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Studying the Effect of Harvest Dates and some Nutrients on the Productivity and Quality of Garlic

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ABSTRACT

Two successful field trials were conducted in the 2022/2023 and 2023/2024 growing seasons to examine the effect of harvest dates (1st April, 15th April, 1st May) and the foliar application of potassium nitrate, calcium nitrate, and magnesium sulfate at a rate of 0.20% (2 gL^{-1}) on plant growth, yield, quality, and nutrient contents of garlic plant (cultivar Sids 40). The first harvest date, 1st April, scored the highest values of total yield at harvest time. The second harvest date, 15th April, produced the highest values for total garlic yield after curing, bulb weight and the contents of nitrogen, protein, potassium, and calcium in the garlic bulbs. However, the maximum sulfur content was achieved under the third harvest date, 1st May.In addition, K nitrate foliar spray recorded the highest values of bulb diameter, fresh and dry weight of plant, total yield at harvest and the cured yield, cured bulb weight and diameter, protein and N, K contents in the bulb. Mg sulfate foliar spray produced the highest values of plant length, neck diameter, bulbing ratio, and Mg content. While Ca nitrate foliar spray recorded the highest values of Ca bulb content.The highest total yield at harvest and after curing, bulb weight, and diameter recorded were assigned for the first harvest date in interaction with K nitrate foliar spray in both tested seasons. Furthermore, on the second harvest date, K nitrate foliar spray highly enhanced significant differences in total yield after curing, garlic bulb quality, and bulb nutrient contents.

Keywords: Foliar spray; potassium nitrate; calcium nitrate, magnesium sulfate; total yield.

INTRODUCTION

Garlic (*Allium sativum* L.) is considered one of the main Allium vegetable crops after onion. Garlic is primarily used for home consumption, like using it as a condiment in cooking (Sung *et al*., 2014). Moreover, garlic has important medicinal values and is used to treat various cardiovascular diseases, stomach diseases, sore eyes, and earaches, as it contains significant quantities of minerals, vitamins, and allicin (Kamel and Saleh, 2000, and Elosta *et al*., 2017). Garlic is a healthy food that may also possess antimicrobial properties, it is an important export crop, and the price of garlic has been rising all over the world during the new coronavirus epidemic (COVID-19).

Harvesting time on garlic can significantly influence its yield, quality, and storage potential. Garlic, being a sensitive crop, requires precise timing for planting and harvest to maximize benefits. Bayat *et al*. (2010) found that the differences between harvest dates have little effect on the yield and firmness of garlic cloves; for that reason, it is possible to harvest the bulbs at the first stage, when the leaf tips turn yellow. Bazon *et al*. (2020) reported that there were no differences between three different harvest dates for garlic (5th of June, 21st of June, and 5th of July), and the bulbs had reached maturity at the first harvest date. Also, evidence suggests that harvesting garlic bulbs at the stage of 80% top fall ensures both good yield and bulb quality (Desta *et al*., 2021).

A majority of the research on the nutrition of garlic limits the recommendations concerning significant nutrients such as NPK, but other nutrients such as calcium and magnesium also play a vital role in the growth, development, and quality of plants. As well, which positive and strong effects were observed on garlic yield attributes through these nutrient applications (Chanchan *et al*., 2013).

Potassium plays an essential role in the energy dynamics of plants, movement and storage of assimilates, and the regulation of tissue water balance. It is also crucial for the quality of crops, as well as necessary for the translocation of sugars and carbohydrates formation (Marschner, 1995). The enhancement of bulb characteristics depends on various factor, one of which is K fertilization (Barakat *et al*., 2019). The application of K leads to a considerable increase throughout the growth period and yield of garlic plants (Ahmed *et al*., 2010; Osman, 2015; Mounir *et al*.; 2020, and Mansour *et al*., 2024).

To support the cell walls and membrane, the plants need Ca nutrient. Ca is important to develop the calcium pectate in the cell middle lamella, which regulates the entry of nutrients that are only non-toxic to plants (McLaughlin and Wimmer, 1999). High levels of Ca^{2+} can modify both growing and Na^{+} exclusion roots of plants exposed to NaCl stress (Mahajan *et al*., 2008). Ca is a crucial nutrient that is essential to the plant structure of parts such as roots, as well as the quality of marketable yield and nutrient contents (Hamail *et al*., 2018; Sajid *et al*., 2019; and Shaban *et al*., 2019). Gülser *et al*. (2010) reported that fresh and dry leaf weight, fresh and dry root weight, stem diameter, root length, and shoot length of pepper seedlings were significantly enhanced by the Ca $(NO_3)_2$ treatment. Likewise, Shaban *et al*. (2019) showed increased plant height, number of leaves/plant, number of cloves/bulb, bulb diameter (cm), yield, and bulb quality of

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garlic under applications of different Ca sources and rates. Ibrahim *et al.* (2017) revealed that Ca $(NO_3)_2$ significantly improved plant growth and tuber production of Jerusalem artichoke. Abd-El-Hamied and Abd El-Hady (2018) added enhanced and increased tomato growth, yield, and nutrient uptake by calcium nitrate application. Ghoname *et al.* (2007) were convinced that onion foliar spray by Ca $(NO_3)_2$ was very useful in increasing the yield. The foliar spray of Ca has more advantages in correcting deficiency disorders of Ca (Hosein-Beigi *et al.*, 2019; and Correia *et al.*, 2020).

Magnesium sulfate is pivotal in affecting the growth, yield, and quality of garlic. The sufficient quantity delivered via foliar application is significant an important role in the plants physiological and biochemical processes (Adnan *et al.*, 2020, and Adnan *et al.*, 2021). Mg is a component of the chlorophyll molecule; research shows that 15–30% of plants total Mg content is linked to the chlorophyll molecule. Since photosynthesis is directly related to Mg deficiency, it will have a significant impact on plant growth and development (Marschner, 1995). Conferring to several researchers, applying Mg spray to plants enhanced their growth, promoted the formation of dry matter, and raised their yield, quality, and chemical composition (Osman and El-Sawah, 2009, on tomato; and El-Morsy, *et al.*, 2011, on garlic). In addition, Al-Barzinji and Naif (2014) confirmed that spraying garlic plants with $MgSO_4$ twice increased yield and its quality.

The aim of this work was to elucidate the impact of harvest dates and the effects of foliar spray of potassium nitrate, calcium nitrate and magnesium sulfate in enhance the growth, yield, quality, and nutrient contents of garlic plant cultivar Sids 40.

MATERIALS AND METHODS

Field Experiment and Treatments

The current trial was carried out during two successive seasons of 2022/2023 and 2023/2024 at Kaha Vegetable Research Farm, Kaliobia Governorate, affiliated to Horticulture Research Institute, ARC, Egypt, located at latitudes 30° 17′ 22.5″ N and longitude 31° 11′ 53.8″ E. This trial was concerned with the influence of harvest dates (1st April, 15th April, 1st May), as well as, foliar application with potassium nitrate (K NO_3), calcium nitrate (Ca $(NO_3)_2$), and magnesium sulfate ($MgSO_4$) at a rate of 0.20% (2 gL^{-1}), and their interaction on growth, yield, bulb quality, main components, and nutrient contents of garlic (*Allium sativum* L.) using cultivar Sids 40.

