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# EFFECT OF SPRAYING WITH PROLINE ACID AND POTASSIUM ON CHEMICAL TRAITS AND YIELD OF STRAWBERRY UNDER WATER STRESS

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## Abstract

The study was conducted in the plastic house of the Department of Plant Production Techniques, Al- Mussaib Technical College in the northern Babylon province during the agricultural season 2018-2019, To study the effect of Proline Acid at a concentration (0, 75, 150) ml.$L^{-1}$ and potassium ($K_2SO_4$) at a concentration (1,500,3000) mg.$L^{-1}$ and interaction between him on Growth and Production of Strawberries under Water Stress. The experiment also including the seedlings to water stress (industrial) by using three concentrations of polyethylene glycol (0,50,100) g.$L^{-1}$. The experiment was conducted according to the Complete Randomized Blocks Design with three replications, The averages were compared using the lowest significant difference (LSD) at a probability level of 0.05. The results were as follows: The treatment of Prolenic acid spraying at a concentration (150 ml.$L^{-1}$) and potassium at a concentration (3000 mg.$L^{-1}$) resulted in an increase in all vegetative growth indicators, while polyethene glycol 100 g.$L^{-1}$ treatment caused a decrease in all studied traits. The triple interaction treatment (Proline 150ml. $L^{-1}$ + Potassium 3000g. $L^{-1}$ + Glycol 75g.$L^{-1}$) led to an increase the number of flowers and the number of fruits and reduced the effects of water stress.
***Keywords*** **:** Proline, potassium, poly ethylene glycol, strawberry

## Introduction

Strawberry (*Fragaria x ananassa* Duch) belongs to the Rosaceae family and the genus Fragaria, one of the world's most widely distributed small fruit plants. North America is the native home of Strawberry, and the name Chillaik in Iraq refers to the word Chillaik, which is called Strawberry in Turkey (Bussell and Ennis, 2007). Strawberry fruits have a high nutritional value because they contain many compounds. Each 100 g of fresh fruits contains 90% water, 7.7 g carbohydrates, 32% kcal energy, 4.9 g sugars, 2 g fiber, 0.67 g protein, 0.3 g fat, minerals, vitamin C and antioxidants that play a major role in treating diseases (USDA, 2016). Strawberry plants are characterized by three composite leaves arranged spirally shape around a pressed stem called the crown and buds in the leaf armpit and may develop into a branch, crown, flower cluster, purlins or remain inactive (Zhao, 2007). Strawberry cultivation is still limited in Iraq due to several factors affecting on the growth, flowering and production of strawberries, including water scarcity, which is one of the environmental abiotic stresses that effect on the growth and production of plants and lead to many physiological and chemical changes from the low rate of cell division and thus lead to poor plant growth, Modern techniques have been used to study the effect of water stress. These techniques are the use of polyethene glycol (PEG) widely in many biochemical and industrial applications due to its non-toxicity in water stress experiments. It gives great accuracy in determining the water stress of the plant, as it does not penetrate through the plant cell wall and leads to a decrease in the Water potential in the soil solution as a method similar to soil dryness and thus have no role in regulating Osmotic pressure in cellular tissues (Kulkarmi and Deshpande, 2007). To reduce the damage of water stress must be followed several scientific ways to increase the efficiency of water use by the plant or the use of some compounds that help withstand drought, such as proline and potassium and others. Proline is an amino acid that plays an important role in protecting plants under the influence of water stress by maintaining the osmotic balance inside plant cells as a defensive method used by plants to withstand drought and maintain the internal structure of the protein and cellular membrane and is one of the most important means to reduce cellular damage as a result of drought and that the collecting of these compounds is important because they are a source of energy. In order to get rid of the stress situation and return to the normal state. (Farooq *et al*., 2012). Potassium also plays an important role in plant resistance to water stress conditions, as a result of entering many biological and physiological processes inside the plant, such as photosynthesis and transfer of photosynthesis products from the leaves to the storage members (Yassin, 2001) Its role in the mechanism of opening and closing stomata and stimulate more than 80 enzymes within the plant, and the formation of sugar, starch and protein, increase cell division and raise plant efficiency in the absorption of nutrients, especially nitrogen and phosphorus, and thus ensure the process of food balance, which is reflected positively in improving plant growth and increase productivity and improve Its quality (Aslam *et al*., 2012). Therefore, the study aims to reduce the damage of drought by using proline and potassium.

