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INFLUENCE OF FOLIAR K, Mg AND MICRO-NUTRIENTS ON THE YIELD, QUALITY AND ESSENTIAL OIL CONSTITUENTS OF GARLIC IN SANDY SOIL

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ABSTRACT

Two field experiments were conducted under newly reclaimed sandy soils irrigated by drip irrigation system at El-Bostan area, Nubaria region, during the winter season's 1999/2000 and 2000/01. The study aimed to determine influence of foliar application of potassium fertilizer (With (K_1) or without (K_0)) accompanied with different mixtures of micronutrients and Mg {M_1 (Fe + Zn + Mn), M_2 (M_1 + Cu) and M_3 (M_2+Mg)} and concentrations (control, 25, 50, 75 and 100 g/100L H_2O) on garlic "Aspani" cultivar growth, productivity, quality, macro- and micronutrients concentration, essential oil content and constituents.

The results showed significant effect for the main effects and interaction of the studied parameters (potassium, nutrients mixtures and concentrations) on vegetative growth characters (plant height, leaf number and leaf area), yield and its components (bulb fresh weight, average clove number and weight and bulbs yield) and bulbs features (neck diameter, bulb diameter, bulbing ratio, TSS% and dry matter%). Main effects and interactions indicated that foliar application of potassium (K_1) and M_3 mixture with increasing foliar spray concentration up to 100g/100 L H_2O increased all Aspani garlic plant growth, yield and bulb features presenting importance of adjusting nutrients supplying.

Foliar application is particularly useful under conditions where nutrient uptake from the soil is restricted. Garlic leaves and cloves N, P, K, Mg, Fe, Zn, Mn and Cu concentrations were significantly affected by interaction of K treatments, nutrient mixtures and concentrations. The differences were located in each nutrient due to application of K_1 in increasing order of $M_3 > M_2 > M_1$ and with increase the concentration.

The oil percentage was found to slight gradually increase with increasing the level of fertilizer inside each mixture of M_1, M_2 and M_3. Nutrients mixture in M_3 treatments was the superior with K_1. Ten constituents identified in the essential oil of garlic 'Aspani' cultivar by using Gas chromatography-mass spectrum technique (GC-MS). They were di-allyl disulfide (di-propenyl disulfide) as major component, the intermediate components were allyl sulfide, methyl allyl tri-sulfide and Allyl tri-sulfide and the rest were minor. Effect of K and different mixtures and concentrations on the percentage of the volatile oil constituents showed the same trend with volatile oil percentage i.e. potassium fertilization significantly increased the essential oil constituents percentage. Also there were differences resulted from adding different mixtures of M_1, M_2 and M_3. As for the main effect of different concentrations of foliar spray application could be also notes that, the percentage of essential oil constituents slight progressively increased by increasing the concentrations of fertilizers.

INTRODUCTION

Garlic, (*Allium sativum,* L.), is one of the oldest crops under cultivation. It is considered as one of the major vegetables for local consumption and exportation. It has become an increasingly popular vegetable in recent years-among producer, marketers, and consumers. It is essentially used as species and condiment. Beside its uses in culinary purpose, it also used for the medical purpose. It's long acclaimed nutritional and medicinal values are proving to be valid, more people are discovering its culinary splendor, and producers have found garlic to be a potentially highly profitable crop.

Garlic bulbs are antiseptic, antispasmodic, diuretic, carminative, expectorant, antiasthmatic, regulates menstruation, hypotensive and prevents accumulation of cholesterol, in the arteries thus preventing arterioscleroses (Watt and Brandwijk, 1962). Externally garlic is use to treat corns, ulcers, skin diseases, earache, toothache and used as herbicide and fungicide (Lewis and Lewis, 1977). The pharmaceutical purpose of garlic cloves due to the presence of 0.1 to 0.25 of essential oil containing active constituents like allin, allicin, inulen, organic sulfur compounds, vitamins A, B, and C, hormone-type substances and pectin (Bianchini and corbetta, 1977). Sulfur compounds in garlic oil have recommended a lot of attention because of their potential and flavor properties (Stoll and Seebeck, 1950).

Garlic is grown, however, on all types of soils, but performs better under light soil in texture. Recently, a great attention has been focused on the possibility of growing garlic under newly reclaimed sandy soils conditions using drip irrigation. It is a heavy feeder and will require considerable amounts of fertilizer over a relatively long growing season. Because garlic is a relatively long season crop, it will require applications of fertilizer throughout the growing season. Nutrients applied to the leaves can be absorbed and utilized by the plant; however, foliar application of these nutrients cannot be expected to supply total amount required for crop production. An appropriate time to consider foliar fertilization would be when a shortage of a nutrient is evident as indicated by tissue analysis or visual symptoms.

Regarding the effect of macro- and micro-nutrients on garlic volatile oil content and its composition, rare literatures were found dealing with this respect, however, Park et al (1998) studied the effect of K_2SO_4 and KCl on the content of S-containing organic compounds of garlic plants by using GC and GC-Mass spice. They reported that, application of K_2SO_4 increased the content of S-containing compounds by two-to-three times when compared with the application of KCl. Bisher *et al.* (1998) on (*Nigella Sativa* L.). They showed that the application of K_2SO_4 at a level of 150 kg fed-1 and adding Zn, Mn and Fe as a foliary spray application of (50 ppm each) gave the highest increase in the volatile oil content as well as fixed oil. Ibrahim *et al.* (1991) found that, application of Zn and Mn at rate of 5kg fed^{-1} from each in addition to the macro elements of NPK is favorable to obtain the largest essential oil yield in Balady c.v. of garlic plants. While in Chinese cv. It advised to be doubled the quantity of Zn and Mn to produce the best results. Eid and Ahmed (2001) concluded that sparying the parsley plants

(*Petroselinum sativum* L.) by Sahara fertilizer (Zn 5.0%, Mn 3.5%, Fe 1.7% at rate of 4.5g L^{-1} had a significant effect on volatile oil percentage and its chemical constituents during different cuts.

Unsuitable cultural practices in the newly reclaimed sandy soils lead to reducing the net revenue from garlic production due to the cost of nutrients used and wrong application. Therefore, improvement application of some macro- and micro-nutrients spraying, including mixtures of the nutrients supplied, and concentration have a great importance in garlic production and quality. Thus, the objective of the present investigation was to determine the effect of foliar application of potassium fertilizer accompanied with different mixtures and concentrations of Mg and micronutrients on garlic “Aspani” cultivar growth, productivity, quality, macro- and micronutrients concentrations and essential oil content and constituents.

MATERIALS AND METHODS

The present study was conducted at the experimental farm, of South Tahrir Horticulture Research Station, at Ali Moubarak village, El-Bostan area, Nubaria region, during the winter season’s 1999/2000 and 2000/01. The experimental site belongs to the newly reclaimed sandy soils irrigated by the drip irrigation system. Prior to the initiation of the investigation, in each season, soil samples from the soil surface of the experimental site to 20 and 20-40cm depth were collected and analyzed for some chemical, physical properties according to the standard procedures (Page, 1982 and Klute, 1986). Results of analysis are presented in Table 1. It was newly reclaimed poor, deep and well drained sandy soil.

Garlic cloves cv. Aspani was sown on October 10^{th} and 16^{th} in the first and second growing seasons respectively. Cloves were sown on the both sides of the drip irrigation lines ridged at 10 cm apart between hills and 80 cm between laterals.

This experiment were evaluated several foliar spray applications included two potassium treatments: with and without foliar K {control (K_0) and 7 kg K_2SO_4/200 liter water fed^{-1} (K_1)}, three mixtures of micronutrients and magnesium (Mg): M_1 (Fe + Zn + Mn), M_2 (Fe + Zn + Mn + Cu) and M_3 (Fe + Zn + Mn + Cu + Mg) added as Fe-EDDHA (6% Fe), Zn-EDTA (15% Zn), Mn-EDTA (12% Mn), $CuSO_4.5H_2O$ (25.45 % Cu) and Mg-EDTA (12% Mg) with ratio of (1: 1: 1: 0.25: 2) respectively.

Finally five concentrations (0, 25, 50, 75 and 100 g/100 L H_2O) of each mixture. Garlic plants were sprayed with macro- and micronutrients solutions twice during the growing seasons, at 90 and 120 days after sowing with rate of 200 L H_2O fed^{-1} which adjusted to fit the shoot growth stage, which started after sprouting until 140 days after planting (Chung, *et al.* 1994).

Table1. Some chemical and physical characteristics of the experimental soil at ' Ali Moubarak' farm in the two growing seasons.