Initially, the garlic cloves were soaked in tap water for a full 24 hours before planting, and were later cultivated on both sides of the row, with a spacing of 10 cm between each clove. The experimental plot area was 10.5 m^2 consisting of 3 rows of 5 m length and 0.70 m width each. The planting date was on the 19th and 24th of September in the first and second seasons. Furrow irrigation was followed. The experimental design was a split-plot in 3 replicates that was adopted. The main plots are three treatments, i.e., harvest date 1st (1st April), harvest date 2nd (15th April), and harvest date 3th (1st May). The sub-plots were foliar application treatments, i.e., control (water), potassium nitrate, calcium nitrate, and magnesium sulfate at a rate of 0.20% (2 gL^{-1}). Garlic plants were sprayed 3 times through the growing seasons. The 1st foliar application was sprayed 60 days after planting and on 21 days intervals between the first, second and third foliar applications. In adding, K NO_3 has (solubility is 45%, 13.8% N, 46% K_2O, and purity 96%), Ca $(NO_3)_2$ has (solubility is 120%, 15.55% N, 19% Ca, and purity 97%), and $MgSO_4$ has (solubility is 113%, 9.8% Mg, 13.1% S, and purity 95%).

Followed to the recommendations of the Egyptian Ministry of Agriculture for diseases and pest control programs. Calcium super-phosphate (15% P_2O_5) at 714 kg/ha. was added at the experiment preparation. Ammonium sulfate (20.5% N) at 595 kg/ha. and potassium sulfate (48% K_2SO_4) at 357 kg/ha. were applied at three doses; the first one was added after four weeks from planting, while the second and third editions were carried out at one-month intervals. NPK fertilizer requirements were implemented, taking into account the soil's available NPK content, which was determined by subtracting the amount of mineral fertilizers recommended from the amount of available nutrients in the soil.

Soil analyses

Before planting, samples of the experiment plots topsoil (0–30 cm) were collected. The soil samples were sieved through a 2 mm sieve after being lightly crashed and allowed to air dry. Then, using the techniques outlined by Soil Survey Staff (2014), laboratory analyses were conducted to identify the primary physicochemical properties of the soil, including the particle size distribution, pH, OM contents, $CaCO_3$, EC, and soluble ions in the soil past extract (Ca^{2+}, Mg^{2+}, Na^+ and K^+, Cl^-, HCO_3^-, and CO_3^{2-}). The flame photometer measured the available K, and the Kjeldahl method was used to determine the available N (Page et al., 1982). Using a spectrophotometer, available P was extracted by Olsen *et al.* (1954) methodology.

Water analysis

A sample from the source of irrigation water was analyzed to determine its chemical characteristics (pH, EC, cations, anions, and SAR) according to USDA methodology (USDA, 2004).

Plant vegetative characters

After duration of 150 days since planting, three randomly selected plants were collected from each experimental plot. Length of plant (cm), number of leaves per plant, neck diameter (cm), bulb diameter (cm), bulbing ratio, fresh weight (g), and dried weight (g) were the vegetative test characteristics.

Total yield and its components

Total yield was determined for each experimental plot at harvest for every harvest date. After curing the harvested plants were reserved in a shaded place for 30 days, plants of each experimental plot were weighted, and the total cured yield was calculated. Five bulbs were selected at random from each plot to calculate the average bulb weight (gm), bulb diameter (cm), and bulb dry matter (%). Weight loss after curing was estimated as the following formula:

Weight loss after curing (%) =

$$\left[\frac{(\textbf{Total yield at harvest time} - \textbf{Cured yield})\ \textbf{x 100}}{\textbf{Total yield at harvest time}} \right]$$

Nutrient contents in garlic bulb

Five cured bulbs were randomly taken from each plot, oven-dried at 70C° till constant weight, and then ground to pass a 1 mm sieve. 0.2 g of the dry samples was digested using an H_2SO_4 and $HCLO_4$ mixture, following A.O.A.C. (2016). In the digested product, N was determined using a micro-Kjeldahl apparatus, P by spectrophotometer, as well as K using a flame photometer (Page et al., 1982). Proteins were calculated as N content multiplied by 6.25. Ca and Mg were determined by Inductively-Coupled Plasma (ICP) according to A.O.A.C. (2016). On the other hand, after digesting bulb tissue in an HNO_3-$HClO_4$ mixture, S in garlic was determined by spectrophotometer (Bianchor *et al*., 1965).

Statistical analysis

According to Di Rienzo *et al.* (2012), InfoStat modeling software (V. 2014) was used for the statistical analyses of the current study. The results of the various experimental treatments were compared via Duncan's Multiple Comparisons Test to determine their respective means. Additionally, the Duncan multiple range tests at the 5% level indicate that values within the column or rows followed by the same capital or small letter(s) do not substantially differ from one another.

RESULTS AND DISCUSSION

The field experiment

Soil analysis:

The physicochemical characteristics of the soil selected for the field experiment are exhibited in Table 1. The data revealed that the soil was of clay texture, where the clay amounted to 64.27%, and therefore, it had a massive structure.

The soil was non-saline and non-alkaline, having 2.15 dSm^{-1}, pH 7.91, and SAR of 4.57.

It was slightly calcareous soil containing about 5.18% of total calcium carbonate and was fertility characterized by a low OM content of about 1.15%, while the available macronutrient status, namely N and P, was medium at 42.36 and 6.40 mg kg^{-1}, respectively, and K was high at almost 418.44 mg kg^{-1}.

Irrigation water analysis:

Furrow irrigation was employed to irrigate the current field experiment. Table 1 contains the analytical data of the irrigation water.

The water was slightly saline (1.16 dSm^{-1}) and non-alkaline (SAR of 2.93); therefore, it was suitable for irrigation with percussions where FAO (1985) stated that the water of EC values between 0.75 and 3.00 dSm^{-1} has an increasing problem for irrigation.

Table 1. Physicochemical soil properties and chemical analyses for irrigation water.

Physiochemical properties of the soil									
Particle Size Distribution (%)				**Chemical properties**			**Available macronutrients (mg kg^{-1})**		
Sand	**Silt**	**Clay**	**Texture (Class)**	**pH (1:2.5)**	**OM (g kg^{-1})**	**Total $CaCO_3$ (g kg^{-1})**	**N**	**P**	**K**
10.50	25.23	64.27	Clay	7.91	11.50	51.77	42.36	6.40	418.44
Soluble cations and anions (mmolc L^{-1})									
ECe (dSm^{-1})	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-	CO_3^{2-}	SO_4^{2-}	SAR
2.15	6.86	3.77	10.53	0.64	10.04	1.13	---	10.63	4.57

Chemical analyses of irrigation water										
Soluble cations and anions (mmolc L^{-1})										
pH	ECe (dSm^{-1})	Ca^{2+}	Mg^{2+}	Na^+	K^+	Cl^-	HCO_3^-	CO_3^{2-}	SO_4^{2-}	SAR
7.20	1.16	3.42	2.89	5.21	0.17	6.23	0.65	---	4.81	2.93

Vegetative characters

Plant length:

It is obvious from Table 2 that there were significant differences among foliar application treatments compared with control. The highest garlic plant length was produced by Mg sulfate at 0.20% treatment, while the lowest was recorded for the control treatment in both seasons (Table 2). Similar results with Mg sulfate were reported by El-Morsy *et al.* (2011), Osman (2015), Mounir *et al.* (2020), and Mansour *et al.* (2024) on garlic plants.

Leaf number per plant:

Data presented in Table 2 show that spraying garlic plants with Ca nitrate at 0.20% produced the highest significant values of leaf number/plant compared with control in the first season.

On the contrary, there were no significant differences between foliar application treatments in leaf number per plant in the second season. Such results are in agreement with those of Shaban *et al.* (2019) upon calcium.