## Materials and Methods

The Factorial Experimental was conducted according to the Complete Randomized Blocks Design with three replications, The averages were compared using the lowest significant difference (LSD) at a probability level of 0.05 (Al Rawi and Khalaf Allah, 1980). strawberry seedlings were cultivated (Ruby Jim) cultivar, which was brought from the nurseries of the al-Abbas's Holy Shrine, which was cultivation in a pot 5 cm diameter contain 2-3 pairs of leaves in the plastic house on 15/10/2018 on the terraces with a height of 15 cm The distance between the terrace and another 75 cm ,Plant and another 25 cm after the creation of the drip irrigation system and cover the terraces with black plastic cover. Random samples were taken from different areas of the terraces soil before preparation for cultivation and at depths ranging from 0-30 cm and then the samples were mixed homogeneously for the purpose of analysis of some of the chemical and physical traits of the soil Table (1). Seedlings were exposed to water stress (drought) by adding polyethene glycol to the root zone of plants and in three concentrations (0,50,100) g.L$^{-1}$ and Which it's symbolized by (G0, G1, G2) respectively The seedlings were sprayed with proline at a concentration of (0, 75,150) ml$^{-1}$ and Which it's symbolized by (P0, P1, P2) respectively. After Two days spraying with potassium ($K_2SO_4$) with three concentrations (0.1500, 3000) mg.L$^{-1}$ and Which it's symbolized by (K0, K1, K2) respectively. To reduce the negative effects resulting from water stress in the early morning and until wetness and sprayed treatment compared to distilled water only, using a hand sprayer capacity (5 liters) and was added with each concentration (1 ml) of the dishwashing solution to break the surface tension, with rate of three sprayings, the distance between spraying and another is 20 days. The following measurements were taken: The leaves Content of Chlorophyll (SPAD Unit) by Chlorophyll meter type SPAD_502, Proline acid content according to (Bates *et al.*, 1973, Protein content according to Kaldal (Jackson, 1958), Number of flowers, Number of fruits, Total plant yield.

**Table 1 :** Some Physical and Chemical traits of Soil Before cultivation

| Values | Units | Traits |
|---|---|---|
| 6 | % | Clay |
| 10 | % | Silt |
| 84 | % | sand |
| silt loam | | Soil Textures |
| 7.20 | ds.m$^{-1}$ | EC |
| 6.80 | --------- | Ph |
| 22.05 | mg.k$^{-1}$ | Nitrogen availability |
| 7.00 | mg.k$^{-1}$ | phosphorus availability |
| 120 | mg.k$^{-1}$ | Potassium availability |
| 8.75 | mg.k$^{-1}$ | Nitrates |

## Results

**The leaves Content of Chlorophyll (SPAD Unit)**

Table (2) indicates that the treatment (P2) was significantly excelled which amounted to (19.33 SPAD), compared with the control treatment (P0) which amounted to (17.57 SPAD). The spraying with Potassium led to a significant increase in the leaves Content of Chlorophyll in strawberry leaves. The treatment (K2) was significantly excelled which gave amounted to (19.35 SPAD), compared to the control treatment (K0) which amounted to (17.69 SPAD). The results also showed that the leaves Content of Chlorophyll was significantly affected by the adding of polyethene glycol. The control treatment (G0) was significantly excelled which gave the highest average amounted to (20.45 SPAD), while treatment G2 gave the lowest the leaves Content of Chlorophyll (16.49 SPAD). Bi-interaction factors differed significantly between proline and potassium spraying. The P2K2 treatment showed the highest average of The leaves Content of Chlorophyll amounted to 21.91 (SPAD), while the control treatment gave P0K1 (17.09 SPAD). The treatment of P2G0 was significantly excelled in increasing the leaves content of chlorophyll which amounted to (22.28 SPAD), while the interaction treatment P0G2 gave the lowest average of this trait amounted to (14.86 SPAD). The relative chlorophyll content in the leaves was given (21.92SPAD), while the leaves content of chlorophyll of strawberries was decreased when treatment K0G2 which amounted to (15.00SPAD). The interaction between the study factors had a significant effect on the leaf content of chlorophyll. The treatment of triple interaction (P2 + K2 + G0) was significantly excelled which gave the highest average the leaf content of chlorophyll amounted to(25.03 SPAD) compared to the treatment P0 + K1 + G2 which gave the lowest average of these. traits which amounted to (13.83 SPAD).