Characteristics	Growing Season			
	1999/2000		2000/2001	
	0-20 cm	20-40 cm	0-20 cm	20-40 cm
EC, dS m^{-1}	0.35	0.29	0.39	0.30
pH (1:2.5)	8.32	8.28	8.38	8.40
OM; %	0.21	0.13	0.25	0.16
$CaCO_3$; %	5.35	5.28	5.36	5.54
NO_3 + NH_4; µg g^{-1}	31.30	40.50	39.60	42.15
Exch.-K; µg g^{-1}	128.20	102.70	115.70	100.30
$NaHCO_3$-P; µg g^{-1}	8.44	5.92	10.80	7.20
DTPA-Fe; µg g^{-1}	4.50	nd*	3.99	nd
DTPA-Zn; µg g^{-1}	0.95	nd	0.92	nd
DTPA-Mn; µg g^{-1}	2.76	nd	2.71	nd
DTPA-Cu; µg g^{-1}	0.85	nd	0.82	nd
Sand; %	93.10	92.90	91.9	92.75
Soil texture class	Sandy	Sandy	Sandy	Sandy

*** nd = not determined**

During field preparation, chicken manure were incorporated under drip irrigation lines at rate of 7 m^3 fed^{-1}, while, nitrogen, phosphorus and potassium fertilizers were supplied at rates of 100, 30 and 24 kg N, P_2O_5 and K_2O fed^{-1} as ammonium nitrate (33.5% N), phosphoric acid (85%) and potassium sulfate (48% K_2O), respectively. N, P and K fertilizers were fertigated through irrigation water 51, 35 and 35 applications (three applications a week) orderly. The recommended cultural practices for commercial garlic production were followed. Irrigation was daily achieved according to the applied irrigation water quantity.

The experimental design used was split split-plot system in a randomized complete block design (RCBD) with three replications. Main plots were consisted of two K treatments (K_0) and (K_1). While sub-plots within main plot were devoted for three mixtures of micronutrients and Mg: M_1, M_2 and M_3. Meanwhile, the sub-sub-plots contained five mixture concentrations: 0, 25, 50, 75, and 100 g/100 H_2O. There were 30 different treatments in total. Each sub-sub-plot (50 m^2) included 2 lateral irrigation lines.

Harvesting was carried out when the garlic leaves tops became pale green and exhibit some necrosis of the tissue, which is usually a good indicator of harvest maturity. This appearance was corresponding to the harvest time. Prior to harvest, ten plants were pulled from different locations in the experimental site and the bulbs assessed as to size and number of wrapper leaves. The garlic reached sufficient size for this variety after about 200 days then bulbs were cured by drying.

During the two growing seasons garlic plants growth as affected by the studded foliar applications were evaluated, five plants were taken from each plot at 150 days after sowing and the following data were recorded: plant height (cm), leaves number $plant^{-1}$, both neck and bulb diameter (cm), bulbing ratio, bulbs total soluble solids (TSS) and dry matter percentage. Then leaf samples were collected to determine macro and micronutrients concentrations. At harvesting time, total yield, average bulb weight, average clove weight, and average number of cloves bulb^{-1} were recorded. Cloves samples were collected from each treatment to determine nutrients concentration, oil percent and oil constituents.

Macro- (N, P, K and Mg) and micronutrients (Fe, Zn, Mn and Cu) were determined in garlic leaves and cloves. Samples were washed, dried at 70 °C then ground and wet digested using H_2SO_4 and H_2O_2 (FAO, 1980). Nitrogen, phosphorus and potassium concentrations were determined using Gerhard Vapodust 50 nitrogen distillation unit, spectrophotometer 21D and Jenway flame photometer, respectively. While Fe, Zn, Mn and Cu were measured using atomic absorption spectrophotometer (Perkin Elmer 3300) (Westerman 1990).

The fully ripe garlic cloves were shelled, sliced and distillated for oil extraction as described by Guenther (1961) and British Pharmacopeia (1968) then oil content (%) was calculated. The constituents of the garlic essential oils were determined by using the Gas Chromatography-Mass Spectrum (GC-MS) Technique.

The oil constituent’s percentage was estimated from the measured peak area of the chromatogram according to Heftman (1967), Gunther and Joseph (1978).

Data of the present study were, statistically, analyzed using MSTAT-C software (Freed, 1988). The comparisons among means of the different treatments were carried out, using the Duncan’s multiple range test as illustrated by Gomez and Gomez (1983).

Conditions of GC-MS:

Information	Condition
Instrument	GC 5890 Mass spectrophotometer 5989, Hewlett Packared (HP),
Column	HP/5 30m × 0.25μm film thickens,
Stationary phase	Polyphenyle methyl sioxane,
Flow rate	0.6 ml Helium min^{-1},
Column temp.	50-200 °C,
Rate temp.	6 °C min^{-1},
Injection temp.	200 °C,
Detected temp.	220 °C,
Recorder	HP

RESULTS AND DISCUSSION

1- Vegetative growth characteristics

Results presented in Table (2) indicated that application of foliar potassium (K_1) to growing garlic plants stand favorable and responsible for the statistically increments in plant height, number of leaves per plant and plant leaf area in both growing seasons compared with control treatment (K_0).

Table 2. Effects of K, Mg and micronutrients mixtures and concentrations on the vegetative growth characteristics of garlic plants during the winter seasons of 1999/2000 and 2000/2001.

K[§] Treat-ment	Mixt[¶]	Conc[!]	Plant height, cm	Leaf no $Plant^{-1}$	Leaf area $Plant^{-1}$, cm^2	Plant height, cm	Leaf no $Plant^{-1}$	Leaf area $Plant^{-1}$, cm^2
			1999/2000			2000/2001		
K_0			50.62 B	7.67 B	550.76B	47.02 A	7.64 B	550.24 B
K_1			55.09 A	10.33 A	571.78A	55.24 A	10.20 A	564.64 A
	M_1		48.60 B	8.27 B	565.3 A	48.60 C	8.13 B	555.4 B
	M_2		53.07 B	8.30 B	554.9 A	50.27 B	8.30 B	554.8 B
	M_3		56.90 A	10.43 A	563.6 A	54.53 A	10.33 A	562.2 A
		Cont	48.78 C	8.28 C	546.0 C	46.00 C	8.33 C	543.7 D
		25	51.89BC	8.83BC	550.1 C	48.28 BC	8.50 C	550.1 C
		50	52.83 B	9.06AB	559.1 BC	50.94 B	8.83 BC	557.9 B
		75	53.22 B	9.22AB	570.3 AB	52.33 B	9.28 AB	569.4 A
		100	57.56 A	9.61A	580.8 A	58.11 A	9.67 A	566.2 A
K_0	M_1	Cont	43.00 a	5.33 a	538.3 de	39.33 g	5.67 d	531.7 k
		25	45.33 a	6.33 a	541.0cde	38.67 efg	5.67 d	539.7 ijk
		50	44.33 a	6.67 a	559.0 b-e	40.67 fg	6.33 d	556.0 fgh
		75	48.33 a	6.67 a	557.7 b-e	41.33 c-g	6.67 d	553.0 f-i
		100	57..67 a	6.67 a	563.7 b-e	57.67 a-d	7.00 d	564.7 c-g
	M_2	Cont	44.00 a	5.67 a	538.3 de	39.00 fg	6.00 d	531.7 k
		25	48.00 a	5.67 a	532.3 e	40.67 d-g	6.00 d	538.0 jk
		50	51.00 a	6.33 a	548.7cde	44.67 b-g	6.33 d	552.0 ghi
		75	51.33 a	6.33 a	559.3 b-e	50.00 b-g	6.67 d	565.3 c-g
		100	51.67 a	7.67 a	553.0 b-e	51.67 b-g	7.33 d	550.0 hij
	M_3	Cont	53.33 a	9.67 a	538.3 de	48.67 a-f	10.0 abc	531.7 k
		25	53.33 a	10.00 a	546.3cde	51.00 a-f	10.0 abc	552.7 f-i
		50	55.00 a	10.67 a	556.0 b-e	54.33 a-e	10.3 abc	561.0 d-h
		75	56.00 a	10.67 a	570.3 b-e	55.33 a-d	10.3 abc	571.0 b-e
		100	57.00 a	10.67 a	559.0 b-e	56.33 a-d	10.3 abc	555.3 fgh
K_1	M_1	Cont	47.67a	9.67 a	550.0cde	52.67 d-g	9.00 c	552.0 ghi
		25	49.00 a	10.00 a	557.0 b-e	53.00 c-g	9.33 bc	555.0 fgh
		50	49.00 a	10.33 a	566.0 b-e	53.00 c-g	10.00abc	563.0 c-h
		75	45.00 a	10.33 a	580.7 bc	52.00 efg	11.00 ab	572.0bcd
		100	56.67 a	10.67 a	639.7 a	61.67 ab	10.67abc	566.7 b-f
	M_2	Cont	52.67 a	9.33 a	554.7 b-e	47.67 a-g	9.33 bc	558.0 e-h
		25	56.00 a	10.33 a	557.0 b-e	52.67 a-d	9.67 bc	549.3 hij
		50	57.67 a	10.00 a	556.7 b-e	57.00 a-d	10.00abc	553.3 f-i
		75	58.33 a	10.67 a	572.3 b-e	56.67abc	10.67abc	575.3abc
		100	60.00 a	11.00 a	577.0bcd	62.67 a	11.00 ab	574.7 a-d
	M_3	Cont	52.00 a	10.00 a	556.3 b-e	48.67 b-g	10.00abc	557.0 fgh
		25	59.67 a	10.67 a	567.0 b-e	53.67 ab	10.33abc	565.7 c-g
		50	60.00 a	10.33 a	568.3 b-e	56.00 ab	10.00abc	562.0 c-h
		75	60.33 a	10.67 a	581.7 bc	58.67 ab	10.33abc	579.7 ab
		100	62.33 a	11.00 a	592.3 b	62.67 a	11.67 a	586.0 a