Neck diameter:

As shown in Table 2, foliar spraying of Mg sulfate recorded the highest neck diameter in the first season with significant differences compared with control, while K nitrate and Ca nitrate recorded the highest neck diameter in the second season with significant differences compared with control.

The current results are in agreement with those of Osman (2015), who reported that potassium increased the neck diameter of garlic.

Bulb diameter:

The foliar application of K nitrate recorded the highest values of bulb diameter in both seasons, with a significant difference compared to the control. While the control recorded the lowest values of bulb diameter in both growing seasons. These findings concur with those of Osman (2015) and Mounir *et al.* (2020) upon treatment with K on garlic plants.

Table 2. Plant length, leaf number, neck, and bulb diameter of garlic plant under the effect of foliar application with some nutrients in 2022/2023 (S1) and 2023/2024 (S2) seasons.

Treatments	Plant length (cm)		Leaf number (per plant)		Neck diameter (cm)		Bulb diameter (cm)	
	S1	S2	S1	S2	S1	S2	S1	S2
Control	72.56 d	70.17 c	9.72 b	9.33 a	1.24 b	1.22 b	4.77 c	3.65 c
K nitrate	78.67 b	89.00 b	9.89 b	9.67 a	1.41 ab	1.62 a	5.93 a	4.82 a
Ca nitrate	76.28 c	89.83 ab	10.55 a	9.17 a	1.29 b	1.62 a	5.39 b	4.55 b
Mg sulfate	81.83 a	91.17 a	9.83 b	9.83 a	1.50 a	1.53 a	4.68 c	4.52 b

Bulbing ratio:

Data presented in Figure (1) show that there were no significant differences between different foliar application treatments in the bulbing ratio of the garlic plant, except foliar spraying of Mg sulfate recorded the highest bulbing ratio in the first season with significant differences compared with all other foliar treatments in the first season only. Similar results were obtained by Osman (2015) and Mounir *et al.* (2020).

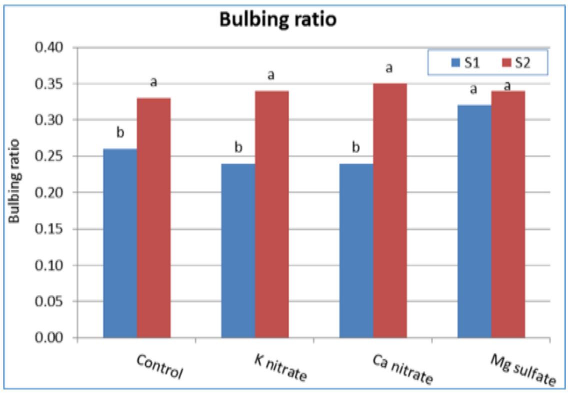

Figure 1. Bulbing ratio of garlic plant under the effect of foliar application with some nutrients in 2022/2023 (S1) and 2023/2024 (S2) seasons.

The fresh and dry weight of garlic plant:

Data in Table 3 clearly show that different foliar spraying treatments increased the fresh and dry weight of the garlic plant compared with the control. This increase reached its maximum values with K nitrate compared with the control in both seasons. These findings are consistent with those of Osman (2015) and Mounir *et al*. (2020) upon potassium application and Shaban *et al*. (2019) upon calcium and El-Morsy *et al*. (2011), who observed an increase in dry weight of the plant when foliar application with magnesium.

These notable results of the increment in vegetative growth (plant length, leaf number per plant, neck diameter, bulb diameter, bulbing ratio, plant fresh weight, and dry weight) could be associated with the promoting role of K on characters of vegetative growth, which might be linked to its physiological role in the exchange of gas and controlling water, photosynthesis, the transport of carbohydrates, the synthesis of proteins, the functioning of various enzymes, and metabolism of plants, which collectively impact the plant (Bednarz and Oosterhuis, 1999). In this respect, Ahmed *et al*. (2010) and Osman (2015) informed that K application significantly affects the vegetative growth of garlic plants. Likewise, Ca plays a crucial part in the composition of cell membranes and walls, plant growth and development, as well as quality and nutrient contents (Kadir, 2004; Hamail *et al*., 2018; and Shaban *et al*., 2019). Regarding the effect of foliar applied Mg, it plays an important function in the physiological and biochemical cycles of plants (Adnan *et al*., 2020). As an illustration, protein synthesis, metabolism of starches, energy transfer, and oxidation and reduction reactions (Thalooth *et al*., 1990). Furthermore, Mg affects physical functions, such as carbohydrate synthesis and activating many enzymes, which in turn impact plant growth (Marschner, 1995). The acquired outcomes aligned with those of Osman and El-Sawah (2009) on tomato, and El-Morsy *et al*. (2011) on garlic.

Table 3. Fresh weight (F.W.) and dry weight (D.W.) of garlic plant under the effect of foliar application with some nutrients in 2022/2023 (S1) and 2023/2024 (S2) seasons.

Treatments	Plant F.W. (g)		Plant D.W. (g)	
	S1	S1	S1	S2
Control	108.55 c	112.00 c	25.26 c	21.29 c
K nitrate	148.15 a	140.50 a	39.50 a	27.91 a
Ca nitrate	131.13 b	125.67 b	32.34 b	24.37 b
Mg sulfate	123.08 b	138.67 a	26.00 c	27.55 a

Total yield and its components

The total yield at harvest and after curing:

Data presented in Table 4 obviously show that garlic yield at harvest is significantly affected by different harvest dates. In this regard, the highest total yield of garlic at harvest was obtained with the first harvest date, followed by the second harvest date in the two seasons. Also, the highest total yield of garlic after curing was obtained with the second harvest date, followed by the first harvest date in the two seasons. The results are in agreement with those of Bayat *et al*. (2010), Bazon *et al*. (2020), and Desta *et al*. (2021).

Foliar spray treatments resulted in significant increases in total yield at harvest (Table 4). K nitrate and Ca nitrate resulted in the highest total yield in both seasons. Moreover, K followed by Ca nitrate and Mg sulfate resulted in higher cured yield than control in both seasons.

Regarding the interaction between harvest dates and foliar spraying treatments, results in Table 4 reveal that the first harvest date with K nitrate and/or Ca nitrate foliar spray produced the highest yield in two seasons. Also, the first harvest date with K nitrate foliar spray and the second harvest date combined with Ca nitrate and K nitrate produced the highest yield after curing in both seasons.

K is a function in moving the carbohydrates synthesized from the foliage of plants to the bulb, which influences yield quality and may be the reason for its effect on raising yield and its components. These findings are consistent with those published by El Sayed and El-Morsy (2012) and Shafeek *et al*. (2016) who showed that K fertilizers affect and increase garlic bulb size. Correspondingly, these results agree with Ahmed *et al*. (2010), Osman (2015), and Mounir *et al*. (2020); they discovered that applying K fertilizer greatly raised both the total yield and its constituent parts. K is role in photosynthesis, controlling stomata's opening and closing, transporting carbohydrates produced in leaves to storage organs, and reducing dark respiration may also have an impact on total yield and its constituent parts. These factors may contribute to the bulb's increased storage of carbohydrates (Patil, 2011).

Also, the obtained results of calcium foliar application are in agreement with those obtained by Ghoname *et al*. (2007) on onion, Ibrahim *et al*. (2017) on Jerusalem artichoke, Abd-El-Hamied and Abd El-Hady (2018) on tomato, Shaban *et al*. (2019) on garlic, and Ismail *et al*. (2022) on artichoke.