**The leaves content of Proline acid (µmol g dry weight $^{-1}$)**

Table (3) showed that the adding of proline to the leaves caused the increase of The leaves content of Proline. The treatment (P2) significantly increased which amounted to (27.03 µmol g dry weight$^{-1}$) compared to the control treatment (P0) amounted to (20.36 µmol g dry weight$^{-1}$). The results also showed the effective effect of potassium spraying on the increase of proline content, as it excelled the treatment of K2 and gave the highest amount of proline in the leaves (25.35 µmol g dry weight$^{-1}$), while treatment K0 recorded the lowest amount of proline in the leaves amounted to (21.68 µmol g dry weight$^{-1}$). The results also showed that polyethene glycol has a significant role in increasing the proline content, as it excelled the treatment of G2 and gave the highest amount of proline in the leaves (31.11 µmol g dry weight$^{-1}$), compared to the control treatment G0 which gave amounted to (17.13 µmol g dry weight$^{-1}$) Table (3) shows there was a synergistic effect between the Bi-interaction treatments. The results showed that the interaction treatment (P2K2) was significantly which gave the highest proline in the leaves amounted to (29.03 µmol g dry weight$^{-1}$), The control treatment P0K0 gave the lowest proline content amounted to (18.58 µmol g dry weight $^{-1}$). The interaction between proline and glycol (G * P) also showed a significant increase in the leaves the content of Proline, The P2G2 treatment recorded the highest average amounted to (34.41 µmol g dry weight $^{-1}$), compared to the control treatment (P0G0) which gave (13.99 µmol g dry weight $^{-1}$). While the interaction between potassium and glycol (G * K) had a significant effect on strawberry leaves content of proline, The treatment K2G2 was recorded average amounted to (33.36 µmol g dry weight$^{-1}$), compared to the control treatment which gave the lowest amounted to (15.57 ملغم gm$^{-1}$). The triple interaction between the study factors (Proline * Glycol * Potassium) had a significant effect on increasing the leaves content of Proline. The interaction treatment P2K2G2 significantly increased which gave the highest amount of proline in the leaves (37.31 µmol g dry weight$^{-1}$), compared with the control treatment P0K0G0 which gave the average amounted to (11.62 µmol g dry weight $^{-1}$).

**The Percentage of protein in leaves (%)**

Table (4) shows that the adding of Proline caused a significant increase in the percentage of protein, where The treatment (P2) significantly increased which gave the highest percentage of protein (20.11%), while the control treatment P0 gave the lowest percentage of protein in the leaves amounted to (19.21%). The results in Table (4) also shows the effective effect of potassium spraying in increasing the percentage of protein in the leaves, where the treatment (K2) significantly excelled which gave the average amounted to (20.24%), compared with the control treatment (K0) amounted to (18.87%). While the results show that polyethene glycol has a significant effect in reducing the percentage of protein in the leaves, where the control treatment( G0 ) was excelled which gave the highest percentage of protein in the leaves amounted to (20.36%), while treatment G1 gave the lowest percentage of protein in the leaves (19.18%). The results also showed a significant increase in the percentage of protein, The interaction treatment (P2K2) was excelled which gave the highest percentage of the protein amounted to (20.87%), compared with the control treatment (P0K0) which gave the lowest percentage of the protein amounted to (18.25%). The interaction between proline and glycol (G * P) achieved a significant increase in the Percentage of protein in leaves, the treatment (P2G0) which gave the average amounted to (21.25%), compared to the treatment P0G2, which gave the lowest percentage of protein in the leaves amounted to (18.64%). While the interaction between potassium and glycol (G * K) had a significant effect in increase of the percentage of protein in strawberry leaves, where the treatment K2G0 gave the highest percentage of protein in the leaves amounted to (21.87%), compared with treatment K0G2, which gave the lowest percentage of protein in the leaves amounted to (18.41 %). Table (4) shows the presence of significant triple interaction between the factors studied, where the interaction treatment (P2 + K2 + G0) was significantly which gave the highest percentage of protein in the leaves amounted to (24.06%), while treatment (P0 + K0 + G2) gave the lowest percentage of protein amounted to (17.49 %).

**The number of flowers (Flower.plant$^{-1}$)**

Proline was significantly affected by reducing water stress and increasing the total number of flowers. Table (5), The treatment (P2) was significantly increased which gave the highest the number of flowers amounted to (24.85 Flower.plant$^{-1}$), while the control treatment gave the lowest number of flowers mounted to(19.63 Flower.plant$^{-1}$). While the potassium spraying significantly effects increase the number of flowers on the plant, where the treatment K2 significantly which gave the highest number of flowers amounted to (23.31 Flower.plant$^{-1}$), compared to the control treatment (K0) which recorded the lowest number of flowers amounted to (21.02 Flower.plant$^{-1}$), While polyethene glycol was a significant effect on the number of flowers, The results showed the significance excelled of the control treatment (G0) gave the highest number of flowers amounted to (23.87 Flower.plant$^{-1}$), while the treatment (G2) gave the lowest number of flowers on the plant amounted to (18.77 Flower.plant$^{-1}$). bi-interactions between the study factors caused significant effects on the number of flowers,. As the results showed the excelled of the interaction treatment (P2K2) which gave the highest number of flowers on the plant amounted to (27.39 Flower.plant$^{-1}$), while the control treatment (P0K0) gave the lowest number of flowers amounted to(18.06 Flower.plant$^{-1}$). The treatment (P2G1) achieved a significant increase in the number of flowers of the strawberry plant amounted to (27.23 Flower.plant$^{-1}$), compared with the treatment (P0G2) which gave the lowest number of flowers amounted to (16.18 Flower.plant$^{-1}$). While the interaction between potassium and glycol (G * K) had a significant effect on the number of flowers of strawberry plant, The treatment (K2G0) recorded the highest number of flowers (27.53 Flower.plant$^{-1}$), compared to the control treatment (K0G0) which gave the lowest number of flowers (17.28 Flower.plant$^{-1}$). The triple interaction between the study factors (proline * glycol * and potassium) had a significant effect on the number of flowers, interaction treatment (P2 + K2 + G1) was significantly excelled which gave the average amounted to (34.83 Flower.plant$^{-1}$), while treatment (P0 + K0 + G2) gave the lowest number of flowers amounted to (11.93 Flower.plant$^{-1}$).

