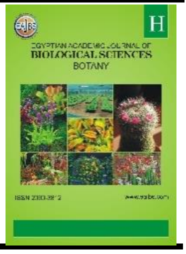
Egypt. Acad. J. Biolog. Sci., 11(1):103- 109 (2020)

Egyptian Academic Journal of Biological Sciences
H. Botany
ISSN 2090-3812
www.eajbsh.journals.ekb.eg.



Effect of Irrigation Intervals and Foliar Application of Potassium Silicate on Growth of Maize

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ARTICLE INFO

Article History
Received: 7/9/2020
Accepted: 8/11/2020

***Keywords*:**
Maize, Irrigation, intervals, water stress, K- silicate, growth, characters

ABSTRACT

Two field experiments were carried out at Etay El-Baroud Station, El-Beheira Governorate, Agricultural Research Center (ARC), Egypt to evaluate the effect of the three irrigation intervals and potassium silicate of the maize grown in the 2017 and 2018 seasons. The treatments of the two factors were distributed in a split-plot design in the four replications. Where three irrigation intervals (10, 15, and 20 days) were assigned in main plots, meanwhile the four foliar applications of potassium silicate (once spray at 40 days after sowing), twice sprays at 40 and 60 days after sowing, three sprays at 40, 60 and 80 days after sowing) and control (water spray) were allocated in a subplot in both seasons. The results revealed that irrigation every 15 days gave the highest values of growth of maize. Foliar application three times of K- silicate gave the highest values of growth characters. However, irrigation every 15 days with foliar application of K- silicate at three times recorded the highest values of the most growth characters in both seasons.

INTRODUCTION

Maize (*Zea mays* L.) is the third most important staple food crop in terms of area and production after wheat and rice in Egypt and the world**.** The cultivated area of maize in Egypt occupies approximately 2.2.million feddan with an average yield of 3.1 ton/fed, while the cultivated area of yellow maize in Egypt (960000 fed) (FAO, 2018).

Application silicon (Si) has a biostimulative impacts, and the positive results are noticed in stressful conditions for many plants as salinity, deficiency or excess of water, high and low temperature, and the stout pressure of diseases and pests, etc. The application of Si of plants is unusual. Positive views of silicon fertilization are related to the foliar application, which is much cheaper and more convenient to use than soil fertilization (Artyszak, 2018). Potassium silicate (K- silicate) is a source of highly soluble potassium and silicon. Potassium silicate contains no volatile organic compounds and applications will not result in the release of any hazardous or environmentally persistent byproducts (Romero-Aranda *et al*., 2006).On the other hand, Clarkson (2011); Liu *et al*. (2011); Ahmad *et al*. (2013); Mikhael *et al*. (2018); Shedeed (2018) they who detected that Si application increased growth in many crops by enhancing utilization rate and absorbing ability of nutrients and increasing photosynthesis efficiency.

The main objectives of this investigation were to study what are the best irrigation intervals which achieve the highest growth, to evaluate the performance of some foliar application of K- silicate to mitigate the water stress effect on maize growth.

MATERIALS AND STUDY AREA

Two field experiments were conducted at Etay El-Baroud Station, El-Beheira Governorate, Agriculture Research Center (ARC), Egypt in cropping seasons 2017 and 2018 to study the effect of irrigation intervals and foliar application of potassium silicate on the growth of maize.

The soil samples were air-dried, passed through a 2 mm sieve, and then analyzed according to the method described by Page *et al.* (1982). The soil type of the experimental site was clay loamy. The mechanical and chemical analysis of the experimental site is presented in Table (1).

Table 1. Physical and chemical properties of the experimental site in both seasons.