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**
§ K treatment, K_0= without foliar K application, K_1= with foliar K application
¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg
! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

These results might be attributed to the favorable effect of potassium on the garlic plants growth. Potassium regulates, photosynthesis, plant respiration rate and carbohydrate supplies, and helps the plant use water more efficiently by promoting turgidity to maintain internal pressure in the plant. The improvement of nutrient status of plant will be helpful in more vegetative growth (Mengle and Kirby, 1987).

Effect of nutrients mixtures differed, significantly (Table 2). The foliar application of M_3 gave significant higher mean values for plant height, number of leaves per plant and plant leaf area. These significant increases might be attributed to the favorable effect of sprayed nutrients on the plant metabolism, and due to the role of these sprayed nutrients on the physiological and biochemical processes (Katyal and Randhawa, 1983 and Pillei, 1967).

In general, increasing concentrations of each mixture up to 100g/100 L H_2O increased, significantly, the mean values of studded parameters compared with that sprayed with lower concentrations and control. Normal growth and high yield were obtained by Gallagher (1969), and El-Habbasha and Behairy (1977), when onion plants were sprayed with solutions of zinc sulfate 0.4%, copper sulphate 0.25% and manganese sulphate 1-2%, respectively.

The interactions among K foliar application, different mixtures and their concentrations had significant effects on the all studied vegetative growth characteristics (Table 2). In general, the highest values were obtained by applying potassium (K_1) with M_3 mixture with 100 g /100 L H_2O concentration. While the lowest mean values were obtained for control treatment (K_0). These results are in accordance with those of Abd El-Hamed (1997) indicated that, spraying Chinese garlic plants with mineral Fe + Zn + Mn in sulphate form at ratio of (1: 1: 1) with 300 ppm concentration, increased significantly the vegetative growth characters such as plant height, number of leaves, leaf area per plant over the control treatment.

2. Yield and its components

Data presented in Table (3) indicated that treating garlic plants K_1 enhanced garlic yield and its components, insignificantly. While, application of potassium promoted significant increases for the mean values of clove fresh weight and bulbs yield in the second growing season. Whereas application of nutrient mixtures containing copper (M_2) gave insignificant increases for bulb fresh weight, number of cloves / bulb, clove weight and bulbs yield compared with M_1 mixture, in the two seasons of the study (Table 3). Campbell and Gusta (1966) mentioned that the addition of Cu improved the quality of onion. Moreover, addition of magnesium into the mixture accompanied with progressive increases in bulb fresh weight number of cloves / bulb and bulbs yield, in the first season. But the differences did not reach the significant level ($p= 0.05$). The stimulated effect of foliar application of macro and micronutrient mixtures on garlic yield and its components may be attributed to the role of combined effect of the macro and micronutrients on the physiological and biochemical processes and plant vegetative growth characteristics. These results are in harmony with that obtained by Abd- El-Hamed (1997).

Table 3. Effects of K, Mg and micronutrients mixtures and concentrations on bulb and yield characteristics of garlic during the winter seasons of 1999/2000 and 2000/2001.

K[§] Treat.	Mixt[¶]	Conc[!]	Bulb fresh wt, g	Av. cloves no $bulb^{-1}$	Av. Clove wt, g	Yield fed^{-1} Ton^{-1}	Bulb fresh wt, g	Av. cloves no $bulb^{-1}$	Av. Clove wt, g	Yield fed^{-1}, Ton^{-1}
			1999/2000				2000/2001			
K_0			57.89A	17.27 A	3.34 A	6.95A	57.12 A	17.38 A	3.28 B	6.86 B
K_1			60.60A	17.02 A	3.56 A	7.7 A	61.22 A	17.07 A	3.58 A	7.35 A
	M_1		58.29 A	16.90 A	3.45 A	6.99A	58.61 A	16.87 B	3.46 A	7.03 A
	M_2		59.56 A	17.10 A	3.47 A	7.15 A	59.69 A	17.23 A	3.46 A	7.16 A
	M_3		59.89 A	17.43 A	3.43 A	7.19 A	59.23 A	17.57 A	3.36 A	7.11 A
		Cont	44.81 D	14.33 E	3.15 C	5.38 D	44.63 D	14.50 D	3.11 B	5.36 D
		25	56.14 C	16.22 D	3.47AB	6.74 C	55.93 C	16.39 C	3.41 A	6.71 C
		50	62.04 B	17.61 C	3.53AB	7.45 B	60.78 B	17.83 B	3.42 A	7.29 B
		75	61.84 B	18.22 B	3.41 B	7.42 B	63.56 B	18.06 B	3.53 A	7.63 B
		100	71.39 A	19.33 A	3.70 A	8.57 A	70.97 A	19.33 A	3.67 A	8.52 A
K_0	M_1	Cont	41.63 k	14.33 lm	2.90 f	5.00 k	38.77 i	13.33 l	2.93 ef	4.65 i
		25	50.67 hij	15.67 ijk	3.23 b-f	6.08 hij	48.80 gh	16.00hij	3.03def	5.86 gh
		50	57.07 e-i	17.33 efg	3.30 b-f	6.85 e-i	58.03 ef	17.33d-g	3.37a-e	6.96 ef
		75	61.63c-g	18.67 bcd	3.33 b-f	7.40c-g	60.47def	18.00c-f	3.37a-e	7.26def
		100	64.67b-f	19.67 ab	3.30 b-f	7.76 b-f	66.00a-e	19.00bc	3.47a-e	7.92a-e
	M_2	Cont	44.10 jk	14.67 kl	2.97 ef	5.29 jk	42.37 hi	16.00 g-j	2.63 f	5.08 hi
		25	55.67f-i	16.33 ghi	3.40 a-f	6.68 f-i	58.00 ef	16.67 f-i	3.47a-e	6.96 ef
		50	58.2d-h	17.67 def	3.30 b-f	6.99d-h	59.73def	17.67 c-f	3.40a-e	7.17def
		75	60.3d-g	18.00 cde	3.33 b-f	7.24d-g	63.83c-f	18.33cde	3.50a-e	7.66 c-f
		100	71.33 ab	19.00 abc	3.73a-d	8.56 ab	69.37abc	19.00 bc	3.67a-d	8.32abc
	M_3	Cont	48.70 ijk	14.67 kl	3.37 a-f	5.84 ijk	45.80 hi	14.67 k	3.17 b-f	5.50 hi
		25	61.3 c-g	16.67 f-i	3.70a-e	7.36c-g	59.77def	17.00e-h	3.53a-e	7.17def
		50	57.7d-h	17.33 efg	3.33 b-f	6.93d-h	55.87 fg	18.00 c-f	3.10 c-f	6.70fg
		75	62.73c-g	19.00 abc	3.30 b-f	7.53c-g	59.97def	19.00 bc	3.13 c-f	7.20def
		100	72.60 ab	20.00 a	3.63 a-f	8.71ab	70.07abc	20.67 a	3.37a-e	8.41abc
K_1	M_1	Cont	45.00 jk	13.33m	3.40 a-f	5.40 jk	45.30 hi	13.33 l	3.43a-e	5.44 hi
		25	59.73d-g	16.00hij	3.77a-d	7.17d-g	61.70 c-f	16.00 hij	3.87ab	7.40 c-f
		50	69.90abc	17.00efgh	4.10 a	8.39abc	67.10a-d	18.00 c-f	3.73a-d	8.05a-d
		75	58.43d-h	17.67def	3.33 b-f	7.01d-h	67.17a-d	18.00 c-f	3.73a-d	8.06a-d
		100	74.13 a	19.33 ab	3.83abc	8.90 a	72.73 ab	19.67 ab	3.70a-d	8.73 ab
	M_2	Cont	43.90 jk	14.00 lm	3.20 c-f	5.27 jk	49.23 gh	14.67 k	3.43a-e	5.91 gh
		25	55.60 f-i	16.00hij	3.47 a-f	6.67 f-i	48.87 gh	15.67 ijk	3.13 b-f	5.86 gh
		50	66.80a-d	18.67bcd	3.60 a-f	8.02a-d	64.50b-f	18.00 c-f	3.60a-e	7.74 b-f
		75	66.13a-e	18.00cde	3.70a-e	7.94a-e	67.23a-d	17.67 c-f	3.83abc	8.07a-d
		100	73.50 a	18.67 bcd	3.97 ab	8.82 a	73.73 a	18.67bcd	3.93 a	8.85 a
	M_3	Cont	45.53 jk	15.00jkl	3.07def	5.46 jk	46.30 hi	15.00 jk	3.07def	5.56 hi
		25	53.87ghi	16.67fghi	3.23 b-f	6.46 ghi	58.43def	17.00e-h	3.43a-e	7.01def
		50	62.50c-g	17.67def	3.53 a-f	7.50c-g	59.47def	18.00 c-f	3.30a-f	7.14def
		75	61.80c-g	18.00cde	3.43 a-f	7.42c-g	62.67 c-f	17.33d-g	3.63a-e	7.52 c-f
		100	72.10 ab	19.33ab	3.73a-d	8.65 ab	73.93 a	19.00 bc	3.90a	8.87 a