**The number of fruits (fruit. plant$^{-1}$)**

Table (6) shows that the number of fruits increased significantly when sprayed with treatment (P2) which gave (10.12 fruit. plant$^{-1}$) compared to the control treatment P0 which gave (9.34 fruit. plant$^{-1}$). The same results showed that there was a significant effect on potassium spraying in increasing the number of strawberries, where the treatment (K2) was excelled and gave the highest number of fruits amounted to (10.04 fruit. plant$^{-1}$), while the control treatment gave the lowest number of fruits amounted to (9.54 fruit. plant$^{-1}$). The results of the same table also showed a significant effect for the adding of polyethene glycol .As the control treatment (G0)was excelled which gave (9.87 fruit. plant$^{-1}$), while the treatment (G2) gave the lowest number of fruits amounted to (9.52 fruit. plant$^{-1}$). Bi-interaction treatment also achieved an increase in the average of the number of fruits. The P2K2 treatment recorded an increase amounted to (10.74 fruit. plant$^{-1}$), compared to the control treatment P0K0 which gave (9.01 fruit. plant$^{-1}$). The interaction treatment between proline and glycol (P2G1) recorded the highest number of fruits amounted to (10.69 fruit-1), excelling to the treatment (P1G2) which gave (9.43 fruit. plant$^{-1}$). While the interaction treatment between potassium and glycol (K2G0) recorded the highest average number of fruits amounted to (11.13 fruit. plant$^{-1}$), excelling to the treatment (K2G2) which gave the lowest value (9.49 fruit. plant$^{-1}$) . the triple interaction between the study factors had a significant effect on the average of the number of fruits, The interaction treatment (P2 + K2 + G1 )which gave the value amounted to (12.63 fruit. plant$^{-1}$). While treatment P0 + K0 + G0 recorded a decrease in the average number of fruits amounted to (8.10 fruit. plant$^{-1}$).

**The plant yield (g. plant$^{-1}$)**

Plant yield represents the final result of all physiological processes during plant life, including the manufacture of photosynthesis products and then the total plant yield. The results of Table (7) indicate that treatment (P2) was significantly excelled which gave (79.43 g. plant$^{-1}$), compared with the control treatment (P0) which recorded the average amounted to (69.64 g. plant$^{-1}$). While the results showed that the treatment (K2)was excelled the increase in yield amounted to (76.46 g. plant$^{-1}$), compared with the control treatment (K0) which gave (73.79 g. plant$^{-1}$), while the results showed that the adding of a polyethene to glycol significantly in reducing the plant yield (g. plant$^{-1}$) as a result of stress caused by, The results showed that the control treatment (G0) was significantly excelled which gave (82.83 g. plant$^{-1}$), compared with treatment (G2), which recorded the lowest plant yield amounted to (67.44 g. plant$^{-1}$). The results also showed that the interaction between proline and potassium (P * K) had a significant effect on plant yield (g. plant$^{-1}$). The treatment (P2K2) was excelled and gave the highest average of the plant yield amounted to (82.70 g. plant$^{-1}$). While treatment (P0K0) gave the lowest the plant yield (68.81 g. plant$^{-1}$). The treatment (P2G0) achieved a significant increase in the plant yield (86.18 g. plant$^{-1}$), excelling to the treatment P0G2, which gave the lowest plant yield (58.14 g. plant$^{-1}$). The interaction treatment K2G0 gave a significant increase in the plant yield (85.53 g plant$^{-1}$) compared to the treatment K0G2, which gave the lowest the plant yield(66.88 g. plant$^{-1}$). The Triple interaction recorded significant differences between the study factors, where the triple interaction treatment (P2 + K2 + G0) achieved a significant increase which gave the average amounted to (91.20 g. plant$^{-1}$) and treatment P0K0G2 gave the lowest yield amounted to (57.30 g. plant$^{-1}$).

