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Effect of pigeon manure extract and foliar application of micronutrients on the growth, flowers, and yield of tuberose *Agave amica* (Medik.)

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ABSTRACT
This study was conducted in Akre District - Iraq, during the period of 15/3/2022 - 1/2/2023 aiming to study the effect of fertilization with pigeon manure extract at three levels (0, 0.25, 0.50) l pot^{-1}, and foliar application of some micronutrients solution at three concentrations (0, 0.5, 1) g l^{-1}, on growth, flowering and yield of *Agave amica* (Medik.), cv. Single. The results showed that the highest values of leaves number, leaf width, length and diameter of the inflorescence, florets number, and diameter of the mother bulb were obtained when treated with pigeon manure extract at a 0.50. l pot^{-1}. Foliar application of microelements at 0.50 g l^{-1} caused significant increase in leaves number, leaf width, length and width of the inflorescence, and florets number. The interaction between the two factors caused a significant increase in leaf length, length and diameter of the inflorescence, florets number, bulb diameter, bulb weight, total bulbs weight, bulbs number. From the data obtained can be concluded that fertilizing with pigeon manure extract and spraying microelements plays a positive role in improving the growth, flowering of tuberose.

تأثير نقيع مخلفات الحمام والرش بالمغذيات الصغرى على نمو وإزهار وإنتاجية أبصال مسك الروم *Agave amica* (Medik)

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الخلاصة
أجريت هذه الدراسة في قضاء عقرة في العراق، خلال الفترة من 2022/3/15 إلى 2023/2/1، بهدف دراسة تأثير التسميد بمنقوع مخلفات الحمام وبثلاثة مستويات (0، 0.25، 0.50) لتر اصيص$^{-1}$، والرش الورقي بمحلول بعض العناصر الصغرى وبثلاثة تراكيز (0، 0.5، 1) غم لتر$^{-1}$، على نمو وإزهار وإنتاجية نبات مسك الروم (Medik) *Agave amica* ، صنف "سينجل". أظهرت النتائج أن أعلى قيم لعدد الأوراق، وعرضها، وطول وقطر النورة، وعدد الزهيرات، وقطر البصلة الأم، تم الحصول عليها عند المعالجة بمخلفات الحمام المنقوعة بتركيز 0.50 لتر اصيص-1. أدى رش العناصر الدقيقة على الأوراق بتركيز 0.50 غم لتر$^{-1}$ إلى زيادة ملحوظة في عدد الأوراق وعرضها، وطول وعرض النورة، وعدد الزهيرات. كما أدى التفاعل بين هذين العاملين إلى زيادة ملحوظة في طول الأوراق، وطول وقطر النورة، وعدد الزهيرات، وقطر البصلة، ووزنها، والوزن الإجمالي للبصيلات، وعددها. وبناءً على البيانات المُتحصل عليها، يُمكن استنتاج أن التسميد بنقيع مخلفات الحمام والرش بالعناصر الصغرى يُسهمان إيجابًا في تحسين نمو وإزهار نبات مسك الروم..

الكلمات المفتاحية: تغذية نبات *Agave amica*, مخلفات الطيور.

INTRODUCTION

Agave amica (Medik.) is one of the most important summer perennial ornamental bulb plants (Singh & Shankar 2011). It belongs to the Asparagaceae family (Singh *et al.* 2025) and grows well in tropical and subtropical regions as a cut flower and is native to Mexico (Thiede & Geovarts 2017). The plant is one of the ten main ornamental plants as cut flowers, so it located at a high economic position for its various uses. The plant has a selective place among all ornamental plants because of its elegant shape and attractive white waxy flowers with a fragrant aroma. It is used as cut flowers mainly for the length of its flower inflorescence and the longevity after cutting. Florets also are using in the perfume industry, as it is considered a primary source of essential oils valued at $200,000 kg used in the production of cosmetics and perfumes (Qureshi *et al*. 2018).