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**
§ K treatment, K_0= without foliar K application, K_1= with foliar K application
¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg
! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

The successive increases in the nutrient mixture concentration led to corresponding and significant increases in the mean values of bulb fresh weight, number of cloves / bulb, clove fresh weight and bulbs yield /feddan of the, "Aspani" garlic cultivar (Table 3). Decreasing mixtures concentrations decreased bulbs yield and its components. Similar results were obtained by Ismail, (1995).

The interaction of potassium, mixtures and their concentrations had significant influences on the garlic yield and its components, in both years (Table 3). Generally, the highest mean magnitude for bulb fresh weight and bulb yields/feddan, were attained with spraying potassium (K_1), M_1 mixture and full strength, (100 g /100 L H_2O), while the reverse was true with spraying without potassium- (control), With respect to the combined effect of K, mixtures and their concentrations, also, clearly, indicated that garlic plants treated with K_1, M_3 with full strength gave the highest mean values, for fresh clove weight and bulb yield/feddan. But there were no significant differences between the mean values of M1 and M3 mixtures.

3- Bulb Features

Respecting bulb neck diameter, bulb diameter, bulbing ratio, bulbs total soluble solids (TSS) and dry matter percentages, results in Table (4) revealed that spraying garlic plants with potassium (K_1), insignificantly, enhanced bulb characteristics during the two years of the study, except that of bulbing ratio character in both seasons.

The results shows that there was insignificant trend among studied mixtures (M_1, M_2 and M_3) on the bulb neck diameter, bulb diameter, bulbing ratio, bulbs total soluble solids (TSS) and dry matter percentages. However, application of M_3 mixture indicated that addition of copper and magnesium, significantly, increased the mean values of TSS compared with M_1 mixture, and increased bulb neck diameter in the first growing season. Addition of copper to the nutrient solution increased bulb characteristics, insignificantly (Table 4). These results are in harmony with that of Sharma *et al*., (1988) who stated that clove size of garlic increased significantly with two sprays of 0.3% multiplex containing Ca, Mg, Cu, B, Zn, Mn, and Mo.

In general, data revealed that increasing nutrients concentrations up to 100 g /100 L H_2O being favorable for the all studied bulb characteristics, compared with those of control. These results might be due to spraying the full strength of nutrient mixtures during the shoot growth stage where, maximum total soluble carbohydrates, leaf area index, net assimilation rate and relative growth rate took place (Chung, *et al.,* 1994).

Spray with macro and micronutrients mixtures and with different concentrations had positive and/or significant mean values of neck and bulb diameter bulb TSS % and dry matter %. The maximum values were accompanied with spraying garlic plants with potassium and M_3 macro and micronutrients mixture with 100 g /100 L H_2O concentration. However, their were no an obvious trend for bulbing ratio character (Table 4).

Ismail (1995) studied the response of Chinese garlic plants cv., to foliar application with Fe, Zn, Mn and Cu at 0, 2000 and 4000 ppm for each nutrient either separated or in mixture at low level (Fe + Zn + Mn + Cu with 0, 2000 ppm for each) and high level (Fe+ Zn+ Mn + Cu at 4000 ppm for each) three times. They found that low and high levels of mixture for all micronutrients promoted markedly the character of dry bulb weight, over the untreated control. Also, Abd El-Hamed (1997) indicated that, spraying Chinese garlic plants (Sids 40 clone) with (Fe + Zn + Mn) at sulphate form as ratio of (1: 1:

1) with 300-ppm concentration, increased significantly the bulb diameter over the untreated control.

Table 4. Effects of K, Mg and micronutrients mixtures and concentrations on the bulb and bulbing characteristics of garlic during the winter seasons of 1999/2000 and 2000/2001.