**Table 2 :** Effect of Proline and Potassium Acid Spraying and Adding of Polyethene glycol and their interaction on The leaves Chlorophyll Content under Water Stress (SPAD unit)

| Proline (ml$^{-1}$) | Potassium (mg$^{-1}$) | Polyethene glycol (g.L$^{-1}$) | | | Average P*K |
|---|---|---|---|---|---|
| | | G0 | G1 | G2 | |
| P0 | K0 | 18.63 | 17.63 | 15.03 | 17.10 |
| | K1 | 20.93 | 16.50 | 13.83 | 17.09 |
| | K2 | 21.27 | 18.60 | 15.70 | 18.52 |
| P1 | K0 | 18.67 | 19.13 | 16.60 | 18.13 |
| | K1 | 18.27 | 17.53 | 17.87 | 17.89 |
| | K2 | 19.47 | 18.00 | 15.37 | 17.61 |
| P2 | K0 | 21.53 | 18.60 | 13.37 | 17.83 |
| | K1 | 20.27 | 14.20 | 20.23 | 18.23 |
| | K2 | 25.03 | 20.27 | 20.43 | 21.91 |
| **LSD 0.05** | | **2.89** | | | **1.67** |
| **Proline* Polyethene glycol** | | | | | **Average P** |
| **P0** | | 20.28 | 17.58 | 14.86 | 17.57 |
| **P1** | | 18.80 | 18.22 | 16.61 | 17.88 |
| **P2** | | 22.28 | 17.69 | 18.01 | 19.33 |
| **LSD 0.05** | | **1.67** | | | **0.96** |
| **Potassium* Polyethene glycol** | | | | | **Average K** |
| **K0** | | 19.61 | 18.46 | 15.00 | 17.69 |
| **K1** | | 19.82 | 16.08 | 17.31 | 17.74 |
| **K2** | | 21.92 | 18.96 | 17.17 | 19.35 |
| **LSD0.05** | | **1.67** | | | **0.96** |
| **Average (Polyethene glycol)** | | 20.45 | 17.83 | 16.49 | |
| **LSD 0.05** | | **0.96** | | | |

**Table 3 :** Effect of Proline and Potassium Acid Spraying and Adding of Polyethene glycol and their interaction in Proline Acid Content in Leaves under Water Stress (μmol g dry weight$^{-1}$)

| Proline (ml$^{-1}$) | Potassium (mg$^{-1}$) | Polyethene glycol(g.L$^{-1}$) | | | Average P*K |
|---|---|---|---|---|---|
| | | G0 | G1 | G2 | |
| P0 | K0 | 11.62 | 18.66 | 25.44 | 18.58 |
| | K1 | 14.72 | 19.33 | 27.78 | 20.61 |
| | K2 | 15.64 | 20.55 | 29.48 | 21.89 |
| P1 | K0 | 15.10 | 20.16 | 29.25 | 21.50 |
| | K1 | 17.57 | 22.54 | 31.55 | 23.89 |
| | K2 | 18.25 | 23.86 | 33.29 | 25.13 |
| P2 | K0 | 19.97 | 23.66 | 31.28 | 24.97 |
| | K1 | 20.30 | 26.32 | 34.66 | 27.09 |
| | K2 | 21.02 | 28.77 | 37.31 | 29.03 |
| **LSD 0.05** | | **2.89** | | | **1.37** |
| **Proline* Polyethene glycol** | | | | | **Average P** |
| **P0** | | 13.99 | 19.51 | 27.57 | 20.36 |
| **P1** | | 16.97 | 22.19 | 31.36 | 23.51 |
| **P2** | | 20.43 | 26.25 | 34.41 | 27.03 |
| **LSD 0.05** | | **0.79** | | | 0.5 |
| **Potassium* Polyethene glycol** | | | | | **Average K** |
| **K0** | | 15.57 | 20.83 | 28.66 | 21.68 |
| **K1** | | 17.53 | 22.73 | 31.33 | 23.86 |
| **K2** | | 18.30 | 24.39 | 33.36 | 25.35 |
| **LSD 0.05** | | **0.79** | | | **0.5** |
| **Average (Polyethene glycol)** | | 17.13 | 22.65 | 31.11 | |
| **LSD 0.05** | | **0.5** | | | |

**Table 4 :** Effect of Proline and Potassium Acid Spraying and Adding of Polyethene glycol and their interaction in the percentage of Protein under Water Stress (%)

