.e. aspartic, cysteine, methionine, phenylalanine, trptophane and proline were positively correlated with pH, $K^+$, $Na^+$, $S^-$, $Ca^{++}$, $Cl^-$, Ec and $Mg^{++}$ in the spring and autumn seasons under WAR. While, the amino acids Aspartic, Methionine and Isoleucine with pH, $K^+$, $Na^+$, WC and EC, as well as the amino acid Trptophane with $S^-$, $Cl^-$ and $Ca^{++}$ were showed positive correlation in the spring and autumn seasons during WGH. It seemed that the *Z. spinosa* and *P. harmala* were adapted with drought conditions in WAR and WGH.




**Key words**:Amino acids–soil analysis–*Zilla spinosa*–*Peganum harmala*.

## INTRODUCTION

South Sinai, an arid to extremely arid region, is characterized by an ecological uniqueness due to its diversity in landforms, geologic structures, and climate that resulted in a diversity in vegetation types, which is characterized mainly by the sparseness and dominance of shrubs and sub-shrubs and the paucity of trees [1,2], and a variation in soil properties [3]. Two plants, namely, the *Zilla spinosa* L. (*Z. spinosa*) and*Peganum harmala* L.(*P. harmala*) are herbs that have been widely used in animal forage or medicinal purposes particularly in South Sinai.

*Z. spinosa*has important uses in the folk medicine and is one of the most common plant species of Crucifereae family. It is used as a drink against kidney and gall bladder stones. Previous phytochemical study of *Z. spinosa* led to the separation of glucosinolates of progotrin, goitrin, free sinapine, and some other chemical constituents which have biological activities comprising antioxidant, hepatoprotective, cytotoxic and antiviral activities [4]. *P. harmala*is the only salt-tolerant perennial herb in the Peganum genus of the family Zygophyllaceae [5]. Also, it is a drought tolerant plant in arid parts of Middle East and North Africa, which thrives in poor sandy or gritty soils [6]. *P. harmala*is used as traditional medical herb since earliest times as a remedy for a wide range of complaints [7]. Traditionally, the seeds have been used to relieve pain, to promote blood circulation, and to treat rheumatism and illnesses such as cough and asthma [8]. It is also effective in the treatment of dermatosis, hypothermia, and cancer; in addition, it has a hepatoprotective effect [9].

Amino acids are organic molecules that contain nitrogen, carbon, hydrogen, and oxygen, and have an organic side-chain in their structure, a characteristic that distinguishes the different amino acids [10]. Proteins are derived from amino acids and are essentially the basic component of all living cells [11]. Amino acids can play different roles in plants; they can act as stress-reducing agents, source of nitrogen and hormone precursors [12]. Also, they regulate ion transport and stomatal opening and affect the synthesis and activity of enzymes, gene expression, and redox homeostasis, helping the plants to cope with the harmful effects of osmotic stress [13]. In the soil, they can be found in different forms, however, their half-life is short and their absorption by plants is only possible due to the presence of transporters in the roots [14]. The main amino acids synthesized by plants are the glutamate, glutamine, and aspartate, and from these other amino acids may be formed. Glutamate stands out for being the first amino acid in which the nitrogen absorbed by the plants is incorporated and from it, a range of amino acids can be obtained through the activity of aminotransferases [10,15]. Proline is one of the most common compatible osmolytes in water-stressed plants. Such metabolism of Proline is inhibited when Proline accumulates during dehydration and it is activated when rehydration occurs [16].The objective of this study was to compare the amino acid of two plants*Z. spinosa*and *P. harmala*at their natural habitats under spring and autumn conditions at Wadi El-arbeen and Wadi Gharndal in South Sinai, Egypt.

## MATERIALS AND METHODS

***Study area:***

Two locations Wadi El-Arbaeen (WAR) and Wadi Ghrandal (WGH) in South Sinai were studied. Samples of the two studied plants and soil were collected from these the two locations. In order to assess the results seasonally, the plant and soil samples were collected from the two locations on 23 March 2015 as spring and 27 September 2015 as autumn.

***Plant material:***

Two plants were used in this study, namely, *Zilla spinosa* L.(*Z. spinosa*) and*Peganum harmala* L. (*P. harmala).Z. spinosa*L. (family Brassicaceae) is a perennial spiny shrub, with stems richly branched, fleshy leaves, glabrous, spathulate, sinuate-crenate, few on young plants or new branches and mature plants almost leafless [17].*P. harmala*(Zygophyllaceae) is a perennial herbaceous, glabrous plant, which may grow to 30-100 cm. It has alternately spaced thong-like leaves, which have a strong deterrent odor when rumpled. Opposite to the leaves are solitary white flowers with green veins. The flowering period is March to April. The fruits are globose capsules with 3 chambers containing many angular blackish seeds [18].

***Soil and amino acids analysis:***

Soil samples were collected as a profile at a depth of 0 to 40 cm in the spring and autumn seasons during the two locations WAR and WGH. Three replicates were taken from each stands and carried to the laboratory in plastic bags. The physical and chemical properties of soil including pH of the soil extract, electrical conductivity (EC), and mineral content ($Na^+$, $K^+$, $Ca^{2+}$, $Mg^{2+}$, $Cl^-$ and $S^-$) were estimated using a saturation paste [19].Total amino acids content were estimated using Clait Amino Acid Analyzer SW [20] at Central Laboratories, Faculty of Agriculture, Al-Azhar University, Cairo, Egypt.

***Statistical analysis:***

The data collected in this study was evaluated using Rank sum and principal component analysis (PCA). Rank sum (RS) = Rank mean ($\bar{R}$) + Standard deviation of rank (SDR) and SDR= $(S_i^2)^{0.5}$[21]. The PCA was performed for better understanding of the relationships among amino acids and soil analysis using a computer software program PAST version 2.17c.

## RESULTS AND DISCUSSIONS

***Soil analysis:***

Mechanical and chemical properties of soil at 0-40 depth from up, mid and down streams in Wadi El-Arbaeen (WAR) and Wadi Ghrandal (WGH) are shown in Table 1. The coarse sand and fine sand percentages of soil at 0-40 depth from up, mid and down at WGH were higher than WAR. The highest values of silt % were registered in the upstream for WGH, as well as in mid and down streams for WAR. While, the clay % had the highest values in up and mid streams at WGH, and downstream at WAR. The values of soil water content in winter season was higher than in the summer at the three streams during the two studied wadis. The values of pH and electric conductivity (EC) of soil solutions were higher in the three streams of WGH than in WAR. While, the values of mineral analysis ($S^-$, $Cl^-$, $Ca^{++}$, $Mg^{++}$, $Na^+$ and $K^+$) in the three streams of WAR were higher than WGH. The pH values fluctuated in the basic range at the three streams during the two wadis (greater than 7), except downstream in WAR was less than 7 (acidic). Therefore, the two locations tended to be slightly alkaline. The estimated soluble salts in the soil were dominated by $Ca^{+2}$ and $Cl^-$[22]. Soil characteristics are the main factors influencing plant growth and the distribution of plant communities. Several researchers have proven that there is a relationship between vegetation and soil features [23,24,25]. El-Khatib [26] stated that the soil depth is an important factor restricting the type of vegetation in the Egyptian desert wadis. A thin soil will be moister during the rainy season, but will be dried by the approach of the dry season, here ephemeral vegetation appear. A deep soil allows the storage of some water in the subsoil.