Season	Soil texture	Sand %	Silt %	Clay %	PH	Organic matter (%)	Anions (meq/1)			Cataions (meq/1)		
							HCO^-_3	CL^-	CL^-	Ca^{++}	Mg^+	K^+
2017	Clay	7.1	32.5	61.4	7.7	3.1	0.8	8.4	7.0	6.1	3.5	1.6
2018	Clay	7.0	33.1	59.9	7.9	3.1	0.9	9.1	7.2	5.9	3.4	1.5

The treatment of experiments distributed in a split-plot system in four replicates in both seasons, where the main plot was irrigation intervals (10, 15, and 20 days), while the subplot was potassium silicate treatments (once spray at 40 days after sowing), twice sprays at 40 and 60 days after sowing, three sprays at 40, 60 and 80 days after sowing) and control (water spray)

Yellow maize hybrid (SC168) was sown on 3rd June and 28th May in both seasons, respectively. Plot area was 21 m^2 (5 ridges, apart = (0.70 m) × 6 m long).

Maize was sown in hill spaced 25 cm and plants were thinned to one plant per hill. Calcium superphosphate (12.5%) at the rate of 25 kg P_2O_5/fed was added during soil preparation, while N- fertilizer in urea from (46.5% N) at the rate of 120 kg N/fed was added in two equal doses before the first and second irrigations, respectively.

The experimental units were hand hoed twice for controlling weeds before the first and second irrigations. Other agricultural practices were done as recommended by the Ministry of Agriculture and Land Reclamation.

Number of leaves/plant, leaf area/plant (cm^2) and leaf area index (LAI) were studied, total chlorophyll content (SPAD unit), ear height (cm), ear position (%) where

$$\text{Leaf area index}(LAI) = \frac{Leaf\ area\ per\ plant\ (cm^2)}{Ground\ area\ per\ plant\ (cm^2)}.$$

All statistical analyses and the least significant difference test (LSD) at the 0.05 level of probability was used to compare the treatment means were done by the CoStat computer software package (CoStat, Ver.6.43, 2005).

RESULTS AND DISCUSSION

Results in Table (2) showed that the leaf area index (LAI) was not significantly affected by irrigation intervals. No. of leafs/plant was significantly affected by irrigation intervals in 2018 season only, the highest leafs/plant were obtained when maize plants irrigated every 10 days (I1). Leaf area/plant and plant height were significantly affected by irrigation intervals in both seasons, the highest values when maize plants irrigated every 10 days (I1) in the two studied seasons. Boobathi and Singh (1984) found that the growth of sorghum increased by shorter irrigation intervals (7-10 days). Irrigation with interval 14 days and spraying K-silicate at concentrations of 1000 mg/l silicate gave root fresh as compared with obtained without spraying K-silicate (Ali *et al.*, 2019).

Data in Table (2) leveled that, leaf area/plant and ear height did not significant as affected by potassium silicate (s). leaf area index (LAI) was significantly affected by potassium silicates in 2018 season only, maize plants were sprayed three-times with potassium silicates (S3) had the highest value of these characters. The number of leafs/plant and plant height was significantly affected by potassium silicate in 2017 seasons only, the highest values have resulted when maize plants sprayed three-times with potassium silicates (S3). Shedeed (2018) denoted that weekly foliar spraying of potassium silicate in a gradually increased series of concentrations (5, 6, 7, 8, 9, 10 cm^3 /L) resulted in a significant effect on all growth parameters: plant height, stem diameter, leaf area, No. of leaves/plant, fresh and dry weight of leaves and stem of maize.

Table 2. Growth characters of maize as affected by irrigation intervals and foliar spray of potassium silicates during 2017 and 2018 seasons.

Treatments	Seasons					
	2017			2018		
Irrigation intervals (I)	No. of leaves /plant	Leaf area/plant (cm2)	Leaf area index (LAI)	No. of leafs /plant	Leaf area/plant (cm^2)	Leaf area index (LAI)
I1 (10 days)	13.05	1.07	5.83	13.57	1.45	5.83
I2 (15 days)	13.14	1.06	5.84	13.39	1.06	5.71
I3 (20 days)	13.10	0.99	5.26	13.25	1.01	5.51
L.S.D.at 5%	N.S.	0.05	N.S.	o.23	N.S.	N.S.
K- silicate (S)						
S1 (once)	12.98	0.99	5.68	13.40	1.06	5.52
S2 (twice)	13.11	1.05	5.70	13.29	1.04	5.68
S3(three time)	13.36	1.08	5.95	13.42	1.10	6.09
S4(control)	12.93	1.03	5.39	13.49	1.02	5.43
L.S.D. at 5%	0.35	N.S.	N.S.	N.S.	N.S.	0.40
Interaction (IxS)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

I=irrigation interval S=spray of potassium silicate N.S=not significant L.S.D.at 5%= the least significant difference at a 5% level of probability.
N.S.: Not significant at 0.05 level of probability.