The plant is one of the most important herbaceous flowering bulbs within monocotyledon group. It is classified as a day-neutral plant in terms of the photoperiod that the plant prefers (Nipa, 2018). It is blooming in summer and fall and advisable to plant in a sunny place at a temperature average of 21-29 C°. The plant height reaches 90-120 cm. The bulb is tapered surrounded by succulent leaves at the base, crowned by a bud at the top. The roots are fibrous, the leaves are tapered, it length about 30-45 cm and are basal (6-9 leaves) wrapped around the bulb, the flower inflorescence reaches a height of 90 cm and its length without the inflorescence around 30-45 cm and the number of florets reaches 30 white, waxy, aromatic, funnel-shaped florets, 6 cm length, growing single or double from the nods of inflorescence (Mandal *et al.* 2018).

Modern agriculture systems usually used different methods to improve production, such as organic fertilizers, where chemical fertilizers are increasingly used well-thought-out a danger to the environment and human health (Tawfeeq 2017, Singh 2017). Organic fertilizers are considered one of the most important materials that play a fundamental role in improving quality and properties of soil such as nutrient mineralization, aeration, and water retention, in addition to increasing water absorption. As well as improving the physical properties of the soil, and increasing the proportion of elements that important for plant growth (Mahmood *et al.* 2017). On the other hand, organic fertilizers are considered slow source provide nutrients, which contain moderate amounts of essential nutrients for plant growth, which it has the ability to solve the problems associated with chemical fertilizer by improving soil fertility through the

necessity of reducing chemical fertilizers frequent use, increasing the supply of nutrients, and improving the functioning of biologically active compounds such as humic acids and plant hormones (Larramendy & Soloneski, 2019). Organic materials, including pigeon droppings, are a suitable source for providing nutrient elements for plants, which also maintain active microorganisms in soil (Akbari *et al.* 2011). In addition to their positive role in seed germination and the development of roots and shoots, as pigeon droppings contains an amount of nitrogen twice what the other organic fertilizer contains such as lab manure. Also, it contain phosphorus, potassium, in addition to calcium, magnesium, sulfur, and some other micronutrients (Alabadan 2009). Therefore, pigeon droppings is considered an interesting alternative natural fertilizer, and it is available easily compared with other fertilizers. It is believed that pigeon droppings fertilizer is like any other fertilizer using to increase the productivity of ornamental plants, vegetables, and fruits in clean and environment friendly agriculture. It contains an estimated amount of nitrogen 4%, phosphorus 1%, and potassium 2% (table 1). These elements are the most important and necessary nutrients which are relatively available for plant growth in soil (Ibrahim & Eleiwa, 2008). These elements are the most important and necessary nutrients which are relatively available for plant growth in soil. Adding these elements as a fertilizer to the soil can be very affective in improving the production, compared to plants that did not fertilized (Li-Xian *et al.* 2007).

Table 1: Chemical analysis of pigeon manure extract

EC (Dsm^{-1})	**O.M.**	**pH**	**Total C%**
7.65	69.8	6.12	33.6
Total N%	**C/N ratio**	**Total P%**	**K%**
4.31	7.80	0.97	0.98
Fe ($\mu g\ g^{-1}$)	**Mn ($\mu g\ g^{-1}$)**	**Zn ($\mu g\ g^{-1}$)**	**Cu ($\mu g\ g^{-1}$)**
240.3	50.8	92.60	7.65

According to Ibrahim & Eleiwa (2008).

The nutrient medium is one of the basic factors for the growth and development of plants, and nutritional deficiency is considered one of the main problems for farmers (Jatav *et al.* 2020). Plants in general and flowering crops especially respond to micronutrients as they are more sensitive to lack of elements and nutrients. However, it appears rarely on ornamental plants, so it is recommended to spray nutrients on the foliage (Atal *et al.* 2021). Foliar application takes into account the appropriate quantities, time, and optimal method to enhance growth and quality of crops, through spraying on the foliage, and it is more effective than ground addition to reduce the symptoms of deficiency, maintain nutritional status, and improve growth and production (Otalora *et al.* 2018). Nowadays, spraying micronutrients on the shoots incrementally in order to overcome nutrients shortage, it is faster than ground application and root absorption (Niu *et al.* 2020). Foliar application of micronutrients on the plant leaves and move towards the inside through the leaf epidermis and transporting via plasmodesmata to the rest of the plant parts causes increase in chlorophyll pigment, proteins, and nucleic acids, which that improves the growth and yield of tulip flowers (Kannan *et al.* 2017, Kumar *et al.* 2017). So, spraying microelements such as iron, zinc, and boron increases the growth and

