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# Response of Cotton Plant to Spraying Some Natural Materials Under Water Stress Conditions

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## ABSTEACT

Two field experiments were carried out at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate during the two successive seasons of 2015 and 2016. These experiments were conducted to find out the proper irrigation interval and the effect of natural material which reduce the negative effect of water stress as well as their interaction on leaf chemical composition, growth, flowering habit, earliness parameters, seed cotton yield and its components and fiber quality of the Egyptian cotton cultivar Giza 86. A split plot design with three replicates was used in both seasons, where the main plots were assigned to three irrigation intervals (15, 30 and 45 days) and the sub-plots contained natural materials (without, glycine betaine (600 ppm), potassium citrate (3g/l) and salsalic acid (200 ppm) The important results could be summarized as follows: Irrigating intervals gave significant effect on leaf total chlorophyll, carotenoids, phenols and proline content at 114 days, when irrigated every 45 days followed by irrigated every 30 and 15 day in a descending order. Irrigation every 15 days significantly increased plant height at harvest, number of fruiting branches/plant, number of flowers/plant, boll weight and decreased setting and earliness percentages in both seasons as compared with the other two irrigation intervals (every 30 and 45 days). However, the higher number of open bolls/plant and seed cotton yield / fed were obtained from plants which irrigated every 30 days. Irrigation intervals had insignificant effect on seed index and significant effect on lint % in both seasons. The highest value of lint % was resulted from irrigated plants every 45 days. Spraying with natural materials significantly affected leaf total chlorophyll, phenols and proline content, in favor of spraying potassium citrate and significantly affected leaf carotenoids content at, in favor of spraying salsalic acidSpraying with natural materials significantly affected boll weight and number of open bolls/plant in both seasons in favor of spraying glycine betaine and potassium citrate. Application of salsalic acid or glycine betaine gave significant increase in lint % and insignificant effect on seed index in both seasons. Spraying cotton plants with glycine betaine lead to a significant increase in seed cotton yield per fed. Untreated Plants caused a significant increase in plant height at harvest and number of fruiting branches/plant in both seasons as compared with the plants which received glycine betaine, potassium citrate and salsalic acid. Concerning the interaction between irrigation intervals and natural materials, there is a significant interaction effect with regard to leaf total chlorophyll, carotenoids, phenols and proline contents, in favor of irrigated cotton plants every 45 days and spraying with potassium citrate for leaf total chlorophyll, phenols and proline contents and in favor of irrigated cotton plants every 45 days and spraying with salsalic acid for leaf carotenoids content. Irrigation every 30 days and spraying with potassium citrate produced the highest values of lint % in both seasons. The interaction gave insignificant effect on seed index, Presley index and micronaire reading in both seasons. The combined treatment of irrigation interval every 30 days when combined with glycine betaine at the concentration (600 ppm) gave significant increase in seed cotton yield / fed (kentar) in both seasons. The flowering curve in irrigation every 30 and 45 days was higher, start earlier and ending earlier as compared to the flowering curves in the irrigation every 15 days. It could be concluding that irrigation cotton plants every 30 days in combination with spraying with glycine betaine (600 ppm) or potassium citrate (3g/l) three times (at the squaring stage, flowering stage and at the top of flowering) under El-Gemmeiza condition). Also, it could be concluding that irrigation every 45 days in combination with glycine betaine (600 ppm) at the end of water sources and water shortage.

## INTRODUCTION

Environmental stress affects plant performance adversely and often results in significant reductions in crop yield and quality worldwide. During square and boll formation, different stresses (such as, drought, shading, fertility problems and insect pressure) can result in fruit abscission. Irrigation among other cultural practices is the most important factor in ensuring high and good quality cotton production. Although cotton is known to be drought tolerant, its yield could significantly be increased with appropriate irrigation management. Mert (2005) reported that non-irrigation condition (water stress) reduced some cotton yield components; moreover, the existing water resources are at risk of near depletion and being heavily degraded. It is believed that studying agricultural production under deficit irrigation conditions may help to develop irrigation programs for minimizing future yield reductions when water scarcity becomes wide spread.

The use of irrigation strategies is fundamental to save more water without putting at risk crop yield. Managing water deficits during plant development and saving water during irrigation by using some natural materials such as glycine betaine gave excellent results, where applying glycine betaine prior to water stress improved photosynthesis by increasing of stomata conductance (Namich and Emara, 2008). Emara (2012) found that foliar application of 5 kg $K_2SO_4$/fed sprayed partly twice at beginning of flowering and two weeks later gave a significant increase in number of open bolls/plant, boll weight and seed cotton yield (kentar/fed) as compared with soil application of 24 or 48 kg $K_2O$ /fed at thinning with or without one foliar application of 0.5 g $ZnSO_4$/l at beginning of flowering. Ashfaq *et al*. (2015) reported that foliar feeding of potassium had great significance for plants because its includes low cost, quick response to plant, small quantity of potassium and it provides compensation for lack of soil fixation. Lokhande and Reddy (2015) found that the retained boll numbers / plant decreased in plants grown under K deficient conditions. Saving water in irrigated areas is the definition of the suppression of irrigation correctly promoting the physiological seasoning of plants without compromising yield.

The objective of this investigation was to assess the effect of irrigation intervals and determine the proper interval and the probability of reducing the effect of water by using natural materials as foliar application *i.e.* glycine betaine, salsalic acid and potassium citrate with regard to the leaf chemical, growth, earliness, flowering habit, yield components, yield and fiber characteristics.

