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# EFFECT OF IRRIGATION LEVELS, SOIL CONDITIONER AND FOLIAR APPLICATION OF POTASSIUM SILICATE OR GLYCINE BETAINE ON VEGETATIVE GROWTH AND CHEMICAL COMPOSITION OF GARLIC

**[156]**

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## ABSTRACT

The field experiments were carried out during the two growing seasons of 2013-2014 and 2014-2015, at the farm of Faculty of Agriculture, Ain Shams University, Shoubra El-Kheima, Egypt, to investigate the effect of irrigation after the depletion of different available soil water levels, soil conditioner, foliar application of glycine betaine and potassium silicate on vegetative growth and chemical composition of garlic (*Allium sativum* L.), cv. Sids-40 under water stress conditions. The experimental treatments were arranged in a split split plot design, with three replicates Irrigation levels were conducted after the depletion of 60%, 75% and 90% of available soil water in the main plots. Irrigation treatments were started six weeks from planting, soil conditioner at the rates of 2 $m^3$/Fed and control were distributed in the sub-plots. Foliar applications of glycine betaine was used at 2 mM/L and potassium silicate was used at 0.5 g /L, after 50, 65, 80, 95, 110, 125 and 140 days respectively, from planting compared with control were devoted in the sub-sub plots. The results indicated that the irrigation after depletion of 60 % available soil water with applying soil conditioner and glycine betaine or potassium silicate increased the Plant length of garlic after 150 days from planting. Bulb diameter and nitrogen content showed significant increase as a result of irrigation after depletion of 60 % available soil water with applying soil conditioner in addition to the foliar application of glycine betaine. Prolin content was significantly increased as a result of irrigation after depletion of 90 % available soil water without applying soil conditioner with the foliar application of distilled water (control).Whereas, the lowest value of Prolin content appeared with irrigation after depletion of 60 % available soil water with applying soil conditioner and foliar application of glycine betaine. Total soluble solids (TSS) and total Sugars increased significantly as a result of irrigation after depletion of 90 % available soil water without applying soil conditioner with the foliar application of glycine betaine. It was therefore concluded that vegetative growth and chemical analyses of garlic responded positively to irrigation, applying soil conditioner and foliar application of 2 mM/L glycine betaine or 0.5 g/L potassium silicate.

**Keywords**: Garlic, Water stress, Soil conditioner, Glycine betaine, Potassium silicate

## INTRODUCTION

Garlic *(Allium sativum L.)* is one of the most important bulb crops in Egypt which is cultivated for both local consumption and export. It is commonly used as a spice or condiment as well as for medical purposes **(Hassan et al 2011).**

According to **Buwalda (1987)** and **Choi et al (1980),** garlic requires adequate moisture from establishment through to maturity for better growth and yield performance and quality. They also reported that the crop did not withstand application of excess water and that water deficiency may cause substantial yield reduction.

Water is the major constituent of all living organisms. The transportation of nutrients to various parts of the plant is carried out by water. It is also important constituent in photosynthesis in two ways, firstly it provides hydrogen for building up of glucose, and secondly opening and closing of stomata is regulated by increase or decrease in the amount of water. Supplemental irrigation, particularly at the pod filling stage, to improve plant water status, gives economic increase in yields in areas of super optimal temperature during the reproductive growth on chickpea **(Ullah et al 2002).**

Drought stress usually causes a decrease in crop production. It inhibits the photosynthesis of plants, causes changes of chlorophyll contents and components and damage of photosynthetic apparatus. It also inhibits the photochemical activities and decreases the activities of enzymes in the Calvin cycle. One of the important reasons that environmental stress inhibits the growth and photosynthetic abilities of plants is the breakdown of the balance between the production of reactive oxygen species (ROS) and the antioxidant defense, causing accumulation of ROS which induces oxidative stress to proteins, membrane lipids and other cellular components**.**

A natural soil conditioner that is made out of dry compressed cellulose and recycles agricultural material, shaped in grains and varies in size (0.2-2.0mm)that is capable of penetrating through the sand grains, forming a new media ideal for growing plants, has a balanced pH of 6.8-7.2, water holding capacity of 300% naturally, which will change sandy soil water capacity and does not absorb heat, so water evaporation is dramatically minimized. A soil conditioner is a product which is added to soil to improve the soil's physical qualities, especially its ability to provide nutrition for plants. **Khalifa et al (1997)** suggested that natural soil conditioners increased soil hydraulic conductivity and water diffusivity of sandy soil.

