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RESPONCE OF GROWTH AND YIELD OF LOCAL GARLIC ALLIUM SATIVUM TO POTASSIUM FERTILIZATION AND PLANTING DATE

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Abstract

A field experiment was carried out at the Agricultural Research Station of the College of Agriculture, University of Anbar for the season 2021- 2022, in order to study the effect of different levels of potassium fertilization and planting dates on the growth and yield of local garlic. Four levels of potassium fertilization were used 0, 150, 200, 250 kg ha^{-1}, they were added at three dates 15/9, 1/10, 15/10. The study was carried out as a factorial experiment in a randomized complete block design (R.C.B.D.) with three replications. Plants fertilized at the level (250 kg ha^{-1}) were significantly outperformed in vegetative growth, yield and quality (leaf area, total yield and oil percentage) and reached (7.33 dm^2 and 14.48 ton ha^{-1} and 14.18%) respectively compared to the unfertilized plants that gave the lowest value was (3.73 dm^2 and 10.33 tons ha^{-1} and 12.39%) respectively. The results also showed that the first (early) date was significantly superior in the characteristics of vegetative growth, yield and quality (leaf area, total yield and oil percentage) with 7.08 dm^2, 17.23 tons ha^{-1}, and 13.84% respectively, compared to the third planting date with the lowest leaf area, yield, and oil percentage (6.34 dm^2 plant, 2.86 tons ha^{-1}, and 12.67%) respectively. The interaction between the factors was significant difference, as the early date and fertilization level of 250 kg ha^{-1} were superior in the vegetative growth, yield and quality characteristics amounted to (7.64 dm^2, 19.70 tons ha^{-1}, and 14.80%) compared to the lowest amount achieved by the late date and non-fertilized plants for the same traits,

which amounted to 5.31 dm^2, 2, 7.35 tones ha^{-1} and 12.39% respectively.

Keywords: Potassium fertilization, Planting dates, Allium Sativum.

استجابة نمو وحاصل الثوم المحلي *Allium sativum L.* للتسميد البوتاسي وموعد الزراعة

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الخلاصة

نفذت تجربة حقلية في محطة الابحاث الزراعية التابعة لكلية الزراعة جامعة الانبار للموسم 2021-2022 بهدف دراسة تأثير المستويات المختلفة من التسميد البوتاسي ومواعيد الزراعة في نمو وحاصل الثوم المحلي، تضمنت التجربة استخدام اربعة مستويات من التسميد الارضي بالبوتاسيوم وهي 0 و150 و200، 250 كغم هكتار$^{-1}$، بالتتابع تم أضافتها بثلاثة مواعيد 9/15، و10/1 و10/15. نفذت الدراسة كتجربة عاملية ضمن تصميم القطاعات العشوائية الكاملة (R.C.B.D) بثلاثة مكررات. تفوقت النباتات المسمدة بالمستوى 250كغم هكتار$^{-1}$ تفوقاً معنوياً في صفات النمو الخضري والحاصل والنوعية المساحة الورقية والحاصل الكلي ونسبة الزيت وبلغت 7.33 دسم^2 و14.48 طن هـ$^{-1}$ و14.18% مقارنة بالنباتات غير المسمدة التي اعطت اقل قيمة وبلغت 3.73 دسم^2 و10.33 طن هـ$^{-1}$ و12.39% بالتتابع. كما أوضحت النتائج تفوق الموعد الاول (المبكر) معنوياً في صفات النمو الخضري المساحة الورقية والحاصل الكلي والنوعية ونسبة الزيت، وبلغت 7.08 دسم^2 للنبات و17.23 طن هـ$^{-1}$ و13.84%، مقارنة بأقل مساحة ورقية ونسبة الحاصل ونسبة الزيت حققتها نباتات الموعد المثالث وبلغت 6.34 دسم^2 و2.86 طن هكتار$^{-1}$ و12.67% بالتتابع. حقق التداخل فرقاً معنوياً اذ تفوق الموعد المبكر ومستوى التسميد 250 كغم هكتار$^{-1}$ في صفات النمو الخضري والحاصل والنوعية بلغ 7.64 دسم^2 و19.70 طن هكتار$^{-1}$ و14.80% مقارنة بأقل مقدار حققته نباتات الموعد المتأخر وغير المسمدة لنفس الصفات وبلغت 5.31 دسم^2 و7.35 طن هكتار$^{-1}$ و12.39% بالتتابع.