## MATERIALS AND METHODS

Two field experiments were carried out on clay soil at El-Gemmeiza Agricultural Research Station, El-Gharbia Governorate during the two successive seasons of 2015 and 2016. These experiments were conducted to find out the proper irrigation interval and the effect natural material which reduce the negative effect of water stress as well as their interaction on leaf chemical composition, growth, flowering habit, earliness parameters, seed cotton yield and its components and fiber quality of the Egyptian cotton (*Gossypium barbadense* L.), cultivar Giza 86.

**A split plot design with three replicates was used in both seasons, where the main plots were assigned to the irrigation intervals:**

$a_1$-Irrigation every 15 days (the control), $a_2$- Irrigation every 30 days

$a_3$- Irrigation every 45 days

**The sub-plots contained natural materials:**

$b_1$-Without, $b_2$-Glycine betaine (600 ppm), $b_3$-Potassium citrate (3g/l)

$b_4$-Salsalic acid (200 ppm).

The natural materials were sprayed three times, at the squaring stage, flowering stage and at the top of flowering.

The experimental plot size was 14 m2, (4m x 3.5m) including 5 rows 70 cm apart and the hills 25 cm. apart with two plants / hill after thinning in both seasons. Planting date was on 8th April in the two seasons.

The preceding crop was Egyptian clover (*Trifolium alexandrinum* L.) "berseem" in both seasons.

Representative soil samples were taken from the experimental soil sites before sowing in both seasons and prepared for analysis according to Jackson (1973). Results of the soil analysis are shown in Table 1.

**Table 1. Chemical properties of the experimental soil sites in the two seasons.**

| Properties | Season | |
|---|---|---|
| | 2015 | 2016 |
| pH | 7.8 | 8.0 |
| EC mmhos/ cm. | 0.26 | 0.54 |
| Organic matter % | 1.29 | 1.42 |
| Total N (mg/100g) | 45.15 | 49.7 |
| Available N (ppm) | 21.3 | 28.7 |
| Available P (ppm) | 10.7 | 11.1 |
| Exchangeable K (ppm) | 312 | 306 |
| Available Fe (ppm) | 10.6 | 11.0 |
| Available Mn (ppm) | 3.8 | 2.9 |
| Available Zn (ppm) | 1.1 | 0.9 |
| Available Cu (ppm) | 3.22 | 3.0 |

Phosphorus fertilizer was added as calcium super phosphate (15.5% $P_2O_5$) at a rate of 22.5 kg $P_2O_5$/fed during land preparation.

Inorganic nitrogen fertilizer was applied as ammonium nitrate (33.5% N) at a rate of 45kg/fed in two equal splits after thinning and at the next irrigation.

Potassium fertilizer ((in the form of potasin –f) was added as spraying three times.

**The irrigation treatments were start after the second irrigation.**

The other cultural practices were carried out as recommended for conventional cotton cultivation in the local production district.

**Studied characters:**

**I-Leaf Chemical compositions:**

After 114 days from planting (top of flowering), the following constituents were determined i.e., total chlorophyll (Arnon, 1949), carotenoids (Rolbelen, 1957), total phenols (Simons and Ross, 1971) and proline content (Bates *et al*., 1973).

**II. Growth traits:**

At harvest, five guarded hills from the second row of each plot were taken at random to determine:

1. Plant height at harvest (cm),
2. No. of fruiting branches / plant.

**III- Flowering habit and earliness attributes:**

Three guarded hills with six plants of each plot were taken at random from the second row. Appearing flowers on the selected plants were recorded daily till the end of the flowering season, each flower was labeled according to its appearance date on the selected plants and the following traits were estimated:

1-Number of flowers/plant.

2-Boll setting %

3-Earliness%

4-Penta daily flowering curves.

**IV-Yield and yield components:**

At harvest, data were taken from five random representative guarded hills from the second row of each plot to determine the following yield components:

1. Number of open bolls/ plant.
2. Average boll weight (g).
3. Lint %.
4. Seed index (g).
5. Seed cotton yield (kentar/fed): Seed cotton yield per plot in kilograms was recorded and transformed to kentars per feddan (one kentar = 157.5 kg).

**V-Fiber quality:**

Samples of lint cotton were taken from the above ten representative plants from each - plot after ginning on a laboratory gin stand to determine the following fiber quality characters:

1) Fiber fineness (Micronaire value).

2) Fiber strength (Pressley index).

The two fiber quality characteristics were determined at the laboratories of Cotton Technology Research Division, at Cotton Research Institute, ARC, Giza, according to ASTM(1986).

**Statistical analysis:-**

The statistical analysis of the data was done and performed according to Le Clerg *et al*., (1966). The treatments means were compared using LSD at 0.05 (Waller and Duncan, 1969).

## RESULTS AND DISCUSSION

**I-leaf chemical composition:**

Irrigating intervals gave significant effect on leaf total chlorophyll, carotenoids, phenols and proline content at 114 days after planting, in favor of irrigated every 45 days followed by irrigated every 30 and 15 days in a descending order (Table 2).

Phenolic content of cotton leaves decreased sharply when the cotton plants were subjected to water stress. On the contrary, leaves of wilted plants accumulated more proline than those of turgid one. This increase may be due to the increase in protein hydrolysis as a result of increasing the activity of hydrolytic enzymes (Nayyer and Walia, 2003) and / or to increase the synthesis of proline Badran (2006). Proline would be a good source of energy and N for the plant under drought conditions. These results are agreement with the findings of Ahmed et al. (1989), Namich (1997) and Ashraf and Foolad (2007).