The beneficial impact of magnesium concentrations on enhancing overall yield and its components can be linked to magnesium's crucial role in boosting plant metabolic activity (Marschner, 1995). These conclusions are in harmony with that of Osman and El-Sawah (2009) on tomato; they found that yield and dry matter marketable the yield was enhanced as the concentration of magnesium increased.

Weight loss after curing:

Regarding weight loss after curing, the second harvest date recorded the lowest values of weight loss after curing in both seasons (Table 4). While the first harvest date recorded the highest weight loss in both seasons.

Mg sulfate foliar spray exhibited the least weight loss in the two seasons. However, K nitrate and the control recorded the highest weight loss in the 1st and 2nd seasons.

Concerning the interaction between harvest dates and foliar spraying treatments effect on weight loss, the lowest significant weight loss was recorded in the second harvest date with Ca nitrate and Mg sulfate foliar spray in the first and second seasons, respectively.

Table 4. Total yield at harvest, total yield after curing, and weight loss after curing of garlic plant under the effect of harvest dates, foliar application with some nutrients, and their interaction in 2022/2023 (S1) and 2023/2024 (S2) seasons.

Treatments		Total yield at harvest (ton/hectare)		Total yield after curing (ton/hectare)		Weight loss after curing (%)	
		S1	S2	S1	S2	S1	S2
Harvest 1		19.66 a	19.06 a	13.54 b	12.69 b	30.75 a	33.29 a
Harvest 2		16.76 b	15.66 b	14.30 a	13.28 a	14.66 c	15.22 c
Harvest 3		13.21 c	14.16 c	10.76 c	11.66 c	18.57 b	17.55 b
	Control	15.07 d	15.04 d	11.92 c	11.52 c	20.55 b	23.17 a
	K nitrate	17.61 a	18.42 a	13.30 a	14.23 a	23.32 a	21.32 ab
	Ca nitrate	17.21 b	16.11 b	13.09 b	12.14 b	22.60 a	22.88 a
	Mg sulfate	16.26 c	15.59 c	13.14 b	12.28 b	18.83 c	20.71 b
Harvest 1	Control	17.26 d	15.64 d	12.40 f	10.83 ef	28.07 c	30.74 b
	K nitrate	22.25 a	22.87 a	14.95 a	15.14 a	32.82 b	33.82 ab
	Ca nitrate	20.99 b	20.73 b	13.26 e	13.40 b	36.86 a	35.30 a
	Mg sulfate	18.11 c	17.02 c	13.54 d	11.35 d	25.25 d	33.30 ab
Harvest 2	Control	15.90 e	15.83 d	13.49 d	12.57 c	15.1 hi	20.58 c
	K nitrate	17.11 d	16.97 c	14.28 c	14.85 a	16.62 gh	12.43 e
	Ca nitrate	17.04 d	14.90 e	14.92 a	12.50 c	12.43 j	16.10 d
	Mg sulfate	16.92 d	14.90 e	14.47 b	13.14 b	14.49 i	11.77 e
Harvest 3	Control	12.04 g	13.66 f	9.83 j	11.19 de	18.47 fg	18.19 cd
	K nitrate	13.49 f	15.40 de	10.71 i	12.66 c	20.52 e	17.69 cd
	Ca nitrate	13.59 f	12.69 g	11.07 h	10.50 f	18.53 f	17.25 d
	Mg sulfate	13.73 f	14.88 e	11.42 g	12.33 c	16.77 f:h	17.05 d

Garlic bulb quality

Bulb weight:

The data displayed in Table 5 indicates that the second harvest date increased the bulb weight, followed by the first harvest date in both seasons. Additionally, different foliar spraying treatments increased the bulb weight compared with the control. This increase reached its maximum values with K nitrate in the first and second seasons. Concerning the interaction between harvest dates and foliar spraying treatments, results in Table 5 indicate that the first harvest date or the second harvest date with K nitrate foliar spray enhanced significant differences in garlic bulb weight in both seasons .

Bulb diameter:

As illustrated in the table 5, there were no significant differences between harvest dates in the bulb diameter of garlic bulbs. Data presented in Table 5 show that different foliar spraying treatments increased the bulb diameter compared with the control in both seasons. This increase reached its greatest values with K nitrate treatment (Table 5). Concerning the interaction, all harvest dates with K nitrate or Ca nitrate foliar spraying gave high values of bulb diameter with or without significant differences compared with control in the first and second seasons.

Table 5. Bulb weight, bulb diameter, and bulb dry matter after curing of garlic plant under the effect of harvest dates, foliar application with some nutrients, and their interaction in 2022/2023 (S1) and 2023/2024 (S2) seasons.

Treatments		Bulb weight(g)		Bulb diameter(cm)		Bulb dry matter(%)	
		S1	S2	S1	S2	S1	S2
Harvest 1		54.76 a	52.89 a	5.53 a	5.52 a	41.53 a	40.86 ab
Harvest 2		55.24 a	53.72 a	5.55 a	5.54 a	41.44 a	41.00 a
Harvest 3		52.86 b	51.33 b	5.54 a	5.48 a	41.58 a	40.14 b
	Control	51.25 c	49.47 c	5.29 c	5.03 c	40.31 d	39.90 b
	K nitrate	56.39 a	56.02 a	5.77 a	5.87 a	41.13 c	41.25 a
	Ca nitrate	54.61 b	52.33 b	5.68 a	5.59 b	42.72 a	40.80 ab
	Mg sulfate	54.91 b	52.77 b	5.43 b	5.56 b	41.90 b	40.71 ab
Harvest 1	Control	51.07 ef	48.43 fg	5.30 de	4.80 e	39.70 g	39.70 c
	K nitrate	59.22 a	57.28 a	5.90 a	5.90 a	40.52 f	41.43 ab
	Ca nitrate	54.88 bc	54.33 bc	5.70 ab	5.83 a	43.94 a	40.80 a:c
	Mg sulfate	53.89 cd	51.50 de	5.23 de	5.53 bc	41.97 b:d	41.53 ab
Harvest 2	Control	52.67 de	51.93 de	5.40 cd	5.20 d	40.68 ef	40.63 a:c
	K nitrate	56.90 b	55.94 ab	5.67 b	5.83 a	41.56 cd	42.22 a
	Ca nitrate	54.83 b:d	52.39 cd	5.73 ab	5.53 bc	42.18 bc	41.04 a:c
	Mg sulfate	56.57 b	54.62 b	5.40 cd	5.60 b	41.33 de	40.10 bc
Harvest 3	Control	50.00 f	48.03 g	5.17 e	5.10 d	40.56 ef	39.37 c
	K nitrate	53.05 c:e	54.83 b	5.73 ab	5.87 a	41.31 d:f	40.11 bc
	Ca nitrate	54.13 cd	50.27 ef	5.60 bc	5.40 c	42.05 b:d	40.56 a:c
	Mg sulfate	54.27 cd	52.20 d	5.67 b	5.53 bc	42.39 b	40.50 bc

Bulb dry matter:

The first harvest date gave higher dry matter in the second season (Table 5). However, no significant differences between all harvest dates in the bulb dry matter were recorded in the first season.

Foliar spray treatments increased the bulb dry matter comparing with the control (Table 5). This increase reached its maximum values with Ca nitrate and K nitrate compared with the bulb dry matter of the control in the 1st and 2nd seasons.

Concerning the interaction, all harvest dates with foliar spraying treatments gave high values of bulb dry matter with or without significant differences compared with control in the both seasons. In this regard the first harvest date with Ca nitrate foliar spray and the second harvest date with foliar spraying garlic plants with K nitrate gave high values of bulb dry matter in the first and second seasons. Similar detecting were reported by El Sayed and El-Morsy (2012) and Shafeek *et al.* (2016) who indicated that K fertilizers enhance garlic bulbs size. Moreover, these results agree with Ahmed *et al.* (2010), and Osman (2015) they institute that the application of K fertilizer increased total yield and its components.

