EFFECTIVE IRRIGATION LEVELS, SOIL CONDITIONER AND FOLIAR APPLICATION OF POTASSIUM SILICATE OR GLYCINE BETAINES ON VEGETATIVE GROWTH AND CHEMICAL COMPOSITION OF GARLIC

[Walaa M. Sapt*, Ragab2 M.E., Abd El-Gawad2 H.G. and Omran1 A.E.
1- Potato and Vegetatively Propagated Vegetables Res. Dept., Horticulture Research Inst., Agric. Research Center, Egypt
2- Horticulture Dept., Fac. of Agric., Ain Shams Univ., P.O. Box 68, Hadayek Shoubra 11241, Cairo, Egypt

*Corresponding author: walaasapt@gmail.com
Received 8 May, 2019 Accepted 15 September, 2019

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 treatments 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 m³/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 1st and 2nd in 2013/2014 and 2014/2015 seasons, respectively.

The area of the experimental plot was 14 m², 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:

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

(?? Source)
Effect of irrigation levels, soil conditioner and foliar application of potassium silicate or glycine betaine on vegetative growth and chemical composition of garlic

Soil conditioner was applied to the soil, the commercial is Hundz soil at the rates of 2 m³/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 caliper.

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 betaine 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 mechanism 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 |
|------------|--------------|---------------|
|            | 1st season | 2nd season | 1st season | 2nd season |
| Irrigation | Soil con.  | Foliar s. | | |
| 55-60% with | Control | KSi | | |
| with | 76.45 c-e | 83.89 a | 4.69 a-e | 4.32 bc |
| | 84.00 a | 85.33 a | 4.79 a-c | 4.41 ab |
| | 84.78 a | 83.89 a | 5.04 a | 4.40 ab |
| without | Control | KSi | | |
| with | 75.33 c-e | 72.78 e-g | 4.59 a-f | 3.55 g |
| | 78.89 bc | 79.00 c | 4.61 a-f | 3.84 f |
| | 83.33 ab | 81.33 b | 4.68 a-e | 4.17 d |
| 70-75% with | Control | KSi | | |
| with | 74.22 d-f | 70.56 gh | 4.47 b-f | 3.91 ef |
| | 78.33 cd | 73.00 d-f | 4.28 d-h | 3.68 g |
| | 74.89 c-f | 74.22 de | 4.71 a-d | 4.23 cd |
| without | Control | KSi | | |
| with | 69.22 gh | 67.00 i | 4.22 e-h | 3.93 ef |
| | 78.44 cd | 75.22 d | 4.91 ab | 4.18 d |
| | 77.44 cd | 71.89 f | 4.67 a-e | 4.48 a |
| 85-90% with | Control | KSi | | |
| with | 66.00 h | 70.44 h | 3.86 h | 4.42 ab |
| | 72.78 e-g | 67.44 h | 4.28 d-h | 4.13 d |
| | 70.33 f-h | 71.56 f-h | 4.38 c-g | 4.13 d |
| without | Control | KSi | | |
| with | 46.44 i | 67.22 i | 2.86 i | 3.41 h |
| | 72.55 e-g | 72.11 e-h | 4.17 f-h | 3.98 e |
| | 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 |
|------------|----------------|-----|
|            | 1st season | 2nd season | 1st season | 2nd season |
| Irrigation | Soil con.  | Foliar s. | | |
| 55-60% with | Control | KSi | | |
| with | 39.30 gh | 32.29 k | 24.23 hi | 21.40 p |
| | 34.09 j | 34.90 j | 28.60 e | 39.02 j |
| | 24.81 m | 27.71 l | 27.67 f | 27.71 o |
| without | Control | KSi | | |
| with | 32.19 k | 42.90 f | 27.57 f | 32.05 m |
| | 38.34 hi | 37.12 i | 24.60 h | 37.12 k |
| | 25.97 l | 42.59 f | 24.13 i | 41.14 h |
| 70-75% with | Control | KSi | | |
| with | 41.80 f | 38.85 h | 29.03 e | 28.85 n |
| | 40.15 g | 41.52 g | 31.80 b | 41.52 h |
| | 50.50 c | 35.62 j | 28.77 e | 35.82 l |
| without | Control | KSi | | |
| with | 50.17 c | 45.40 e | 25.37 g | 47.59 f |
| | 38.26 i | 44.83 e | 28.93 e | 53.17 b |
| | 45.29 e | 45.58 e | 24.47 hi | 49.26 d |
| 85-90% with | Control | KSi | | |
| with | 48.13 d | 52.87 d | 31.13 c | 48.79 e |
| | 50.86 c | 53.07 d | 27.97 f | 53.42 b |
| | 45.54 e | 38.67 h | 30.37 d | 39.77 l |
| without | Control | KSi | | |
| with | 54.97 a | 60.74 a | 31.60 b | 51.83 c |
| | 53.41 b | 56.21 b | 28.87 e | 46.18 g |
| | 53.97 ab | 55.01 c | 33.47 a | 57.02 a |