| Proline ($ml^{-1}$) | Potassium ($mg^{-1}$) | Polyethene glycol($g.L^{-1}$) | | | Average P*K |
|---|---|---|---|---|---|
| | | **G0** | **G1** | **G2** | |
| **P0** | **K0** | 18.15 | 19.12 | 17.49 | 18.25 |
| | **K1** | 20.15 | 18.06 | 20.00 | 19.40 |
| | **K2** | 21.21 | 20.30 | 18.42 | 19.98 |
| **P1** | **K0** | 19.54 | 19.19 | 17.84 | 18.86 |
| | **K1** | 20.13 | 20.33 | 19.21 | 19.89 |
| | **K2** | 20.33 | 20.15 | 19.12 | 19.87 |
| **P2** | **K0** | 20.38 | 18.19 | 19.89 | 19.49 |
| | **K1** | 19.32 | 20.16 | 20.44 | 19.97 |
| | **K2** | 24.06 | 17.10 | 21.45 | 20.87 |
| **LSD 0.05** | | **2.89** | | | **1.36** |
| **Proline* Polyethene glycol** | | | | | **Average P** |
| **P0** | | 19.84 | 19.16 | 18.64 | 19.21 |
| **P1** | | 20.00 | 19.89 | 18.72 | 19.54 |
| **P2** | | 21.25 | 18.48 | 20.59 | 20.11 |
| **LSD 0.05** | | **0.78** | | | **0.42** |
| **Potassium* Polyethene glycol** | | | | | **Average K** |
| **K0** | | 19.36 | 18.83 | 18.41 | 18.87 |
| **K1** | | 19.87 | 19.52 | 19.88 | 19.76 |
| **K2** | | 21.87 | 19.18 | 19.67 | 20.24 |
| **LSD 0.05** | | **0.78** | | | **0.42** |
| **Average (Polyethene glycol)** | | 20.36 | 19.18 | 19.32 | |
| **LSD 0.05** | | **0.42** | | | |

**Table 5 :** Effect of Proline and Potassium Acid Spraying and Adding of Polyethene glycol and their interaction in the number of flowers under Water Stress ($Flower.plant^{-1}$)

| Proline ($ml^{-1}$) | Potassium ($mg^{-1}$) | Polyethene glycol ($g.L^{-1}$) | | | Average P*K |
|---|---|---|---|---|---|
| | | **G0** | **G1** | **G2** | |
| **P0** | **K0** | 22.40 | 19.83 | 11.93 | 18.06 |
| | **K1** | 21.30 | 19.30 | 17.93 | 19.51 |
| | **K2** | 24.07 | 21.20 | 18.67 | 21.31 |
| **P1** | **K0** | 22.33 | 21.63 | 19.60 | 21.19 |
| | **K1** | 22.00 | 22.60 | 18.47 | 21.02 |
| | **K2** | 23.70 | 20.70 | 19.33 | 21.24 |
| **P2** | **K0** | 27.37 | 23.77 | 20.30 | 23.81 |
| | **K1** | 27.53 | 23.20 | 19.47 | 23.40 |
| | **K2** | 24.13 | 34.83 | 23.20 | 27.39 |
| **LSD 0.05** | | **2.89** | | | **4.62** |
| **Proline* Polyethene glycol** | | | | | **Average P** |
| **P0** | | 22.59 | 20.11 | 16.18 | 19.63 |
| **P1** | | 22.68 | 21.64 | 19.13 | 21.15 |
| **P2** | | 26.34 | 27.23 | 20.99 | 24.85 |
| **LSD 0.05** | | **2.67** | | | **1.54** |
| **Potassium* Polyethene glycol** | | | | | **Average K** |
| **K0** | | 24.03 | 21.74 | 17.28 | 21.02 |
| **K1** | | 23.61 | 21.70 | 18.62 | 21.31 |
| **K2** | | 27.53 | 22.01 | 20.40 | 23.31 |
| **LSD 0.05** | | **2.67** | | | **1.54** |
| **Average (Polyethene glycol)** | | 23.87 | 20.56 | 18.77 | |
| **LSD 0.05** | | **1.54** | | | |

**Table 6 :** Effect of Proline and Potassium Acid Spraying and Adding of Polyethene glycol and their interaction in The number of fruits under Water Stress (fruit. plant$^{-1}$)

| Proline (ml$^{-1}$) | Potassium (mg$^{-1}$) | Polyethene glycol(g.L$^{-1}$) | | | Average P*K |
|---|---|---|---|---|---|
| | | G0 | G1 | G2 | |
| P0 | K0 | 8.10 | 9.23 | 9.70 | 9.01 |
| | K1 | 9.63 | 9.43 | 9.63 | 9.57 |
| | K2 | 10.33 | 8.80 | 9.20 | 9.44 |
| P1 | K0 | 9.90 | 9.97 | 9.23 | 9.70 |
| | K1 | 9.93 | 9.90 | 9.43 | 9.76 |
| | K2 | 10.43 | 9.73 | 9.63 | 9.93 |
| P2 | K0 | 10.40 | 9.73 | 9.63 | 9.92 |
| | K1 | 10.30 | 9.43 | 9.60 | 9.78 |
| | K2 | 9. 97 | 12.63 | 9.63 | 10.74 |
| **LSD 0.05** | | **2.89** | | | **0.74** |
| **Proline* Polyethene glycol** | | | | | **Average P** |
| **P0** | | 9.36 | 9.16 | 9.51 | 9.34 |
| **P1** | | 10.09 | 9.87 | 9.43 | 9.80 |
| **P2** | | 10.16 | 10.60 | 9.62 | 10.12 |
| **LSD 0.05** | | **0.43** | | | **0.25** |
| **Potassium* Polyethene glycol** | | | | | **Average K** |
| **K0** | | 9.47 | 9.64 | 9.52 | 9.54 |
| **K1** | | 9.96 | 9.59 | 9.56 | 9.70 |
| **K2** | | 11.13 | 9.50 | 9.49 | 10.04 |
| **LSD 0.05** | | **0.43** | | | **0.25** |
| **Average (Polyethene glycol)** | | 9.86 | 9.87 | 9.52 | |
| **LSD 0.05** | | **0.25** | | | |