**Table 2: Effect of irrigation periods and natural materials as well as their interaction on leaf chemical composition in 2015**

| Treatments | | Total clorophyll (mg/g.dw.) | Leaf phenols content | Carotenoids (mg/ g.dw.) | Proline (mg/ g.dw.) |
|---|---|---|---|---|---|
| Irrigation intervals (A) | | | | | |
| a1 Irrigation every 15 day | | 14.17 | 14.17 | ٠.٦٦١ | ٢.٧٤ |
| a2 Irrigation every 30 day | | 15.72 | 15.72 | 0.683 | 2.87 |
| a3 Irrigation every 45 day | | 17.11 | 17.11 | 0.723 | 3.40 |
| LSD at 0.05 | | 0.04 | 0.04 | 0.02 | 0.02 |
| Spraying with natural materials B | | | | | |
| b1 Control | | 12.17 | 12.17 | 0.666 | 2.44 |
| b2 Glycine betaine | | 16.20 | 16.20 | 0.685 | 3.00 |
| b3 Potassium citrate | | 18.24 | 18.24 | 0.696 | 3.30 |
| b4 Salsalic acid | | 16.06 | 16.06 | 0.710 | 3.27 |
| LSD at 0.05 | | 0.03 | 0.03 | 0.01 | 0.03 |
| Interaction (AxB) | | | | | |
| a1 | b1 | 10.79 | 10.79 | 0.637 | 2.41 |
| | b2 | 15.33 | 15.33 | 0.643 | 2.68 |
| | b3 | 17.25 | 17.25 | 0.677 | 2.85 |
| | b4 | 13.32 | 13.32 | 0.688 | 3.02 |
| a2 | b1 | 12.34 | 12.34 | 0.653 | 2.34 |
| | b2 | 15.98 | 15.98 | 0.690 | 2.89 |
| | b3 | 18.32 | 18.32 | 0.686 | 3.15 |
| | b4 | 16.24 | 16.24 | 0.703 | 3.11 |
| a3 | b1 | 13.38 | 13.38 | 0.708 | 2.57 |
| | b2 | 17.29 | 17.29 | 0.722 | 3.43 |
| | b3 | 19.15 | 19.15 | 0.723 | 3.92 |
| | b4 | 18.63 | 18.63 | 0.740 | 3.69 |
| LSD at 0.05 | | 0.15 | 0.06 | 0.02 | 0.05 |

Natural materials significantly affected leaf total chlorophyll, phenols and proline content at 114 days after planting, in favor of spraying potassium citrate and significantly affected leaf carotenoids content, in favor of spraying salsalic acid. The positive effect of potassium citrate may be due to the role of K in activation of enzymes and its involvement in adenosine triphosphate (ATP) production is probably more important in regulating the rate of photosynthesis than is the rate of K in stomatal activity. When the sun's energy is used to combine $CO_2$ and water to form sugars, the initial high – energy product is ATP. The ATP is then used as the energy source for many other chemical reactions. The electrical charge balance at the site of ATP production is maintained with K ions. When plants are K deficient, the rate of photosynthesis and rate of ATP production are reduced and all of the processes dependent on ATP are showed down. Conversely, plant respiration increases which also contributes to slower growth and development (Dibb, 1998). In addition, the simulative effect due to the role of potassium on enzymes promotion activity and enhancing the translocation of assimilates and protein. Potassium nutrition had pronounced effect on carbohydrates partitioning by affecting either phloem export of photosynthesis (sucrose) or growth rate of sink and/or sources organ (Cakmak *et al*., 1994). In this concern, Meek *et al.* (2003) and Nayryar and Walia (2003) reported that glycine betaine increased chlorophyll, phenols, carbohydrates and proline contents of cotton leaves.

Concerning the interaction between irrigation intervals and natural materials, there is a significant interaction affect with regard to leaf total chlorophyll, carotenoids, phenols and proline contents. Irrigated cotton plants every 45 days in combined with spraying potassium citrate increased leaf total chlorophyll, phenols and proline contents, while irrigated cotton plants every 45 days in combined with spraying salsalic acid affected leaf carotenoids content. The interaction between irrigation intervals and glycine betaine had significant effects on leaf carotenoids, total phenols and proline contents but there were insignificant effects occurred on total chlorophyll. This result, may be a mean of osmotic adjustment by which glycine betaine exerted the previously reported improvement in leaf turgor pressure and water potential under water stress conditions and increased of stomatal resistant.

**II-Growth traits:**

The three tested irrigation intervals had significant effect on plant height at harvest and number of fruiting branches/plant in both seasons(Table 4). The highest values were obtained when the plants were irrigated every 15 days as compared with the other two irrigation intervals (every 30 days or 45 days). This increment may be due to that normal irrigation supply the plants with water supply at the early stages of growth which is essential in the photosynthesis and the hydrolytic processes. These results were in agreement with Ibrahim and Moftah (1997), Ali (2002), and Ahmad and Kassem (2008).

Untreated Plants caused a significant increase in plant height at harvest number of fruiting branches/plant in both seasons as compared with the plants which received glycine betaine, potassium citrate and salsalic acid.

Concerning the interaction effect between irrigation intervals and natural materials, the results show insignificant interaction on plant height at harvest, number of fruiting branches/plant.