Glycine betaine is an amino acid derivative. Synthesis of glycine betaine is promoted by salt and drought stress as it functions as a compatible solute regulating the intracellular osmotic balance. **Wahid and Shabbir (2005)** reported that glycine betaine plays a protective role under stressful conditions.Externally-applied GB can rapidly penetrate through leaves and be transported to other organs, where it would contribute to improved stress tolerance **(Ashraf and Foolad, 2007).**

Silicone is a silicon-containing synthetic polymer. It is known to increase drought tolerance in plants by maintaining plant water balance, photosynthetic activity, erectness of leaves and structure of xylem vessels under high transpiration rates. Potassium silicate is a source of highly soluble potassium and silicon. It is used in agricultural production systems primarily as a silica amendment, and has the added benefit of supplying small amounts of potassium. Potassium silicate can be used as effective antitranspirants and ameliorative substances for alleviating the hazardous effects of water deficit on tomato plants **(Abu El-Azm and Youssef 2015).**

## MATERIALS AND METHODS

In this study, field experiments were carried out during the two growing seasons of 2013/2014 and 2014/2015, at the experimental farm, Fac. of Agric., Ain Shams Univ., Shoubra El-Kheima, Egypt, in order to investigate the effect of irrigation after the depletion of different available soil water levels, soil conditioner, foliar application of glycine betaine and Potassium silicate on vegetative growth and chemical composition of garlic bulb (*Allium sativum* L.), cv. Sids-40 under water stress conditions.

Planting material was the garlic cloves cv. Sids-40 which were planted on October 1$^{st}$ and 2nd in 2013/2014 and 2014/2015 seasons, respectively.

The area of the experimental plot was 14 m$^2$, consisted of five rows; each row was 4 m length and 0.7 m width. Garlic cloves were planted at a distance of 7 cm apart on both sides of ridges, an alley (1 m wide) was left as border between irrigation treatments.

All agricultural practices, disease and pest control programs were followed according to the recommendations of the Egyptian Ministry of Agriculture. Harvesting was carried out for each planting date, after 180 days from planting.

### The experimental design and treatments

Irrigation was conducted after the depletion of 60%, 75% and 90% of the available soil water. Irrigation treatments were started six weeks after planting. The percentage of soil moisture was measured using the following equation:

$$\text{Soil moisture} = \frac{\text{Weight before drying} - \text{weight after drying}}{\text{weight after drying}} \times 100$$

(?? Source)

Soil conditioner was applied to the soil, the commercial is Hundz soil at the rates of 2 $m^3$/Fed and control (the control was without conditioner). It was applied to the field surface before planting. Glycine betaine (MW 117.18) from Sigma company was used at 2 mM/L, applied after 50, 65, 80, 95, 110, 125 and 140 days from planting as foliar application. Potassium silicate (MW 132) was used at 0.5 gm /L as foliar application also and control (control, plants were sprayed with distilled water).
The experiment was laid out in a split-split plot design with three replicates. The irrigation levels were assigned in the main plots, soil conditioner was distributed in the sub-plots and foliar applications of glycine betaine, potassium silicate and control were devoted in the sub-sub plots.

**Studied characteristics**

Three Plants were chosen at random from three replications (from the inner rows) at 150 days from planting. Plant length was measured from base of swelling sheath to the tip of the largest linear blade in plant, Bulb diameters was measured by Vernier caliber.

Free proline content was assayed according to the method of **Bates et al (1973),** Proline concentration was determined using calibration curve. Total soluble solids (TSS) measured by hand refractometer in will mixed juice of 5 cloves.

