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Effect of Irrigation Intervals under Different Sources of Potassium on Growth and Productivity of Garlic

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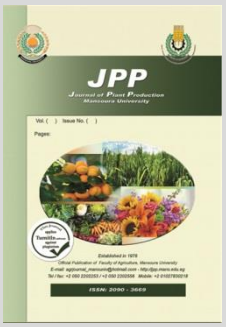

ABSTRACT

Two field experiments were carried out at the Vegetable Crops Farm in Baramoon Research Station, Dakahlia governorate, Egypt, during the two winter seasons, to investigate the effect of irrigation intervals under different sources of potassium combined with foliar application nano-K fertilizer on plant growth and productivity of garlic cv.Sids 40. The experiment includes 42 treatments which arranged in strip-split block design, as the interactions between three irrigation intervals (14, 21 and 28 days) as vertical plots, seven sources of potassium fertilization (100% K-mineral (150 kg Potassium Sulphate/fed.), 100% K-biofertilizer (2 L/fed., PSDB, Bacillus circulans), 100 % K-natural (700 kg Feldspar/fed.), 50 % K- mineral (75 kg/fed.) +50 % K-natural (350 kg/fed.), 50 % K- mineral (75 kg/fed.)+inoculated by PSDB, 50 % K-natural (350 kg/fed.)+inoculated by PSDB, and 33% K- mineral (50 kg/fed.)+33% K-natural (235 kg/fed.)+inoculated by PSDB as horizontal plots and two foliar applications (with nano-K and without) as split plots. Obtained results indicated that, the fertilization of plants with different sources of potassium as 33% K-mineral (50kg/fed.)+33% K-natural (235 kg/fed.) combined with inoculated by PSDB (2 L/fed), showed the best vegetative growth parameters and the highest yield productivity followed by the treatment of 50% K- mineral+50 % K-natural combined with foliar application by 3000 ppm nano-K particles under irrigation every 21 days Therefore, we recommend this treatment because it saves in the amount of mineral potassium and the amount of irrigation water and thus reduces the costs of garlic production and environmental pollution under the same conditions.

Keywords: Garlic, irrigation intervals, natural sources, potassium, K-feldspar, potassium silicate, nano-K.

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the important vegetable crops in Egypt for local consumption and exportation. It has been used for its medical value. It is the second important bulb crop grown after onion. In Egypt, the total cultivated area of Garlic reached 15503 ha and the total production exceeded 318800 tons (FAO, 2019).

Water in Egypt was considered an important economic source because 80% of the water used was related to agriculture. In recent years, Egypt has suffered from severe water shortages. One of the most important methods of water conservation are saving irrigation water by increasing irrigation intervals. In this respect, garlic plant requires irrigation frequency and adequate moisture to improve the yield and bulb quality. The optimum soil moisture for emergence of garlic cloves was 80-100% of field capacity. However, keeping quality was poorer than that of plant grown at a lesser soil moisture (Karaye and Yakubu, 2007).The previous experiments showed that there is linear relationship between the amounts of water applied and garlic yield (Patel *et al.*, 1996). Hence, it was mentioned that garlic plants doesn't tolerate the excess water and water stress which decrease bulb yield up to 60 % (Ahmed, 2006).

Nutrients are also the other important factor for determinant of growth and productivity in garlic. Among the major nutrients, potassium plays a vital role in plant metabolism and resistance against pests and diseases. It is important for transpiration and regulates stomatal opening and closing, helping improve water use efficiency particularly in periods of moisture stress. It is also considered as a quality element, as it improves quality parameters of many crops including garlic and onion (Wang *et al.*, 2013). The high price of K chemical fertilizers is responsible for increasing production cost and environmental pollution. The use of natural potassium fertilizer (Feldspar) or bio-fertilizer (Potassium solubilizing bacteria) is low cost resources which could alternate the expensive applied K-chemical fertilizers.(Mohamed *et al.* 2019) indicated that spraying garlic with potassium silicate increased dry weight of leaves/plant, bulb and total dry weight/plant, yields of, exportable, marketable and total yield/fed., as well as average bulb weight.

Nanotechnology-derived devices are employed as delivery systems to combat crop pathogens, to minimize nutrient losses during fertilization, and to improve yield.

The encapsulation of different chemicals in slow release particles can be very important for sustainable agriculture and food safety (Adisa *et al.*, 2019). Nano

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fertilizers enhance growth parameters, dry matter production, which result more production and translocation of photosynthates to different parts of the plant compare with traditional fertilizers (Ali and Al-Juthery, 2017). (Elshamy *et al.* 2019) resulted that yield parameters of potato plants (number of tubers /plant, tuber yield /plant average tuber weight, dry weight of tubers /plant and tuber dry mater/plant (%) for tuber yield) significantly increased with nano foliar application as compared with the control treatment. The highest effective treatment in this respect was 10% Nano NPK as compared with the other two levels.

Therefore, the present study was conducted to investigate the effect of different potassium sources and foliar application with nano-K fertilizer on vegetative growth parameters and productivity of garlic plants (Chinese cv) under different irrigation intervals.

MATERIALS AND METHODS

Two field experiments were carried out at the Vegetable Crops Farm in Baramoon Research Station, Mansoura, Dakahlia Governorate, Egypt, during the winter season of 2017/2018 and 2018/2019 seasons, to investigate the effect of irrigation intervals under different sources of potassium (mineral + natural + bio) and foliar application with nano-K fertilizer (K nano particles) on plant growth and productivity of Chinese garlic *(Allium sativum* L). cv. Sids 40.

The textural class of soil for experimentation is Clay and, before the start of the experiment, had the following characteristics: EC 1.58 dSm^{-1}, pH 7.78, organic matter % 1.75, available N 74.7; available P 5.2 and available K 370 $mg \cdot kg^{-1}$.

The experiment includes 42 treatments were arranged in strip-split block design with 3 replicates, which were the interactions between three irrigation intervals, seven sources of potassium fertilization and two foliar applications as follow:

A. Irrigation intervals were allocated in the vertical plots:

1- 14 days
2- 21 days
3- 28 days

B.- Sources of potassium fertilization were allocated in the horizontal plots:

1.100 % K-Mineral (150 kg Potassium Sulphate, PS),
2.100% K-Biofertilizer (2 L/fed. Potassium silicate dissolving bacteria, PSDB) (*Bacillus circulans*),
3.100 % K-Natural (700 kg Feldspar/fed., FS),
4.50 % K- Mineral (75 kg/fed.) + inoculated by PSDB,
5.50 % K- Mineral (75 kg/fed.) +50 % K-Natural (350 kg/fed.),
6.50 % K-Natural (350 kg/fed.) +inoculated by PSDB,
7.33 % K- Mineral (50 kg/fed.) +33 % K-Natural (235 kg/fed.)+ inoculated by PSDB

C.-Foliar applications with nano-K particles were allocated to the split plots:

1- With nano-K (3000 ppm)
2- Without nano-K

Each experimental basic unit (sub-plot) included 6 ridges 3.0 m length and 0.7 m width resulted an area of 12.6 m^2.

Fertilization:

Experimental field was ploughed and all agricultural practices for garlic commercial production were conducted according to the recommendations of the Ministry of Agriculture Land Reclamation. in Egypt. The organic manure fertilizer and 300 kg /fed. were applied during soil preparation.