**III-Earliness traits:**

Data presented in Table (3) show that irrigation every 15 days significantly increased number of flowers/plant and decreased setting and earliness percentages in both seasons compared with the other two irrigation intervals (every 30 and 45 days). In this concern, Ibrahim and Moftah (1997), Ali (2002); and Hameed and Abod (2010) obtained the same results.

Natural materials treatments gave significant effect on number of total flowers/plant, number of open bolls/plant and boll setting% in both seasons, in favor of treated plants with potassium citrate (3g/l) or with glycine betaine (600 ppm), where these two treatments gave the highest values without significant differences between them. While the lowest values were produced from untreated plants. Natural materials treatments gave insignificant effect on earliness % in both seasons.

**Table 3. Effect of irrigation periods and natural materials as well as their interaction on earliness traits and fiber quality in 2015 and 2016 seasons.**

| Treatments | | No. of flowers/ plant | | No. of open bolls/plant | | Boll setting % | | Earliness % | | Pressley index | | Micronire reading | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ |
| Irrigation intervals (A) | | | | | | | | | | | | | |
| a1 Irrigation every 15 day | | 28.81 | 29.39 | 20.59 | 20.99 | 71.43 | 72.96 | 65.21 | 66.64 | 10.00 | 10.10 | 4.20 | 4.50 |
| a2 Irrigation every 30 day | | 28.01 | 28.68 | 20.87 | 21.36 | 74.10 | 75.64 | 74.42 | 75.96 | 9.50 | 9.70 | 4.30 | 4.60 |
| a3 Irrigation every 45 day | | 26.65 | 27.21 | 18.84 | 20.27 | 74.91 | 76.58 | 77.20 | 78.81 | 10.00 | 10.20 | 4.50 | 4.50 |
| LSD at 0.05 | | 0.35 | 0.33 | 0.45 | 0.49 | 1.33 | 1.37 | 1.15 | 1.08 | Ns | Ns | Ns | Ns |
| Spraying with natural materials B | | | | | | | | | | | | | |
| b1 Control | | 26.63 | 27.20 | 18.98 | 19.38 | 71.22 | 72.65 | 71.08 | 72.56 | 9.50 | 9.60 | 4.40 | 4.60 |
| b2 Glycine betaine | | 28.75 | 29.32 | 21.52 | 22.07 | 74.77 | 76.26 | 72.87 | 74.34 | 9.20 | 9.50 | 4.20 | 4.50 |
| b3 Potassium citrate | | 28.90 | 29.48 | 21.68 | 22.09 | 75.06 | 76.63 | 71.59 | 73.18 | 9.70 | 9.90 | 4.30 | 4.50 |
| b4 Salsalic acid | | 27.02 | 27.70 | 19.56 | 19.96 | 72.88 | 74.69 | 73.65 | 75.11 | 9.50 | 9.70 | 4.20 | 4.40 |
| LSD at 0.05 | | 0.77 | 0.77 | 0.73 | 0.72 | 0.31 | 1.35 | Ns | Ns | Ns | Ns | Ns | Ns |
| Interaction (AxB) | | | | | | | | | | | | | |
| a1 | b1 | 27.42 | 27.97 | 19.22 | 19.60 | 70.08 | 71.42 | 64.99 | 66.51 | 9.80 | 9.85 | 4.30 | 4.55 |
| | b2 | 30.15 | 30.75 | 22.02 | 22.46 | 73.07 | 74.53 | 65.52 | 66.85 | 9.70 | 9.80 | 4.30 | 4.50 |
| | b3 | 29.89 | 30.49 | 21.51 | 21.94 | 71.95 | 73.62 | 63.43 | 64.97 | 10.00 | 10.00 | 4.40 | 4.50 |
| | b4 | 27.79 | 28.35 | 19.62 | 19.96 | 70.64 | 72.28 | 66.89 | 68.24 | 9.50 | 9.90 | 4.50 | 4.45 |
| a2 | b1 | 26.88 | 27.42 | 19.79 | 20.18 | 72.67 | 74.12 | 72.47 | 73.92 | 9.80 | 9.65 | 4.40 | 4.60 |
| | b2 | 28.95 | 29.53 | 21.93 | 22.59 | 75.32 | 76.83 | 75.19 | 76.71 | 9.40 | 9.60 | 4.40 | 4.55 |
| | b3 | 29.64 | 30.23 | 22.46 | 22.91 | 75.77 | 77.29 | 74.49 | 76.20 | 9.70 | 9.80 | 4.20 | 4.55 |
| | b4 | 26.58 | 27.55 | 19.31 | 19.76 | 72.62 | 74.31 | 75.52 | 77.01 | 9.60 | 9.85 | 4.20 | 4.50 |
| a3 | b1 | 25.60 | 26.22 | 17.95 | 18.36 | 70.90 | 72.42 | 75.79 | 77.32 | 9.50 | 9.60 | 4.20 | 4.55 |
| | b2 | 27.15 | 27.69 | 20.60 | 21.15 | 75.92 | 77.42 | 77.90 | 79.48 | 9.50 | 9.55 | 4.30 | 4.55 |
| | b3 | 27.17 | 27.91 | 21.07 | 21.42 | 77.46 | 78.98 | 76.85 | 78.38 | 9.70 | 9.75 | 4.20 | 4.50 |
| | b4 | 26.68 | 27.21 | 19.76 | 20.17 | 75.36 | 77.48 | 78.53 | 80.07 | 9.60 | 9.65 | 4.20 | 4.50 |
| LSD at 0.05 | | 1.34 | Ns | 1.27 | Ns | 0.65 | Ns | Ns | 3.51 | Ns | Ns | Ns | Ns |

Concerning the interaction between irrigation intervals and natural materials, there is a significant interaction effect with regard to number of total flowers/plant, number of open bolls/plant, boll setting% and earliness % in one season only. The highest value of number of total flowers/plant was obtained from irrigated plants every 15 days and received glycine betaine (600 ppm). But the highest value of number of open bolls/plant was obtained from irrigated plants every 30 days and received potassium citrate (3g/l). Irrigated cotton plants every 45 days, combined with glycine betaine (600 ppm) produced the highest boll setting% and when combined with potassium citrate (3g/l) produced the highest earliness %.