Table 1: Mechanical and chemical properties of soil at 0-40 depth from up, mid and down streams in Wadi El-Arbaeen and Wadi Ghrandal.

| Location | Sites | Mechanical properties | | | | | | Chemical properties | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Coarse sand (1-0.5) | Fine sand (0.25-0.1) | Silt (0.05-0.002) | Clay <(0.002) | Water content | | pH | EC | $S^-$ | $Cl^-$ | $Ca^{++}$ | $Mg^{++}$ | $Na^+$ | $K^+$ |
| | | | | | | Summer | Winter | | | | | | | | |
| Wadi El-Arbaeen | Up | 18.61 | 7.43 | 3.14 | 3.11 | 8.12 | 12.11 | 7.31 | 1.31 | 3.45 | 15.31 | 5.90 | 170.21 | 10.12 | 0.87 |
| | Mid | 22.45 | 8.69 | 4.15 | 4.12 | 9.01 | 14.13 | 7.10 | 0.81 | 1.91 | 2.91 | 3.92 | 120.12 | 4.90 | 0.42 |
| | Down | 20.41 | 15.12 | 11.13 | 17.16 | 12.11 | 16.12 | 6.80 | 0.91 | 1.79 | 3.12 | 3.80 | 142.10 | 4.32 | 0.32 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Wadi Ghrandal | Up | 46.23 | 41.31 | 3.42 | 6.71 | 2.41 | 4.16 | 7.60 | 1.44 | 0.80 | 2.51 | 1.80 | 0.68 | 0.62 | 0.05 |
| | Mid | 47.13 | 45.13 | 3.13 | 8.10 | 4.22 | 8.15 | 7.90 | 2.36 | 0.70 | 2.69 | 1.85 | 0.69 | 2.31 | 0.12 |
| | Down | 50.16 | 48.40 | 3.12 | 9.12 | 9.14 | 12.11 | 7.80 | 8.12 | 0.63 | 0.72 | 1.00 | 3.20 | 3.10 | 0.13 |

**Amino acids:**

The concentration of amino acids present in *Z. spinosa* and *P. harmala* at the spring and autumn seasons under WAR and WGH are given in Table 2.The concentrations of eleven out of eighteen amino acids in the spring season were higher than the autumn season for both species *Z. spinosa*and *P. harmala*during the location WAR. Opposite, twelve and eleven amino acids concentrations of *Z. spinosa*and *P. harmala*in the autumn season were higher than the spring season during the location WGH. Proline was the amino acid with the highest accumulation compared to the rest of amino acids in the two studied species at the spring and autumn seasons during the two studied locations. This agrees with the earlier findings of El-Absy [27] and Kasim et al. [28] in *Artemisia judaica* and *Achillea fragrantissima* at the wet and dry season during WAR. On the other hand, the amino acid Histidine recorded the lowest accumulation in our study. Generally, amino acids content in the studied two species were differed from one species to another at the spring and autumn seasons under the two locations. Similar findings were mentioned by Salama et al [22]. Proline is believed that acts as an osmoprotectant in plants subjected to drought conditions, whereas it is plays an important role in the stimulation of root elongation at low water potentials [29]. Studies on fourteen grasses, eleven annuals and three perennials by Bawa [30], reveal a multifold increase in free proline content from stress free to moisture stress conditions, whereas some well adapted grasses show insignificant amount of proline under similar conditions.

During WAR in the spring and autumn seasons, *Z. spinosa*had the highest values of Aspartic, Cysteine, Methionine, Phenylalanine, Trptophane, Proline, while *P. harmala* showed the highest content of Serine, Histidine, Theronine, Arginine, Tyrosine, Valine, Isoleucine, Leucine. The highest values of Glutamic, Glycine and Alanine were found for*Z. spinosa* at spring season and for *P. harmala*at autumn season. Lysine concentration of *Z. spinosa*and *P. harmala*were increased in autumn and spring seasons, respectively. In WGH, Serine, Glycine, Theronine, Phenylalanine, Leucine and Trptophane were the amino acids which showed highest accumulation in *Z. spinosa*under the spring and autumn season; whilst, the amino acids Aspartic, Methionine and Isoleucine recorded highest accumulation in *P. harmala* at spring and autumn seasons. The amino acids Glutamic, Histidine, Arginine and Lysine were give the highest values of *Z. spinosa*and *P. harmala*in autumn and spring seasons, (recast)respectively, unlike of the amino acids Alanine, Tyrosine, Cysteine, Valine and Proline. Migahid [31] and Salama et al. [22] reported that, the total free amino acids content in *Z. spinosa* had significantly in the summer season higher than the winter season(check).The main amino acids identified at the organic acid and amino acid region were isoleucine, valine, threonine, alanine, proline, lysine, 4-hydroxyisoleucine, and asparagine in the different *P. harmala*parts [32].

Table 2: The amino acids (mg/g) of *Z. spinosa* and *P. harmala* at the spring and autumn seasons under the two locations WAR and WGH.