Concerning the advantageous effect of Mg as a foliar fertilizer on the yield and its components the obtained results are in harmony with that of Osman and El-Sawah (2009) on tomato; confirmed that the yield, dray matter marketable yield increased with Mg application.

Bulb nutrient contents

Nitrogen and protein contents:

Table 6 and Figures 2, 3, and 4 show that the first harvest date in the last growing season and the second harvest date in 1st and 2nd tested seasons obtained the highest nitrogen and protein percentages in garlic bulb compared to the third harvest date. The bulb N and protein concentrations in the K nitrate treatment were (1.96 and 2.01%) and (12.22 and 12.59%) in the two seasons, respectively, and were among the highest during all treatments.

Furthermore, optimum interactions were reached by the second harvest date and applying K nitrate in both tested seasons.

In this regard, potassium nitrate is an important source of potassium and nitrogen for plant growth; it improves the absorption of nutrients and, when used as foliar applications, has raised the amount of nitrogen in garlic bulbs. This is important for bulb growth since nitrogen is an essential part of proteins and amino acids (Jabeen and Ahmad, 2011).

Table 6. NPK contents of garlic bulb under the effect of harvest dates, foliar application with some nutrients, and their interaction in 2022/2023 (S1) and 2023/2024 (S2) seasons.

Treatments		N(%)		P(%)		K(%)	
		S1	S2	S1	S2	S1	S2
Harvest 1		1.83 b	1.87 a	0.283 a	0.279 b	1.68 a	1.71 a
Harvest 2		1.86 a	1.88 a	0.285 a	0.285 a	1.70 a	1.72 a
Harvest 3		1.80 c	1.82 b	0.278 b	0.284 a	1.65 b	1.67 b
	Control	1.69 d	1.75 d	0.276 b	0.274 c	1.55 c	1.57 d
	K nitrate	1.96 a	2.01 a	0.285 a	0.287 a	1.84 a	1.86 a
	Ca nitrate	1.92 b	1.87 b	0.284 a	0.288 a	1.68 b	1.69 b
	Mg sulfate	1.75 c	1.79 c	0.283 a	0.283 b	1.65 b	1.66 c
Harvest 1	Control	1.72 e	1.82 ef	0.277 e	0.272 g	1.55 f	1.57 g
	K nitrate	1.93 bc	1.96 b	0.281 b:e	0.284 cd	1.85 a	1.89 a
	Ca nitrate	1.90 bc	1.87 cd	0.288 a	0.280 d:f	1.64 c:e	1.74 c
	Mg sulfate	1.77 d	1.84 de	0.285 a:c	0.278 ef	1.68 bc	1.63 ef
Harvest 2	Control	1.71 e	1.75 g	0.281 b:e	0.276 fg	1.61 d:f	1.59 fg
	K nitrate	2.04 a	2.10 a	0.290 a	0.289 a:c	1.82 a	1.91 a
	Ca nitrate	1.95 b	1.89 c	0.286 ab	0.291 ab	1.72 b	1.71 cd
	Mg sulfate	1.74 de	1.79 fg	0.285 a:d	0.286 bc	1.66 b:d	1.66 de
Harvest 3	Control	1.64 f	1.68 h	0.270 f	0.273 g	1.49 g	1.55 g
	K nitrate	1.90 c	1.98 b	0.285 a:c	0.287 a:c	1.84 a	1.80 b
	Ca nitrate	1.91 bc	1.86 c:e	0.279 de	0.292 a	1.67 b:d	1.64 ef
	Mg sulfate	1.73 de	1.75 g	0.279 c:e	0.283 c:e	1.59 ef	1.68 de

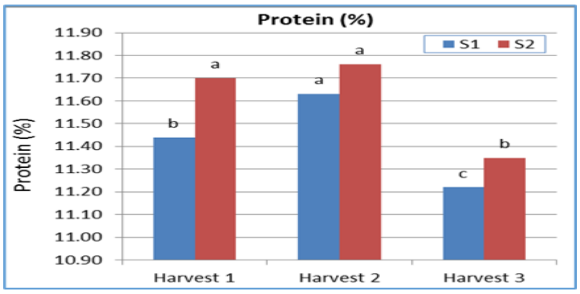

Figure 2. Protein content of garlic bulb for three harvest dates in 2022/2023 (S1) and 2023/2024 (S2) seasons.

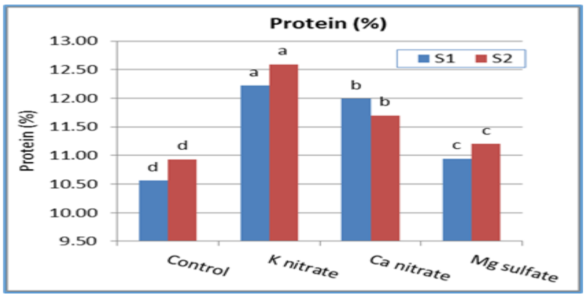

Figure 3. Protein content of garlic bulb under the effect of foliar application with some nutrients in 2022/2023 (S1) and 2023/2024 (S2) seasons.

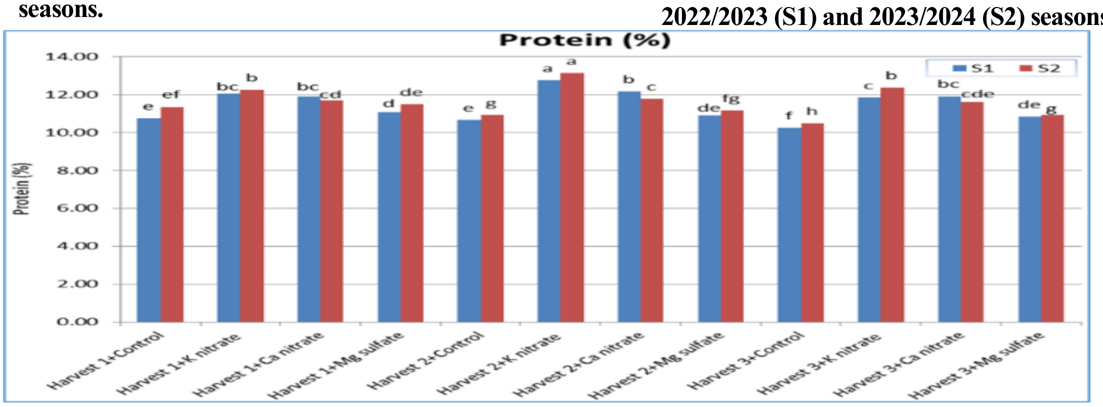

Figure 4. Protein content of garlic bulb under the effect of harvest dates, foliar application with some nutrients, and their interaction in 2022/2023 (S1) and 2023/2024 (S2) seasons

Phosphorus content:

The acquired data revealed that there were non-significant differences in P content between the three harvest dates (the first season for the first harvest date, the two seasons for the second harvest date, and the second season for the third harvest date), Table 6. As well, non-significant differences were found between K nitrate and Ca nitrate treatments in both tested seasons, and Mg sulfate in the first season. Moreover, the best interaction was achieved by several treatments that have insignificant differences between them. Adding, foliar application of Ca nitrate improved the P content in tomato plants as reported by Abd-El-Hamied and Abd El-Hady (2018) and Peyvast *et al.* (2018). Likewise, foliar application of K nitrate improved the P content in sorghum plants (Ávila *et al.*, 2020).