**IV-Daily flowering curve:**

The general trend of curves shape of the accumulative number of flowers produced per plant of natural materials treatments as compared with control (without application) and their distribution during the flowering period was shown in figures 1, 2 and 3 for the first, second and third irrigation intervals, respectively.

Figures 1, 2 and 3 show that at the first irrigation interval (every 15 days) flowering start at 24/6, 25/6, 26/6 and 27/6 in untreated plants, plants which received glycine betaine, potassium citrate and salsylic acid, respectively. While, at the second irrigation interval (every 30 days) flowering start early by about 4 days, where flowering start at 20/6 for untreated plants, and plants which received glycine betaine-, and at 22/6 and 23/6 for plants which received potassium citrate and salsylic acid, respectively. Delaying irrigation interval from 15days to 45 days flowering start early by about 7 to 8 days, where flowering start at16/6 for plants which received glycine betaine and potassium citrate and at 18/6 and 20/6 for plants which received salsylic acid and control (untreated plants), respectively.

From the same figures, it could noticed that at the first irrigation interval (every 15 days), the difference in the accumulative number of flowers per plant was low in the early part of flowering period and increased with progress of plants towards maturity, where there are two curves peak, the first peak reached its maximum of flowers production after approximately 18 days from flowering for untreated plants, and plants which received potassium citrate-, and after 19 and 25 days from flowering for plants which received glycine betaine and salsylic acid, respectively. The second curve peak reached its maximum of flowers production at approximately 34 and 36 days from flowering for plants which received glycine betaine and potassium citrate, respectively and after 36 and 37 days from flowering for untreated plants, and plants which received salsylic acid, respectively. The two main curves peak was higher in case of plants which received glycine betaine and potassium citrate, respectively, as compared with untreated plants and plants which received salsylic acid. Also, it could noticed that flowering start from 24/6 and 25/6 until 17/8 in untreated, plants and plants which received glycine betaine, respectively, and from 26/6 to

16/8 in plants which received potassium citrate and from 26/7 to 15/8 in plants which received salsylic acid.