| Species | *Z. spinosa* L. | | | | *P. harmala* L. | | | |
|---|---|---|---|---|---|---|---|---|
| Locations | WAR | | WGH | | WAR | | WGH | |
| Seasons / Amino acids | Spring | Autumn | Spring | Autumn | Spring | Autumn | Spring | Autumn |
| Aspartic | 13.40 | 15.30 | 9.17 | 10.70 | 11.40 | 9.18 | 11.10 | 12.60 |
| Glutamic | 9.60 | 7.90 | 8.17 | 11.12 | 8.20 | 10.16 | 11.12 | 10.12 |
| Serine | 2.60 | 1.90 | 4.10 | 2.80 | 4.20 | 4.30 | 3.20 | 2.40 |
| Histidine | 0.86 | 0.73 | 0.84 | 1.80 | 1.82 | 1.33 | 0.93 | 0.90 |
| Glycine | 3.70 | 1.70 | 1.90 | 4.20 | 2.80 | 1.86 | 1.73 | 3.30 |
| Theronine | 1.96 | 2.20 | 2.56 | 3.60 | 6.20 | 4.70 | 1.78 | 1.90 |
| Arginine | 5.10 | 3.94 | 4.63 | 8.10 | 7.30 | 6.80 | 6.20 | 3.92 |
| Alanine | 7.22 | 6.12 | 7.30 | 5.37 | 6.10 | 7.32 | 5.60 | 6.10 |
| Tyrosine | 2.90 | 1.88 | 3.20 | 3.30 | 4.60 | 4.12 | 2.82 | 3.60 |
| Cysteine | 1.20 | 1.12 | 1.21 | 0.72 | 0.94 | 0.90 | 0.96 | 1.10 |
| Valine | 3.20 | 2.70 | 4.80 | 3.40 | 5.42 | 3.60 | 3.40 | 4.72 |
| Methionine | 1.30 | 1.62 | 1.22 | 0.92 | 1.20 | 1.30 | 1.40 | 1.66 |
| Phenylalanine | 6.10 | 6.30 | 6.13 | 6.90 | 5.20 | 4.30 | 5.60 | 4.26 |
| Isoleucine | 7.19 | 7.30 | 5.90 | 6.80 | 8.12 | 7.60 | 6.30 | 7.66 |
| Leucine | 8.03 | 8.90 | 8.93 | 9.10 | 8.30 | 9.66 | 8.12 | 8.80 |
| Lysine | 4.06 | 3.70 | 3.81 | 4.12 | 4.60 | 3.68 | 4.15 | 3.80 |
| Trptophane | 2.20 | 1.88 | 2.06 | 2.60 | 1.72 | 1.86 | 1.62 | 2.50 |
| Proline | 19.38 | 24.81 | 24.11 | 14.45 | 11.88 | 17.31 | 23.29 | 21.11 |



To determine the highest concentration of amino acids in our study, the mean rank and standard deviation of ranks for all factors study (species, seasons and locations) were calculated (Table 3). Based on rank method, the amino acids Proline, Aspartic, Glutamic, Leucine, Isoleucine and Alanine showed that the lowest values of rank mean, standard deviation and rank sum. Thus, these amino acids were identified as the most accumulation amino acids in the two species. The concentration percentages of these amino acids in the two plants were ranged from 54.00% to 70.33% in the two seasons under the two locations. These amino acids concentrations of the autumn season were greater than those of the spring season in *Z. spinosa*under WAR, and in *P. harmala*under WAR and WGH., while the spring season were higher than autumn season in*Z. spinosa*under WGH. El-Absy [27] and Kasim et al. [28] stated that during WAR the amino acids values in the dry season were greater than the wet season in *Achillea fragrantissim*a.On the other hand, the amino acids Histidine, Cysteine and Methionine showed that the highest values of rank mean, standard deviation and rank sum. Therefore, the lowest concentrations of amino acids were registered by Histidine, Cysteine and Methionine. The concentrations of other amino acids were moderate in the two studied species at the spring and autumn seasons during WAR and WGH. Movafeghia et al.[33] reported that, the concentration of proline was high, followed by glutamic acid and tyrosine, while, the amino acids cysteine and methionine, lysine and arginine, leucine and isoleucine, threonine and asparagine were low in *P. harmala*. On the other hand, Ahmed et al. [34] stated that, the highest content was recorded for tyrosine, whereas the lowest levels were recorded for arginine, alanine, and histidine in *P. harmala*.

Table 3: Ranks of amino acids in the two species at the spring and autumn seasons during the two locations WAR and WGH.

| Species | *Z. spinosa* L. | | | | *P. harmala* L. | | | | MR | VR | SDR | RS |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Locations | WAR | | WGH | | WAR | | WGH | | | | | |
| Seasons / Amino acids | Spring | Autumn | Spring | Autumn | Spring | Autumn | Spring | Autumn | | | | |
| Aspartic | 2 | 2 | 2 | 3 | 2 | 4 | 3 | 2 | 2.50 | 0.57 | 0.76 | 3.26 |
| Glutamic | 3 | 4 | 4 | 2 | 4 | 2 | 2 | 3 | 3.00 | 0.86 | 0.93 | 3.93 |
| Serine | 13 | 12 | 10 | 14 | 13 | 9 | 11 | 14 | 12.00 | 3.43 | 1.85 | 13.85 |
| Histidine | 18 | 18 | 18 | 16 | 15 | 16 | 18 | 18 | 17.13 | 1.55 | 1.25 | 18.37 |
| Glycine | 10 | 15 | 15 | 9 | 14 | 14 | 14 | 12 | 12.88 | 5.27 | 2.30 | 15.17 |
| Theronine | 15 | 11 | 13 | 11 | 7 | 8 | 13 | 15 | 11.63 | 8.84 | 2.97 | 14.60 |
| Arginine | 8 | 8 | 9 | 5 | 6 | 7 | 6 | 9 | 7.25 | 2.21 | 1.49 | 8.74 |
| Alanine | 5 | 7 | 5 | 8 | 8 | 6 | 7 | 6 | 6.50 | 1.43 | 1.20 | 7.70 |
| Tyrosine | 12 | 13 | 12 | 13 | 11 | 11 | 12 | 11 | 11.88 | 0.70 | 0.83 | 12.71 |
| Cysteine | 17 | 17 | 17 | 18 | 18 | 18 | 17 | 17 | 17.38 | 0.27 | 0.52 | 17.89 |
| Valine | 11 | 10 | 8 | 12 | 9 | 13 | 10 | 7 | 10.00 | 4.00 | 2.00 | 12.00 |
| Methionine | 16 | 16 | 16 | 17 | 17 | 17 | 16 | 16 | 16.38 | 0.27 | 0.52 | 16.89 |
| Phenylalanine | 7 | 6 | 6 | 6 | 10 | 9 | 7 | 8 | 7.38 | 2.27 | 1.51 | 8.88 |
| Isoleucine | 6 | 5 | 7 | 7 | 5 | 5 | 5 | 5 | 5.63 | 0.84 | 0.92 | 6.54 |
| Leucine | 4 | 3 | 3 | 4 | 3 | 3 | 4 | 4 | 3.50 | 0.29 | 0.53 | 4.03 |
| Lysine | 9 | 9 | 11 | 10 | 11 | 12 | 9 | 10 | 10.13 | 1.27 | 1.13 | 11.25 |
| Trptophane | 14 | 13 | 14 | 15 | 16 | 14 | 15 | 13 | 14.25 | 1.07 | 1.04 | 15.29 |
| Proline | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.00 | 0.00 | 0.00 | 1.00 |

MR: mean rank; VR: variance rank; SDR: standard deviation of ranks; RS: rank sum.