Potassium content:

Data in Table 6 shows that the first and/or the second harvest date achieved the highest potassium level in both growing seasons. K nitrate treatment resulted in the highest value of K percentage in garlic bulbs in 1st and 2nd tested seasons; similar results were recorded by Ávila *et al.* (2020), confirming that foliar application of potassium nitrate was associated with increased K content by pre-flowering sorghum plants. Also, K application on garlic increased potassium content (Wang *et al.*, 2022). Additionally, in the first and the second harvest date, applying K nitrate led to the highest interaction for potassium levels in both tested seasons, with insignificant differences for the third harvest date in the first season.

Calcium content:

Concerning the main effect of harvest dates, the maximum Ca content of garlic bulbs was recorded in the second harvest date in two seasons, without significant differences for the third harvest date in the first season (Table 7). Moreover, the addition of Ca nitrate showed an obvious increase in Ca content compared to the other treatments. In the interactions when comparing the three harvest dates besides the nutrient spray, the results showed that in the first and second harvest dates and applying Ca nitrate, the highest value was recorded for Ca content in the first tested season, without significant differences for the third harvest date in the second season. The obtained positive results can be related to Ca concentration in the spray solution. As well, Tejashvini and Thippeshappa (2019) confirmed that using foliar spray with different sources and levels of calcium (among them $CaNO_3$) was associated with increased Ca content in tomato.

Magnesium content: As revealed in Table 7, the results confirmed that there were no significant differences in Mg content for all harvest dates. On the other hand, foliar application of Mg sulfate in both tested seasons improved the Mg content in the bulb, compared to other treatments. Comparably, observation reported by Al-Barzinji and Naif (2014) declared that the application of Mg sulfate as a foliar spray caused greater contents of Mg in garlic leaves. The highest Mg value recorded was assigned for administering the first and third harvest dates in both tested seasons and/or the second harvest date in season one in interaction with Mg sulfate.

Sulfur content: The minimum S content in bulb was found under the first harvest date and the maximum was achieved under the third harvest date in two growing seasons (Table 7). Similarly, in their study on garlic cloves that were harvested at 2 stages, Singh *et al.* (1995) stated that sulfur content increased by the last harvest. In general, Bažon *et al.* (2020) confirmed that compared to the first harvest date, the last and second harvest dates had a noticeably greater concentration of the two minor volatiles, allyl mercaptane and thieno[2,3-b]thiophene. The variance analysis revealed a significant increase in S content in bulbs under Mg sulfate foliar spray. Bouranis and Chorianopoulou (2023) confirmed that foliar spraying with sulfates in their various forms increases the sulfur content in the plant. The interaction between the third harvest date and Mg sulfate showed the most significant differences in S content compared to the other treatments.

Table 7. Ca, Mg, and S contents of garlic bulb under the effect of harvest dates, foliar application with some nutrients, and their interaction in 2022/2023 (S1) and 2023/2024 (S2) seasons.

Treatments		Ca (%)		Mg (%)		S (%)	
		S1	S2	S1	S2	S1	S2
Harvest 1		0.164 b	0.162 c	0.076 a	0.079 ab	0.581 c	0.569 c
Harvest 2		0.167 a	0.170 a	0.075 a	0.077 b	0.613 b	0.614 b
Harvest 3		0.167 ab	0.165 b	0.076 a	0.082 a	0.630 a	0.623 a
	Control	0.151 d	0.146 d	0.058 d	0.060 d	0.530 d	0.528 d
	K nitrate	0.162 b	0.164 b	0.072 c	0.075 c	0.580 c	0.593 c
	Ca nitrate	0.192 a	0.198 a	0.077 b	0.087 b	0.621 b	0.607 b
	Mg sulfate	0.158 c	0.154 c	0.097 a	0.101 a	0.701 a	0.681 a
Harvest 1	Control	0.148 g	0.142 h	0.058 fg	0.063 e	0.489 j	0.505 i
	K nitrate	0.161 d	0.156 f	0.071 de	0.069 d	0.546 i	0.535 h
	Ca nitrate	0.193 a	0.197 b	0.078 bc	0.081 c	0.612 ef	0.595 f
	Mg sulfate	0.155 ef	0.151 g	0.097 a	0.102 a	0.676 c	0.642 c
Harvest 2	Control	0.154 ef	0.158 ef	0.054 g	0.060 ef	0.538 i	0.533 h
	K nitrate	0.159 de	0.166 d	0.068 e	0.074 d	0.589 g	0.615 e
	Ca nitrate	0.197 a	0.195 b	0.080 b	0.078 c	0.620 e	0.622 de
	Mg sulfate	0.158 de	0.162 de	0.098 a	0.096 b	0.705 b	0.686 b
Harvest 3	Control	0.152 fg	0.139 h	0.061 f	0.057 f	0.562 h	0.545 g
	K nitrate	0.167 c	0.171 c	0.076 b:d	0.081 c	0.605 f	0.628 d
	Ca nitrate	0.187 b	0.202 a	0.072 c:e	0.083 c	0.631 d	0.605 f
	Mg sulfate	0.161 d	0.148 g	0.095 a	0.105 a	0.723 a	0.714 a

CONCLUSION

This research indicates that it is achievable to harvest garlic in the first harvest date at 1st April or the second harvest date at 15th April with the application of K nitrate spray at 0.20% (2 gL^{-1}) to vegetative growth, increasing total yield, bulb quality, and nutrient contents of garlic (cultivar Sids 40). Also, foliar spraying with Ca nitrate at 0.20% (2 gL^{-1}) can be applied, as it showed a significant positive relationship for many of the studied traits, with the recommendation of examine higher concentrations in subsequent studies.

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REFERENCES

A.O.A.C. (2016). Official Methods of Analysis, 20th edition, Association of Official Analytical Chemists (A.O.A.C.), Part 51, of the Code of Fed.eral Regulations, ISBN 0-935584-87-0, USA.

Abd-El-Hamied, A. S., and Abd El-Hady, M. A. (2018). Response of Tomato Plant to Foliar Application of Calcium and Potassium Nitrate Integrated with Different Phosphorus Rates under Sandy Soil Conditions. Egypt. J. Soil Sci., 58 (1): 45 – 55. DOI: 10.21608/ejss.2017.1645.1126

Adnan, M., Hayyat, M. S., Imran, M., Rehman, F., Saeed, M. S., Mehta, J., and Tampubolon, K. (2020). Impact of Foliar Application of Magnesium Fertilizer on Agronomic Crops: A Review. Ind. J. Pure App. Biosci., 8 (6):281-288. www.ijpab.com DOI: http://dx.doi.org/10.18782/2582-2845.8465

Adnan, M., Tampubolon, K., Rehman, F., Saeed, M. S., Hayyat, M. S., Imran, M., Tahir, R., and Mehta, J. (2021). Influence of Foliar Application of Magnesium on Horticultural Crops: A Review. Jurnal Agroteknologi dan Perkebunan, 4 (1): 13-21. DOI: https://doi.org/10.36490/agri.v4i1.109

Ahmed, M. E. M., El-Aidy, A. A., Radwan, E. A., and Abd-Bary, T. S. (2010). Response of garlic plants to humic acid and different application methods of potassium fertilizer. Menoufia Journal of Agriculture Research, 35 (6): 2159-2175.