Total nitrogen content (gm/100 gm D. wt.) was determined in the digested solution by the modified microkeldahl method as described by **Plummer (1971).** Total soluble sugars were determined according to **Tanaka et al (1975).**

**Statistical analysis**

Obtained data were statistically analyzed using Mstatic (M.S.) software. The comparison among means of the different treatments was determined, as illustrated by **Snedecor and Cochran (1982).**

## RESULTS AND DISCUSSION

Data presented in **Table (1)** show that irrigation at depletion of 55-60% available soil water with applying soil conditioner and the foliar application of glycine betaineor potassium silicate increased the Plant length in the two seasons as compared with the other studied combination treatments. Similar results were reported by **Akbari et al (2017)** who found that Applying drought stress at the irrigation treatment of 80% Etc. decreased studied growth characteristics of garlic, and results also agree with **Ghodke *et al* (2018)** on onion found that drought stress significantly reduces the leaf length. Drought stress decreased fresh and dry weight, length of bulbs and the bulb diameter significantly.

Data presented in the same **Table (1)** show also that irrigation at depletion of 60 % available soil water with applying soil conditioner and the foliar application of glycine betaine gave the highest values of bulb diameter in the first season. In the second test season the highest values of bulb diameter was produced with irrigation after depletion of 75 % available soil water without applying soil conditioner and the foliar application of glycine betaine as compared with the other studied treatments. These results are agree with **Zayton (2007)** on onion obtained that the long water-stress periods, produced small onion bulbs, also **Akbari *et al* (2016)** found that drought stress decreased fresh and dry weight, length of bulbs and the bulb diameter significantly.

Data in **Table (2)** demonstrate that irrigation at depletion of 90 % available soil water without applying soil conditioner and the foliar application of water treatment (control) increased Prolin content as compared with the other studied treatments in the two seasons. Whereas, the lowest value appeared with irrigation after depletion of 60 % available soil water with applying soil conditioner and the foliar application of glycine betaine. Data presented in the same **Table (2)** show also that irrigation at depletion of 90 % available soil water without applying soil conditioner and the foliar application of glycine betaine gave the highest values of total soluble solids (TSS) in the two seasons as compared with the other studied combination treatments. Similar results were found by **Ghodke et al (2018)** and **Zayton (2007)** who found that accumulation higher proline, total soluble solids and antioxidant enzyme activity in response to drought as one of the tolerance mechanismon onion.

Data presented in **Table (3)** show that irrigation at depletion of 55-60% available soil water with applying soil conditioner and the foliar application of glycine betaine increased the nitrogen content in the two seasons as compared with the other studied combination treatments. Similar results were found by **Khalak and Kumaraswamu (1992)** on potato, **Gawish and Fattahallah (1997)** on taro, **El-Zohiri (1999)** on taro, **Mahmoud (2006)** on potato and **Abu El-Azm and Youssef (2015)** on tomato. Data presented in the same **Table (3)**

**Table 1.** Effect of irrigation levels, soil conditioners and foliar application of potassium silicate (KSi) or glycine betaine (GB) on Plant length and Bulb diameter of garlic during 2013/2014 and 2014/2015 seasons

| Treatments | | | Plant length | | Bulb diameter | |
|---|---|---|---|---|---|---|
| Irrigation | Soil con. | Foliar s. | 1st season | 2nd season | 1st season | 2nd season |
| 55-60% | with | Control | 76.45 c-e | 83.89 a | 4.69 a-e | 4.32 bc |
| | | KSi | 84.00 a | 85.33 a | 4.79 a-c | 4.41 ab |
| | | GB | 84.78 a | 83.89 a | 5.04 a | 4.40 ab |
| | without | Control | 75.33 c-e | 72.78 e-g | 4.59 a-f | 3.55 g |
| | | KSi | 78.89 bc | 79.00 c | 4.61 a-f | 3.84 f |
| | | GB | 83.33 ab | 81.33 b | 4.68 a-e | 4.17 d |
| 70-75% | with | Control | 74.22 d-f | 70.56 gh | 4.47 b-f | 3.91 ef |
| | | KSi | 78.33 cd | 73.00 d-f | 4.28 d-h | 3.68 g |
| | | GB | 74.89 c-f | 74.22 de | 4.71 a-d | 4.23 cd |
| | without | Control | 69.22 gh | 67.00 i | 4.22 e-h | 3.93 ef |
| | | KSi | 78.44 cd | 75.22 d | 4.91 ab | 4.18 d |
| | | GB | 77.44 cd | 71.89 f-h | 4.67 a-e | 4.48 a |
| 85-90% | with | Control | 66.00 h | 70.44 h | 3.86 h | 4.42 ab |
| | | KSi | 72.78 e-g | 67.44 i | 4.28 d-h | 4.13 d |
| | | GB | 70.33 f-h | 71.56 f-h | 4.38 c-g | 4.13 d |
| | without | Control | 46.44 i | 67.22 i | 2.86 i | 3.41 h |
| | | KSi | 72.55 e-g | 72.11e-h | 4.17 f-h | 3.98 e |
| | | GB | 70.67 fg | 71.11 f-h | 3.93 gh | 4.22 cd |