The recommended dose (by the Ministry of Agriculture), was 120 kg N / fed., 75 kg P_2O_5 / fed. and 72 kg K_2O / fed. Ammonium sulphate were (20.6 % N) added in 3 batches at 30, 60 and 90 days after planting. Calcium super phosphate was added in one

batch with broadcasted during soil preparation. For potassium sulfate (48 % K_2O) were added at 72 Kg K_2O/fed. in 3 batches at 30, 60 and 90 days after planting.

As for the sources of natural potassium fertilization as follows:

- K-feldspar at the rate of 700 kg/fed is a natural local potassium rock powder produced by Al- Ahram for mining Co., Ltd., Egypt. Its powder contains 10.6 % K_2O.
- Potassium Silicate dissolving bacteria (PSDB) (Bacillus circulans) inoculation were kindly obtained from the biofertilizers Unit, Fac. Agric., Ain Shams Univ., Cairo, Egypt. Cloves were dipping 6 hours in a suspension of silicate dissolving bacteria to inoculate before planting. Also, the bacteria strains were added after 21 days from planting date with the rate of 2 L/fed.

-**As for foliar application**: nano-K Fertilizer (Nano Fab Technology Company, Cairo, Egypt) at 3000 ppm nano-K were sprayed at 45 days old three times with 15 days interval.

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Irrigation:

The irrigation treatments began after 30 days from planting. All treatments received equal amounts of water at the first irrigation. Irrigation was applied at 14, 21 and 28 days interval but withholding of irrigation was done according to each treatment. First hoeing was given 20 days after planting and repeated twice to control the weeds. The recommended plant protection measures were adopted as and when required for raising healthy crop. To obtained uniform maturity, irrigation was stopped two weeks before harvesting.

Cultivation of garlic:

The garlic cloves (side 40) were planted on the mid of October in both seasons. The uniform garlic cloves were soaked in running water for 24 h prior to cultivation and hand-planted at 10 cm apart on two sides of each ridge. All cultural practice; pests and diseases control. etc., were carried out when it was necessary according to the recommendation of the commercial production of garlic as outlined by Ministry of Agriculture and Land Reclamation.

Sampling dates and data recorded:

Plant Growth parameters:

Sample of five plants from each plot were randomly taken at 115 days after planting and the following data were recorded:

- Plant height, - Plant fresh weight/plant,
- Plant dry weight/plant, - Number of leaves plant^{-1},
- Leaf area plant^{-1}: It was calculated according to Koller (1972).

Yield and Its Components:

As garlic bulbs reached the proper maturity stage, bulbs of each experimental unit were harvested separately, transferred to a shady place for about two weeks. Bulbs of each grade were weighed and the following measurements were recorded:

- Bulb fresh weight, - Bulb dry matter (%),
Bulb diameter, -Average cloves weight,
-Total yield/fed.,
- Bulbing ratio at harvesting time: It is measured according to Mann (1952) as the following formula:

$$\text{Bulbing ratio} = \frac{\text{Neck diameter (cm)}}{\text{Bulb diameter (cm)}}$$

Statistical analysis

All data were statistically analyzed according to the technique of analysis variance (ANOVA) and the least significant difference (L.S.D) method at 5% level of significance was used to compare the difference between the means of treatment values to the methods described by Gomez and Gomez, (1984). All statistical analyses were performed using analysis of variance technique by means of Statistix Computer Software.

RESULTS AND DISCUSSION

1-Vegetative growth parameters:

Effect of irrigation intervals:

Regarding to the effect of irrigation intervals on vegetative growth of garlic plants, data presented in Table (1) indicated that all irrigation intervals (14, 21 and 28 days) had significant effects on vegetative growth parameters during both seasons. With increasing irrigation intervals from 14 to 21 days increased vegetative growth parameters and then decreased with 28 days. The abundance of moisture in the soil created good conditions for increasing the mobility of nutrients in the soil and consequently increased the minerals uptake by the plant which in turn increasing the carbohydrates assimilation that are necessary for different growth processes (Ahmed *et al*., 2009) and led to the increase in the vegetative growth (Ezzo *et al*., 2010). Similar findings were obtained by Moustafa *et al*. (2017); Der *et al.* (2018) and Ahmed and Kasem (2019).

Table 1. Vegetative growth parameters of garlic as affected by irrigation intervals, different sources of potassium and foliar applications with nano-K treatments in 2017/2018 and 2018/2019 seasons

Treatment	Plant height (cm)		No. of leaves /plant		Leaves fresh weight (g)		Leaves dry weight (g)		Leaf area / plant (cm^2)	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Irrigation intervals										
14 Days	59.60	58.70	9.2	9.5	28.83	29.41	13.73	14.55	51.56	50.83
21 Days	60.20	61.60	9.1	9.6	29.19	28.45	14.43	15.52	52.79	52.77
28 Days	57.40	56.10	9.7	9.6	27.42	28.47	12.78	14.29	50.23	52.16
F. Test	**	**	*	*	**	**	**	**	**	**
LSD (.05)	0.77	0.82	0.54	0.36	0.44	0.64	0.38	0.73	0.49	0.55
Sources of K fertilization										
100% K-Mineral (150 kg)	56.93	56.10	9.2	9.4	27.44	32.46	27.72	24.66	47.56	50.21
100% K-Bio (2 L/fed PSDB)	51.11	50.39	8.7	8.9	26.09	28.94	27.05	23.82	52.36	49.59
100% K-Natural (700 kg)	59.17	55.05	9.3	9.4	29.02	27.87	27.87	24.61	53.58	50.51
50%K- Mineral (75kg) + PSDB	60.47	60.18	9.3	9.7	29.04	28.14	28.14	25.09	50.59	52.03
50% K- Mineral (75kg) + 50% K- Natural (350kg)	63.35	62.01	9.5	9.8	30.84	27.72	29.47	25.16	48.59	53.44
50% K- Natural (350kg) + PSDB	61.66	60.57	9.5	9.8	29.72	27.05	28.94	25.04	50.79	52.42
33% Mineral (50 kg)+33% Natural (235kg)+PSDB	73.14	69.83	9.4	9.9	31.23	29.47	32.49	26.44	52.79	54.22
F. Test	**	**	*	*	**	**	**	**	*	*
LSD (.05)	0.85	0.99	0.62	0.53	0.56	0.81	0.66	0.98	0.67	0.63
Foliar applications										
With Nano-K	61.01	61.60	9.6	10.8	29.55	35.28	15.37	15.94	52.67	54.27
Without	57.12	56.42	9.1	9.3	27.42	22.28	11.93	12.31	47.5	49.28
F. Test	**	**	**	**	**	**	**	**	**	**

Effect of different sources of K-fertilization:

Data in Table (1) cleared that all sources of K-fertilization had significant effect on plant growth parameters. The highest mean values of mentioned parameters recorded with the application of mix from 33 % K- mineral +33 % K-natural + inoculated by PSDB followed by the treatment of 50 % K-mineral +50 % K- natural over the individual forms from the different sources of K-fertilization. The same trend was happened in the second season. The use of inoculation by Potassium Silicate dissolving bacteria, PSDB as bio-fertilizer, was suggested as a sustainable solution to improve plant growth, nutrition, root growth, plant competitiveness and responses to external stress factors (Dawwam *et al*, 2013). The increments in growth parameters due to inoculation with potassium solubilizing bacteria might be attributed to bacteria that can solubilize them and provide faster and continuous supply of K for optimal plant growth (Asem *et al.*, 2020). These results are in general accordant with the findings of Shafeek *et al.* (2016); Abou El-Khair and Mohsen (2016); Arisha *et al.* (2017); Eragegowda *et al.*

(2018); Zyada and Bardisi (2018) and Barakat *et al.* (2019) and Hasan and Ragab (2020).