Al-Barzinji, I., and Naif, Alla, Sh. (2014). Effect of Magnesium Salts on Growth and Production of Garlic (*Allium sativum* L.). ARO-The Scientific Journal of Koya University, 2 (1). http://dx.doi.org/10.14500/aro.10038

Ávila, R. G., Magalhães, P. C., da Silva, E. M., de Alvarenga, A. A., dos Reis, C. O., Custódio, A. M., Jakelaitis, A., and de Souza, Th. C. (2020). Foliar application of potassium nitrate induces tolerance to water deficit in pre-flowering sorghum plants. Acta Scientiarum. Agronomy, 44: 53069. Doi: 10.4025/actasciagron.v44i1.53069

Barakat, M. A., Osman, A. S., Semida, W. M., and Gyushi, M. A. (2019). Integrated use of potassium and soil mulching on growth and productivity of garlic (*Allium sativum* L.) under deficit irrigation. International Letters of Natural Sciences, 76:1-12. DOI: 10.18052/www.scipress.com/ILNS.76.1

Bayat, F., Rezvani, S., and Nosrati, A. E. (2010). Effect of harvesting time and curing temperature on some properties of Iranian white garlic. Acta Hort. 877: 869-875. Proc. 6th International Postharvest Symposium Eds.: M. Erkan and U. Aksoy. DOI: 0.17660/ActaHortic.2010.877.116

Bažon, I., Lukić, I., Ban, D., Horvat, I., Prekalj, B., and Goreta Ban, S. (2020). Impact of harvest date on the content of volatile components in garlic. Journal of Central European Agriculture, 21 (2): 333-337. DOI: / 10.5513/JCEA01/ 21.2.2728

Bednarz, C. W., and Oosterhuis, D. M. (1999). Physiological changes associated with potassium deficiency in cotton. Journal of Plant Nutrition, 22 (2): 303-313. https://doi.org/10.1080/01904169909365628

Bianchor, R. W., George Rehm, and Caldwell, A. C. (1965). Sulfur in plant materials by digestion with nitric and perchloric acid. Soil Sci. Am. Proc. 29: 71-72.

Bouranis, D. L., and Chorianopoulou, S. N. (2023). Foliar application of sulfur-containing compounds—pros and cons. Plants, 12 (22): 3794. https://doi.org/10.3390/plants12223794

Chanchan, M., Hore, J. K., and Ghanti, S. (2013). Response of garlic to foliar application of some micronutrients. Journal of Crop and Weed, 9 (2): 138-141. https://www.cropandweed.com/archives/?year=2013&vol=9&issue=2&article_id=525

Correia, S., Queiros, F., Ferreira, H., Morais, M. C., Afonso, S., Silva, A. P., and Goncalves, B. (2020). Foliar Application of Calcium and Growth Regulators Modulate Sweet Cherry (Prunus avium L.) Tree Performance. Plants, 9 (4): 410.

Desta, B., Woldetsadik, K., and Ali, M. W. (2021). Effect of harvesting time, curing and storage methods on storability of garlic bulbs. The Open Biotechnology Journal, 15 (1): 36-45. DOI: 10.2174/1874070702115010036, 2021, 15, 36-45

Di Rienzo, J.A., Casanoves, F., Balzarini, M.G., Gonzalez, L., Tablada, M. and Robledo C.W. “InfoStat” (2012) InfoStat Group, Statistical software, *version 2014,* Facultad de Ciencias Agropecuarias, Universidad Nacioal de Córdoba, Argentina. http://www.infostat.com.ar

El Sayed, H. E. A., and El-Morsy, A. H. A. (2012). Response of productivity and storability of garlic (*Allium sativum* L.) to some potassium levels and foliar spray with mepiquat chloride (PIX). International Research Journal of Agricultural Science and Soil Science, 2(7): 298-305. https://www.interesjournals.org/abstract/response-of-productivity-and-storability-of-garlicallium-sativum-l-to-some-potassium-levels-and-foliarspray-with-mepiqua-16038.html

El-Morsy, A. H. A., Saif El-Deen, U. M., and Ezzat, A. S. (2011). Response of Growth, Productivity and Storability of Garlic (*Allium Sativum* L.) To Foliar Spray with Magnesium and Yeast Extract. J. Plant Production, Mansoura Univ., 2 (1): 39-51. DOI: 10.21608/jpp.2011.85458

Elosta, A., Slevin, M., Rahman, K., and Ahmed, N. (2017). Aged garlic has more potent antiglycation and antioxidant properties compared to fresh garlic extract in vitro. Scientific reports, 7(1): 39613. DOI: 10.1038/srep39613

FAO (1985). Guidelines: Land Evaluation for irrigated Agriculture. FAO Soils Bulletin No. 55, Rome, Italy.

Ghoname, A., El-Bassiony, A. M., Riad, G. S., and Abd El-Baky, M. M. H. (2007). Reducing Onion Bulbs Flaking and Increasing Bulb Yield and Quality by Potassium and Calcium Application. Australian Journal of Basic and Applied Sciences, 1 (4): 610-618. https://www.researchgate.net/publication/267198230

Gülser, F., Ferit, G. S., and Sibel, B. (2010). Effects of calcium nitrate and humic acid on pepper seedling growth under saline condition. J. of Enviro. Biology. 31 (5): 873 – 876.

Hamail, A. F., Hamada, M. S., Awady, A. A., and Salim, M. A. (2018). Effect of foliar spray with some plants extracts and different calcium sources on productivity and Quilty of strawberry fruits. I. Vegetative growth, Productivity and fruit quality. J. Product. & Dev., 23 (3): 653- 667. DOI: 10.21608/jpd.2018.42551

Hosein-Beigi, M., Zarei, A., Rostaminia, M., and Erfani-Moghadam, J. (2019). Positive effects of foliar application of Ca, B and GA on the qualitative and quantitative traits of pomegranate (*Punica granatum* L.) cv. ‘Malase-Torshe-Saveh’. Scientia Horticulturae, 254: 40–47.

Ibrahim, N. M., Ismail, S. A., Mohammed, N. A., and Ashour, H. M. (2017). Effect of Some Calcium Sources on Growth, Yield, Quality and Storability of Jerusalem Artichoke. Middle East J. Agric. Res., 6 (3): 766-778.

Ismail, Shadia A., Fathy, Wedian, and Ganzour, Shimaa K. (2022). Impact of Foliar Application of Calcium Nitrate and Chelated Calcium in Combination with Boric Acid on the Vegetative Growth, Yield, Quality Components and Insect Control of Globe Artichoke. J. of Plant Production, Mansoura Univ., 13 (9):743-752. DOI: 10.21608/jpp.2022.159772.1165

Jabeen, N., and Ahmad, R. (2011). Foliar application of potassium nitrate affects the growth and nitrate reductase activity in sunflower and safflower leaves under salinity. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 39 (2): 172-178. DOI: https:// doi.org/ 10.15835/nbha3926064

Kadir, S. A. (2004). Fruit quality at harvest of "Jonathan" apple treated with foliar applied calcium chloride. J Plant Nutro., 27: 1991–2006.

Kamel, A., and Saleh, M. (2000). Recent studied on the chemistry and biological activities of the organosulfur compounds of garlic (*Allium sativum*). Studies in natural products chemistry, 23: 455-485. https://doi.org/10.1016/S1572-5995(00)80135-0

Mahajan, S., Pandey, G. K., and Tuteja, N. (2008). Calcium-and salt-stress signaling in plants: shedding light on SOS pathway. Arch Biochem Biophys.

Mansour, F. Y. O., Khalil, H. A. M., and Bardisi, E. A. (2024). Effect of Soil and Foliar Feeding with some Sources of Potassium on Growth, Yield and Quality of Garlic. Journal of Plant Production, 15 (11): 687-697. DOI:10.21608/jpp.2024.321963.1383

Marschner, H. (1995). Mineral Nutrition of Higher Plants, 2nd Ed. Academic Press, Inc. San Diego, CA, USA.