productivity of flowering crops. Particularly, iron is important for the synthesis of protein and chlorophyll and is a catalyst for activating enzymes and transferring energy (Zewide & Sherefu 2021). Conversely, iron chlorosis decreases the photosynthesis, as the leaves appear yellow, especially new leaves and new grown parts before the old leaves (Havlin 2014). Similarly, zinc involved in improving photosynthesis and carbohydrate synthesis, and increases the resistance of oxidative stress effect and thus increases flower lifespan (Sofy *et al.* 2020). However, when zinc is deficient, it reduces leaf size, shortens internodes, increases fungal infection, and decreases its ability to withstand extremes in temperature and light (Cakmak 2000). Furthermore, boron is important because it is role in photosynthesis as well through increasing carbohydrates synthesis average, transporting sugars, activating enzymes, strengthening the cell wall, producing hormones, as well as improving cell division and maintaining cell membranes (Yermiyahu *et al.* 2008). However, to date, there are few available studies regarding the nutrient treatment of tuberose with organic and inorganic fertilizers. Therefore, the principal aim of this work is to improve the growth, flowering and yield quality by detecting the optimum suitable fertilizer type and detecting the optimum dose and its impact on flowering and production.

MATERIALS AND METHODS

This study was conducted in a privet farm in Akre – Dohuk - Iraq (Latitude: 36.75° N, and Longitude: 43.89° E). The bulbs were obtained from a nursery in Syria and planted during the period 15/3/2022 – 1/2/2023.

The bulbs were planted with a diameter of 25 - 30 mm, in plastic pots with a diameter of 25 cm, after being soaked with the fungicide (Rival 2 ml L^{-1}) for two hours on March 20th, 2022. The soil mixture of (2:1) mixed soil, peat moss used in this experiment was prepared, and the bulbs were planted at a depth of 5-8 cm in the upper third of the pot. All the plants were serviced by irrigated regularly, and shaded by a green sunshade net provided 33% shad rate in June for 60 days to protect the plants from the scorching rays of the sun.

Pigeon droppings fertilizer was prepared by fermenting 20 kg of pigeon droppings that had been aged for 3 years in the open field in 100 liters of water for 30 days, then filtered with a piece of clothing, the extracted water placed in a large tank with a capacity of 500 liters. The fertilization process of pigeon droppings was carried out after the formation of 4-6 true leaves on the plant, where fertilizer is added after plants irrigated.

Fertilization with micronutrients was done using IQ COMBI fertilizer which produced by Agri Sciences company (Pancar Torbalı, İzmir, Turkey), which contains the following micronutrients (iron 6%, manganese 6%, copper 0.5%, boron 0.2%, and molybdenum 0.2%). It was sprayed on the plant shoot twice. The first one was after the formation of the fourth to sixth leaf on the plant, and the second time was after a month from the first one, and both applications were conducted early in the morning.

The experiment was carried out in a randomized complete block design (R.C.B.D) with three replications. The experiment included two factors which were organic fertilization with pigeon manure extract as a first factor at three concentrations: 0, 0.25, 0.50 liters pot^{-1}. The second factor was spraying plants with IQ COMBI fertilizer (micronutrients mixture) in three concentrations: 0, 0.5, 1 g L^{-1}. As a result for the interaction between the different concentration of the two factors3 x 3, there were nine

factorial treatments formed the experiment. Six pots have been used in each experimental unit, and in total there were 162 pots (plant) in this experiment. SAS program was used to analyses variance. Duncan's test at 0.05 probability levels was employed to separate mean values (SAS 2002).

Measurements:

1. Vegetative growth characteristics included leaf length (cm), leaf width (mm) measured using Vernier caliper, and number of leaves (leaf plant $^{-1}$) counted manually by hand.
2. Flowering growth characteristics: inflorescence length (cm), inflorescence diameter (mm) measured using Vernier caliper, number of florets (florets inflorescence^{-1}) counted manually by hand..
3. Characteristics of the yield of bulbs and bulblets: The plants were left to grow until 15/1/2023, irrigation had been stopped 15 days before uprooting plants from the soil. Then, the bulbs and bulblets were cleaned of soil in order to measure the following characteristics: diameter of the mother bulb (cm), weight of the bulb (g), number of bulblets (bulblet plant $^{-1}$), number of bulbs (bulb plant $^{-1}$), bulb diameter (cm), bulb weight (g), single bulblet diameter (mm), single bulblet weight (g).