K[§] Treat	Mixt[¶]	Conc!	Neck diam cm	Bulb diam. cm	Bulb-ing ratio	TSS %	Dry matter %	Neck diam cm	Bulb diam. cm	Bulb-ing ratio	TSS %	Dry matter %
			1999/2000					2000/2001				
K_0			1.44A	6.37B	0.227A	24.18 B	6.65 A	1.46A	6.29 A	0.233A	24.29 A	6.43 A
K_1			1.50A	6.65A	0.226A	25.19 A	6.80 A	1.47A	6.57 A	0.225B	24.36 A	6.47 A
	M_1		1.42B	6.19B	0.230A	23.90 B	6.52 A	1.41C	6.25 A	0.226A	24.07 B	6.28 B
	M_2		1.50A	6.54AB	0.230A	24.50 B	6.68 A	1.47B	6.43 A	0.229A	24.30AB	6.46 A
	M_3		1.48AB	6.80A	0.219A	25.66 A	6.96 A	1.52A	6.61 A	0.232A	24.60 A	6.60 A
		Cont	1.32D	5.99 C	0.221A	22.00 C	6.00 C	1.33E	5.95 D	0.224A	21.67 C	5.78 D
		25	1.43 C	6.24 C	0.229A	24.33 B	6.58 B	1.41D	6.23CD	0.226A	24.39 B	6.26 C
		50	1.44 C	6.63 B	0.219A	24.78 B	6.89AB	1.48C	6.48BC	0.229A	24.44 B	6.51BC
		75	1.52 B	6.67 B	0.231A	25.33 B	6.89AB	1.53B	6.59 B	0.233A	25.33 A	6.64 B
		100	1.62 A	7.02 A	0.232A	26.98 A	7.24 A	1.58A	6.89 A	0.232A	25.78 A	7.06 A
K_0	**M_1**	Cont	1.23 a	5.60 a	0.220 a	20.67 g	5.50 d	1.27 a	5.57 a	0.227 a	21.67 fg	5.20 g
		25	1.30 a	5.77 a	0.227 a	24.33 b-f	6.17abc	1.37 a	5.93 a	0.230 a	23.67 de	6.33b-f
		50	1.30 a	6.13 a	0.213 a	24.33 b-f	7.13abc	1.40 a	6.13 a	0.230 a	24.33bcd	6.30b-f
		75	1.43 a	5.93 a	0.247 a	24.00 b-f	7.00abc	1.53 a	6.37 a	0.240 a	25.33abc	6.33b-f
		100	1.57 a	6.60 a	0.240 a	26.67 b	7.17 ab	1.53 a	6.37 a	0.243 a	25.67 ab	6.70a-e
	M_2	Cont	1.27 a	5.87 a	0.213 a	21.67efg	6.13bcd	1.33 a	5.93 a	0.223 a	21.67 fg	6.07c-g
		25	1.43 a	6.23 a	0.230 a	23.67b-g	6.20bcd	1.40 a	6.30 a	0.22 a	23.67de	6.07c-g
		50	1.43 a	6.47 a	0.223 a	24.00 b-f	6.73abc	1.53 a	6.37 a	0.243 a	24.33bcd	6.53 a-f
		75	1.53 a	6.80 a	0.227 a	25.00b-e	6.70abc	1.57 a	6.37 a	0.247 a	25.33abc	6.97abc
		100	1.63 a	7.20 a	0.227 a	25.00b-e	7.10ab	1.60 a	6.43 a	0.253 a	26.00 a	6.93a-d
	M_3	Cont	1.27 a	5.87 a	0.217 a	22.00efg	6.13bcd	1.33 a	5.80 a	0.230 a	22.33 ef	6.20b-g
		25	1.47 a	6.30 a	0.237 a	25.00b-e	6.73abc	1.47 a	6.13 a	0.240 a	25.00a-d	6.53 a-f
		50	1.53 a	6.93 a	0.223 a	25.00b-e	6.70abc	1.50 a	6.67 a	0.223 a	25.00a-d	6.57 a-f
		75	1.57 a	6.93 a	0.230 a	25.67bcd	7.20 ab	1.57 a	6.87 a	0.230 a	25.00a-d	6.43b-f
		100	1.60 a	6.93 a	0.230 a	25.67bcd	7.17 ab	1.53 a	7.10 a	0.217 a	25.33abc	7.23 ab
K_1	**M_1**	Cont	1.40 a	5.93 a	0.237 a	22.67d-g	5.77cd	1.27 a	5.87 a	0.213 a	20.67 g	5.73efg
		25	1.40 a	6.33 a	0.220 a	22.67d-g	6.27bcd	1.30 a	6.27 a	0.207 a	24.00 cd	6.03c-g
		50	1.43 a	6.43 a	0.223 a	23.33c-g	6.70abc	1.43 a	6.30 a	0.230 a	24.00 cd	6.50 a-f
		75	1.50 a	6.47 a	0.233 a	24.67b-e	6.33abc	1.43 a	6.43 a	0.223 a	25.33abc	6.33a-e
		100	1.60 a	6.70 a	0.240 a	25.67bcd	7.23ab	1.57 a	7.27 a	0.217 a	26.00 a	7.37abc
	M_2	Cont	1.40 a	6.20 a	0.227 a	21.33 fg	6.30bcd	1.37 a	6.23 a	0.220 a	22.00 fg	5.60 fg
		25	1.53 a	6.20 a	0.247 a	25.67bcd	6.87abc	1.37 a	6.30 a	0.217 a	25.00a-d	6.43b-f
		50	1.50 a	6.57 a	0.233 a	26.33 bc	6.90abc	1.43 a	6.63 a	0.217 a	24.33bcd	6.37b-f
		75	1.63 a	6.67 a	0.243 a	26.33 bc	6.80abc	1.50 a	6.60 a	0.227 a	25.00a-d	6.70a-e
		100	1.67 a	7.23 a	0.233 a	26.00 bc	7.10 ab	1.57 a	7.13 a	0.223 a	25.67ab	6.97abc
	M_3	Cont	1.37 a	6.47 a	0.210 a	23.67b-g	6.17bcd	1.43 a	6.30 a	0.230 a	21.67fg	5.90d-g
		25	1.43 a	6.60 a	0.217 a	24.67b-e	7.23ab	1.57 a	6.47 a	0.243 a	25.00a-d	6.17c-g
		50	1.47 a	7.27 a	0.200 a	25.67bcd	7.20ab	1.57 a	6.80 a	0.233 a	24.67a-d	6.77a-e
		75	1.47 a	7.20 a	0.203 a	26.33 bc	7.33 ab	1.57 a	6.90 a	0.233 a	26.00 a	6.73a-e
		100	1.67 a	7.47 a	0.223 a	32.90 a	7.70a	1.67 a	7.07a	0.237 a	26.00 a	7.50 a

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**

§ K treatment, K_0= without foliar K application, K_1= with foliar K application

¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg

! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

4. Leaves macro- and micronutrients content

Growing high yielding garlic varieties under nutrient imbalance as in many crops, may reduce quality and affecting total yield. Under newly reclaimed sandy soils conditions applying all manageable practices including foliar fertilization to increase leaves macro- and micronutrients concentration to near optimum level it will induce good vegetative growth and performance causing tremendous increase in both bulbs yield and quality including oil content and constituents.

Results depicted in Table (5) pointed out that foliar fertilization with potassium (K_1) comparing with control treatment (K_0) increased concentrations of N and P significantly, while K and Mg concentrations increased insignificantly in garlic plants leaves during the two growing seasons of 1999/2000 and 2000/01. Spraying mixture of nutrients in form (M_3) caused significant increase in the concentrations of N, P, and Mg comparing with the other two mixtures (M_2 and M_1) respectively, while K concentration had insignificant differences between M_2 and M_3, during the two growing seasons (Table 5). The results indicated that N, P, K and Mg concentrations reached to the maximum significant values when foliar nutrients concentration increased up to 100 g.Interaction between K application, nutrients mixtures and concentrations on garlic leaves N, P, K and Mg concentrations were presented in Table (5). The results indicted that increasing concentration of the three different mixtures of M_1, M_2 and M_3 caused remarkable positive or/and significant increase in the studied nutrients especially under applying foliar K (K_1) than that for control K treatment (K_0). Foliar application of plant nutrients can be very efficient, but leaves are only able to take up a relatively small quantity of nutrients in comparison with the plant's demand. Foliar application of N, P is not very common in practice while K and Mg are frequently applied as K_2SO_4 and Mg-EDTA, several researchers reported that spraying K and Mg resulted in significant yield responses (Mingel and Kirkby, 1987).

Foliar application is particularly useful under conditions where nutrient uptake from the soil is restricted. This is often the case for the micronutrients such as Fe, Zn, Mn and Cu. These nutrients are frequently fixed by soil particles and for this reason are scarcely available to plant roots. Data presented in Table (6) show main and interaction effects of the tested treatments on leave Fe, Zn, Mn and Cu concentrations. Potassium foliar application (K_1) increased significantly leaves micronutrients content as well as foliar application of nutrients mixtures and increasing the concentration from 0 up to 100 g /100 L H_2O during the two growing seasons. Interaction of K treatments, nutrient mixtures and concentrations indicated that significant differences were located in each nutrient due to application of K_1 in increasing order of $M_3 > M_2 > M_1$ and with increase the concentration. Foliar application in the form of inorganic salts or chelates is valuable tool in combating nutrient deficiencies (Tukey *et al.,* 1962). As micronutrients are only required in small quantities, foliar spray applied once or twice and correctly timed, is adequate to meet the demand of the crop (Cooke, 1975).

Table 5. Effects of K, Mg and micronutrients mixtures and concentrations on the N, P, K and Mg concentration in garlic leaves during the winter seasons of 1999/2000 and 2000/2001.