Effect of K nano-fertilization:

Data presented in Table (1) indicated the effect of nano-K particles fertilization on vegetative growth parameters of garlic plants. With foliar application by nano-K, all plant parameters had a significant effect. Foliar application with nano-K fertilization increased plant height, number of leaves, fresh, dry weight and leaf area during both seasons compared to un-sprayed plants. The positive morphological effects included enhanced rate of roots, shoots, and their ratio and vegetative biomass of seedlings. Enhancement of many physiological parameters such as enhanced photosynthetic activity and nitrogen metabolism by metal-based nano-materials in a few crops (Sekhon, 2014). The obtained results are in a good accordance with those recorded by Ali and Al-Juthery (2017) and Al-juthery *et al.* (2019).

Interaction effect between irrigation intervals and different sources of K-fertilization:

Regarding with the interaction of irrigation intervals and different forms of K-fertilization, data in Table (2) indicated that all forms of K-fertilization as (K- mineral, K-natural, K-biofertilizer and mix among them) under irrigation intervals (14, 21 and 28 days) significantly had effects on all parameters of vegetative growth during both seasons.

With addition of different sources from K-fertilization found the interaction among the treatment of 33 % K- mineral +33 % K-natural + K-biofertilizer were recorded the highest mean values of plant growth parameters with irrigation every 21 days. The same trend was true in the 2nd season. This finding was in agreement with what was reported by Ibrahim *et al.* (2015); Al-Shaheen *et al.* (2016); Abd- El Sayed and Mansour (2018) and Mahmoud and Swaefy (2020).

Table 2. Interaction effect between irrigation intervals and source of potassium on vegetative growth parameters in 2017/2018 and 2018/2019 seasons

Treatment		Plant height (cm)		No. of leaves /plant		Leaves fresh weight (g)		Leaves dry weight (g)		Leaf area/plant (cm^2)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
14 days	100% K-Mineral (150 kg/fed)	61.60	59.75	9.4	9.6	30.32	33.44	14.58	14.73	47.36	44.77
	100% K-Bio (2 L/fed., PSDB)	50.10	50.90	8.3	8.5	30.33	29.44	10.94	13.07	52.17	53.98
	100% K-Natural (700 kg/fed)	64.20	63.31	9.3	9.9	24.25	28.60	13.3	14.21	53.68	53.60
	50%K- Mineral + PSDB	61.62	61.94	10.2	10	30.23	27.88	13.51	15.39	49.09	48.91
	50% K- Mineral + 50% K- Natural	59.25	59.22	9.1	9.8	29.87	28.92	15.37	15.43	51.57	52.15
	50% K- Natural + PSDB	56.85	51.31	8.4	9.8	24.92	27.92	15.02	15.36	51.36	51.51
	33% Mineral +33% Natural +PSDB	55.64	57.14	9.8	10.1	26.92	29.72	15.42	15.58	48.68	47.76
21 days	100% K-Mineral (150 kg/fed)	58.68	59.60	9.1	9.7	28.57	31.31	14.79	15.59	53.47	53.99
	100% K-Bio (2 L/fed., PSDB)	55.32	54.72	9.6	9.9	34.23	28.21	11.57	14.57	53.68	54.93
	100% K-Natural (700 kg/fed)	64.74	64.87	9.3	9.6	28.28	28.34	13.48	15.21	52.65	53.65
	50%K- Mineral + PSDB	57.24	63.88	9.6	9.9	28.48	29.44	14.35	17.63	50.48	52.44
	50% K- Mineral + 50% K- Natural	66.50	63.50	9.8	9.6	29.25	25.57	16.11	15.85	52.39	52.76
	50% K- Natural + PSDB	54.30	56.85	8.2	8.8	26.07	27.95	16.38	15.44	45.68	47.73
	33% Mineral +33% Natural +PSDB	67.11	68.02	10.9	10.7	39.50	38.30	16.93	16.61	53.58	53.90
28 days	100% K-Mineral (150 kg/fed)	51.64	51.97	9.1	9.7	21.67	22.62	13.78	13.66	49.58	50.02
	100% K-Bio (2 L/fed., PSDB)	44.23	48.18	8.9	8.9	26.15	29.18	10.54	12.82	52.47	53.75
	100% K-Natural (700 kg/fed)	62.39	60.60	9.9	9.9	25.75	26.39	12.24	13.41	53.26	53.08
	50%K- Mineral + PSDB	56.10	55.98	10	9.9	28.33	27.08	12.02	14.05	53.98	54.74
	50% K- Mineral + 50% K- Natural	50.74	52.85	9.6	9.2	26.17	26.28	12.05	14.69	49.69	50.77
	50% K- Natural + PSDB	61.91	59.26	9.6	9.6	28.02	27.66	13.52	14.21	51.43	52.98
	33% Mineral +33% Natural +PSDB	55.52	54.32	9.9	9.7	25.90	30.11	13.72	14.31	47.62	49.83
F. Test		**	**	**	**	**	**	**	**	**	**
LSD (.05)		1.45	1.69	1.07	0.90	0.96	1.38	1.13	1.67	1.14	1.07

Interaction effect between irrigation intervals and nano-K fertilization:

As for the effect of irrigation intervals and nano-K fertilization, data in Table (3) revealed that foliar application with nano-K fertilization had significantly effect on the most growth parameters under all irrigation intervals comparing with the untreated plants during both seasons. The highest mean values of the most of parameters of vegetative growth were recorded with foliar application with nano-K fertilization and irrigation every 21 days followed by 14 days then decreased with 28 days. The same trend was true in the 2nd season.

Table 3. Interaction effect between irrigation intervals and nano-K fertilization on vegetative growth parameters of garlic in 2017/2018 and 2018/2019 seasons

Treatment		Plant height (cm)		No. of leaves /plant		Leaves fresh weight (g)		Leaves dry weight (g)		Leaf area (cm^2)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
14 days	With Nano-K	62.81	61.51	9.5	9.7	29.99	28.79	15.51	15.11	50.29	51.88
	Without	56.47	56.31	8.9	9.4	27.67	23.04	11.96	12.99	45.21	48.88
21 days	With Nano-K	63.48	65.60	9.4	9.9	30.31	36.61	16.34	16.60	54.61	56.01
	Without	56.91	57.60	8.8	9.3	28.09	29.28	12.52	13.44	47.61	49.53
28 days	With Nano-K	56.93	57.73	9.7	9.8	28.33	33.42	14.25	13.09	52.46	54.94
	Without	57.96	54.57	9.7	9.4	26.52	23.53	10.31	11.50	48.67	49.39
F. Test		**	**	N.S	N.S	**	**	**	**	*	.*
LSD (.05)		0.91	1.02	-	-	0.48	0.64	0.42	0.87	0.68	0.62

Interaction effect between different sources of K and nano-K fertilization:

Data presented in Table (4), cleared the effect of different sources of K-fertilization and foliar application with nano-K on vegetative growth parameters. The statistical analysis of the obtained data revealed that, the differences within different potassium fertilizer were great enough to be significant in presence of foliar application of nano-K fertilization on the most of parameters of vegetative growth during the two seasons. The highest mean values realized with potassium source of the treatment of 33 % K- mineral +33 % K-natural + inoculated by PSDB combined with foliar application of nano-K fertilization followed by 50% mineral + 50 % natural treatment comparing with the untreated plant under the same soil addition. Recently, with regard to the effect of the interaction treatments between potassium fertilizer and foliar spray with different sources of nano boron treatments on growth parameters, data reveal that using the rate 80% of the potassium recommended dose added with bio fertilizer and foliar application reflected the highest values all measured of growth during the two seasons (Shafshak *et al.,* 2020).