KSi = potassium silicate  GB = glycine betaine  Soil Con. = soil conditioner  Foliar S. = foliar spray
Effect of irrigation levels, soil conditioner and foliar application of potassium silicate or glycine betaine on vegetative growth and chemical composition of garlic

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 |
|------------|-----------|-------------|
|            | 1st season | 2nd season | 1st season | 2nd season |
| Irrigation | Soil con. | Foliar s. |                  |                  |
| 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      | 3.09 de      | 3.32 h      | 3.14 h      |
|            | without   | Control   | 4.63 cc      | 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.

**REFERENCES**

Abu El-Azm N.A.I. and Youssef S.M.S. 2015. Spraying potassium silicate and sugar beet molasses on tomato plants minimizes transpiration, relieves drought stress and rationalizes water use. *Middle East J. Agriculture Research, 4*(4), 1047-1064.

Akbari S., Kafi M. and Beidokhti S.R. 2016. The Effects of Drought Stress on Yield, Yield Components and Anti-oxidant of Two Garlic (*Allium sativum* L.) Ecotypes with Different Planting Densities. *Būm/shināsī-ikishāvarzī, 8*(1), 95-106.

Akbari S., Kafi M. and Beidokhti S.R. 2017. Effect of drought stress on growth and morphological characteristics of two garlic (*Allium sativum* L.) ecotypes in different planting densities. *J. of Agro Ecology 9*(2), 559-574.

Ashraf M. and Foolad M.R. 2007. Roles of glycine betaine and proline in improving plant abiotic stress resistance. *Environmental and Experimental Botany 59*, 206–216.

Bates L.S., Waldren R.P. and Teare I.D. 1973. Rapid determination of free proline for water-stress studies. *Plant Soil 39*, 205–207.

Buwalda J.G. 1987. Nitrogen nutrition of garlic (*Allium sativum* L.) under irrigation. *Crop Growth Dev. Sci. Hortic.*, 29, 55-68.

Choi J.K., Ban C.D. and Kwon Y.S. 1980. Effects of the amount and times of irrigation on bulbing and growth in garlic research reports on the effect of rural development. *Hortic. Sericul. Swun, 22*, 20-33.

El-Zohiri S.S.M. 1999. Effect of some agricultural treatments on growth and yield of taro. *M.Sc. Thesis, Fac. Agric., Zagazig Univ., Egypt*, pp. 43-55.

Gawish R.A. and Fattahallah M.A. 1997. Modification of irrigation requirements of taro (*Colocasia esculenta* L. Schott) through the application of antitranspirants. Menofiya J. Agric. Res. 22, 1353-1387.

Ghodke P.H., Andale P.S., Gijare U.M., Thangasamy A., Khade Y.P., Mahajan V. and Singh M. 2018. Physiological and Biochemical
Responses in Onion Crop to Drought Stress. Int. J. Curr. Microbiol. App. Sci. 7(1), 2054-2062.

Hassan M.A., El-Tohamy M.A. and Mohamed A.A.A. 2011. Response of garlic cultivated in alkaline soil to foliar application of some plant nutritive compounds. Egypt. J. of Appl. Sci., 26(5), 113-123.

Khalifa E.M., Abo-Zeid M.I., Nassar I.N. and Esmail S.M. 1997. Effect of a sugarcane industry by-product (filter mud cake) on some physical properties of soils. The First Scientific Conference of Agric. Sci. Fac. Agric.Univ.,13-14 December 1, 467-482.