K§ Treat	Mixt¶	Conc!	N	P	K	Mg	N	P	K	Mg
			%							
			1999/2000				2000/2001			
K_0			3.487 B	0.368 B	4.350 A	0.444A	3.447 B	0.381 B	4.536 A	0.453 A
K_1			3.777 A	0.460 A	5.460 A	0.466A	3.741 A	0.484 A	5.454 A	0.469 A
	M_1		3.491 B	0.369 B	4.184 B	0.441 C	3.430 C	0.384 C	4.298 B	0.450 C
	M_2		3.560 B	0.433 A	5.051 A	0.457 B	3.567 B	0.443 B	5.227 A	0.464 B
	M_3		3.845 A	0.439 A	5.479 A	0.467A	3.785 A	0.470 A	5.460 A	0.470 A
		Cont	3.180 D	0.313 D	3.485 D	0.396 E	3.189 E	0.334 D	3.516 D	0.400 D
		25	3.466 C	0.340 D	4.294 C	0.418D	3.362 D	0.356 D	4.678 C	0.419 D
		50	3.619BC	0.403 C	5.209 B	0.439 C	3.571 C	0.427 C	5.188BC	0.446 C
		75	3.752 B	0.452 B	5.593AB	0.485 B	3.770 B	0.463 B	5.554AB	0.502 B
		100	4.142 A	0.561 A	5.943 A	0.537A	4.078 A	0.583 A	6.038 A	0.539 A
K_0	M_1	Cont	3.163ijk	0.250 hi	2.667hij	0.342m	2.867 l	0.263 m	2.387 h	0.373 kl
		25	3.187ijk	0.253 hi	3.433f-j	0.410ijk	3.250 h-l	0.263 m	3.600e-h	0.410 h-l
		50	3.330g-j	0.263 hi	3.480f-j	0.412 ij	3.333h-k	0.303 lm	3.497fgh	0.434g-k
		75	3.423f-j	0.307fgh	4.767b-g	0.428 hi	3.363h-k	0.323j-m	4.733 a-f	0.457e-h
		100	3.427f-j	0.520 ab	5.533a-e	0.501 d	3.650 d-j	0.523 def	6.067abc	0.507b-f
	M_2	Cont	2.783 k	0.217 l	2.233 j	0.363 l	3.217 jkl	0.247 m	2.327 h	0.367 l
		25	3.333 g-j	0.263 hi	3.267 g-j	0.402 jk	3.303 h-l	0.253 m	4.833 a-f	0.393 i-l
		50	3.220 ijk	0.370c-g	5.107 a-f	0.412 ij	3.277 h-l	0.393g-k	5.233a-e	0.427 g-l
		75	3.577 e-j	0.537 a	5.467a-e	0.513bcd	3.490f-k	0.523def	5.500a-d	0.517a-d
		100	4.190a-d	0.563 a	5.667a-e	0.560 a	3.553e-k	0.550 cd	5.967abc	0.577 a
	M_3	Cont	3.170 ijk	0.287ghi	3.333 g-j	0.400 jk	3.103 kl	0.313klm	3.500fgh	0.400 h-l
		25	3.623 e-i	0.297 f-i	4.033 e-i	0.413 ij	3.227 i-l	0.360 i-l	4.033d-g	0.419 g-l
		50	3.433 f-j	0.420cde	5.267a-e	0.452 f	3.707d-h	0.427 ghi	5.133 a-f	0.452 f-i
		75	3.907 c-f	0.450 bc	5.300a-e	0.506 cd	3.830c-g	0.440 f-i	5.233a-e	0.530abc
		100	4.533 a	0.527 ab	5.700a-e	0.549 a	4.533 a	0.533 de	6.00 abc	0.536abc
K_1	M_1	Cont	3.127jk	0.367c-g	2.563 ij	0.393 k	3.133 kl	0.367 h-l	2.600 gh	0.387 jkl
		25	3.563e-j	0.380 c-f	4.133 e-i	0.415 ij	3.260 h-l	0.380 g-l	4.600b-f	0.418 g-l
		50	3.727d-h	0.397cde	4.533c-g	0.442fgh	3.473f-k	0.400 g-j	4.833 a-f	0.441 g-j
		75	3.770c-h	0.360d-g	5.267a-e	0.502 d	3.887 c-f	0.407 g-j	5.267a-e	0.519 a-d
		100	4.190a-d	0.597 a	5.467a-e	0.564 a	4.083bcd	0.613abc	5.400a-d	0.553 ab
	M_2	Cont	3.297 hij	0.347efg	4.380d-h	0.451 f	3.383g-k	0.363 i-l	4.420 c-f	0.426 g-l
		25	3.483 f-j	0.402cde	4.800b-g	0.446 fg	3.663 d-j	0.417 ghi	4.833 a-f	0.426 g-l
		50	3.790c-g	0.520 ab	6.587ab	0.446 fg	3.687 d-i	0.523def	6.433 a	0.460 d-h
		75	3.810c-g	0.523 ab	6.290abc	0.454 f	3.897 c-f	0.523def	6.293 ab	0.513 b-e
		100	4.117a-d	0.590 a	6.713 a	0.526 b	4.197abc	0.637 ab	6.427 a	0.530 abc
	M_3	Cont	3.540 f-j	0.413cde	5.733a-e	0.428ghi	3.433g-k	0.450e-h	5.867abc	0.447 g-j
		25	3.603 e-j	0.443bcd	6.100a-d	0.422 i	3.467 f-k	0.463efg	6.167abc	0.447 g-j
		50	4.217abc	0.450 bc	6.280abc	0.473 e	3.947cde	0.513def	6.000abc	0.461 d-h
		75	4.027b-e	0.537 a	6.467 ab	0.509bcd	4.153 bc	0.560bcd	6.300 ab	0.480 c-g
		100	4.393 ab	0.570 a	6.580 ab	0.522 bc	4.450 ab	0.643 a	6.367 ab	0.529 abc

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**

§ K treatment, K_0= without foliar K application, K_1= with foliar K application

¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg

! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

Table 6. Effects of K, Mg and micronutrients mixtures and concentrations on the Fe, Zn, Mn and Cu concentration in garlic leaves during the winter seasons of 1999/2000 and 2000/2001.

K§ Treat	Mixt¶	Conc!	Fe	Zn	Mn	Cu	Fe	Zn	Mn	Cu
			mg kg^{-1}							
			1999/2000				2000/2001			
K_0			618.04B	60.02 B	57.51 B	26.18 B	622.9 B	59.58 B	57.53 B	26.09B
K_1			756.93A	76.09 A	63.38 A	28.22 A	767.5 A	76.22 A	62.73 A	28.27A
	M_1		649.2 C	59.70 C	55.10 C	20.63 C	648.9 C	59.07 C	55.43 C	21.19C
	M_2		687.1 B	70.57 B	59.83 B	29.20 B	696.9 B	71.03 B	58.03 B	28.78B
	M_3		726.2 A	73.90 A	66.40 A	31.77 A	739.9 A	73.60 A	66.93 A	31.57A
		Cont	496.8 E	54.06 E	48.11 E	8.333 E	528.4 E	55.39 E	49.00 E	7.839E
		25	595.1 D	64.67 D	54.50 D	20.39 D	593.3 D	64.56 D	53.83 D	20.56D
		50	639.0 C	67.94 C	59.44 C	29.39 C	640.4 C	67.28 C	58.39 C	29.78C
		75	764.1 B	73.22 B	66.50 B	33.17 B	770.7 B	72.83 B	66.39 B	33.83B
		100	942.4 A	80.39 A	73.67 A	44.72 A	943.2 A	79.44 A	73.06 A	43.89A
K_0	**M_1**	Cont	476.7mn	46.00 l	39.33 n	8.67 k	497.3klm	45.33 j	42.67 l	9.00 j
		25	479.3mn	48.33 kl	45.00 lm	17.67 ij	475.7 m	47.33 ij	41.67 l	18.67hi
		50	530.3 kl	52.33 jk	51.33 k	21.00 hi	516.0j-m	51.33 hi	52.33 jk	22.67fgh
		75	519.7 l	56.00 ij	53.00 k	24.00 gh	532.7 jk	56.00 gh	55.00 j	25.33efg
		100	740.0 fg	61.67gh	70.00 cd	26.00 fg	732.0 f	60.67efg	72.33 bc	25.67efg
	M_2	Cont	442.7 n	43.67 l	47.33 l	10.00 k	483.7 lm	47.33 ij	47.33 kl	8.67 j
		25	497.3 lm	61.33gh	54.67 ijk	14.67 j	519.3j-m	60.33 fg	53.33 jk	15.00 i
		50	521.0 kl	61.67gh	59.00ghi	28.00efg	486.3klm	62.00efg	56.00 ij	27.00def
		75	585.0 ij	72.67 cd	65.33 ef	31.00 de	593.0 hi	71.00 cd	63.67efg	30.33cde
		100	1057.0 a	75.33 c	69.33 de	53.67 a	1072.0 a	74.33 c	68.33 c-f	53.33 a
	M_3	Cont	525.7 kl	52.67 jk	52.00 k	9.33 k	526.7 jkl	52.00 hi	53.33 jk	8.67 j
		25	558.0 jk	60.00ghi	55.67 ijk	19.67 i	557.3 ij	61.00efg	57.67 hij	20.33 ghi
		50	609.0 i	63.33 fg	62.33fgh	33.33 cd	613.0 h	62.00efg	61.33ghi	32.67 cd
		75	839.3 e	69.67de	64.33 f	41.67 b	836.0 e	70.33 cd	66.00d-g	42.67 b
		100	889.7 d	75.67 c	74.00 bc	54.00 a	902.7 d	72.67 c	72.00bcd	51.33 a
K_1	**M_1**	Cont	456.3 n	58.00 hi	42.67mn	7.33 k	486.3klm	59.67 fg	43.33 l	6.87 j
		25	603.7 i	62.67gh	53.67 k	17.00 ij	601.7 hi	61.00efg	53.33 jk	17.67 hi
		50	743.7fg	64.67 fg	54.00 jk	26.00 fg	749.0 f	63.33 ef	53.00 jk	26.67def
		75	880.0 d	67.00 ef	71.00 cd	28.00efg	878.0 d	64.67 ef	69.67b-e	28.67def
		100	1062.0 a	80.33 b	71.00 cd	30.67 de	1020.0 b	81.33 b	71.00bcd	30.67cde
	M_2	Cont	567.3 j	60.00ghi	44.33 lm	6.667 k	580.0 hi	61.33efg	44.67 l	6.83 j
		25	760.3 f	74.00 cd	54.67 jk	24.67fgh	727.7 f	75.67 c	53.00 jk	26.67 ef
		50	708.0 g	81.00 b	58.33 hij	32.00cde	730.0 f	81.67 b	54.33 j	34.67 c
		75	805.3 e	81.00 b	69.33 de	40.00 b	828.3 e	82.67 b	68.67 c-f	35.00 c
		100	926.7 c	95.00 a	76.00 b	51.33 a	948.7 c	94.00 a	71.00bcd	50.33 a
	M_3	Cont	512.0lm	64.00 fg	63.00 fg	8.00 k	596.7 hi	66.67 de	62.67fgh	7.00 j
		25	672.0 h	81.67 b	63.33 f	28.67 ef	678.3 g	82.00 b	64.00efg	25.00efg
		50	722.0 g	84.67 b	71.67 cd	36.00 c	748.0 f	83.33 b	73.33 bc	35.00 c
		75	955.3 c	93.00 a	76.00 b	34.33 cd	956.0 c	92.33 a	75.33 b	41.00 b
		100	979.3 b	94.33 a	81.67 a	52.67 a	984.0 bc	93.67 a	83.67 a	52.00 a

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**
§ K treatment, K_0= without foliar K application, K_1= with foliar K application
¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg
! Concentrations, Control, 25, 50, 75, 100 gm /100 L H_2O.