Table 4. Interaction effect between source of potassium and nano-K fertilization on vegetative growth parameters of garlic in 2017/2018 and 2018/2019 seasons

Treatment		Plant height (cm)		No. of leaves /plant		Leaves fresh weight (g)		Leaves dry weight (g)		Leaf area/plant (cm^2)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
100% K-Mineral (150 kg/fed)	With Nano-K	59.65	60.25	9.7	9.9	31.99	32.54	15.34	15.38	50.89	52.24
	Without	54.92	54.12	9.4	9.5	26.70	28.37	12.48	13.94	44.51	46.95
100% K-Bio (2 L/fed., PSDB)	With Nano-K	56.32	53.30	9.3	9.6	30.30	35.25	14.29	14.50	53.17	50.07
	Without	48.51	46.84	9.3	9.2	22.18	22.63	10.29	12.14	41.46	43.73
100% K-Natural (700 kg/fed)	With Nano-K	65.41	66.32	9.6	9.2	32.01	34.06	15.21	15.29	50.34	56.55
	Without	61.85	59.31	9.4	9.6	25.18	21.55	13.65	13.94	48.62	47.33
50%K- Mineral + PSDB	With Nano-K	59.74	63.43	10	10.1	30.13	35.16	15.47	15.80	53.76	55.84
	Without	56.92	57.77	8.7	9.8	27.90	21.12	12.34	13.57	45.59	48.22
50% K- Mineral + 50% K-Natural	With Nano-K	64.93	65.42	9.9	10.4	33.08	36.96	15.99	16.75	54.59	55.77
	Without	50.82	51.80	8.6	8.6	25.36	21.48	14.11	14.29	45.69	47.93
50% K- Natural + PSDB	With Nano-K	63.14	62.71	8.6	10.2	30.37	35.78	15.67	16.05	50.48	52.50
	Without	61.95	58.62	8.6	9.3	27.72	28.32	13.79	14.18	46.26	49.05
33% Mineral +33% Natural +PSDB	With Nano-K	68.62	67.69	9.9	10.1	38.94	39.24	16.78	17.80	55.58	56.98
	Without	56.21	58.93	9.6	9.5	26.93	22.51	14.36	15.09	45.68	49.04
F. Test		**	**	N.S	N.S	**	**	**	**	*	*
LSD (.05)		1.39	1.56	-	-	0.73	0.98	0.65	1.33	1.04	0.95

Triple interaction among irrigation intervals, different sources of K and K nano-fertilization:

The present data investigated in Table (5) indicated the interaction effect among irrigation intervals (14, 21 and 28 days), different sources of K fertilization in soil way (K-mineral, K-natural, K-biofertilizer and mix among of them) in presence or absence of nano-K fertilization on plant growth parameters during 2017/2018 and 2018/2019 seasons. Different treatments had a significant effect on the most of parameters of vegetable growth during the both seasons. The highest mean values recorded with mix among the 33 % K- mineral +33 % K-natural + inoculated by PSDB treatment of K fertilization with irrigation every 21 days and combined foliar application with nano fertilization followed by the same treatments with irrigation every 14 days then 28 days. The same trend was true during both seasons.

2-Yield and its components:

Effect of irrigation intervals:

Statistical analysis of the results show that all irrigation intervals significantly affected garlic yield and its components, with increasing irrigation intervals from 14 to 21 increased all yield parameters as show in Table (6). The highest mean values of total yield, bulb diameter, neck diameter, average cloves weight, bulb fresh and dry matter % as well as bulbing ratio indicated with the irrigation every 21 days followed by 14 days and decreased with irrigation every 28 days. The same trend was true in the 2nd season. It might be due to the availability of water at the root zone, which is attributed to 21 days irrigation interval, increased the mobility of nutrients in the soil that consequently increased the minerals uptake by plant and this increased carbohydrate assimilation, photosynthetic and other physiological activity that are necessary for different growth processes that lead to increased bulb yield. The irrigation intervals of 14 and 28 day produced the lowest total bulb yield in both seasons. This might be connected with the water stress imposed or over from moisture because of long interval. The inadequacy in moisture or over of moisture could be responsible to the reduction in crop vigor and consequently the final yield. This finding was in agreement with what was reported by Gwandu and Idris (2016); Islam and Zaman (2017); Nandle *et al.* (2018) and Taha *et al.* (2019).

Effect of different sources of K-fertilization:

Results in Table (6) show significant increases in all studied parameters in the treated plants with different sources of K fertilization individually or mixed. In this respect, the highest values of all the previous mentioned yield parameters were recorded when plants fertilized with the treatment of 33% K-mineral +33 % K-natural+ inoculated by potassium silicate dissolving bacteria inoculation (PSDB) comparing with the other treatments during the two seasons of study. Generally, bio-potassium bacteria fertilization especially in presence of feldspar increased the vegetative growth, mineral content and dry matter accumulation. In addition, the improvement in garlic yield might be the direct effect of the increase in average bulb weight. Outcome reported that bio-potassium bacteria fertilization promote bulb quality by increasing bulb diameter and bulb weight. Similar conclusion was acquired by Abou El-Khair and Mohsen (2016); Badoni *et al.* (2017); Eragegowda *et al.* (2018); Asem *et al.* (2020) and Hasan and Ragab (2020)

Table 5. Interaction effect among irrigation intervals, sources of potassium and foliar application with nano-K fertilization on vegetative growth parameters of garlic plants in 2017/2018 and 2018/2019 seasons