RESULT AND DISCUSSION

The results presented in Table (2) about the effect of fertilizing with pigeon manure extract and microelements on some characteristics of vegetative and flowering growth indicate that there are significant differences between the treatments, where fertilization with pigeon manure extract at both concentrations 0.25 and 0.50 L pot^{-1} caused a significant increase in the characteristics of number of leaves. While the concentration of 0.50 gave the highest rate of leaf width, while there were no significant effects noticed in leaf length.

Foliar application of micronutrients showed that both concentrations 0.5 and 1 g L^{-1} caused a significant increase in the characteristics of inflorescence length and diameter, 79.86 and 83.56 cm and 7 43 and 7.56 mm, respectively, and the number of florets 27.13 and 29.33 bulblet inflorescences^{-1}, respectively. On the other hand, the interaction between 1 g L^{-1} microelements and 0.50 L pot^{-1} of pigeon droppings infusion caused significant increasing in the characteristics of leaf length, inflorescence length, inflorescence diameter, and number of florets, which amounted 47.00 cm, 91.72 cm, 8.33 mm, and 35.22 florets. inflorescence^{-1} respectively.

The results shown in Table (3) indicates that the effect of fertilizing by pigeon manure extract and microelements did not achieve any significant effect on most traits of bulbs and bulblets yield expect the mother bulb diameter trait which differed significantly by reaching 31.52 mm at a concentration of 0.50 l pot^{-1} compared with other two concentrations.

On the other hand, foliar application of micronutrients caused significant increase in number and weight of bulbs, and number of bulblets which were 9.96 bulbs plant^{-1}, 62.99 g plant^{-1}, and 17.62 bulblet bulb^{-1} respectively. Also, the interaction between 1 g l^{-1} of microelements and 0.50 l pot^{-1} concentration of pigeon manure extract distinguished significantly in the characteristics of mother bulb diameter 35.69 mm, weight of the mother bulb 25.39 g, bulb weight 9.55 g, bulbs weight 86.78 g, number of bulblets 20.83 bulblet bulb $^{-1}$.

Table 2. Effect of fertilization with a solution of pigeon manure extract and micronutrients on some vegetative and flowering growth characters of *Agave amica* (Medik.) during 2021/22 season.

Concentrations		Leaf length (cm)	Leaf width (mm)	No. of leaves (leaf plant^{-1})	inflorescences length (cm)	inflorescences diameter (mm)	No. of florets (floret inflorescence^{-1})
Fertilization with a pigeon manure extract (l Pots^{-1})							
0		37.83 a	15.41 c	38.59 b	72.26 b	7.10 b	24.77 b
0.25		39.92 a	16.86 b	48.72 a	79.86 a	7.43 ab	27.13 ab
0.50		41.07 a	18.06 a	43.05 ab	83.56 a	7.56 a	29.33 a
Microelements fertilization (g l^{-1})							
0		36.55 b	15.61 b	37.01 b	75.21 a	6.82 b	22.00 b
0.5		40.57 a	17.16 a	43.24 ab	78.33 a	7.53 a	29.22 a
1		41.70 a	17.56 a	50.11 a	82.15 a	7.74 a	30.01 a
Fertilization with a solution of pigeon manure extract × Microelements							
Microelements (g l^{-1})	pigeon manure extract (l Pots^{-1})						
0	0	33.00 c	13.76 c	24.38 b	72.26 bc	6.57 d	19.67 d
	0.5	40.16 b	16.29 b	38.33 ab	75.13 bc	7.59 b	29.00 abc
	1	40.33 b	16.20 b	53.05 a	69.39 c	7.15 bcd	25.66 bcd
0.25	0	39.27 bc	16.42 b	48.00 a	76.31 bc	7.14 cd	23.89 bcd
	0.5	42.72 ab	17.06 b	47.61 a	77.95 bc	7.42 bc	28.33 abc
	1	37.78 bc	17.09 b	50.55 a	85.34 ab	7.73 ab	29.16 abc
0.50	0	37.39 bc	16.66 b	38.66 ab	77.06 bc	6.76 cd	22.44 cd
	0.5	38.83 bc	18.14 ab	43.78 a	81.91 abc	7.59 b	30.33 ab
	1	47.00 a	19.39 a	46.72 a	91.72 a	8.33 a	35.22 a

Values with the same letters for each individual factor and for interaction don't significantly differ according to Duncan's Multiple Range Test at 0.05 level of probability.