McLaughlin, S. B., and Wimmer, R. (1999). Tansley Review No. 104 Calcium physiology and terrestrial ecosystem processes. New Phytol., 142: 373–417. DOI:10.1046/j.1469-8137.1999.00420.x

Mounir, A. M., Osman, Y. M. M., and Khalil, O. A. (2020). Impact of potassium solubilizing bacteria on growth and yield of garlic. Plant Archives, 20 (2): 8374-8388. https://plantarchives.org/20-2/8374-8388%20(7107).pdf

Olsen, S. R., Cole, C. V., Watanable, F.S., and Dean, L. A. (1954). Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S. Dept. Agric., 939, Washington DC, USA.

Osman, A. S., and El-Sawah, N. A. (2009). Response of tomato plants grown under reclaimed soil conditions to foliar application of magnesium. Journal of Plant Production, 34 (5): 4929-4942. DOI: 10.21608/jpp.2009.117314

Osman, Y. M. M. (2015). Effect of some foliar application on yield, quality and storability of garlic. Ph. D. Thesis, Faculty of Agriculture. Ain Shams University, Egypt.1-116.

Page, A. L., Miller, R. H., and Keeney, D. R. (1982). Methods of Soil Analysis. Part 2, Chemical and Microbiological Properties. 2nd (Ed.), Amer. Soc. of Agronomy. Madison, Wisconsin, USA.

Patil, R. B. (2011). Role of potassium humate on growth and yield of soybean and black gram. International Journal of Pharma and Bio Sciences, 2 (1): 242-246.

Peyvast, G., Olfati, J. A., Ramezani-Kharazi, P., and Kamari-Shahmaleki, S. (2018). Uptake of calcium nitrate and potassium phosphate from foliar fertilization by tomato. International Journal of Horticulture and Floriculture, 6 (6): 001-007. www.internationalscholarsjournals.org

Sajid, M., Ullah, I., Rab, A., Shah, S., Wahid, F., Ahmad, N., Ahmad, I., Ali, A., Basit, A., Bibi, F., and Ahmad, M. (2019). Foliar application of calcium improves growth, yield and quality of tomato cultivars. Pure Appl. Biol., 9 (1): 10-19. http:// dx.doi.org/ 10.19045/bspab.2020.90002

Shaban, K. A., Abd El-All, A. E., and El-Agyzy, F. H. (2019). Effect of Different Calcium Sources on some Soil Chemical Properties and Garlic (*Allium sativum* L.) Productivity under Saline Soil Conditions. Alexandria Science Exchange Journal, 40 (4): 693-704.

Shafeek, M. R., Ali, A. H. Mahmoud, A. R., and Hafez, M. M. (2016). The influence of foliar and soil fertilization of potassium on growth, yield and quality of garlic plants (*Allium sativum* L.). International Journal of Pharm. Tech. Research, 9 (9): 390 - 397.

Singh, J. J., Vashist, D. D., and Khurana, S. (1995). Effect of harvesting stages and storage methods on quality of garlic cloves. cabidigitallibrary.org

Soil Survey Staff (2014). Soil Survey Field and Laboratory Methods Manual. Soil Survey Investigations Report No. 51, Version 2.0. R. Burt and Soil Survey Staff (ed.). U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, DC, USA.

Sung, S. Y., Sin, L. T., Tee, T. T., Bee, S. T., Rahmat, A. R., and Rahman, W. A. (2014). Control of bacteria growth on ready-to-eat beef loaves by antimicrobial plastic packaging incorporated with garlic oil. Food Control, 39: 214-221. https:// doi.org/ 10.1016/ j.foodcont.2013.11.020

Tejashvini, A., and Thippeshappa, G.N. (2019). Effect of Foliar Application of Different Sources and Levels of Calcium on Physico-Chemical Properties of Harvested Soil and Correlation of Calcium Nutrition with Fruit Quality. Int. J. Curr. Microbiol. App. Sci., 8 (02): 1447-1455. https:// doi.org/ 10.20546/ ijcmas.2019.802.168

Thalooth, A. T., El-Zeiny, H. A., and Saad, A. O. M. (1990). Application of potassium fertilizer for increasing salt tolerance of broad bean (Vicia faba L.). Bull Egypt Soc. Physiol. Sci., 10: 181-193.

USDA (2004). Soil Survey Laboratory Methods Manual. Soil Survey Investigation Report No.42: version 4.0, United States Department of Agriculture, Natural Resources Conservation Service, USA.

Wang, M., Ye, Y., Chu, X., Zhao, Y., Zhang, S., Chen, H., and Wang, Y. (2022). Responses of garlic quality and yields to various types and rates of potassium fertilizer applications. Hort. Science, 57 (1): 72-80. DOI: https://doi.org/10.21273/HORTSCI15984-21

دراسة تأثير مواعيد الحصاد وبعض المغذيات على الإنتاجية والجودة للثوم

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الملخص

أُجريت تجربتان حقليتان ناجحتان خلال موسمي ٢٠٢٣/٢٠٢٢ و٢٠٢٤/٢٠٢٣ لدراسة تأثير مواعيد الحصاد (١ أبريل، ١٥ أبريل، ١ مايو) والرش الورقي بنترات البوتاسيوم ، ونترات الكالسيوم ، وكبريتات المغنيسيوم بمعدل ٠,٢٠٪ (٢ جم/لتر) على نمو النبات، والمحصول، والجودة، ومحتوى العناصر الغذائية لنبات الثوم (صنف سدس ٤٠). أظهرت النتائج أن موعد الحصاد الأول ١ أبريل حقق أعلى قيم للمحصول الكلي وقت الحصاد، أما موعد الحصاد الثاني ١٥ أبريل، فقد حقق أعلى قيم للمحصول الكلي للثوم بعد المعالجة (بعد اجراء عملية العلاج التجفيفى)، ووزن البصلة، ومحتوى النيتروجين، والبروتين، والبوتاسيوم، والكالسيوم في الأبصال. ومع ذلك، تم تحقيق أقصى محتوى للكبريت في موعد الحصاد الثالث ١ مايو. بالإضافة إلى ذلك، سجل الرش الورقى بنترات البوتاسيوم أعلى قيم لقطر البصلة والوزن الطازج والجاف للنبات، وكذلك المحصول الكلي عند الحصاد والمحصول المعالج ووزن البصلة وقطر البصلة في عينة المحصول بعد المعالجة ومحتوى النيتروجين والبروتين والبوتاسيوم في الأبصال. وأنتج الرش الورقى بكبريتات المغنيسيوم أعلى قيم لطول النبات وقطر العنق ونسبة التبصيل ومحتوى المغنيسيوم. بينما سجل الرش الورقى بنترات الكالسيوم أعلى قيم لمحتوى الكالسيوم فى الأبصال. تم تعيين أعلى محصول كلى عند الحصاد، وبعد المعالجة، ووزن وقطر البصلة المسجلين للحصاد الأول بالتفاعل مع نترات البوتاسيوم في كلا الموسمين المختبرين. علاوة على ذلك، في موعد الحصاد الثاني، أدى الرش الورقي بنترات البوتاسيوم إلى تعزيز كبير في المحصول الكلي بعد المعالجة، وجودة الأبصال ومحتوياتها الغذائية.

الكلمات الدالة : الرش الورقي، نترات البوتاسيوم، نترات الكالسيوم، كبريتات المغنيسيوم، المحصول الكلي.