Treatment			Plant height (cm)		No. of leaves /plant		Leaves fresh weight (g)		Leaves dry weight (g)		Leaf area/pant (cm^2)	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
14 days	100% K-Mineral (150 kg/fed)	With	61.66	59.66	9.5	9.7	34.22	33.72	16.91	15.22	44.71	46.82
		Without	60.60	53.20	9.3	9.5	30.4	30.17	12.26	13.94	40.23	42.73
	100% K-Bio (2 L/fed., PSDB)	With	51.26	54.18	9.4	9.6	36.8	35.98	12.41	14.22	49.58	55.85
		Without	50.26	45.88	9.3	9.4	23.87	22.90	9.47	11.93	49.68	45.12
	100% K-Natural (700 kg/fed)	With	67.86	67.88	9.4	10.2	26.23	33.45	14.63	16.13	54.78	56.48
		without	51.20	58.13	9.3	9.6	24.2	23.75	11.69	14.29	48.61	50.73
	50%K- Mineral + PSDB	With	66.46	65.36	9.4	10.2	31.8	35.75	14.87	15.8	51.47	50.28
		Without	60.06	58.55	10.1	9.9	28.67	20.02	12.15	13.45	44.25	47.14
	50% K- Mineral + 50% K-Natural	With	76.40	67.01	8.2	9.1	25.13	34.78	16.73	16.55	51.42	53.95
		Without	50.80	51.53	8.0	8.5	24.7	23.05	13.32	14.16	48.36	50.34
	50 % K-Natural + PSDB	With	59.33	61.38	10	10.5	31.5	37.22	15.87	16.64	52.19	53.18
		Without	59.00	57.78	6.9	9.2	28.23	18.62	12.87	14.23	48.57	50.24
	33 % K- Mineral +33 % K-Natural + PSDB	With	86.93	69.80	10.4	10.5	34.3	36.63	17.17	17.93	54.76	50.69
		without	65.33	56.43	9.7	9.8	27.6	22.8	11.67	14.9	44.57	45.22
21 days	100% K-Mineral (150 kg/fed)	With	67.33	67.23	9.3	10	29.3	38.33	17.23	16.3	54.57	61.27
		Wihout	54.46	52.71	8.8	9.4	27.83	24.28	12.35	14.89	48.63	46.72
	100% K-Bio (2 L/fed., PSDB)	With	58.40	56.86	9.7	10.1	36.2	36.25	12.95	15.39	53.76	54.9
		Without	51.66	50.55	9.5	9.8	32.27	20.17	10.2	13.75	48.68	50.95
	100% K-Natural (700 kg/fed)	With	68.40	68.60	9.5	10	36.47	36.5	15.04	15.99	54.69	54.12
		without	56.26	61.01	9.1	9.2	27.1	20.18	11.97	14.43	47.52	49.17
	50%K- Mineral + PSDB	With	67.73	66.53	10.1	9.9	30.9	35.83	15.09	17.09	55.21	58.16
		Without	56.00	59.46	9.6	9.8	26.9	21.62	12.25	13.95	45.29	47.53
	50 % K- Mineral +50 % K-Natural	With	68.13	67.58	9.7	10.2	30.16	37.27	16.45	16.82	52.47	57.35
		Without	59.66	54.20	8.1	8.4	25.66	20.15	14.01	14.85	44.69	45.71
	50% K- Mineral + 50% K-Natural	With	72.46	68.16	8.3	9.2	26.46	35.75	16.75	16.39	50.14	49.74
		Without	64.53	55.43	9.4	9.4	27.60	25.30	11.55	14.6	45.79	46.02
	33 % K- Mineral +33 % K-Natural + PSDB	With	89.06	79.88	10.8	10.9	39.76	41.37	18.92	18.25	56.69	59.51
		without	66.53	64.68	8.9	9.2	29.23	20.23	14.95	14.97	48.12	52.74
28 days	100% K-Mineral (150 kg/fed)	With	50.46	52.76	10.2	9.8	26.47	28.58	15.07	14.33	51.79	52.74
		Wihout	46.06	50.01	9.9	9.6	20.87	20.65	12.5	12.99	45.62	47.3
	100% K-Bio (2 L/fed., PSDB)	With	49.53	49.98	8.7	9.3	26.9	33.52	11.7	13.89	53.52	50.41
		Without	45.53	46.88	8.2	8.6	15.4	14.83	9.38	9.75	45.8	44.09
	100% K-Natural (700 kg/fed)	With	61.33	62.41	10	10.1	27.27	32.07	14.06	13.75	51.68	55.04
		without	50.00	54.26	9.9	9.8	24.23	20.71	12.43	11.08	46.88	51.12
	50%K- Mineral + PSDB	With	57.40	55.23	10	10	28.53	32.45	14.04	14.79	54.58	59.48
		Without	54.80	52.88	10	9.8	28.13	21.72	9.99	11.31	48.5	50.01
	50 % K- Mineral +50 % K-Natural	With	59.20	56.13	9.7	9.4	26.63	31.33	13.76	14.15	51.58	53.81
		Without	50.60	49.03	9.5	8.9	25.7	21.23	10.34	11.22	46.72	47.73
	50% K- Mineral + 50% K-Natural	With	59.06	60.03	9.7	9.9	28.7	34.28	14.88	15.53	52.47	54.64
		Without	58.33	56.30	9.6	9.3	27.33	21.03	11.33	12.72	48.06	51.32
	33 % K- Mineral +33 % K-Natural + PSDB	With	73.60	63.75	9.9	9.9	27.83	35.72	15.23	17.22	51.47	50.48
		without	57.40	53.43	9.8	9.6	23.97	24.5	10.2	15.41	47.59	49.18
F. Test			**	**	N.S	N.S	**	**	*	*	*	*
LSD (.05)			2.37	2.65	-	-	1.25	1.67	1.10	2.27	1.77	1.62

Effect of nano-K fertilization:

Results in Table (6) point to that total yield and its components were significantly affected by the foliar application with nano potassium comparing to untreated plants in the two growing seasons. Generally, results revealed that the most suitable treatment recorded significant higher mean values of garlic yield and its components was the foliar with K nano particles compared with the untreated one. The results are in conformity with the findings of Abdel-Aziz *et al.* (2018); Qureshi *et al. (*2018); Elshamy *et al.* (2019) and Asem *et al.* (2020).

Interaction effect between irrigation intervals and different sources of K-fertilization:

Data in Table (7) showed the interaction effect of irrigation intervals and different forms of K-fertilization on total yield, bulb diameter, neck diameter, bulb fresh and dry matter % as well as bulbing ratio. All mentioned parameters were significantly affected due to all treatments. Data showed that yield and its components were significantly increased with increasing irrigation intervals to 21 days with all forms of K-fertilization then beginning to decrease with irrigation every 28 days. The irrigation every 21 days and fertilized with the treatment of 33 % K- mineral +33 % K-natural + inoculated by PSDB were recorded the highest values of all yield components days were recorded the lowest ones with application of previously mentioned parameters while irrigation every 28 PSDB. The results are in conformity with the findings of Mahmoud and Swaefy (2020).

Interaction effect between irrigation intervals and nano-K fertilization:

Regarding the interaction effect between irrigation intervals and nano-K application in Table (8) on yield and its components. It's clear from such data that all yield components were significantly increased in response to all applications treatments in the two growing seasons comparing to untreated treatment. In this respect found that, the increase of mentioned yield parameters were recorded with foliar application from nano potassium under all irrigation intervals, in addition the highest mean values realized with irrigation every 21 days followed by 14 days then decreased with 28 days with foliar application from nano fertilization. All data realized high values over the untreated plants during both seasons of the experiments.