كلمات مفتاحية: التسميد البوتاسي، مواعيد الزراعة، Allium sativum L.

Introduction

Garlic (*Allium sativum* L.) crop belongs to the Alliaceae family (11), one of the most important annual vegetable crops of high economic and nutritional importance as it contains carbohydrates, niacin and phosphorous element as well as containing good

amounts of protein, calcium, iron, thiamine, riboflavin, ascorbic acid, and contain the compound allicin, as well as its wide uses in the medical field (1). Garlic is used as fresh consumption and to add flavors to foods as well as its medicinal uses as a natural antibiotic, antioxidant and insect repellent (6). Many local and imported varieties are used in cultivation in Iraq, the local variety is one of the best varieties in Iraq, but it is criticized for the small size of the heads and cloves and the lack of yield per unit area despite the quality of the variety and the high content of its fruits of dry matter, chemical and therapeutic elements compared to the imported varieties. So, it started thinking about developing solutions that improve the growth and productivity of the local variety and make it compete with the imported verities, chemical fertilization is a determining factor for the growth and yield of garlic, as it aims to obtain the largest possible amount of vegetative growth before the plants begin to form cloves. Providing the right amount of chemical fertilization to the plant showed a significant increase in growth and yield due to the length of the plant's growing season and the fact that garlic is classified as one of the vegetable crops that are greedy for fertilizing (6 and 7).

Potassium is one of the major nutrients and is of great importance in plant nutrition for its important physiological roles. It activates the work of a large number of enzymes, the absorption and transfer of ions and disease resistance, as well as an increase in plant productivity as it works to increase sugars and increase the dry matter in garlic (12).

The garlic plant is greatly affected by the change of environmental and climatic conditions, and a shift from its original habitat and cultivation in other areas different in its conditions led not only to the sterility of its flowers, but also to changes in many characteristics that negatively affected the growth and yield (3). Garlic needs a cool and mild climate during its initial growth phases to form good vegetative growth, before the plants begin to form bulbs, and planting dates greatly affect growth, productivity and the quality of the yield as it is a specific factor on which the garlic plant life cycle depends (14). From the foregoing, the study aims to:

1. Study the best level of potassium fertilization and the best date for planting of local garlic in the conditions of Anbar Governorate.
2. Improving the size of bulbs, increasing the yield and improving its quality.

Materials and Methods

A field experiment was carried out to study the effect of potassium fertilization levels and planting date on the growth and yield of local garlic at the Agricultural Research Station of the College of Agriculture, University of Anbar during the 2021-2022 growing season. Samples of field soil were taken before planting at a depth of (0-30) cm to determine some physical and chemical properties of field soil (Table 1). The soil of the field was prepared by performing perpendicular plowing, smoothing and leveling operations, then dividing the field into terraces with dimensions of 2.0 m length x 0.6 m width (with an area of 1.2 m^2) and the distance between one terracing and another is 0.5 m with a one terrace for each experimental unit. Organic manure (decomposed cow manure) was added pre planting at a rate of 10 tons ha^{-1} to all

experiment treatments (12). All the field was fertilized with the fertilizer recommendation 70 and 120 N, P kg ha^{-1} (4). Garlic cloves were planted in three dates 15/9, 1/10 and 15/10 at a depth of 5 cm on the lines of 20 cm distance between one line and another and between one plant and another 10 cm. The experimental unit contained 60 plants. The field was equipped with a T tape drip irrigation system with two tubes for each terrace. Service operations were conducted for the crop, including irrigation, weeding, insect and fungal control, whenever needed.