The principle component analysis (PCA) was performed to better understand the relationship among amino acids and the two species in the spring and autumn seasons during the two locations. Eigenvalues can be defined as those values showing the significance of ordination axes where the highest eigenvalues is the most significant one [2]. In the Table 4, the first main (PCA1) extracted had eigenvalues larger than one (Eigen value >1) with value 7.50, thus, the eigenvalue can be used as an inclusion criterion. While, the other PCAs had eigenvalues less than one (Eigen value < 1). According to Helmy et al. [2] the eigenvalues had lower than one for the first four axes of CCA ordination.The analysis displayed that the PCA1 contributed in 93.74% of the variance of the original variables with amino acids Proline, Aspartic, Glutamic, Leucine, Isoleucine, Alanine, Arginine and Phenylalanine, and indicate that these amino acids had maximum loadings on PCA in the two species at the spring and autumn seasons during the two locations. Therefore, the PCA1 can be named as the high amino acids content in the the two species. As for the PCA2 explained 3.54% of the total variability with other studied amino acids in our study. Thus, the PCA2 can be named a least content of amino acids in the two species during the studied environments. The PCA1 and PCA2 explained 97.28% of the total variance of the original variables. The first three principal components (PC1, PC2, and PC3) accounted for 92.07% of the original variable information in *P. harmala*(PC1: 62.77%, PC2: 19.81%, and PC3: 9.49%). The accumulation of amino acids that have high PCA1 in the two species are suitable at spring and autumn seasons under the two locations. Thus, Proline, Aspartic, Glutamic, Leucine, Isoleucine, Alanine, Arginine and Phenylalanine are superior amino acids in the two species with their high PCA1 under these studied environments. PCA was applied to the amino acid contents of different plants by Kumar et al.[35] and they stated that the first four components of PCA explained 86.33% of the total variance, and the amino acids i.e., alanine, lysine, cysteine, leucine and arginine had maximum loadings on PCA.

Table 4: Results of principal component analysis (PCA) for amino acids of the two species based on wet and dry seasons during the two locations.

| Amino acids | PCA1 | PCA2 |
|---|---|---|
| Aspartic | 3.64 | 0.54 |
| Glutamic | 2.48 | 0.52 |
| Serine | -1.41 | -0.07 |
| Histidine | -2.67 | -0.30 |
| Glycine | -1.74 | -0.13 |
| Theronine | -1.36 | 0.65 |
| Arginine | 0.25 | 0.87 |
| Alanine | 0.51 | -0.05 |
| Tyrosine | -1.31 | 0.10 |
| Cysteine | -2.80 | -0.68 |
| Valine | -0.97 | 0.03 |
| Methionine | -2.62 | -0.65 |
| Phenylalanine | 0.01 | -0.03 |
| Isoleucine | 1.00 | 0.50 |
| Leucine | 1.96 | 0.42 |
| Lysine | -0.94 | -0.05 |
| Trptophane | -2.15 | -0.48 |
| Proline | 8.13 | -1.18 |
| Eigen value | 7.50 | 0.28 |
| Percent of variance | 93.74 | 3.54 |
| Cumulative variance | 93.74 | 97.28 |



The relationships (similarities and dissimilarities) among amino acids based on the two species and the studied environments are graphically displayed in a biplot of PCA1 and PCA2 (Fig. 1). The PCA1 and PCA2 mainly distinguish the amino acids into four groups (Fig. 1a). The first group (G1) contained the Proline, this indicate that Proline concentrations were higher than other the amino acids in the two species at the spring and autumn seasons during the two locations. The proline concentration in nine plant species had the highest in autumn and the lowest in spring, this can be attributed to both salinity and water stress in the halophytes, and water stress alone in the psammophytes [36]. The second group (G2) consists of the most abundant amino acids after proline in decreasing order were aspartic , glutamic, leucine, isoleucine, alanine, arginine and phenylalanine. The third group (G3) comprised of the amino acids lysine, valine, tyrosine, serine, theronine and glycine, while, the fourth group include of the amino acids trptophane, methionine, cysteine and histidine. In general, the two species at the spring and autumn seasons during the two locations have the highest concentration of proline, moderate concentrations of the amino acids in G2 and G3 groups, and finally the lowest concentration from amino acids in G4 group. According to biplot analysis in the Fig.1b, the smallest acute angles (positive and significant correlations) were observed among serine, valine, tyrosine and theronine and were located in the first quadrant with *P. harmala*at the spring and autumn seasons during WAR. In the spring season under WGH, the amino acids alanine, cysteine, methionine and proline in *Z. spinosa*were located in the second quadrant and showed positive and significant correlations. The *Z. spinosa*in WAR was similar (the fourth quadrant) at the spring and autumn seasons and suitable for the two amino acids Aspartic and Phenylalanine (positive and significant correlations). The other amino acids of *Z. spinosa*in the dry seasons under WGH are grouped into the third quadrant and showed significant correlations in positive direction. The positive correlation between methionine and cysteinein *Z. spinosa*at the spring season during WGH and between proline and aspartic in *P. harmala*at the spring and autumn season under WGH were found. The positive correlation between the amino acids indicates the increasing of one amino acids leads to the increase of the other amino acid under studied environments. Kumar et al. [35] mentioned that all the amino acids showed positive correlation with each other except GABA and citrulline, and highest correlation existed between valine and aspartic acid.Amino acids are involved in the synthesis of other organic compounds, such as protein, amines, alkaloids, vitamins, enzymes, terpenoids and plant hormones that control various plant processes [37]. Gzik [38]reported that, the composition of free amino acids estimated by reversed phase high pressure liquid chromatography (HPLC) was changed by different stress conditions. In contrast to aspartic and glutamic acids that were only slightly influenced by the stress, the contents of acid amides and basic amino acids increased sharply. Most levels of the other free amino acids, except serine, were enhanced. The concentrations of serine, glycine and glutamate increased upon water stress, their total amount in severely stressed leaves ranging 5- to 6-fold higher than the total amount of valine, tyrosine, leucine and isoleucine at this stage of water deficit [39].