**Table 7 :** Effect of Proline and Potassium Acid Spraying and Adding of Polyethene glycol and their interaction in The plant yield under Water Stress(g. plant$^{-1}$)

| Proline (ml$^{-1}$) | Potassium (mg$^{-1}$) | Polyethene glycol(g.L$^{-1}$) | | | Average P*K |
|---|---|---|---|---|---|
| | | G0 | G1 | G2 | |
| P0 | K0 | 79.17 | 69.97 | 57.30 | 68.81 |
| | K1 | 78.73 | 70.57 | 58.30 | 69.20 |
| | K2 | 83.20 | 70.70 | 58.83 | 70.91 |
| P1 | K0 | 81.33 | 77.33 | 67.53 | 75.40 |
| | K1 | 82.30 | 76.27 | 66.97 | 75.18 |
| | K2 | 82.20 | 77.43 | 67.70 | 75.78 |
| P2 | K0 | 84.23 | 71.27 | 74.80 | 76.77 |
| | K1 | 83.10 | 71.03 | 82.33 | 78.82 |
| | K2 | 91.20 | 83.67 | 73.23 | 82.70 |
| **LSD 0.05** | | **2.89** | | | **5.85** |
| **Proline* Polyethene glycol** | | | | | **Average P** |
| **P0** | | 80.37 | 70.41 | 58.14 | 69.64 |
| **P1** | | 81.94 | 77.01 | 67.40 | 75.45 |
| **P2** | | 86.18 | 75.32 | 76.79 | 79.43 |
| **LSD 0.05** | | **3.38** | | | **1.95** |
| **Potassium* Polyethene glycol** | | | | | **Average K** |
| **K0** | | 81.43 | 73.06 | 66.88 | 73.79 |
| **K1** | | 81.52 | 72.42 | 68.87 | 74.27 |
| **K2** | | 85.53 | 77.27 | 66.59 | 76.46 |
| **LSD0.05** | | **3.38** | | | **1.95** |
| **Average (Polyethene glycol)** | | 82.83 | 74.25 | 67.44 | |
| **LSD 0.05** | | **1.95** | | | |