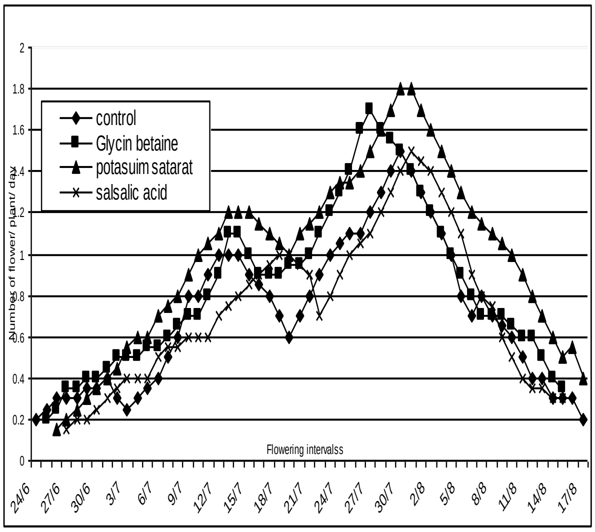


**Fig. 1. Penta daily flowering curve for irrigation every 15 days**

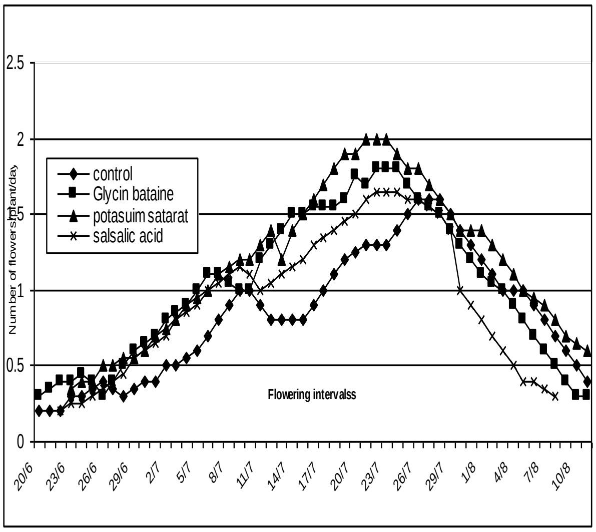


**Fig. 2. Penta daily flowering curve for irrigation every 30 days**

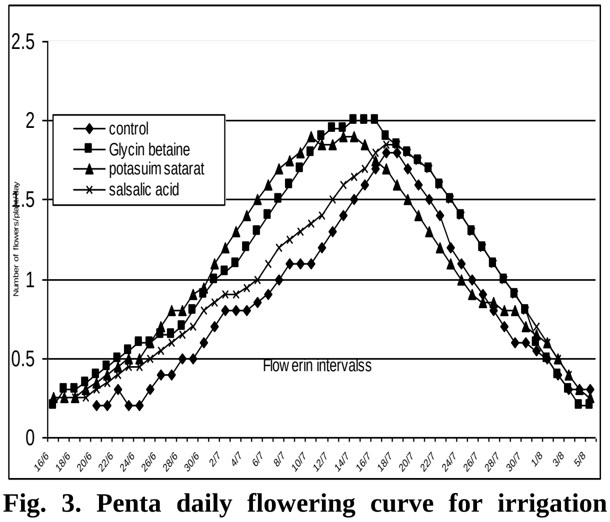


**Fig. 3. Penta daily flowering curve for irrigation every 45 days**

At the second irrigation interval (every 30 days), the difference in the accumulative number of flowers per plant was low in the early part of flowering period and increased with progress of plants towards maturity, where there are two curves peak, the first peak reached its maximum of flowers production after approximately 17, 16, 19 and 20 days from flowering for plants which received glycine betaine, potassium citrate, untreated plants and plants which received salsylic acid, respectively. The second curve peak reached its maximum of flowers production at approximately 31, 32, 33 and 34 days from flowering for plants which received potassium citrate, glycine betaine, salsylic acid and untreated plants, respectively and after 36 and 37 days from flowering for untreated plants and plants which received salsylic acid, respectively. The two main curves peak was higher in case of plants which received potassium citrate and glycine betaine, respectively, as compared with untreated plants and plants which received salsylic acid. Also, it noticed that flowering start from 20/6 until 11/8 in untreated plants and plants which received glycine betaine and from 23/6 to 16/8 in plants which received potassium citrate and from 26/7 to7/8 and11/8 in plants which received salsalic acid and potassium citrate, respectively.

At the third irrigation interval (every 45 days), the difference in the accumulative number of flowers per plant was low in the early part of flowering period and increased with progress of plants towards maturity, where there is one main curve peak, it reached its maximum of flowers production after approximately 24 and 28 days from flowering for plants which received potassium citrate and glycine betaine, respectively, and after 25 and 30 days from flowering for untreated plants and plants which received salsylic acid, respectively. The main curve peak was higher in case of plants which received glycine betaine and potassium citrate respectively, as compared with untreated plants and plants which received salsylic acid. Also, it noticed that flowering start from 16/6 until 3/8 in plants which received glycine betaine and potassium citrate and from 18/6 to 31/7 in plants which received salsylic acid and from 20/6 to 5/8 in untreated plants.

In general, the highest values of flowers at the main peaks of flowering in the three irrigation intervals were obtained from plants treated with potassium citrate(3g/l) followed by those treated with glycine betaine(600ppm) under 15 and 30 days intervals and the inverse was true under irrigation every 45 days and the lowest values were produced from plants treated with salsalic acid (200ppm) and untreated plants under irrigation every 15 days, while under irrigation every 30 and 45 days the lowest values were produced from untreated plants. Also, it could be noticed that the flowering curve in irrigation every 30 and 45 days was higher, start earlier and ending earlier as compared to the flowering curves in the irrigation every 15 days.

**Table 4. Effect of irrigation periods and natural materials as well as their interaction on growth and yield in 2015 and 2016 seasons.**