5. Cloves macro- and micronutrients content

Application foliar spray contained K, Mg, Fe, Zn, Mn and Cu were increased garlic bulbs production and quality (Tables 2, 3 and 4) willful increase farm profitability. Data in Table (7) show concentrations of N, P, K and Mg whereas Table (8) presence concentrations of Fe, Zn, Mn and Cu.

Table 7. Effects of K, Mg and micronutrients mixtures and concentrations on the N, P, K and Mg concentration in garlic cloves during the winter seasons of 1999/2000 and 2000/2001.

K§ Treat	Mixt¶	Conc!	N	P	K	Mg	N	P	K	Mg
			%							
			1999/2000				2000/2001			
K0			2.606 B	0.367 A	0.864 B	0.072A	2.550 B	0.377 B	0.382 B	0.081A
K1			3.274 A	0.369 A	0.934 A	0.070A	3.175 A	0.926 A	0.899 A	0.074A
	M1		2.639 C	0.322 C	0.798 C	0.064B	2.591 B	0.563 C	0.580 C	0.065B
	M2		3.037 B	0.342 B	0.906 B	0.068B	2.924 A	0.652 B	0.619 B	0.082AB
	M3		3.144 A	0.440 A	0.993 A	0.084A	3.072 A	0.740 A	0.722 A	0.085A
		Cont	2.446 E	0.282 E	0.758 E	0.060C	2.334 D	0.532 E	0.545 D	0.070 B
		25	2.664 D	0.324 D	0.808 D	0.064C	2.628 C	0.585 D	0.594 C	0.066 B
		50	2.805 C	0.354 C	0.904 C	0.072B	2.796BC	0.638 C	0.621 C	0.076AB
		75	2.973 B	0.383 B	0.942 B	0.078B	2.949 B	0.706 B	0.659 B	0.079AB
		100	3.811 A	0.496 A	1.082 A	0.087A	3.605 A	0.797 A	0.783 A	0.096 A
K0	**M1**	Cont	2.410 ijk	0.223 n	0.687mn	0.039 l	1.687 i	0.343 gh	0.223 i	0.092 bc
		25	2.437 ijk	0.220 n	0.727lm	0.047kl	2.400fgh	0.340 gh	0.247 i	0.038 c
		50	2.617g-j	0.270lmn	0.823g-l	0.049jkl	2.550d-h	0.363fgh	0.270 hi	0.045 bc
		75	2.660ghi	0.273lmn	0.867e-j	0.054l-l	2.600d-h	0.370fgh	0.287ghi	0.052 bc
		100	2.853 gh	0.500 bc	0.950 de	0.092a-d	2.950c-f	0.390fgh	0.547 f	0.056 bc
	M2	Cont	2.350 jkl	0.220 n	0.813h-l	0.040 l	2.483e-h	0.303 h	0.220 i	0.044 bc
		25	2.537 ij	0.240mn	0.823g-l	0.043 l	2.567d-h	0.353fgh	0.247 i	0.058 bc
		50	2.580 hij	0.290klm	0.897e-i	0.061h-k	2.580d-h	0.377fgh	0.287ghi	0.090 bc
		75	2.637g-j	0.313ijkl	0.900e-i	0.084a-g	2.670c-h	0.383fgh	0.347 gh	0.099 bc
		100	2.933 ef	0.510 bc	0.933def	0.094abc	2.677c-h	0.430 fg	0.530 f	0.156 a
	M3	Cont	2.360 jkl	0.337g-k	0.803i-l	0.088 a-f	2.307gh	0.357fgh	0.357 g	0.085 bc
		25	2.427 ijk	0.457 cd	0.820g-l	0.090 a-e	2.477e-h	0.377fgh	0.520 f	0.090 bc
		50	2.403 ijk	0.503 bc	0.910e-i	0.099 a-b	2.547d-h	0.383fgh	0.517 f	0.098 bc
		75	2.870efg	0.523 b	0.923efg	0.097a- b	2.683c-h	0.423 fg	0.540 f	0.101 bc
		100	3.010c-f	0.620 a	1.087bc	0.101a	3.070cd	0.457 f	0.590 f	0.102 b
K1	**M1**	Cont	2.110 l	0.307 jkl	0.603 n	0.062h-k	2.200 h	0.607 e	0.707 e	0.062 bc
		25	2.180 kl	0.313 i-l	0.613 n	0.069 f-i	2.240 h	0.613 e	0.763 e	0.069 bc
		50	2.193 kl	0.337g-k	0.730klm	0.071 f-l	2.437fgh	0.653 e	0.870 d	0.069 bc
		75	2.343 jkl	0.383e-h	0.833 f-k	0.071 e-i	2.467e-h	0.810cd	0.910bcd	0.067 bc
		100	4.587 a	0.393e-h	1.143 ab	0.086a-g	4.383 a	1.137 a	0.980 b	0.091 bc
	M2	Cont	2.467 ijk	0.273lmn	0.763j-m	0.063h-k	2.367 gh	0.693 e	0.897bcd	0.066 bc
		25	3.263 c	0.363 f-j	0.840 f-j	0.068 g-j	2.867c-g	0.793 d	0.900bcd	0.068 bc
		50	3.240 cd	0.370 f-i	0.917e-h	0.073 d-i	3.033cde	0.900 c	0.870 d	0.078 bc
		75	3.657 b	0.410def	0.960de	0.084a-g	3.610 b	1.113ab	0.927bcd	0.080 bc
		100	4.703 a	0.433 de	1.213a	0.068 g-j	4.383 a	1.173 a	0.970 bc	0.081 bc
	M3	Cont	2.980def	0.333h-k	0.880 e-i	0.067 g-j	2.960 c-f	0.890 c	0.867 d	0.068 bc
		25	3.140cde	0.353 f-j	1.023 cd	0.070 f-i	3.217 bc	1.033 b	0.887 cd	0.069 bc
		50	3.797b	0.353 f-j	1.150 ab	0.076c-h	3.627 b	1.153 a	0.913bcd	0.074 bc
		75	3.673 b	0.397efg	1.170 ab	0.075c-h	3.667 b	1.133 a	0.947bcd	0.075 bc
		100	4.777 a	0.520 b	1.167 ab	0.080b-h	4.167 a	1.193 a	1.083 a	0.088 bc

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**

§ K treatment, K_0= without foliar K application, K_1= with foliar K application

¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg

! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

Table 8. Effects of K, Mg and micronutrients mixtures and concentrations on the Fe, Zn, Mn and Cu concentration in garlic cloves during the winter seasons of 1999/2000 and 2000/2001.