The results in Table (3) showed that irrigation intervals had a significant effect on total chlorophyll. The highest values produced when maize plants irrigated every 10-days (I1), followed by when maize plants irrigated every 15-days (I2) and did not significantly differ between them. However, the lowest value was produced when maize plants irrigated every 20-days (I3) interval. The increase in chlorophyll content in leaf tissue by decreasing ware applied interval from S3 to S1, these results may be due to root plants resulting in the higher absorption of nutrients. Lawson *et al.* (2003) reported that water deficit or drought leads to closure of stomatal, reduced transpiration, decrease in water potential of plant tissues, decrease in photosynthesis and ultimately plant growth and development is inhibited.

Data tabulated in Table (3) revealed that irrigation intervals had a significant effect on total chlorophyll in both seasons. The highest values for total chlorophyll were produced from growing maize under foliar spray condition {three-time potassium silicate (S3)} in both seasons, respectively. Foliar sprayed of maize plants with water (S4) gave the lowest values for this character and this treatment had no significant difference from foliar spray maize plants once with potassium silicate (S1) in 2017 and 2018 seasons, respectively. The increase in total chlorophyll content in leaf tissues by intercropping systems could be attributed to the effective use of inputs like water, nutrients, light, pesticides, and energy, which can significantly increase crop yield compared with water spray {(control) (S4) treatment}. Cottenie *et al.* (1982) found that potassium silicate foliar application has many benefits in improving leaf erectness, and improving photosynthesis efficiency also reducing the capability to lodging in grasses.

Data presented in Table (3) revealed that the interaction between irrigation intervals under foliar spray with potassium silicate had no significance on total chlorophyll in both seasons.

As for the effect of irrigation intervals, results in Table (3) indicated that irrigation intervals had a significant effect on ear height per plant (cm) in the two studied seasons. Maize plants that were irrigated every 10-days (I1) interval gave the highest ear height in the first and second seasons. While the less ear height was recorded when exposed maize plants to water stress 20-days interval (I3). Irrigation interval every 10 days resulted in the tallest ear height throughout the different measurement periods, then a reduction in ear height was observed as irrigation interval prolonged this may be due to the fact that water stress gave short ear height. The results reported that 10 days interval resulted in the tallest ear height with all combinations of irrigation water amounts in both seasons. Westgate (1994) confirmed the same results. On the other hand, Si spray had no effect on this studied character in both seasons (Table 3).

It is shown clearly from Table (3) that irrigation intervals had no significant effect on ear position (%) in both seasons. Also, results in Table (3) revealed that foliar spray with potassium silicates had a significant effect on ear position (%) per plant in the 2018 season only. The highest ear position (%) per plant was observed when maize plants sprayed three-times with potassium silicates (S_3), followed by sprayed maize plants twice with potassium silicates (S_2). While the lowest ear position (%) per plant was recorded when maize plants sprayed water (control) without potassium silicates (S_4). So, silicon has a positive effect on growth. Silicon also has a good effect on plants chlorophyll content and helps plants to maintain over a longer period with better shelf life and appearance (Balakhnina and Borkowska, 2013). In addition, Si had the main role such as increased growth and yield, improved strength, minimized climate stress, and provided impedance to mineral stress, improving leaf erectness, and improving photosynthesis efficiency in grasses (Ahmad *et al.* 2013).

The interaction between irrigation intervals and foliar spray with potassium silicates as shown in Table (3) had no significance on these studied characters in both seasons.

Table 3. Growth characters of maize as affected by irrigation intervals and foliar spray of potassium silicates during 2017 and 2018 seasons.