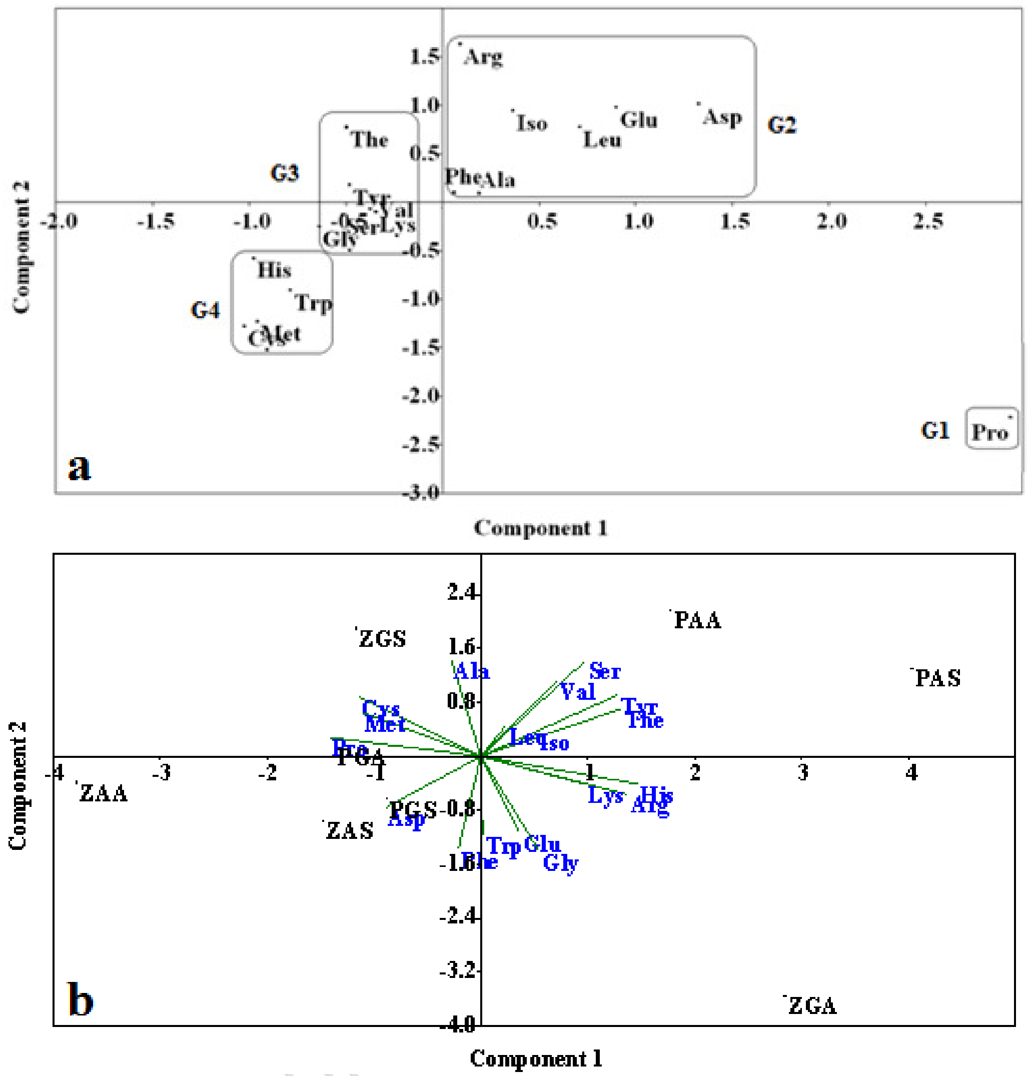



Fig. 1. Principal component analysis of the amino acids in Z. spinosa and P. harmala at the spring and autumn seasons during WAR and WGH. Asp: Aspartic; Glu: Glutamic; Ser: Serine; His: Histidine; Gly: Glycine; The: Theronine; Arg: Arginine; Ala: Alanine; Tyr: Tyrosine; Cys: Cysteine; Val: Valine; Met: Methionine; Phe: Phenylalanine; Iso: Isoleucine; Leu: Leucine; Lys: Lysine; Trp: Trptophane; Pro: Proline.ZAS and ZAA: *Z. spinosa* in WAR at the spring and autumn seasons, respectively; ZGS and ZGA: *Z. spinosa* in WGH at the spring and autumn seasons, respectively; PAS and PAA: *P. harmala* in WAR at the spring and autumn seasons, respectively; PGS and PGA: *P. harmala* in WGH at the spring and autumn seasons, respectively.

***Relationship between amino acids and soil analysis:***

The amino acids showed a dissimilar performance once they were positioned in opposing quadrants according to soil analysis data in the spring and autumn seasons under the two locations (Fig 2 and 3). Each amino acid behaves differently according to environmental conditions, indicating compensatory effects among them [40]. According to biplot analysis in the Fig 2, the amino acids glycine (5), methionine (12), cysteine (10), aspartic (1), glutamic (2), alanine (8), phenylalanine (13), trptophane (17) and proline (18) were located in the first and third quadrants and positively correlated with pH, $K^+$, $Na^+$, $S^-$, $Ca^{++}$, $Cl^-$, Ec and $Mg^{++}$, while the other amino acids are located in the second quadrant and positively correlated with water content (WC) in the spring season during the WAR. On the other hand, positive correlation among the amino acids (aspartic, cysteine, methionine, phenylalanine, lysine, trptophane and proline) and soil analysis (pH, $K^+$, $Na^+$, $S^-$, $Ca^{++}$, $Cl^-$, Ec and $Mg^{++}$) were found, whilst the other amino acids and WC were showed correlation in positive direction at the autumn season under the WAR.