Table 6. Yield and its components of garlic as affected by irrigation intervals, different sources of potassium and foliar applications with nano-K treatments in 2017/2018 and 2018/2019 seasons

Treatment	Total yield (ton/fed.)		Bulb diameter (cm)		Neck diameter (cm)		Average cloves wt. (g)		Bulb fresh wt. (g)		Dry matter/100 g cloves (%)		Bulbing ratio	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Irrigation intervals														
14 Days	9.63	10.79	4.75	4.97	1.35	1.37	4.36	4.48	72.3	88.83	43.17	52.81[b]	0.364	0.357
21 Days	10.57	11.11	5.06	5.32	1.37	1.39	4.76	4.55	76.32	92.9	44.03	55.97	0.345	0.330
28 Days	8.43	8.01	4.76	4.73	1.33	1.36	3.82	4.36	70.4	74.3	39.69	50.52	0.335	0.326
F. Test	**	**	*	*	**	**	**	**	**	**	**	**	*	*
LSD (.05)	0.43	0.48	0.26	0.21	0.12	0.05	0.32	0.31	0.31	0.23	0.62	0.49	0.01	0.01
Sources of K fertilization														
100% K-Mineral (150 kg)	9.33	9.83	4.61	4.76	4.13	4.14	70.54	72.38	43.12	51.28	0.355	0.347	11.94	11.33
100% K-Bio (2 L/fed. PSDB)	8.94	8.33	4.59	4.62	4.32	4.14	69.72	70.91	38.1	45.46	0.321	0.345	12.39	12.5
100% K-Natural (700 kg)	8.94	9.5	4.97	4.98	4.63	4.84	72.84	73.53	41.42	49.78	0.351	0.345	12.94	12.83
50%K- Mineral (75kg) + PSDB	9.39	9.92	4.65	4.98	4.29	4.35	74.92	84.93	43.49	52.6	0.365	0.314	12.33	13.39
50% K- Mineral (75kg) + 50% K- Natural (350kg)	9.64	10.39	5.01	5.09	4.63	4.29	73.51	73.51	40.27	55.13	0.357	0.365	12.61	13.86
50% K- Natural (350kg) + PSDB	9.91	10.86	4.59	4.78	4.29	3.96	72.37	72.11	41.06	54.44	0.362	0.321	11.94	12.92
33% Mineral (50 kg)+33% Natural (235kg)+PSDB	10.0	10.97	5.11	5.86	4.93	4.96	84.81	104.45	48.66	63	0.372	0.385	13.00	13.97
F. Test	**	**	**	**	**	**	**	**	**	**	**	**	**	**
LSD (.05)	0.60	0.63	0.43	0.34	0.21	0.10	0.46	0.35	0.53	0.46	0.82	0.82	0.03	0.02
Foliar applications														
With Nano-K	10.06	10.31	5.14	5.77	1.49	1.57	4.86	4.74	76.35	98.72	48.17	62.17	0.359	0.389
Without	7.84	8.64	4.57	4.25	1.15	1.19	3.78	4.02	68.99	64.63	36.43	44.02	0.257	0.293
F. Test	**	**	**	**	**	**	**	**	**	**	**	**	**	**

Table 7. Interaction effect between irrigation intervals and source of potassium on yield and its components in 2017/2018 and 2018/2019 seasons

Treatment		Total yield (ton/fed.)		Bulb diameter (cm)		Average cloves wt. (g)		Bulb fresh wt. (g)		Dry matter/100g cloves (%)		Bulbing ratio	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
14 days	100% K-Mineral (150 kg/fed)	9.17	9.67	4.58	4.61	4.05	4.05	67.4	74.8	42.32	46.86	0.335	0.399
	100% K-Bio (2 L/fed., PSDB)	8.33	8.67	5.30	4.69	3.8	4.03	65.63	69.56	37.94	47.74	0.329	0.327
	100% K-Natural (700 kg/fed)	9.00	9.42	4.90	5.00	3.97	5.09	74.41	83.23	43.81	53.13	0.378	0.353
	50%K- Mineral + PSDB	9.17	9.75	4.86	4.44	4.57	4.16	73.85	74.85	41.99	55.96	0.349	0.341
	50% K- Mineral + 50% K- Natural	9.33	9.75	4.61	5.30	3.67	4.37	75.93	75.18	45.73	54.10	0.361	0.338
	50% K- Natural + PSDB	9.33	9.92	4.55	4.83	3.30	4.04	68.5	74.38	43.65	53.69	0.345	0.331
	33% Mineral +33% Natural +PSDB	9.83	10.92	4.61	5.90	4.40	5.61	76.4	88.78	46.81	65.16	0.391	0.343
21 days	100% K-Mineral (150 kg/fed)	10.33	11.17	4.86	5.08	4.58	4.06	74.41	73.55	43.87	56.99	0.351	0.360
	100% K-Bio (2 L/fed., PSDB)	9.83	11.00	5.08	4.93	4.03	4.00	69.96	70.59	39.99	56.24	0.361	0.284
	100% K-Natural (700 kg/fed)	10.17	11.00	5.16	5.06	5.50	4.42	79.28	80.86	41.82	57.63	0.367	0.329
	50%K- Mineral + PSDB	10.50	11.17	4.60	4.99	4.27	4.90	71.56	73.24	44.07	57.22	0.249	0.286
	50% K- Mineral + 50% K- Natural	11.17	11.17	5.43	5.36	5.47	5.97	86.51	71.94	45.04	59.26	0.326	0.345
	50% K- Natural + PSDB	11.67	11.67	5.25	4.97	4.80	4.84	79.75	71.82	40.31	56.02	0.255	0.315
	33% Mineral +33% Natural +PSDB	11.83	11.83	6.03	6.20	5.70	5.70	92.75	106.31	53.12	69.44	0.387	0.385
28 days	100% K-Mineral (150 kg/fed)	7.67	7.58	4.38	4.60	4.12	4.31	66.81	68.78	43.17	40.99	0.349	0.374
	100% K-Bio (2 L/fed., PSDB)	7.00	7.17	4.50	4.44	3.77	3.78	61.56	64.8	36.38	41.4	0.352	0.355
	100% K-Natural (700 kg/fed)	7.00	7.25	4.85	4.88	4.42	5.00	66.85	83.23	38.62	43.58	0.361	0.354
	50%K- Mineral + PSDB	7.83	7.75	4.78	4.70	4.05	3.81	71.71	74.85	37.11	51.14	0.374	0.338
	50% K- Mineral + 50% K- Natural	8.00	8.08	4.75	4.74	4.77	5.18	76.08	74.38	39.69	49.1	0.312	0.267
	50% K- Natural + PSDB	8.00	8.08	4.98	4.98	4.75	4.54	70.28	75.18	36.87	52.04	0.362	0.373
	33% Mineral +33% Natural +PSDB	8.33	8.42	5.08	5.49	4.68	4.58	76.51	88.78	46.06	63.4	0.329	0.335
	F. Test	**	**	*	*	**	**	**	**	**	**	**	**
	LSD (.05)	1.02	1.08	0.73	0.58	0.79	0.59	0.90	0.78	1.39	1.39	0.05	0.05

Table 8. Interaction effect between irrigation intervals and foliar application with nano fertilization on yield and its components of garlic in 2017/2018 and 2018/2019 seasons