According to statistical analysis results, it is clear that fertilizing by pigeon manure extract lead to significant differences in some tuberose plants characteristics under study. Leaf width, number of leaves, as well as inflorescence indictors like length, diameter, and number of spike appeared positive response due to the nutrition value of this treatment. The superiority of organic fertilization treatments in increasing vegetative growth indicators can be attributed to the role of organic fertilization in supplying the soil with the macro- and micro-nutrients necessary for plant growth, as well as the role of organic fertilizer in improving the properties of the soil and increasing its porosity and physical composition, which enables plants to actively grow, expand, and increase the size of the aggregate. The root system increases its efficiency in absorbing nutrients, which reflects positively on increasing vegetative growth indicators (Wickham & Davis 2023). Birds manure is generally considered one of the organic fertilizers rich in elements, especially nitrogen. It is known the important and essential role that elements play in revitalizing plant and increasing its energetic activity. Hernández-Cruz *et al,* (2002) found that application of N increased the number of leaves, leaf fresh weight, leaf length and leaf diameter of Aloe vera. Manjula & Kumari (2015) indicated that

accumulation of carbohydrate was greater due to photosynthesis rate increased which caused by the supply and optimum balance of plant nutrients.

Table 3. Effect of fertilization with a solution of pigeon manure extract and micronutrients on flowering characters of *Agave amica* (Medik.).

Concentrations		Mother bulb diameter (cm)	Mother bulb weight (g)	No. bulbs bulb^{-1}	bulb weight (g)	bulbs weight (g)	No. bulblet bulb^{-1}	bulblet weight (g)	bulbs weight (g)
Fertilization with a Solution of pigeon manure extract (l pots^{-1})									
0		24.26 c	18.00 a	7.63 a	6.16 a	47.82 a	13.27 a	1.02 a	12.00 a
0.25		28.20 b	18.03 a	7.73 a	7.21 a	45.64 a	15.13 a	0.90 a	11.46 a
0.50		31.52 a	21.30 a	8.99 a	7.37 a	55.10 a	15.83 a	0.83 a	11.16 a
Microelements fertilization (g l^{-1})									
0		27.24 a	18.19 a	7.13 b	6.15 a	45.25 b	12.99 b	0.90 a	10.51 a
0.5		28.00 a	18.37 a	7.27 b	7.08 a	40.32 b	13.61 b	0.92 a	11.23 a
1		28.74 a	20.77 a	9.96 a	7.51 a	62.99 a	17.62 a	0.93 a	12.88 a
Fertilization with a solution of pigeon manure extract × Microelements									
pigeon manure extract (l pots^{-1})	Microelements (g l^{-1})								
0	0	20.99 c	11.68 d	6.19 b	6.09 b	33.69 d	11.26 bc	0.97 a	10.75 a
	0.5	26.42 bc	23.26 ab	6.38 b	6.38 b	48.38bc d	13.72 bc	1.20 a	15.20 a
	1	25.37 bc	19.07 ab	10.33 ab	6.00 b	61.40 ab	14.83 bc	0.90 a	10.04 a
0.25	0	31.27 ab	22.14 ab	7.77 ab	8.18 ab	68.39 ab	16.72 abc	0.79 a	13.17 a
	0.5	28.18 b	14.10 cd	7.72 ab	6.48 b	27.72 d	11.45 bc	0.78 a	6.38 a
	1	25.15 bc	17.86 bcd	7.72 ab	6.98 ab	40.81 cd	17.22 ab	0.91 a	14.82 a
0.50	0	29.46 b	21.29 ab	7.44 ab	6.98 ab	33.67 d	10.99 c	0.93 a	9.76 a
	0.5	29.41 b	17.21 bcd	7.72 ab	5.58 b	44.85 cd	15.66 abc	0.79 a	9.94 a
	1	35.69 a	25.39 a	11.83 a	9.55 a	86.78 a	20.83 a	0.98 a	13.77 a

Values with the same letters for each individual factor and for interaction don't significantly differ according to Duncan's Multiple Range Test at 0.05 level of probability.