| Treatments | | Plant height (cm) | | No. of fruiting branches /plant | | Boll Weight (g) | | Seed Index (g) | | Lint % | | Seed cotton yield (kentar/fed.) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ | ٢٠١٥ | ٢٠١٦ |
| Irrigation intervals (A) | | | | | | | | | | | | | |
| a1 Irrigation every 15 day | | 167.43 | 172.46 | 16.60 | 17.13 | 3.37 | 3.31 | 11.77 | 11.70 | 40.82 | 40.03 | 10.70 | 10.48 |
| a2 Irrigation every 30 day | | 159.85 | 162.91 | 15.94 | 16.35 | 3.38 | 3.20 | 11.89 | 11.79 | 41.70 | 41.28 | 10.82 | 10.57 |
| a3 Irrigation every 45 day | | 150.17 | 152.56 | 15.00 | 15.46 | 3.29 | 3.19 | 11.6 | 11.40 | 41.80 | 41.38 | 10.05 | 9.83 |
| LSD at 0.05 | | 2.36 | 2.07 | 0.12 | 0.22 | 0.13 | 0.06 | Ns | Ns | 0.22 | 0.32 | 0.29 | 0.25 |
| Spraying with natural materials B | | | | | | | | | | | | | |
| b1 Control | | 161.36 | 164.80 | 16.08 | 16.53 | 3.26 | 3.10 | 11.94 | 11.00 | 40.86 | 40.45 | 9.81 | 9.59 |
| b2 Glycine betaine | | 158.78 | 162.37 | 15.86 | 16.32 | 3.44 | 3.32 | 11.50 | 10.64 | 41.76 | 41.34 | 11.11 | 10.87 |
| b3 Potassium citrate | | 159.58 | 163.17 | 15.92 | 16.40 | 3.43 | 3.26 | 12.10 | 10.36 | 41.87 | 41.46 | 11.03 | 10.81 |
| b4 Salsalic acid | | 156.89 | 160.23 | 15.53 | 16.00 | 3.21 | 3.25 | 11.35 | 10.91 | 40.92 | 40.50 | 10.16 | 9.90 |
| LSD at 0.05 | | NS | 3.11 | 0.29 | 0.27 | 0.10 | 0.04 | Ns | Ns | 0.26 | 0.35 | 0.39 | 0.36 |
| Interaction (AxB) | | | | | | | | | | | | | |
| a1 | b1 | 171.15 | 176.29 | 17.00 | 17.51 | 3.35 | 3.15 | 11.82 | 10.97 | 40.21 | 39.81 | 9.94 | 9.78 |
| | b2 | 166.00 | 170.98 | 16.58 | 17.18 | 3.43 | 3.37 | 11.63 | 11.06 | 41.69 | 41.27 | 11.20 | 10.98 |
| | b3 | 168.17 | 173.21 | 16.75 | 17.25 | 3.41 | 3.32 | 11.94 | 10.82 | 41.45 | 41.04 | 11.32 | 11.08 |
| | b4 | 164.42 | 169.35 | 16.08 | 16.57 | 3.28 | 3.37 | 11.75 | 10.46 | 39.78 | 39.38 | 10.35 | 10.08 |
| a2 | b1 | 160.71 | 163.37 | 16.00 | 16.41 | 3.29 | 3.14 | 11.92 | 11.40 | 41.67 | 41.25 | 10.45 | 10.14 |
| | b2 | 160.75 | 163.96 | 16.00 | 16.32 | 3.49 | 3.28 | 11.69 | 11.31 | 42.07 | 41.65 | 11.55 | 11.28 |
| | b3 | 160.33 | 163.53 | 16.00 | 16.47 | 3.47 | 3.23 | 11.99 | 11.09 | 42.28 | 41.86 | 11.29 | 11.08 |
| | b4 | 158.17 | 160.76 | 15.75 | 16.21 | 3.28 | 3.14 | 11.62 | 12.06 | 40.34 | 39.94 | 10.00 | 9.77 |
| a3 | b1 | 152.75 | 154.75 | 15.25 | 15.68 | 3.15 | 3.00 | 11.77 | 10.63 | 40.71 | 40.30 | 9.37 | 8.86 |
| | b2 | 149.58 | 152.17 | 15.00 | 15.95 | 3.41 | 3.29 | 11.55 | 10.56 | 41.31 | 40.87 | 10.57 | 10.35 |
| | b3 | 150.25 | 152.75 | 15.00 | 15.48 | 3.41 | 3.23 | 11.85 | 10.19 | 42.11 | 41.68 | 10.46 | 10.26 |
| | b4 | 148.08 | 150.58 | 14.75 | 15.23 | 3.23 | 3.24 | 11.47 | 10.21 | 41.06 | 40.65 | 10.14 | 9.87 |
| LSD at 0.05 | | NS | Ns | NS | Ns | NS | 0.08 | Ns | Ns | 0.42 | 0.48 | 0.67 | 0.64 |

**V- Yield and yield components**

Regarding the effect of irrigation intervals on boll weight and number of open bolls/plant, results in Table 4 show significant differences among irrigation intervals in both seasons. The heaviest bolls were obtained from the plants irrigated every 15 days compared with the other two irrigation intervals. However, the higher number of open bolls/plant was obtained from plants which irrigated every 30 days without differences between irrigation every 15 and 30 days.

Irrigation intervals had insignificant effect on seed index and significant effect on lint % in both seasons. The highest value of lint % was resulted from irrigated the plants every 45 days.

Growing cotton plants under irrigation every 30 days had significant increase in seed cotton yield / feddan compared with the other two irrigation intervals (every 15 and 4 5 days). The increase of seed cotton yield / fedden might be attributed to increase of boll weight and number of open bolls / plant. Similar results were obtained by Soomaro *at al.* (2001) and Abdelatif *et al.* (2002) who found that irrigation cotton plants every 14 days produced the highest values of seed cotton yield / plant and per fed.

Water stress could restrict internode elongation and leaf expansion through inhibiting cell expansion, the process known to be sensitive to water stress. Also, drought could lower biomass accumulation by driving the plants to minimize water loss through transpiration by inducing stomatal closure and since carbon gain can occur only while water is being lost (Radin, 1989) These results are in general agreement with the finding of Kassem and Namich (2003) and Gebaly, (2007).

Natural materials significantly affected boll weight and number of open bolls/plant in both seasons in favor of spraying glycine betaine and potassium citrate.

Application of salsalic acid or glycine betaine gave significant increase in lint % and insignificant effect on seed index in both seasons.

Spraying cotton plants with glycine betaine at the concentration (600 ppm) lead to a significant increase in seed cotton yield per feddan. Such increase in chemical contents due to glycine betaine application may be attributed to that glycine betaine could be a good storage form of nitrogen because of its metabolic proximity and ready conversion to glutamic acid, a key compound in nitrogen metabolism and source of reducing power. Applying glycine betaine prior to water stress improved photosynthesis by increasing of stomata conductance. These results are parallel with the findings of Namich (2003).

With regard to the effect of the interaction between irrigation intervals and natural materials on seed index and lint %, the data indicate that irrigation every 30 days in combination with spraying potassium citrate produced the highest values of lint % in both seasons. However, this interaction gave insignificant effect on seed index in both seasons.

The reduction in yield and yield components was observed as results of water stress. On the other hand, spraying cotton plants with glycine betaine under normal and drought conditions tended to increase physiological processes i.e., stomatal conductance, photosynthetic rate and this tended to a significant increase in growth parameters i.e., number of nodes and fruiting branches and some chemical contents in cotton leaves i.e., chlorophyll A, B and carotene, total phenols and proline. Also, the application of glycine betaine tend to a significant increase in number of flowers and bolls per plant, boll setting and lint percentage, boll weight, seed index and seed cotton yield.