Experimental factors: The study included two factors: The first factor is ground fertilization with potassium added at four levels 0, 150, 200, 250 kg ha^{-1} a symbolled as K0, K1, K2, K3 (6). Potassium sulfate K_2SO_4 K_2O 50% was used as a source of potassium (6), in three patches (First after 90 days from planting, second after 120 days of planting, and third after 150 days from planting. The second factor include three dates of plantings 15/9, 1/10, and 15/10 as T1, T2, T3. The plants were harvested on 1/4 /2022 after signs of maturity appeared on 90% of the plants, represented by the yellowing of the plants, the curvature of the vegetative system towards the ground, and the softness of the neck tissues.

Table 1 Physical and chemical properties of field soil.

Soil chemical and physical properties			Measuring units
Soil separators	Sand	59	%
	Clay	12	
	Silt	29	
EC		0.922	dSm^{-1}
pH		6.95	
TPS		4.63	gL^{-1}
N		61.15	mg kg^{-1}
P		34.12	mg kg^{-1}
K		111.20	
SO4		25.31	mmol L^{-1}
NaCl		17.1	%

***Analyzed in the central laboratory of the College of Agriculture -Anbar University.**

Characters studied: First: Vegetative growth characteristics: taken after 120 days of planting, as a sample of five plants was randomly selected from each experimental unit and included the following:

1- Plant Height (cm):

The leaves of the plant were collected in a bundle and the height was measured from the area of contact of the stem with the soil to the top of the leaf in the plant by measuring tape.

2- Leaf area (dm^2 plant $^{-1}$):

The leaf area was measured through the Digimizer leaf area measurement program on the computer. Five plants were randomly selected from each treatment and the fourth leaf was taken from each plant before harvest according to the following equation:

Plant leaf area = number of plant leaves x leaf area. (13).

Second, yield characteristics: After the plants reached 90% of maturity, the plants were uprooted and a drying treatment was conducted for them. Ten plants were

randomly selected from each experimental unit and the following measurements were recorded:

1. Number of cloves in the head: The average number of cloves was calculated in ten plants taken at random for the purpose of calculating the number of cloves per head.
2. Head weight (gm): After cutting the vegetative growths, leaving 2 cm from the bulb neck area, the measurement was done using a sensitive scale.
3. Total yield (ton ha^{-1}): The experimental unit yield was calculated and converted to the hectare (10000 m^2) according to the following equation:

$$\text{Total bulb yield}\,(\text{ton ha}^{-1}) = \frac{\text{Exp. unit yield x 10000 m}^2}{\text{Exp. unit area}\,(\text{m}^2)}$$

Third: Qualitative characters:

1. Potassium content in cloves: The potassium content was estimated according to the method proposed by (2) using a Flame photometer device.
2. Oil percentage in cloves: According to what was stated in (2) using a fat extraction device (Soxhlet), 10 gm of the sample was placed in the place where the sample was placed and extracted with Diethyl ether solvent at a temperature of 30° C for 10 hours to preserve the oils from high heat damage. After extraction, the fat was weighed and its percentage was extracted (2).

Results and Discussion

Vegetative growth characters: The results indicated that the plants fertilized at the level of 250 kg/ha^{-1} of potassium fertilizer had the highest value of plant height 100.07 cm and the highest leaf area 7.33 dcm^2 plant compared to the lowest value achieved by plants that were not fertilized with potassium, which amounted to 93.35 cm, 5.73 dcm^2 plant, for the same traits (Table 2 and 3). The results also showed that the plants of the first date 15\9 were significantly superior by with highest plant height and leaf area (100.44 cm, and 7.08 dcm^2 respectively, compared to what was achieved by the plants of the last date 15\10, of (90.79 cm, and 5.31 dcm^2) respectively. The interaction had a significant effect on the vegetative growth characteristics, as the treatment 250 kg ha^{-1} and 15\9, outperformed with the highest plant height of 106.45 cm and leaf area of 7.64 dcm^2, respectively, compared with the lowest plant height and leaf area achieved by the (0 K_2O and 15\10) treatment (90.79 cm and 5.31 cm^2 respectively. The increase in vegetative growth characteristics is due to the abundance of potassium in sufficient quantities in the soil solution to meet the plant's need of the element. As well as the role of physiological potassium, as it is a necessary element for growth and a catalyst for many enzymes responsible for cell division and elongation, and this explains the increase in plant height and increase in leaf area (6). These results are consistent with what was reached by (6) Who showed that the vegetative growth characteristics of garlic increased significantly with the increase of potassium fertilization levels. This proves the importance of potassium in controlling the activities of various enzymes and protein synthesis and increasing the efficiency of the plant in utilizing nitrogen that improves leaf growth (8). The importance of potassium within the plant is also due to the increase in the activity of