Furthermore, nitrogen performs many roles directly related to the main plant processes, such as photosynthesis, respiration, growth regulation, transmission of genetic traits, pollination, and seed formation. It is included in the composition of both chlorophyll and cytochromes, which have an effective role in the processes of photosynthesis and respiration as well as its role in the formation of vitamins , proteins, nucleic acids, cellular membranes and energy compounds (Mengel & Kirkby 2001).

On the other hand, the superiority of organic fertilization treatments can be explained by the role of these fertilizers in increasing the ability of the soil to retain water and increasing the activity of beneficial microorganisms, which increased the ability of these plants to absorb water and nutrients, which reflected positively on the increase in vegetative growth indicators when compared to the comparison treatment that It was not

fertilized with organic fertilizer (Shayaa & Hussein 2019). Also, organic matters play an important role to reduce the damage of environmental stress. It reduces the absorption of the toxic elements of sodium and chlorine and also helps rise the absorption of essential nutrients (Mora *et al.* 2014). Organic matters regulate the permeability of cell membranes and reduce the absorption of ions such as chloride and sodium, thus reducing their negative effects on metabolic processes (Kusvuran *et al.* 2021). Moreover, organic fertilizer has an effective role in decreasing the salinity effects on plants, also it improving growth in general, as organic acids work through two different mechanisms, directly through the action of the active components of organic acids to regulate the growth process and the system, and the second is indirect by improving the chemical and physical properties of the soil (Nardi *et al.* 2017).

Regarding the effect of spraying micronutrients on the content of some vegetative and flowering growth traits of tuberose plant. It was indicated that micronutrients caused significant effect in many vegetative traits. This may be credited to the positive effect of nutrients in increasing the concentration of the elements by facilitating their absorption, especially nitrogen and phosphorus, and their role in the synthesis of proteins, enzymatic attachments, nucleic acids, and all processes and reactions associated with enzymatic reactions, protoplasm, and photosynthesis (Nardi *et al.* 2002). The increase in vegetative growth characteristics was also reflected in several traits, including an increase in the number of bulblets and an increase in their diameter, as well as their fresh weight (Aparna *et al.* 2018). This may be attributed to the fact that humic acid leads to the activation of the physiological functions of the plant and increases the biomass of the plant by stimulating the division of plant cells and increasing their length and size, as well as delaying the decomposition of chlorophyll and proteins, and leads to an increase in the production of vitamins and plant hormones in the treated plants, which led to an increase in the size of the shoot and an improvement in the rates of Growth, flowering and productivity (O'Dell 2003).

Among the studies that show the importance of spraying for micronutrients, the results of this study were in the same line with Patel *et al.* (2017) indicated by spraying the *Agave amica* (Medik.) plant with nutrients and obtained a significant increase in the number of leaves, number bulbs, weight and diameter of the largest bulb for each plant. As well as, Sudhagar, *et al.* (2019) found a significant effect on *Agave amica* (Medik.)cultivar by spraying with some micronutrients, and Al dur & Al-atrakchii, (2021) on *Agave amica* (Medik.) cultivar.

CONCLUSION

The present study provided comprehensive information on the effect of pigeon manure extract and interaction with micronutrients fertilizers on some vegetative and flowering growth characters of *Agave amica* (Medik.). The study concluded that organic fertilizers (pigeon manure extract) stimulated most of the vegetative traits in this study. The main important point observed that the soak (extract) is rich in essential nutrients for plant growth. The highest concentration in this study (0.50 l pot^{-1}) is more effective than 0.25 l pot^{-1}. As well as, the results enhance to use of micronutrients due to the significant role that has been noticed in most of vegetative and flowering characteristics of the plants whether when sprayed separately or in interact with organic fertilizer.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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