Treatment		Total yield (ton/fed.)		Bulb diameter (cm)		Average cloves wt. (g)		Bulb fresh wt. (g)		Dry matter/100g cloves (%)		Bulbing ratio	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
14	With	8.48	9.98	5.11	5.62	5.02	4.69	75.00	90.18	50.34	62.4	0.398	0.407
days	without	7.24	8.62	4.46	4.31	3.42	4.29	66.61	67.47	36.01	43.21	0.296	0.288
21	With	10.33	10.22	5.27	6.25	5.33	4.86	80.07	93.07	51.18	66.29	0.367	0.368
days	without	8.81	9.00	4.84	4.20	4.20	3.56	72.57	74.73	36.88	45.65	0.297	0.293
28	With	8.38	8.74	5.03	5.43	4.22	4.67	73.99	82.92	42.99	57.38	0.385	0.394
days	without	7.48	7.92	4.40	4.24	3.71	4.23	64.8	65.69	36.41	43.21	0.278	0.299
F. Test		**	**	**	**	**	**	**	**	**	**	N.S	N.S
LSD (.05)		0.47	0.45	0.29	0.24	0.42	0.38	0.18	0.16	0.49	0.37	-	-

Interaction effect between different sources of K and nano-K fertilization:

The effect of the interaction between different forms of potassium fertilization and nano-K foliar application on yield and its components was showed in Table (9). Generally, it was noticed that all the interactions between different forms of potassium

fertilization and nano-K foliar application significantly affected yield and its components as compared to untreated plants in the two growing seasons. The highest values of the aforementioned parameters were recorded by plants fertilized with mix from different potassium fertilization 33% Mineral as potassium sulfate + 33% Natural as feldspar + inoculated by potassium silicate dissolving bacteria (PSDB) and sprayed with nano potassium followed by 50 % potassium sulfate + 50 % feldspar only with nano-K foliar in descending order. The results are in conformity with the findings of Asem *et al.* (2020); Mahmoud and Swaefy (2020) and Shafshak *et al.* (2020).

Table 9. Interaction effect between source of potassium and foliar application with nano fertilization on yield and its components of garlic in 2017/2018 and 2018/2019 seasons

Treatment		Total yield (ton/fed.)		Bulb diameter (cm)		Average clove wt. (g)		Bulb fresh wt. (g)		Dry matter/100g cloves (%)		Bulbing ratio	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
100% K-Mineral	With	10.12	10.28	5.01	5.39	4.67	4.50	72.87	83.2	46.91	58.38	0.397	0.44
(150 kg/fed)	without	7.78	9.11	4.21	4.14	3.6	3.77	66.21	61.55	32.33	40.18	0.324	0.316
100% K-Bio (2	with	10.00	10.11	5.25	5.24	4.92	4.68	77.84	92.85	42.1	51.16	0.367	0.397
L/fed., PSDB)	Without	7.55	6.56	4.85	4.31	3.21	3.11	62.37	62.97	34.09	39.76	0.284	0.294
100% K-Natural	with	10.11	10.17	5.01	5.73	4.57	4.29	76.77	95.3	45.16	57.73	0.364	0.334
(700 kg/fed)	without	7.67	8.94	4.93	4.22	3.69	3.38	70.25	66.22	37.67	41.82	0.369	0.358
50%K- Mineral +	with	10.13	10.44	4.9	5.15	4.97	4.23	77.67	83.72	47.41	65.53	0.329	0.358
PSDB	without	7.78	9.39	4.28	4.09	3.61	3.67	67.07	60.5	34.7	43.35	0.347	0.287
50% K- Mineral +	with	10.25	10.61	5.14	6.07	4.71	4.73	79.06	85.17	51.59	66.20	0.366	0.392
50% K- Natural	Without	7.89	9.44	4.71	4.10	3.87	4.07	72.00	64.96	35.38	44.29	0.278	0.297
50% K- Natural +	with	10.33	10.67	5.15	5.85	4.96	4.63	75.15	84.22	46.01	60.92	0.419	0.36
PSDB	Without	8.00	9.50	4.86	4.10	4.30	3.85	70.53	62.84	39.54	44.07	0.287	0.296
33% Mineral +33%	with	10.89	10.89	5.51	6.93	5.20	5.11	85.1	96.65	58.02	75.3	0.387	0.430
Natural +PSDB	Without	8.22	9.50	4.15	4.79	3.66	4.81	64.52	69.63	39.29	50.7	0.286	0.273
F. Test		*	*	**	**	*	*	**	**	**	**	**	**
LSD (.05)		0.73	0.69	0.44	0.38	0.65	0.58	0.28	0.25	0.76	0.57	0.04	0.03

Triple interaction among irrigation intervals, different sources of K and spray by nano-K fertilization:

Results in Table (10) showed the effect of irrigation intervals, different forms of potassium fertilization and foliar with nano-fertilization on yield and its components during the two seasons. With application of all K-fertilization found an increase in the most of yield and its components also, with foliar application of nano comparing with the untreated plants. Generally the highest mean values of total yield, average cloves weight, bulb fresh and dry matter % of garlic yield associated with plants fertilized with 33 % K- mineral +33 % K-natural + inoculated by PSDB followed by the treatment of 50 % K-natural + 50 % K-biofertilizer with foliar application by 3000 ppm nano-K particles under irrigation every 21 days. The same trend was true during both seasons.

Table 10. Interaction effect among irrigation intervals, source of potassium and foliar application with nano-K fertilization on yield and its components of garlic plants in 2017/2018 and 2018/2019 seasons