Treatments	Seasons					
	2017			2018		
Irrigation intervals (I)	Total chlorophyll	Ear height (cm)	Ear position (%)	Total chlorophyll	Ear height (cm)	Ear position (%)
I1 (10 days)	58.41	127.84	56.57	61.13	122.00	54.59
I2 (15 days)	58.48	124.56	57.69	58.67	113.03	53.22
I3 (20 days)	56.76	117.85	58.66	54.88	106.06	53.36
L.S.D.at 5%	1.00	6.29	N.S.	2.48	6.69	N.S.
K- silicate (S)						
S1 (once)	57.01	121.50	56.03	57.66	110.30	53.04
S2 (twice)	58.90	123.48	58.85	58.59	110.00	53.35
S3(three time)	60.21	129.27	58.99	62.06	113.67	56.28
S4(control)	55.41	119.47	56.67	54.58	121.71	52.22
L.S.D. at 5%	2.58	N.S.	1.00	2.77	N.S.	3.41
Interaction(IxS)	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

I=irrigation interval S=spray of potassium silicate N.S=not significant L.S.D.at 5%= the least significant difference at a 5% level of probability.
N.S.: Not significant at 0.05 level of probability

CONCLUSION

Based on this investigation and under the same conditions, the results can recommend under water scarcity, with foliar spraying three-times of potassium silicate (S3) increased growth characters of maize in both seasons in El- Behira Governorate, Egypt.

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ARABIC SUMMARY

تأثير فترات الرى والرش الورقي بسليكات البوتاسيوم على نمو الذرة الشامية

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2- محطة بحوث إيتاى البارود – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية- الجيزة – مصر.

أقيمت تجربتان حقليتان خلال موسمى 2017 و2018 بمحطة البحوث الزراعية – إيتاى البارود – محافظة البحيرة – مصر, لدراسة تأثير ثلاث فترات رى وهى [كل 10 أيام (**I**$_1$), كل 15 أيام (**I**$_2$), كل 20 أيام (**I**$_3$)] . وأربع نظم رش نباتات الذرة بسيليكات البوتاسيوم أضيفت بالنظم الأتية [الرش بسيليكات البوتاسيوم مرة واحدة بعد 40يوم من الزراعة (S1), الرش بسيليكات البوتاسيوم مرتين بعد40 و60يوم من الزراعة (S2), الرش بسيليكات البوتاسيوم ثلاث مرات بعد40 ,60و80يوم من الزراعة (S3) وعدم الرش بسيليكات البوتاسيوم أو الرش بالماء (كنترول) (S4)]. تصميم التجربة القطع المنشقة مرة واحدة فى أربع مكرارات.

ولخصت أهم النتائج فيما يلي:

- الرى 10يوم (**I**$_1$) أعطى زيادة معنوية فى صفات النمو الخضرى مثل عدد الأوراق للنبات ومساحة الورقية للنبات ودليل المساحة الورقية وقراءة الكلوروفيل الكلي في الورقة و أرتفاع الكوز (سم) و مكان الكوز (%) متبوعاً بالرى كل 15يوم (**I**$_2$) أعطى. فى هذة الاثناء لا يوجد أختلافات معنوية بين فترتى الرى كل (**I**$_1$) وكل 15يوم (**I**$_2$) فى معظم الصفات الدراسية.
- في حين أن الرش ثلاث مرات بسيليكات البوتاسيوم (S3) سجلت أعلى القيم فى كل صفات النمو التى أخذت. تحت ظروف العجز المائى يتم الرش ثلاث مرات بسيليكات البوتاسيوم (S3). للحصول أعلى نمو بالرى كل 15يوم (**I**$_2$) , مع الرش ثلاث مرات بسيليكات البوتاسيوم (S3).
- بينما التداخل بين عاملي الدراسة لم يحقق اى تأثير معنوي على معظم الصفات المدروسة.

التوصية:

تحت ظروف منطقة ايتاي البارود – محافظة البحيرة والظروف المماثلة لها في جمهورية مصر العربية وجد أن الرش ثلاث مرات من سيليكات البوتاسيوم والري كل 10 أو 15 يوم حققا أعلى متوسطات قيم لصفات نمو محصول الذرة الشامية.