The combined treatment of irrigation interval every 30 days when combined with glycine betaine at the concentration (600 ppm) gave significant increase in seed cotton yield / fedden (kentar) in both seasons and when combined with potassium citrate at the concentration (3g/l) in the first season only. This could be due to that glycine betaine promoted some morphological and physiological responses that control water stress plants more than well-watered, such as increasing leaf area, increasing root / shoot ratio, increasing leaves content of sugars and increasing proline content which all could improve water relations of water-stressed plants (Ashraf and Foolad, 2007).

**VI-Fiber quality:**

Data in Table 3 show that Presley index and micronaire reading did not affect by irrigation intervals, natural materials and their interaction in both seasons.

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## استجابة القطن للرش بالمواد الطبيعية تحت ظروف الاجهاد المائى

**على السيد الجعبيرى**
**قسم بحوث الفسيولوجى ـ معهد بحوث القطن- مركز البحوث الزراعية-الجيزة- جمهورية مصر العربية.**

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالجميزة محافظة الغربية خلال موسمى٢٠١٥ و٢٠١٦م لتحديد أفضل فترة رى(كل ١٥يوم،٣٠ يوم،٤٥ يوم) وتأثير بعض المواد الطبيعية(بدون، جليسين بيتاين(٦٠٠جزء فى المليون)،سترات بوتاسيوم(٣جم/لتر)،حمض سالسيلك(٢٠٠جزء فى المليون) فى تقليل التأثير السلبى للاجهاد المائى وكذلك التفاعل بينهما على التركيب الكيماوى لأوراق القطن،النمو، التبكير، منحنى التزهير،المحصول ومكوناته وجودة التيلة للقطن جيزة ٨٦. استخدم تصميم القطع المنشقة حيث وضعت فترات الرى فى القطع الرئيسية ووضعت معاملات الرش بالمواد الطبيعية فى القطع الشقية. ويمكن تلخيص أهم النتائج المتحصل عليها كما يلي: أعطى الرى كل ٤٥ يوم زيادة معنوية فى صفات محتوى الأوراق من الكلوروفيل الكلى، الكاروتينيدات، الفينولات،البرولين والنسبة المئوية للتيلة بينما أعطى الرى كل ١٥ يوم زيادة معنوية فى ارتفاع النبات عند الحصاد ،عدد الافرع الثمرية / نبات ،عدد الازهار الكلية / نبات ووزن اللوزة مع خفض النسبة المئوية للعقد والتبكير. كما أعطى الرى كل ٣٠ يوم زيادة معنوية فى صفات عدد اللوز المتفتح / نبات ومحصول القطن الزهر للفدان. اثرت المواد الطبيعية تأثيرا معنويا على صفات محتوى الورقة من الكلوروفيل الكلى, الفينولات،البرولين عند الرش بسترات البوتاسيوم على محتوى الورقة من الكاروتينيدات عند الرش بحمض السالسيلك. أدى الرش بجليسين بيتاين ،سترات بوتاسيوم زيادة معنوية فى عدد اللوز المتفتح / نبات ووزن اللوزة. أعطى الرش بجليسين بيتاين و بحمض السالسيلك زيادة معنوية فى النسبة المئوية للتيلة كما أعطى الرش بجليسين بيتاين زيادة معنوية فى محصول القطن الزهر للفدان فى الموسمين. فى حين أعطت النباتات غير المعاملة زيادة معنوية فى ارتفاع النبات عند الحصاد وعدد الافرع الثمرية / نبات فى الموسمين. أعطى التفاعل تأثيرا معنويا على صفات محتوى الأوراق من الكلوروفيل الكلى، الكاروتينيدات، الفينولات،البرولين عند الرى كل ٤٥ يوم مع الرش بسترات البوتاسيوم بالنسبة الى محتوى الأوراق من الكلوروفيل الكلى، الفينولات،البرولين وعند الرى كل ٤٥ يوم مع الرش بحمض السالسيلك بالنسبة الى محتوى الأوراق من الكاروتينيدات. أعطى الرى كل ٣٠ يوم مع الرش بسترات البوتاسيوم زيادة معنوية فى النسبة المئوية للتيلة فى حين أعطى الرى كل ٣٠ يوم مع الرش بجليسين بيتاين زيادة معنوية فى محصول القطن الزهر للفدان فى الموسمين. لم يعطى التفاعل أى تأثير معنوى على معامل البذرة ومعامل بريسلى وقراءة الميكرونير فى الموسمين. أوضح منحنى التزهير ان التزهير فى الرى كل ٣٠ و٤٥ يوم بدأ مبكراً وأنتهى مبكرا مع تراكم أعلى لعدد الازهار وخاصة عند الرش بجليسين بيتاين او سترات بوتاسيوم مقارنة بالرى كل ١٥ يوم والرش بحمض السالسيلك أو عدم المعاملة. توصى الدراسة بالرى كل ٣٠ يوم مع الرش بجليسين بيتاين بمعدل ٦٠٠ جزء فى المليون أو بسترات البوتاسبوم(٣جم/لتر) ثلاث مرات فى مرحلة الوسواس، التزهير وقمة التزهير) تحت ظروف منطقة الجميزة. وفى حالة نهايات الترع وعدم وصول المياه يمكن التوصية بالرى كل ٤٥ يوم مع الرش بجليسين بيتاين بمعدل ٦٠٠ جزء فى المليون ثلاث مرات(فى مرحلة الوسواس، التزهير وقمة التزهير) .