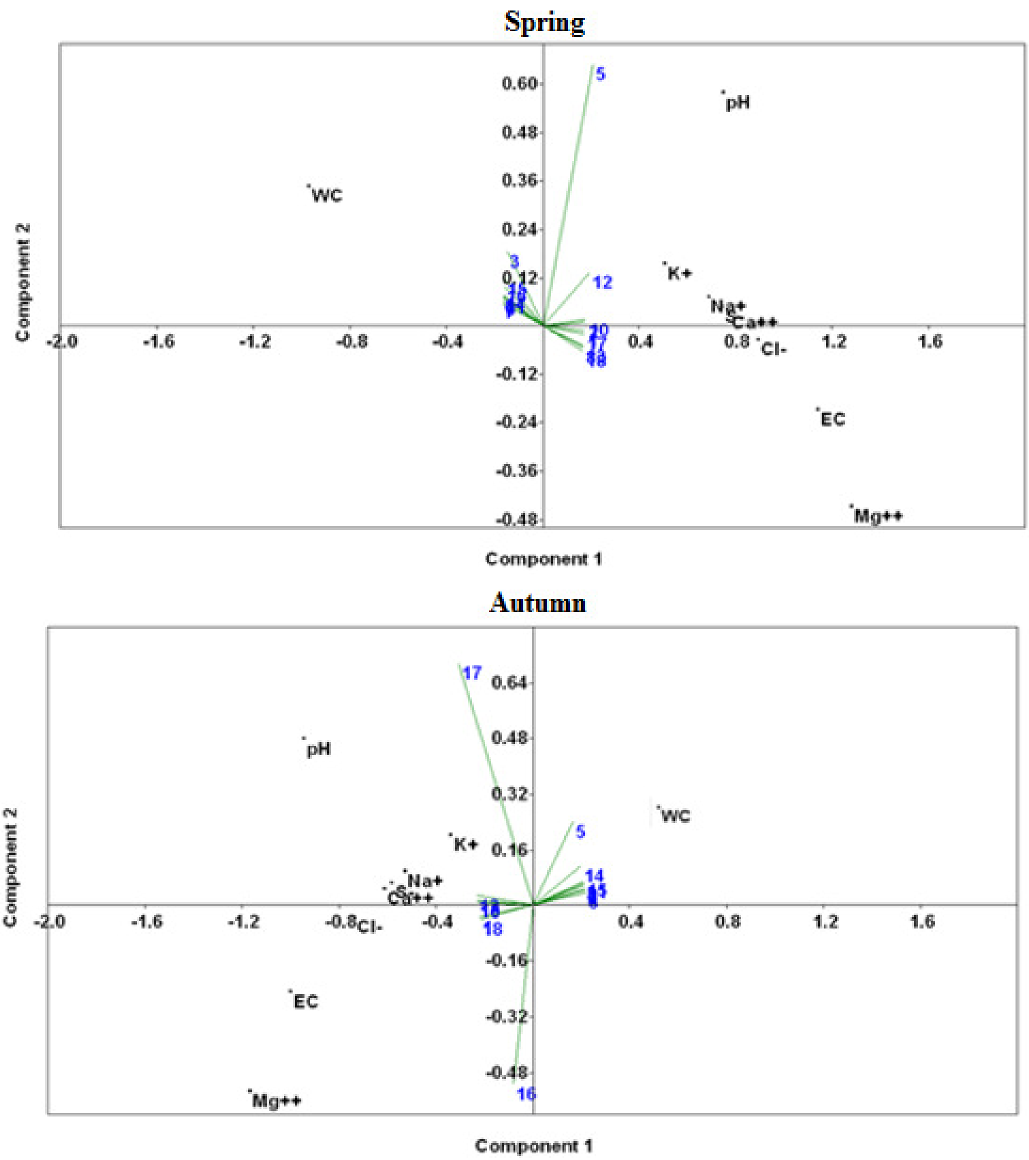
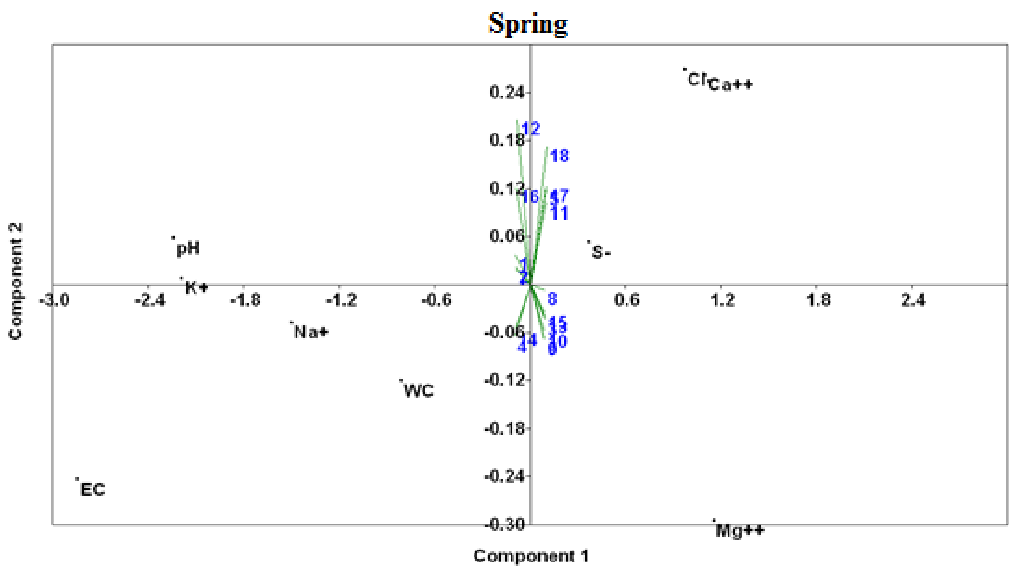



Fig. 2. Biplot diagram based on first two principal component axes of amino acids and soil analysis in the spring and autumn seasons under Wadi El-Arbaeen. 1: Aspartic; 2: Glutamic; 3: Serine; 4: Histidine; 5: Glycine; 6: Theronine; 7: Arginine; 8: Alanine; 9: Tyrosine; 10: Cysteine; 11: Valine; 12: Methionine; 13: Phenylalanine; 14: Isoleucine; 15: Leucine; 16: Lysine; 17: Trptophane; 18: Proline.

As for WGH as shown in Fig. 3, the pH, $K^+$, $Na^+$, WC and EC positively correlated with the amino acids aspartic (1), glutamic (2), histidine (4), arginine (7), methionine (12), isoleucine (14) and lysine (16) in the spring season, and with the amino acids aspartic (1), alanine (8), tyrosine (9), cysteine (10), valine (11), methionine (12), isoleucine (14) and proline (18) in the autumn season. While, the mineral elements $S^-$, $Cl^-$ and $Ca^{++}$ were positively correlated with the amino acids glycine (5), valine (11), trptophane (17) and proline (18) in the spring season, and with the amino acids leucine (15), lysine (16) and trptophane (17) in the autumn season. However, the other amino acids were showed correlation in positive direction with $S^-$ and $Mg^{++}$ in the spring and autumn seasons.



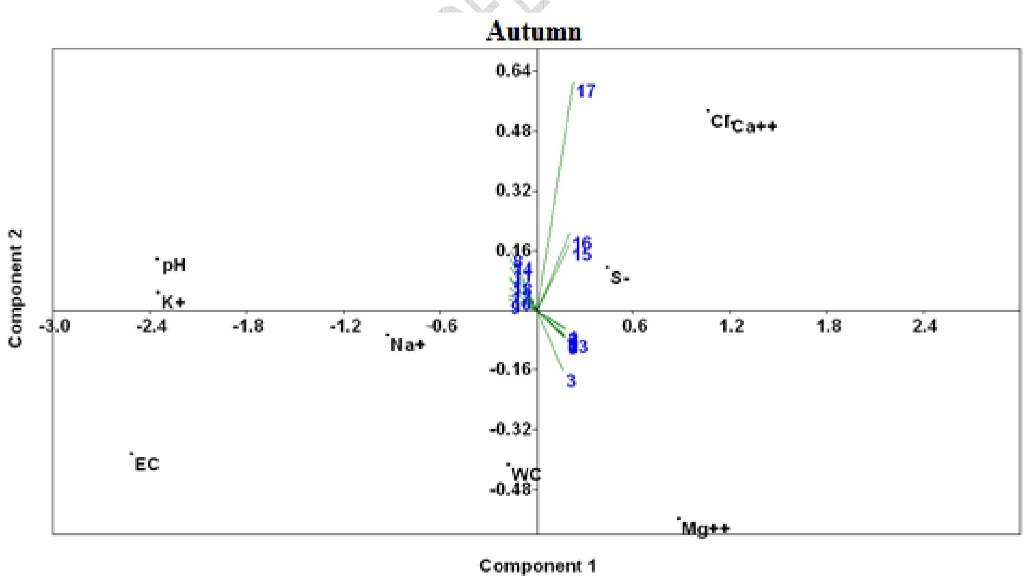




Fig. 3. Biplot diagram based on first two principal component axes of amino acids and soil analysis in the spring and autumn seasons under Wadi Ghrandal.1: Aspartic; 2: Glutamic; 3: Serine; 4: Histidine; 5: Glycine; 6: Theronine; 7: Arginine; 8: Alanine; 9: Tyrosine; 10: Cysteine; 11: Valine; 12: Methionine; 13: Phenylalanine; 14: Isoleucine; 15: Leucine; 16: Lysine; 17: Trptophane; 18: Proline.