KSi = potassium silicate GB = glycine betaine Soil Con. = soil conditioner Foliar S. = foliar spray

**Table 2.** Effect of irrigation levels, soil conditioners and foliar application of potassium silicate (KSi) or glycine betaine (GB) on prolin content and TSS of garlic during 2013/2014 and 2014/2015 seasons

| Treatments | | | Prolin content | | TSS | |
|---|---|---|---|---|---|---|
| Irrigation | Soil con. | Foliar s. | 1st season | 2nd season | 1st season | 2nd season |
| 55-60% | with | Control | 39.30 gh | 32.29 k | 24.23 hi | 21.40 p |
| | | KSi | 34.09 j | 34.90 j | 28.60 e | 39.02 j |
| | | GB | 24.81 m | 27.71 l | 27.67 f | 27.71 o |
| | without | Control | 32.19 k | 42.90 f | 27.57 f | 32.05 m |
| | | KSi | 38.34 hi | 37.12 i | 24.60 h | 37.12 k |
| | | GB | 25.97 l | 42.59 f | 24.13 i | 41.14 h |
| 70-75% | with | Control | 41.80 f | 38.85 h | 29.03 e | 28.85 n |
| | | KSi | 40.15 g | 41.52 g | 31.80 b | 41.52 h |
| | | GB | 50.50 c | 35.62 j | 28.77 e | 35.62 l |
| | without | Control | 50.17 c | 45.40 e | 25.37 g | 47.59 f |
| | | KSi | 38.26 i | 44.83 e | 28.93 e | 53.17 b |
| | | GB | 45.29 e | 45.58 e | 24.47 hi | 49.26 d |
| 85-90% | with | Control | 48.13 d | 52.87 d | 31.13 c | 48.79 e |
| | | KSi | 50.86 c | 53.07 d | 27.97 f | 53.42 b |
| | | GB | 45.54 e | 38.67 h | 30.37 d | 39.77 i |
| | without | Control | 54.97 a | 60.74 a | 31.60 b | 51.83 c |
| | | KSi | 53.41 b | 56.21 b | 28.87 e | 46.18 g |
| | | GB | 53.97 ab | 55.01c | 33.47a | 57.02 a |

KSi = potassium silicate GB = glycine betaine Soil Con. = soil conditioner Foliar S. = foliar spray

**Table 3.** Effect of irrigation levels, soil conditioners and foliar application of potassium silicate (KSi) or glycine betaine (GB) on nitrogen content and total sugars of garlic during 2013/2014 and 2014/2015 seasons

| Treatments | | | N content | | Total sugars | |
|---|---|---|---|---|---|---|
| Irrigation | Soil con. | Foliar s. | 1st season | 2nd season | 1st season | 2nd season |
| 55-60% | with | Control | 5.03 bc | 3.48 b-d | 3.00 h | 3.81 fg |
| | | KSi | 4.48 de | 3.55 b-d | 3.23 h | 4.72 e |
| | | GB | 5.63 a | 4.41 a | 6.41 cd | 3.82 fg |
| | without | Control | 4.55 de | 3.28 cd | 5.81 ef | 4.63 e |
| | | KSi | 4.56 c-e | 3.19 d | 5.82 e | 3.47 gh |
| | | GB | 5.21 ab | 3.86 b | 5.95 de | 3.37 gh |
| 70-75% | with | Control | 3.28 hi | 3.09 de | 6.68 bc | 3.72 fg |
| | | KSi | 4.79 b-d | 3.92 b | 6.37 cd | 3.99 f |
| | | GB | 4.14 ef | 3.09de | 3.32 h | 3.14 h |
| | without | Control | 4.63 cd | 3.18 d | 4.22 g | 7.45 cd |
| | | KSi | 3.91 fg | 3.23 d | 6.76 bc | 7.52 cd |
| | | GB | 3.86 fg | 3.72 bc | 5.60 ef | 7.18 d |
| 85-90% | with | Control | 3.09 ij | 3.53 b-d | 4.15 g | 7.99 ab |
| | | KSi | 3.97 f | 3.09 de | 7.03 b | 8.13 ab |
| | | GB | 3.48 g-i | 3.86 b | 4.24 g | 8.08 ab |
| | without | Control | 2.76 j | 2.51 fg | 7.99 a | 8.41 a |
| | | KSi | 3.14 ij | 2.70 ef | 7.73 a | 7.73 bc |
| | | GB | 3.72 f-h | 2.07 g | 5.35 f | 7.99 ab |