Treatment			Total yield (ton/fed)		Bulb diameter (cm)		Average cloves wt. (g)		Bulb fresh wt. (g)		Dry matter (%)		Bulbing ratio	
			1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
14 days	100% K-Mineral (150 kg/fed)	With	11.00	10.67	5.2	5.2	4.3	4.18	73.63	85.33	46.63	54.52	0.459	0.478
		Without	9.00	8.33	3.96	4.03	3.8	3.92	61.16	64.27	38	39.19	0.342	0.32
	100% K-Bio (2 L/fed., PSDB)	With	10.67	10.33	5.3	4.98	4.07	4.52	76.8	95.26	42.4	47.38	0.386	0.385
		Without	8.00	8.16	5.0	4.41	3.53	3.53	60.16	62.86	33.48	44.1	0.247	0.268
	100% K-Natural (700 kg/fed)	With	11.00	10.67	5.0	5.72	4.5	5.08	78.56	96.2	49	59.8	0.412	0.402
		Without	9.00	8.33	4.8	4.28	3.43	3.1	70.26	70.27	38.62	46.46	0.321	0.305
	50%K-Mineral + PSDB	With	11.00	10.67	4.93	4.8	5.6	4.4	79.3	86.58	94.72	66.97	0.386	0.387
		Without	9.00	8.67	4.43	4.07	3.53	3.92	68.4	63.12	34.25	44.95	0.286	0.295
	50% K-Mineral + 50% K-Natural	With	11.00	10.83	5.0	5.56	3.63	4.42	69.43	85.07	55.59	65.72	0.358	0.368
		Without	9.33	8.67	4.1	4.1	2.97	3.66	62.43	63.69	35.86	41.66	0.276	0.293
	50% K-Natural + PSDB	With	11.30	11.00	4.8	6.21	4	4.82	71.13	84.83	50.99	67.48	0.415	0.42
		Without	9.33	8.67	4.43	4.39	3.33	3.91	65.86	65.54	36.3	40.73	0.246	0.257
	33% Mineral +33% Natural +PSDB	With	11.33	11.33	6.00	6.89	4.47	5.27	79.1	98.01	58.04	74.93	0.418	0.407
		without	9.33	8.67	4.23	4.92	3.33	3.95	66	79.55	35.57	45.4	0.286	0.281
21 days	100% K-Mineral (150 kg/fed)	With	11.33	11.57	5.1	5.89	5.3	4.78	76.33	88.41	51.33	62.3	0.421	0.402
		Without	9.67	9.00	4.63	4.27	3.87	3.33	72.5	68.68	36.41	51.68	0.356	0.318
	100% K-Bio (2 L/fed., PSDB)	With	11.30	11.00	5.33	5.63	6.03	5.23	82.56	99.56	42.54	55.05	0.389	0.405
		Without	9.33	8.67	4.83	4.24	4.03	4.01	77.36	61.62	37.43	37.42	0.312	0.303
	100% K-Natural (700 kg/fed)	With	11.33	11.33	5.03	6.15	7.03	5.25	85.36	101.5	45.38	60.65	0.357	0.367
		Without	9.66	8.83	4.3	3.96	3.97	3.58	73.2	60.2	38.25	44.6	0.289	0.292
	50%K-Mineral + PSDB	With	11.33	11.60	5.16	5.84	4.47	4.32	79.06	88.68	52.76	73.49	0.301	0.298
		Without	9.67	9.33	4.03	4.14	4.07	3.48	64.06	57.8	35.39	38.95	0.274	0.273
	50% K-Mineral + 50% K-Natural	With	11.36	11.67	5.543	6.47	5.8	4.77	85.13	87.47	55.65	72.76	0.403	0.412
		Without	9.67	9.33	5.56	4.25	4.7	3.25	80.4	57.05	34.44	47.32	0.246	0.278
	50% K-Natural + PSDB	With	11.37	11.67	5.45	6.31	4.9	4.43	80.9	86.58	48.39	62.73	0.362	0.351
		Without	9.67	9.67	4.43	3.64	5.13	3.17	78.56	66.41	32.23	45.77	0.359	0.358
	33% Mineral +33% Natural +PSDB	With	11.66	11.67	6.36	6.77	5.77	5.82	91.13	99.24	62.25	77.08	0.339	0.338
		without	10.33	9.67	4.13	4.93	3.63	4.15	71.9	83.38	34.44	45.77	0.215	0.23
28 days	100% K-Mineral (150 kg/fed)	With	7.66	7.50	4.73	5.08	4.4	4.53	68.66	75.86	49.77	58.33	0.401	0.44
		Without	7.00	7.00	4.03	4.11	3.13	4.08	64.97	61.7	43.58	41.66	0.316	0.308
	100% K-Bio (2 L/fed., PSDB)	With	7.33	7.50	5.13	5.13	4.67	4.3	61.53	60.73	41.38	51.05	0.389	0.4
		Without	6.67	6.33	4.43	4.28	3.57	3.26	57.6	58.43	31.38	37.75	0.315	0.31
	100% K-Natural (700 kg/fed)	With	7.34	7.50	5.0	5.33	5.17	5.53	70.4	72.22	41.09	52.75	0.41	0.415
		Without	6.67	6.83	4.7	4.42	3.67	4.47	67.3	68.2	36.15	34.42	0.278	0.293
	50%K-Mineral + PSDB	With	7.66	7.67	4.6	4.8	4.87	3.98	74.66	75.9	39.75	56.13	0.379	0.388
		Without	7.24	7.00	4.4	4.07	3.23	3.63	68.76	60.59	34.46	46.14	0.285	0.288
	50% K-Mineral + 50% K-Natural	With	7.67	7.67	5.03	5.53	5.6	5.03	79	83.87	43.53	54.32	0.258	0.275
		Without	7.33	7.03	4.46	3.96	3.93	4.31	73.16	73.34	35.85	43.89	0.316	0.318
	50% K-Natural + PSDB	With	7.67	7.83	5.23	5.67	5.06	4.62	73.4	80.35	38.65	58.36	0.426	0.475
		Without	7.33	7.17	4.73	4.29	4.43	4.46	67.16	66.58	35.08	45.72	0.246	0.272
	33% Mineral +33% Natural +PSDB	With	8.00	8.00	6.06	6.44	5.37	4.8	77.36	88.53	53.78	73.89	0.364	0.362
		Without	7.33	7.28	4.1	4.54	4	4.35	65.66	67.96	38.34	52.91	0.316	0.308
F. Test			**	**	N.S	N.S	**	**	**	**	**	**	N.S	N.S
LSD (.05)			1.24	1.18	-	-	1.11	0.99	0.48	0.43	1.29	0.98	-	-

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تأثير فترات الرى تحت مصادر بوتاسيوم مختلفة على نمو وإنتاجية الثوم

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تم اجراء تجربتين حقليتين في المزرعة البحثية بالبرامون- محافظة الدقهلية خلال الموسمين الشتويين 2018/2017 و2019/2018 لدراسة تأثير كل من فترات الرى ومصادر البوتاسيوم المختلفة والرش الورقى بجزيئات البوتاسيوم النانومترية على النمو الخضرى وإنتاجية نبات الثوم (سدس 40). اشتملت التجربة على 42 معامله وزعت في ثلاث مكررات خلال تصميم الشرائح المتعامدة في قطع منشقه تتمثل في التفاعلات الممكنة بين 3 فترات الرى كمعاملات في الشرائح الرأسية (14، 21 و 28 يوم)، 7 مصادر مختلفة من التسميد البوتاسي كمعاملات فى الشرائح الأفقية (100% بوتاسيوم معدنى (150 كجم سلفات بوتاسيوم/فدان)، 100% بوتاسيوم حيوى (تلقيح 2 لتر/فدان بكتريا سليكات مذيبه للبوتاسيوم *Bacillus circulans*)، 100% بوتاسيوم طبيعي (700 كجم فلسبار/فدان)، 50% بوتاسيوم معدنى + تلقيح 2 لتر/فدان بكتريا سليكات ، 50% بوتاسيوم معدنى + 50% بوتاسيوم طبيعى، 50% بوتاسيوم طبيعي + تلقيح 2 لتر/فدان بكتريا سليكات وأخيرا المعاملة ب 33% بوتاسيوم معدنى + 33% بوتاسيوم طبيعي + تلقيح 2 لتر/فدان بكتريا سليكات) مع الرش بأسمدة النانو كمعاملات شقية (بدون رش، 3000 جزء في المليون بوتاسيوم نانومتريه). أوضحت النتائج أن تسميد نباتات الثوم بمعدل 33% بوتاسيوم معدنى (50 كج/فدان) + 33% بوتاسيوم طبيعي (235 كج/فدان) مع استخدام البوتاسيوم الحيوى (2 لتر/فدان بكتريا سليكات مذيبه للبوتاسيوم (*Bacillus circulans*) يليها 50% بوتاسيوم معدنى (75 كج/فدان) + 50% بوتاسيوم طبيعى (350 كج/فدان) مع الرش الورقى ب 3000 جزء في المليون بوتاسيوم نانومتريه مع الرى كل 21 يوم هي الأفضل للحصول على أفضل نمو خضرى وأفضل انتاجيه من المحصول. ولذلك، نوصي بهذه المعاملة لأنها توفر في كمية البوتاسيوم المعدنى وكمية مياه الري المستخدمة وبالتالي تقلل من تكاليف انتاج الثوم والتلوث البيئي في مثل هذه الظروف