many vital reactions such as photosynthesis processes by activating the enzymes of the process as well as energy production (ATP) (8). In addition to the appropriateness of the planting date for an early date 15\9 (temperature and humidity) for the local variety, as the metabolic processes and photosynthesis increased. The plants of early planting gave a great vegetative growth (compared to the late planting 15\10), which positively affected the height of the plant and the leaf area. The plants were able to take a sufficient period for the purpose of forming a strong vegetative group at an early stage (10). It is mentioned here that it is necessary to build a large vegetative growth of garlic plant in the early stages and that this will reflect positively on the increase in yield (9).

Table 2 Effect of potassium fertilization and planting dates on plant height (cm) of local garlic.

Potassium concentration	Planting dates			Mean K
	T1 (15\9)	T2(1\10)	T3(15\10)	
K0(0)	95.34	93.93	90.79	93.35
K1 (150)	98.98	94.94	91.39	95.10
K2(200)	101.00	95.95	93.37	96.77
K3 (250)	106.45	101.00	94.76	100.07
Mean planting date	100.44	96.46	92.58	
LSD $_{0.05}$	T	K	T * K	
	1.35	1.56	2.70	

Table 3 Effect of potassium fertilization and planting dates on leaf area (dcm^2) of local garlic.

Potassium concentration	Planting dates			Mean K
	T1(15\9)	T2(1\10)	T3(15\10)	
K0 (0)	6.28	5.60	5.31	5.73
K1(150)	6.99	6.07	5.93	6.33
K2(200)	7.40	7.21	7.00	7.20
K3(250)	7.64	7.21	7.13	7.33
Mean planting date	7.08	6.52	6.34	
LSD $_{0.05}$	T	K	T * K	
	0.11	0.12	0.21	

Yield characters: The results showed the significant effect of potassium fertilization, as plants of treatment K3 achieved the highest number of cloves per head, the highest head weight, and the highest total yield of 33.42 cloves, 67.57 gm and 14.18 tons ha^{-1}, respectively. The first date 15\9 was significantly superior to the rest of the dates in terms of yield and yielded 34.18 cloves, 80,41 gm and 17.23 tons ha^{-1} respectively compared to the lowest values achieved by the plants of the last date 15\10, which were 27.94 cloves and 41.35 gm and 8.86 ton ha^{-1} respectively (Tables 4, 5 and 6). The interaction had a significant effect on increasing the yield traits, as the treatment K3T1, 250 kg K_2O and 15\9 date, gave the highest yield 36.24 cloves, 91.93 gm, and 19.70 tons ha^{-1} respectively, compared to the treatment K0 T3 (0 K2O and 15\10 date) gave 24.16 cloves, 34.32 gm, and 7.35 tons ha^{-1}, respectively, for the same traits. The reason for this superiority is attributed to the role of potassium fertilization in increasing the characteristics of vegetative growth and building a large vegetative system at an early age, which gives plants a great opportunity to increase the

accumulation of photosynthetic and storage products in the plant's storage organs (bulbs), which increased the amount of yield (9). The reason for the superiority of early planting dates is also attributed to the existence of a direct relationship between the size of the vegetative growth and the yield quantity, as the large vegetative growth formed early had an impact on the quantity and quality of the yield formed compared with the late planting dates that gave the least yield components (a few cloves and heads of small sizes). These results are in line with what (3) found.