KSi = potassium silicate GB = glycine betaine Soil Con. = soil conditioner Foliar S = foliar spray

show also that irrigation at depletion of 90 % available soil water without applying soil conditioner and the foliar application of glycine betaine gave the highest values of total sugars in the two seasons as compared with the other studied combination treatments.

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# تأثير مستويات الري ومحسن التربة والرش بسيليكات البوتاسيوم والجليسين بيتيين على النمو الخضرى والمحتوى الكيميائى للثوم

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**الموجـــــز**

أجريت هذه الدراسة في مزرعة كلية الزراعة – جامعة عين شمس–شبرا الخيمة–محافظة القليوبية – جمهورية مصر العربية خلال موسمي 2014/2013 و2015/2014 لدراسة تأثير الـري بعـــد استنفـــاد مستويات مختلفة من الماء الميسر فى التربه ومحسنات التربة ومعاملات الرش الورقي بالجليسين بيتيين وسليكات البوتاسيوم على النمو الخضرى والمحتوى الكيميائى للثوم وكان التصميم المتبع هو قطع منشقة مرتين وذلك في ثلاثة مكررات. واشتملت القطع الرئيسية على ثلاثة مستويات من الري وهي الري بعد إستنفاذ 60، 75 , 90 % من الماء الميسر في التربة. بينما احتوت القطع الفرعيه على مستويين من محسن التربة 2 م$^3$ للفدان وبدون اضافة اما القطع تحت الفرعيه تم فيها معاملات الرش الورقى بالجليسين بيتيين 2ملليمول/لتر او سيليكات البوتاسيوم 0.5 جم / لتر او المقارنه ( رش بالماء المقطر) وقد بدأت معاملات الري بعد ستة أسابيع من الزراعة . اشارت النتائج ان الرى بعد استنفاذ 60 % من الماء الميسر فى التربة مع اضافة محسن التربة ورش الجليسين بيتيين أوسيليكات البوتاسيوم أدى إلى زيادة طول النبات، قطر البصله فى الثوم بعد 150 يوم الزراعه وايضا محتوى البرولين بالاوراق والمواد الصلبة الذائبه الكلية للفصوص فى البصله. ظهرت زياده معنوية فى محتوى البرولين مع الرى بعد استنفاذ 90 % من الماء الميسر فى التربة مع عدم اضافة محسنات تربه والرش بماء مقطر فى حين سجلت اقل القيم عند الرى بعد استنفاذ 60 % من الماء الميسر فى التربة واضافة محسن التربة مع الرش بالجليسين بيتيين.أدى ري النباتات بعد إستنفاذ 90 % من الماء الميسر في التربة مع عدم اضافة محسن تربة والرش بالجليسين بيتيين إلى تسجيل أعلى قراءة للمواد الصلبة الذائبه الكلية للبصله.

وقد خلصت النتائج إلي ان استيفاء الاحتياجات المائيه للثوم واضافة محسن للتربه بمعدل 2 متر$^3$ والرش الورقى بالجليسين بيتيين بتركيز 2ملى /لتر أوسيليكات البوتاسيوم بتركيز 0.5 جرام/لتر ادى الى تحسين جودة وانتاجية محصول الثوم.

**الكلمات الدالة:** الثوم, مستويات الرى, محسن التربة, الجليسين بيتيين, سيليكات بوتاسيوم

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