Generally, there are positive correlation among the amino acids i.e. Aspartic, Cysteine, Methionine, Phenylalanine, Trptophane and Proline; and the soil analysis i.e., pH, $K^+$, $Na^+$, $S^-$, $Ca^{++}$, $Cl^-$, Ec and $Mg^{++}$ in the spring and autumn seasons during WAR. While, positive association among the amino acids (Aspartic, Methionine and Isoleucine) and pH, K+, Na+, WC and EC; as well as among the amino acid Trptophane and soil analysis ($S^-$, $Cl^-$ and $Ca^{++}$) in the spring and autumn seasons during WGH. Finally, the amino acids Aspartic, Methionine and Trptophane had positive correlation with the most soil analysis in the spring and autumn season under the two wadis.According to Prommer et al. [41], the gross production rates of amino compounds were strongly correlated with soil physicochemical parameters. As to water availability, Carrera et al. [42] stated that, under water stress conditions in the field, protein had a linear negative correlation with increasing water deficit. Significant linear regressions were detected for amino acid content regarding precipitation minus potential evapotranspiration [40]. Anderson & Bedford [43] suggested that the suppression of amino-acid uptake in the clam *Rangia cuneafa* at low salinities was not directly due to the reductions in the levels of $Na^+$ or $Cl^-$ in the incubation medium but to osmoregulatory factors.Prommer et al.[41] mentioned that the glucosamine exhibited significant negative correlations with soil pH. In contrast, gross production rates of the other four amino compounds, i.e. muramic acid, L-alanine, D-alanine, and mDAP, were all positively related to pH and cation exchange capacity. No significant effect of pH on amino-acid absorption was observed over the pH range 6.2-8.8 [44]. In contrast, the positive relationship between production rates of D-alanine with soil pH [45]. The amino acids were negatively related to soil pH [46].



## CONCLUSION

The values of $S^-$, $Cl^-$, $Ca^{++}$, $Mg^{++}$, $Na^+$ and $K^+$ of soil solutions at the up, mid and down streams were higher in Wadi El-Arbaeen (WAR) and Wadi Ghrandal (WGH), while unlike of pH and electric conductivity (EC). Amino acids content in *Z. spinosa* and *P. harmala*were differed from one species to another at the spring and autumn seasons under the two locations. According to PCA, the amino acids can be classified into four groups. Based on rank method and PCA, the amino acids Proline (Group 1), Aspartic, Glutamic, Leucine, Isoleucine, Alanine, Arginineand and Phenylalanine (Group 2) were recorded the highest content of total amino acids, while, Histidine, Cysteine and Methionine (group 4) were found to contain th lowest values of the total amino acids. The amino acids Aspartic, Methionine and Trptophane were positively correlated with most soil analysis in the spring and autumn season under the two wadis. It seemed that the *Z. spinosa*and *P. harmala*were adapted with drought conditions in WAR and WGH.

## REFERENCES


1. Moustafa AA, Klopatek JM. Vegetation and landforms of the St. Katherine area, Southern Sinai, Egypt. Journal of Arid Environments, 1995;30: 385-395.
2. Helmy MA, Moustafa AA, Abd El-Wahab RH, Batanouny KH. Distribution behavior of seven common shrubs and trees growing in South Sinai, Egypt. Egyptian Journal of Botany, 1996;36(1): 53-70.

3. Kamh RN, El-Kadi MA, El-Kadi AH, Dahdoh MSA. Evaluation of Mn forms in selected soils of Sinai. Desert Institute Bulletin, A.R.E. 1989;39(1):183-197.
4. El-Sawi SA, Motawe HM, Ahmad SS, Ibrahim ME. Survey and Assessment of Chemical Composition and Biological Activity of Some Wild Plants Growing in the Egyptian Eastern Desert. J. Mater. Environ. Sci. 2018;9(50):1495-1502.
5. Ahmed MZ, Khan MA. Tolerance and recovery responses of playa halophytes to light, salinity and temperature stresses during seed germination," Flora-Morphology, Distribution, Functional Ecology of Plants, 2010;205(11):764–771.
6. Mahmoudian M, Jalilpour H, Salehian P. Toxicity of *Peganum harmala*: Review and a case report. Iranian Journal of Pharmacology and Therapeutics, 2002;1(1):1–4.
7. Lamchouri F, Settaf A, Cherrah Y, Hassar M, Zemzami M, Atif N. In vitro celltoxicity of *Peganum harmala* alkaloids on cancerous cell-lines. Fitoterapia, 2000;71(1), 50–54.
8. Li S, Wang K, Gong C. Cytotoxic quinazoline alkaloids from the seeds of *Peganum harmala*," Bioorganic and Medicinal Chemistry Letters, 2018;28(2):103–106.
9. Hamden K, Masmoudi H, Ellouz F. Protective effects of *Peganum harmala* extracts on thiourea-induced diseases in adult male rats. J Environ Biol. 2008;29: 73–77.
10. Buchanan BB, Gruissem W, Jones RL. Biochemistry and Molecular Biology of Plants. Rockville, MD: American Society of Plant physiologists. 2000.
11. Shaheen AM, Fatma AR, Awatef GB, Nagwa MK, Hassan HH, and Foly HH. Total and exportable bulbs yield of onion as affected by msw compost and urea fertilizers," Journal of Applied Sciences Research, 2013;9(1):156–162.
12. Maeda H, Dudareva N. The shikimate pathway and aromatic amino acids biosynthesis in plants. Annu. Rev. Plant Biol. 2012;63, 73–105.
13. Rai VK. Role of amino acids in plant responses to stresses. Biologia Plantarum, 2002;45(4):481–487.
14. Jamtgard S, Nasholm T, Huss-Danell K. Nitrogen compounds in soil solutions of agricultural land. Soil Biol. Biochem. 2010;42, 2325–2330.
15. Taiz L, Zeiger E. Plant Physiology, 5$^{th}$ Edn. Sunderland: Sinauer Associates. 2013.
16. Yoshiba Y, Kiyosue T, Nakashima K, Yamaguchi-Shinozaki K, Shinozaki K. Regulation of levels of proline as an osmolyte in plants under water stress. Plant Cell Physiol., 1997;38:1095-1102.
17. Boulos L. Flora of Egypt, Vol 2: Geraniaceae – Boraginaceae: Al Hadara Publ., Cairo. 2000.
18. Rechinger KH. Flora Iranica, Akademische Druck Verlagsanstalt; 1982;18-20.
19. Tuzuner A. Soil and Water Laboratory Analysis Guide. Ankara: General Directorate of Rural Services Publications. 1990.
20. Pellet PL, Young VR. Nutritional evaluation of protein foods. Published by the United Nation Univ. 1980.
21. Farshadfar E, Elyasi P. Screening quantitative indicators of drought tolerance in bread wheat (*Triticum aestivum* L.) landraces, Eur. J. of Exper. Biol., 2012;2(3): 577-584.