Table 4 Effect of potassium fertilization and planting dates on number of cloves per head of local garlic.

Potassium concentration	Planting dates			Mean K
	T1(15\9)	T2(1\10)	T3(15\10)	
K0 (0)	32.52	28.19	24.16	28.29
K1(150)	33.22	29.60	26.17	29.66
K2(200)	34.73	30.60	30.20	31.84
K3(250)	36.24	32.82	31.21	33.42
Mean planting date	34.18	30.30	27.94	
LSD 0.05	T	K	T * K	
	0.32	0.37	0.64	

Table 5 Effect of potassium fertilization and planting dates on head weight (gm) of local garlic.

Potassium concentration	Planting dates			Mean K
	T1(15\9)	T2(1\10)	T3(15\10)	
K0 (0)	59.72	50.62	34.32	48.22
K1(150)	82.59	54.06	38.24	58.30
K2(200)	87.40	56.52	45.35	63.09
K3(250)	91.93	63.27	47.50	67.57
Mean planting date	80.41	56.12	41.35	
LSD 0.05	T	K	T * K	
	3.49	4.03	6.98	

Table 6 Effect of potassium fertilization and planting dates total yield (ton ha^{-1}) of local garlic.

Potassium concentration	Planting dates			Mean K
	T1(15\9)	T2(1\10)	T3(15\10)	
K0(0)	12.80	10.85	7.35	10.33
K1(150)	17.70	11.58	8.20	12.49
K2(200)	18.73	12.11	9.72	13.52
K3(250)	19.70	13.56	10.18	14.48
Mean planting date	17.23	12.02	8.86	
LSD 0.05	T	K	T * K	
	0.75	0.86	1.50	

Qualitative characters: The results showed that the potassium fertilization had a significant effect on increasing the qualitative characteristics of garlic, as the plants treated with K3 250 kg K_2O achieved the highest potassium content, and oil content in the bulbs, which amounted to 1.5787% and 14.18%, respectively, compared to the plants that were not fertilized with potassium, which gave 1.5492% and 12.67% respectively (Tables 7 and 8). The first date 15\9 achieved the highest potassium

content (250 kg K_2O) and the highest oil content, which amounted to 1.5740% and 13.84%, respectively, compared to the plants of the last date 15\10, which gave 1.5446% and 12.39% for the same two traits, respectively. The interaction had a significant effect as the treatment (250 kgK_2O and 15\9) outperformed and gave the highest potassium content and the highest oil content amounting to 1.5995% and 14.80% compared to the lowest value for the two planting dates which was given by the treatment (K0T3, 0 potassium and 15\10 planting date), which amounted to 1.5442% and 12.35%, respectively. The reasons for the above mentioned superiority may be attributed to the role of potassium and the early date in stimulating vegetative growth and improving the yield, which was positively reflected on the quality of garlic heads resulting from these treatments. These results are in line with what was reached (5).

Table 7 Effect of potassium fertilization and planting dates on potassium content in cloves of local garlic.

Potassium concentration	Planting dates			Mean K
	T1(15\9)	T2(1\10)	T3(15\10)	
K0 (0)	1.5467	1.5429	1.5442	1.5446
K1 (150)	1.5608	1.5508	1.5463	1.5526
K2(200)	1.5891	1.5683	1.5483	1.5686
K3(250)	1.5995	1.5787	1.5579	1.5787
Mean planting date	1.5740	1.5602	1.5492	
LSD 0.05	T	K	T * K	
	0.0183	0.0212	N.S	

Table 8 Effect of potassium fertilization and planting dates on oil percent in cloves of local garlic.