Khalak A. and Kumaraswamy A.S. 1992. Dry matter accumulation and growth attributes of potato as influenced by irrigation and fertilizer application. J. of the Indian Potato Association, 19(1-2), 40-44.

Mahmoud M.M.S. 2006. The response of potato (Solanum tuberosum, L.) to water regimes and irrigation systems. Ph.D. Thesis, Fac. Agric., Minufiya Univ. Egypt, pp. 65-69.

Plummer D.T. 1971. An introduction to practical biochem. 2nd Ed., McGraw Hill, London, ISBN: 10-0070941629, pp. 144-145.

Snedcor G.W. and Cochran W.G. 1982. Statistical methods. 7th ed. Iowa State Univ., Press, Iowa, U.S.A.

Tanaka M., Thananunku D.L., Lee T. and Chichester C.O. 1975. A simplified method for the quantitative determination of sucrose, raffnose and stachyose in legume seeds. J. of Food Sci., 40(5), 1087-1088.

Ullah A., Bakht J., Shaf M., Shah W.A. and Islam Z. 2002. Effect of various irrigations levels on different chickpea varieties. Asian J. of Plant Sci., 1(4), 355-357.

Wahid A. and Shabbir A. 2005. Induction of heat stress tolerance in barley seedlings by presowing seed treatment with glycine betaine. Plant Growth Regulation 46, 133–141.

Zayton A.M. 2007. Effect of soil-water stress on onion yield and quality in sandy soil. Misr J. Ag. Eng., 24(1), 141-160.
تأثير مستويات الري ومحسن التربة والرش بسيلكات البوتاسيوم والجليسين بيتيين على النمو الخضري والمحتوى الكيميائي للثوم

ولاء محمد سبت1، محمد امام رجب2، هاني جمال عبدالجواد، أبو العز عيسى عمران1
1- قسم بحوث البطاطس والخضر خضرية التكاثر – معهد بحوث الزراعية – جامعة عين شمس و_multiply_eq (3) – القاهرة – مصر
2- قسم البساتين – كلية الزراعة – جامعة عين شمس – ص.ب.68 – حيادق شبرا 11241 – القاهرة – مصر
*Corresponding author: walaasapt@gmail.com

Received 8 May, 2019
Accepted 15 September, 2019

الموجز

أجريت هذه الدراسة في مزرعة كلية الزراعة – جامعة عين شمس- مدينة الخيرية- محافظة الاقصر – جمهورية مصر العربية خلال موسمين 2014/2015 و2015/2016 لدراسة تأثير الري بعد استنفاد مستويات مختلفة من الماء الميسر في التربة ومعالجات الرش الورقي بالجليسين بيتيين وسيلكات البوتاسيوم على النمو الخضري والكيميائي للثوم. وكانت التصميم المتبوع هو قطع متفرقة مرتين وذلك في ثلاثة مكررات. وشملت القطع الرئيسية على ثلاثة مستويات من الري وهي الري بعد استنفاد 60، 75 و 90% من الماء الميسر في التربة. بينما احتوت القطع الفرعية على مستويات من محسن التربة 2م للفدان ودون اضافة إضافات أخرى. وشملت القطع الفرعية التي تناولت الرش الورقي بالجليسين بيتيين 1.2 جرام/لتر أو سيلكات البوتاسيوم 0.5 جم/ لتر، وقد بدأت عمليات الرش بعد ستة أسابيع من الزراعة. اشارت النتائج ان الري بعد استنفاد 90% من الماء الميسر في التربة، والذي كان ينفخ محل ترشيح النباتات بالناء المنحني الجليسين بيتيين وسيلكات البوتاسيوم أدى إلى زيادة نمو النباتات وطول الرش، واصبحت المواد الصلبة الكلية للثوم على أعلى قراءة. وقامت النتائج بتبرير احتياجات الثوم ومحسن التربة، والرجوع إلى الري بعد استنفاد 90% من الماء الميسر في التربة، والذي كان ينفخ محل ترشيح النباتات بالناء المنحني الجليسين بيتيين وسيلكات البوتاسيوم.  

الكلمات الدالة: النمو، مستويات الري، محسن التربة، الجليسين بيتيين، سيلكات البوتاسيوم