22. Salama F, Gadallah M, Sayed S, Abd El-Galil A. Adaptive Mechanisms in *Zilla spinosa* and *Leptadenia pyrotechnica* Plants to Sever Aridity in the Egyptian Deserts. Not Sci Biol, 2016;8(4):498-510.
23. Liangpeng Y, Jian M, Yan L. Soil salt and nutrient concentration in the rhizosphere of desert halophytes. Acta Ecologica Sinica, 2007;27: 3565–3571.
24. Morsy AA. Molecular variations of *Achillea fragrantissima* (Forssk.) SCH. BIP. growing in five areas of South Sinai. International Journal of Agriculture and Biology,2007; 9: 11–17.
25. Youssef AM, Al-Fredan MA. Community composition of major vegetations in the coastal area of Al-Uqair, Saudi Arabia in response to ecological variations. Journal of Biological Sciences, 2008;8:713–721.
26. El-Khatib AAA. Ecophysiological and palynological studies on the vegetation of the extreme arid part of Egypt. Ph.D. Thesis. Botany Department, Faculty of Science, Assiut University. 1993.
27. El-Absy KM. Ecophysiological studies on some economic plants from wadi El-Arbaeen and wadi El-Sheikh, South Sinai, Egypt. Ph.D. Thesis, Botany Department, Faculty of Science, Tanta University, Egypt. 2011.
28. Kasim WA, El-Shourbagy MN, El-Absy KM. Ecophysiological studies on Achillea fragrantissima and Artemisia judaica in two wadis of Southern Sinai, Egypt. Journal of Biodiversity and Environmental Sciences, 2014;5(1):306-321.
29. Yamada M, Morishita H, Urano K, Shiozaki N, Kazuko Y, Shinozaki K, Yoshiba Y. Effects of free proline accumulation in petunias under drought stress. Journal of Experimental Botany, 2005;56(417):1975 – 1981.
30. Bawa AK (1993). Moisture stress-induced proline accumulation in ephemeral grasses from the arid zone of India. Journal of Arid Environments, 1993;24(2):135-137.
31. Migahid MM. Effect of salinity shock on some desert species native to the northern part of Egypt. Jouranal of Arid Environments, 2003;53(2):155-167.
32. Herraiz T., Guillén H., Arán V. J., Salgado A. Identification, occurrence and activity of quinazoline alkaloids in *Peganum harmala* . *Food and Chemical Toxicology*. 2017;103:261–269.
33. Movafeghia A., Abedinia M, Fathiazadb F, Aliasgharpoura M, Omidic Y. Floral nectar composition of Peganum harmala L. Natural Product Research, 2009; 23(3):01–308.
34. Ahmed H, Abu El Zahab H, Alswiai G. Purification of antioxidant protein isolated from Peganum harmala and its protective effect against CCl4 toxicity in rats. Turkish Journal of Biology, 2013;37: 39-48.
35. Kumar V, Sharma A, Thukral AH, Renu Bhardwaj R. Amino acid profiling of the leaves of plants in the vicinity of river Beas, India. Journal of Chemical and Pharmaceutical Research, 2015;7(11):504-510.
36. Ozturk M, Turkyilmaz B, Gucel S, Guvensen A. Proline Accumulation in Some Coastal Zone Plants of the Aegean Region of Turkey. The European Journal of Plant Science and Biotechnology, 2011;5(Special Issue 2):54-56.
37. Glawischnig E, Tomas A, Eisenreich W, Spiteller P, Bacher A, Gierl A. Auxin biosynthesis in maize kernels. Plant Physiol., 2000;12(3): 1109-1120.
38. Gzik A. Accumulation of proline and pattern of amino acids in sugars beet plants in response to osmotic water and salt stress Environ. Exp. Bot., 1996;36:29-38.

39. Becker TW, Fock HP. The activity of nitrate reductase and the pool size of some amino acids and some sugars in water –stress maize leaves. Photosynthesis Research, 1986;8:267-274.
40. Carrera CS, Reynoso CM, Funes GJ, Martínez MJ, Dardanelli J, Resnik SL. Amino acid composition of soybean seeds as affected by climatic variables. Pesq. agropec. bras., Brasília, 2011;46(12):1579-1587.
41. Prommer, J., Wanek, W., Hofhansl, F., Trojan, D., Offre, P., Urich, T., ... & Hood-Nowotny, R. C. (2014). Biochar decelerates soil organic nitrogen cycling but stimulates soil nitrification in a temperate arable field trial. *PloS one*, *9*(1), e86388.
42. Carrera C, Martínez MJ, Dardanelli J, Balzarini M. Water deficit effect on the relationship between temperature during the seed fill period and soybean seed oil and protein concentrations. Crop Science, 2009;49:990‑998.
43. Anderson JW, Bedford WB. Physiological response of the estuarine clam Rangia cuneatu to salinity. i&l. Bull. mar. b&l. Lab., Woods Hole, 1973;144:229-247.
44. Stewart MG, Bamford DR. The effect of environmental factors on the absorption of amino acids by isolated gill tissue of the bivalve, *Mya arenarza* (L.). J. exp. mar. Biol. Ecol., 1976;24:205-212.
45. Padan E, Bibi E, Ito M, Krulwich TA. Alkaline pH homeostasis in bacteria: new insights. Biochimica et Biophysica Acta, 2005;1717, 67–88.
46. Cao X, Ma Q, Zhong C, Yang X, Zhu L, Zhang J. Elevational Variation in Soil Amino Acid and Inorganic Nitrogen Concentrations in Taibai Mountain, China. PLoS ONE, 2016;11(6):1-17.

.