Potassium concentration	Planting dates			Mean K
	T1(15\9)	T2(1\10)	T3(15\10)	
K0(0)	12.44	12.38	12.35	12.39
K1(150)	13.35	13.30	12.42	13.02
K2(200)	14.78	14.58	12.87	14.08
K3(250)	14.80	14.69	13.05	14.18
Mean planting date	13.84	13.74	12.67	
LSD 0.05	T	K	T * K	
	0.39	0.45	0.78	

Conclusion: From the results of this study, we conclude that there is a clear response of local garlic to potassium fertilization, which caused a significant increase in the characteristics of vegetative growth, yield, its components and the quality of its bulbs. Therefore, we recommend increasing the levels of potassium fertilization to 250 kg ha^{-1} because there is a direct response to the added quantities, and we also recommend the early planting date 15/ 9 which gave the best growth, yield, quality and best response to high levels of potassium fertilization.

Reference

1- Abedi, M., Biat, F., and Nosrati, A. E. (2013). Evaluation of agronomical traits and pyruvic acid content in Hamedan garlic (Allium sativum L.) ecotypes. European Journal of Experimental Biology, 3(2): 541-544.

2- AOAC. (1980). Official Methods of Analysis. 13th ed. Association of Official Analytical Chemists. Washington, D. C. USA.

3- Al-Ayoubi, M. N, S. Raidy, and O. Al-Abdullah. (2007). The effect of planting date and climatic conditions on the growth and productivity of some garlic varieties spread in local agriculture. Tishreen University Journal for Scientific Studies and Research - Biological Sciences Series, 29(2): 191-207.

4- Al-Mohammadi, H. S. S, F. M. A. Al-Mohammadi, and H. J. Al-Hadithi. (2016). The Role of Macro and Micro Nutrients in The Growth and Yield of Garlic (*Allium Sativum* L.) And Some of Its Qualitative Characteristics. PhD thesis - Department of Soil Sciences and Water Resources - College of Agriculture - Anbar - Iraq.

5- Al-Samarrai, M. H. H. (2005). The Effect of Adding Some Mineral Nutrients on The Quantitative and Qualitative Characteristics of Some Garlic Cultivars. PhD thesis - Department of Horticulture - University of Baghdad - Baghdad - Iraq.

6- Barakat, M. A., Osman, A. S., Semida, W. M., and Mohammed, A. G. (2019). Integrated use of potassium and Ssoil mulching on growth and productivity of garlic (Allium sativum L.) under deficit irrigation. International Letters of Natural Sciences, 76: 1-12.

7- Behairy, A. G., Mahmoud, A. R., Shafeek, M. R., Ali, A. H., and Hafez, M. M. (2015). Growth, yield and bulb quality of onion plants (Allium cepa L.) as affected by foliar and soil application of potassium. Middle East Journal of Agriculture Research, 4(1): 60-66.

8- 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.

9- Hassan, A. A. M. (2000). Production of Onions and Garlic. Vegetable Crops Series, Production Technology and Advanced Agricultural Practices - First Edition - Arab House for Publishing and Distribution – Egypt.

10- Islam, M. N., Rahim, M. A., and Anawar, H. R. M. M. (1998). Effects of date of planting and different germplasms on the growth and seed bulb yield of garlic. Bangladesh journal of seed science and technology, 2: 45-54.

11- Khan, H., Khan, T. N., Ramzan, A., Jillani, G., and Ali, M. (2016). Genotypic response of Garlic to various fertilizers levels under Agro-climatic conditions of Islamabad. Journal of Agricultural Research, 54(1):63-73.

12- Mahmoud, H. A., Sedera, F. A., and Yousef, S. B. (2000). Effect of organic and inorganic fertilizers on onion crop. Journal of Plant Production, 25(9): 5813-5830.

13- Sadik, S. K., Al-Taweel, A. A., Dhyeab, N. S., and Khalaf, M. Z. (2011). New computer program for estimating leaf area of siveral vegetable crops. American-Eurasian Journal of Sustainable Agriculture, 5(2): 304-310.

14- Suleiman, A. (2000). The effect of planting date on the speed of growth and productivity of some garlic cultivars. Damascus University, Faculty of Agriculture. 26(2): 15-26.