## Discussion

The reduces the leaves content of chlorophyll in the treatment of polyethene glycol concentrations of 100 g can be due to water stress which negatively affected the photosynthesis activity which is very sensitive to water stress due to Partial or total stomatal closure, which caused a lack of gas exchange, especially $CO_2$ which negatively affected On the growth of chloroplasts (Al-Saadi, 2016). This, in turn, reflected negatively on the content of chlorophyll. The decrease in photosynthesis is due to the role of glycol in the decomposition of proteins responsible for the manufacture of chlorophyll a and b, which caused the lack of absorption of nitrogen from the roots in adding to water stress, which caused a shortage of soil water and nutrient readiness, absorption and transport. Into the plant (Al-Hamzawi, 2016 and Neocleous *et al*., 2012). The increase in the leaves content of the proline (Table 3) with the increase in the concentration of polyethene glycol may be due to the that proline is produced from the decomposition of protein under water stress conditions or because of the tendency of the plant to reduce energy consumption on the construction of multiple peptides of proteins of large molecular sizes and converting it to amino acids with shorter molecular weights (Dalila, 2004). Or the increase may be due to the state of osmotic imbalance within the cells exposed to water stress.In order to treating this imbalance, the cells increase the production of proline acid in the cytoplasm of the cells, to counteract the osmotic pressure of the cells with their outer surroundings, this increases their ability to draw water. Also, the decrease in yield traits (Table 5, 6, 7) due to the increase in PEG concentration is due to the reduces of water caused by polyethene glycol and the decrease of biological activity inside the plant, the most important are occurring the damage of chloroplasts and demolition of chlorophyll in the leaves and thus reducing photosynthesis and their products and Impedes the transmission and storage of these products within the fruits, drought also impedes fruit set, pollen death, cause fruit falling (Al-Jebory, 2012). Also, increasing the water stress rates increase the speed of respiration and this is at the expense of photosynthesis process, which leads to the consumption of food stocks and thus reduced the size of fruits and plant product. These results agree with Neocleous *et al*. (2012) on strawberry plant and (Qayyum and Shoaib, 2013) on potato plant and Ziogas and Vasilakakis (2012) on strawberry and Ameri *et al*. (2018). The increase in the percentage of proline (Table 3) may be due to the external adding of proline to the leaves or a natural reaction to water stress, which leads to the accumulation of proline in the leaves, and the accumulation of proline in the leaves lead to an increase in protein (Table 4) because proline is an amino acid, They are the building blocks of proteins. Proteins are long chains of amino acids. These results agree with Jenscen (2014, Taha and Mohamed (2008) found on strawberries and Parvin *et al*. (2015) on strawberries (PAROS) and Sun *et al*. (2015) when studying the effect of proline in reducing the effects of water stress and increasing the chemical properties of strawberry plants. Also, the increase in the yield traits (Table 5, 6 and 7) may be due to the role of proline which increases the process of withdrawing nutrients from the growth medium through a cycle in the osmotic regulation, increasing the osmotic pressure and thus increasing the absorption of water and nutrients that are involved in photosynthesis and increasing the accumulation of nutrients (Hassan, 2012). Increased nutrient transport and photosynthesis products within the plant, leading to increase this traits (Anjum *et al*., 2011). This may be due to the role of proline in increasing the chlorophyll content (Table 2). This is due to the stimulation of chlorophyll as well as in maintaining the enzymatic activity of chloroplasts (Singh *et al*., 1994), thus increasing photosynthesis and nutrient accumulation in fruits (Neri *et al*., 2002) and then increase the fruit traits of the Strawberry. These results agree with Mustafa, (2017) on the strawberry plant Festival and Gulen *et al*. (2018) on strawberries. Al-Saadi, (2013) in his experiment on the cucumber plant. Potassium also plays an important role in increasing the studied traits .It works to regulate the osmotic pressure inside the plant, which helps in increasing the absorption of nutrients that are involved in the formation of proteins and increase the efficiency of photosynthesis and has an important role in the formation of nucleic acids and increase cell division (Elsaged, 2012) It helps in the construction of chlorophyll important in photosynthesis and the formation of sugars and ATP energy compounds, all of which increase the growth and size of the plant. Potassium stimulates cell division and elongation of cells and increases the stability and stiffness of the stems and resistance to bending (Mathis, 2009). It helps in the building of chlorophyll important in photosynthesis and the formation of sugars and ATP energy compounds, all of which affect the growth and plant size (Mathis, 2009) and thus increase the leaves content of chlorophyll (table 2). These results agree with the Taha and Mohammed (2015) on Strawberry and Authors and Galletta (1998) on Strawberry and Jasim (2013). Potassium also has an important role in activating many bioprocesses within the plant, including the manufacture of sugars, as some enzymes participate in the manufacture of sugars and accumulation in fruits. Potassium activates the enzyme Phenylalanine ammonia acid, which converts amino acids to Cinnamic, which alters the course of processes from the formation of amino acids to the formation of phenolic compounds (Gerailoo and Ghasemnezhad, 2011) and thus increase the protein table 4. These results agree with Valentinuzzi *et al*. (2017), Awad *et al*. (2010) and Muslim, (2010) and Eshghi *et al*. (2012) and Rodas *et al*. (2013). Potassium also plays an important role in stimulating fruit growth as it accelerates flowering (Taha and Mohamed, 2010) and Increasing the number of flowers and also works to prevent the fruits falling and improve the quality and early maturity and increase the fruit size and weight of the fruit and increase the number, prevention of disease and has an important role in promoting vegetative and radical growth in addition to the biology role in the process of division and elongation of cells (Niedziela *et al*., 2008), which positively reflected the number of flowers and the number of fruits (Table 5, 6), Potassium also plays a role in activating many enzymes such as Synthetase and Reductase-oxidase ,Hydrogenase enzymes, transportase enzymes, transferase enzymes, Kinases and proteolytic enzymes have an effect on membrane permeability, regulate intracellular PH and improve quality. (Taiz and Zeiger, 2002) These results are consistent with Ebrahimi *et al*. (2012) and Shamaila *et al*. (2016) and Valentinuzzi *et al*. (2017) and Schwarz *et al*. (2018) and Poodeh *et al*. (2015) in their experiment on strawberry plant have found that potassium has an effect on the qualities and yield of strawberry plant.

## Conclusions

It was concluded from this study that there is a synergistic effect between potassium and proline in reducing the effect of water stress and that proline cause increased osmotic pressure and thus open and close stomata as potassium plays an important role in opening and closing stomata and thus increase the process of photosynthesis and manufacture of nutrients important in the growth and production The crop.

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