K§ Treat	Mixt¶	Conc!	Fe	Zn	Mn	Cu	Fe	Zn	Mn	Cu
			mg kg^{-1}							
			1999/2000				2000/2001			
K_0			704.7 B	45.378B	15.11B	9.16 A	733.6 B	45.36 A	16.09 A	12.13 A
K_1			769.6 A	47.778A	16.76 A	9.64 A	814.7 A	46.96 A	16.09 A	11.87 A
	M_1		509.9 C	43.97 C	13.20 C	8.93 A	537.5 C	43.53 B	15.07 B	10.40 B
	M_2		581.7 B	47.07 B	16.07 B	9.40 A	632.2 B	47.00 A	17.20 A	12.40 A
	M_3		1120.0A	48.70 A	18.53 A	9.87 A	1153.0A	47.93 A	16.00 B	13.20 A
		Cont	209.3 E	35.67 E	11.56 E	5.78 E	231.0 E	35.89 E	13.22 D	9.11 D
		25	343.6 D	39.00 D	13.56 D	7.22 D	410.3 D	38.78 D	13.89CD	11.44 C
		50	439.9 C	43.67 C	14.44 C	9.11 C	481.1 C	43.44 C	15.11 C	11.56 C
		75	989.7 B	51.22 B	19.00 B	11.22 B	1014.0B	51.50 B	17.56 B	13.00 B
		100	1703.0A	63.33 A	21.11 A	13.67 A	1734.0A	61.17 A	20.67 A	14.89 A
K_0	**M_1**	Cont	197.3 l	34.33 i	12.00 ijk	5.33 i	219.3 k	34.33 i	13.33de	8.00 e
		25	295.3 k	37.67 hi	12.67h-k	5.33 i	336.0 i	37.67 hi	12.67de	9.33 de
		50	344.7 jk	42.67fgh	12.67h-k	10.00d-g	370.0 i	42.67fgh	14.00de	9.33 de
		75	363.3 j	43.67 fg	14.00ghi	10.67 c-f	382.0 i	43.67 fg	14.67de	12.00bcd
		100	1338.0c	48.00def	14.67fgh	12.00bcd	1297.0 c	48.00def	14.67de	13.33abc
	M_2	Cont	201.3 l	41.33 gh	10.67 k	5.33 i	234.7 k	41.33 gh	12.67de	9.33 de
		25	214.7 l	44.67 fg	13.33 hij	7.33 ghi	318.0 ij	44.67 fg	15.33de	13.33abc
		50	309.3 jk	46.00efg	14.67fgh	8.00 f-i	350.0 i	46.00efg	16.67cd	13.33abc
		75	589.3 h	51.33 de	16.67 ef	11.33b-e	606.7 g	51.33 de	16.67cd	13.33abc
		100	1245.0d	52.33 cd	18.67 de	14.00 ab	1262.0 c	52.33 cd	20.00bc	14.67 ab
	M_3	Cont	214.3 l	41.67 gh	11.33 jk	6.00 hi	208.7k	41.67 gh	14.67de	10.67cde
		25	217.3 l	44.67 fg	14.67fgh	7.33 ghi	234.0 k	44.67 fg	14.67de	12.67a-d
		50	469.3 i	46.00efg	16.00 fg	10.00d-g	535.3gh	46.00efg	16.00cd	12.67a-d
		75	1832.0 b	52.33 cd	20.67 d	11.33b-e	1824.0b	52.33 cd	21.33 b	14.00abc
		100	2739.0a	53.67 cd	24.00 c	13.33abc	2827.0 a	53.67 cd	24.00ab	16.00 a
K_1	**M_1**	Cont	201.3 l	33.67 i	12.00 ijk	5.33 i	234.7 k	33.67 i	11.33 e	8.00 e
		25	214.7 l	35.00 i	12.67h-k	7.33 ghi	318.0 ij	35.00 i	12.67de	9.33 de
		50	309.3 jk	41.67 gh	12.67h-k	8.00 f-i	350.0 i	41.67 gh	14.00de	9.33 de
		75	589.3 h	51.00 de	14.00ghi	11.33b-e	606.7 g	51.00 de	16.67cd	12.00bcd
		100	1245.0d	67.67 b	14.67fgh	14.00 ab	1262.0 c	67.67 b	26.67 a	13.33abc
	M_2	Cont	224.0 l	32.33 i	11.33 jk	6.00 hi	254.7 jk	32.33 i	14.67de	8.00 e
		25	649.3 g	34.67 i	14.67fgh	7.33 ghi	777.3 ef	34.67 i	14.67de	11.33b-e
		50	737.3 f	42.67fgh	16.00 fg	10.00d-g	746.0 f	42.67fgh	16.00cd	12.00bcd
		75	732.0 f	57.00 c	20.67 d	11.33b-e	840.7 e	57.00 c	21.33 b	12.67a-d
		100	914.0 e	67.67 b	24.00 c	13.33abc	932.0 d	67.67 b	24.00ab	16.00a
	M_3	Cont	217.3 l	32.00 i	12.00 ijk	6.67 hi	234.0k	32.00 i	12.67de	10.67cde
		25	470.0 i	36.00 i	13.33 hij	8.67 e-h	478.7h	36.00 i	13.33de	12.67a-d
		50	469.3 i	41.67 gh	14.67fgh	8.67 e-h	535.3gh	41.67 gh	14.00de	12.67a-d
		75	1832.0 b	53.67 cd	28.00 b	11.33b-e	1824.0b	53.67 cd	14.67de	14.00abc
		100	2739.0a	77.67 a	30.67 a	15.33 a	2827.0 a	77.67 a	14.67de	16.00 a

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**
§ K treatment, K_0= without foliar K application, K_1= with foliar K application
¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg
! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

The results showed that, there were significant differences among the studied factors on the N, P, K and Mg contents of the cloves during the seasons on the study (Table 7). Application of potassium increased significantly Fe, Zn, Mn in the first growing season. While, the increments did not reach the significant levels for Zn, Mn and Cu in the second growing season.

The results showed also that addition of copper to the nutrient mixtures M1 or M2 gave significant increases for Fe, Zn, Mn and Cu contents in the years of the study. Meanwhile, the addition of copper did not increase the Mg and Cu contents of the cloves in the second growing seasons. Fe concentration was increased more than two times for treatment M_3 compared with M_2 and M_1.

Increasing foliar nutrients concentration up to 75 and 100g increased significantly concentration of Fe, Zn, Mn and Cu. Regarding to interaction between K foliar application, nutrients mixtures and concentrations on garlic cloves micronutrients content (Table 8) it could be noticed that, the data were improved in case of treatment K_1 than in control treatment (K_0).

The micronutrients content was found to gradually increase with increasing the level of fertilizer inside each mixture of M_1, M_2 and M_3.

Maintenance of macro- and micronutrients concentrations seem to improves plant growth, increase produced yield and quality. Potassium is important for cell growth, cell walls are thicker and provide tissue stability. It is required for production of high-energy phosphate (ATP) and it involved in N uptake, protein synthesis, lipid metabolism, photosynthetic processes and carbohydrate metabolism (Bennett1993). Magnesium is an essential part of chlorophyll molecule. It is a cofactor for a number of enzymes including transphosphorylase and dehydrogenase (Follett *et al.* 1981). Mg aids in the formation of oils and fats it also activates formation of polypeptide chains from amino acids (Tisdale *et al.,* 1985). Iron is essential for the synthesis of chlorophyll, electron transfer and carrier, involved in oxidation-reduction reactions, respiratory enzymes (Follett *et al.* 1981). Zinc is a metal component in a number of enzyme systems that function as part of electron transfer and in protein synthesis and degradation. Zn is a part of auxin, one of the best-known enzymes regulating plant growth (Tisdale *et al.,* 1985 and Foy *et al.,* 1981). Manganese is a structural component of certain metallo-proteins, it is a component in several enzyme systems and electron transfer and transport (oxidation-reduction) reactions (Follett *et al.,* 1981). Copper is involved in several enzyme systems and apparently cannot be replaced by other metal ions. It involved in cell wall formation, and like other micronutrients, in electron transport and oxidation reactions (Tisdale *et al.,* 1985).

6. Essential oil percentage

Results presented in Table (9) indicated clearly that, the main effect of potassium application (K_1) on the bulb essential oil content of garlic plants was significant as compared to those in control treatments (K_0). These results hold true in the two seasons and the oil percentage was (0.139, and 0.130) due to potassium application. The increment had reached about 6.11% and 13.04% over the control in the first and second seasons respectively. Our results are in agreement with the findings of those reported by Farid (1979) on (*Mentha Virides* L.) and Dey and Choudhari (1984a) on (*Ocimum Sanctum* L.). Atanasove *et al.* (1979) found that fertilization of peppermint (*Mertha Piperita* L.) plants with potassium increased oil yield by 43 to 53% compared with control plants. El-Masry *et al*. (1996) showed that spraying peppermint plant by K_2SO_4 at level of 3.0 g l^{-1} resulted in maximum total essential oil.

Regarding, the main effect of different mixtures of macro- and micro-elements M_1, M_2, and M_3 on the essential oil percentage, it is evident from the previous data that, there were significant differences between the essential oil percentages as a result of applying M_1, M_2, and M_3. The best results were obtained after using M_3 followed by M_2 then M_1. The highest values due to applying M_3 were (0.170 and 0.163%) in the first and second seasons respectively.

Table 9. Effects of K, Mg and micronutrients mixtures and concentrations on percentage of garlic oil content during the winter seasons of 1999/2000 and 2000/2001.

K§ Treat	Mixt¶	Conc!	Oil, %			
			1999/2000		2000/2001	
K_0			0.131 B		0.115 B	
K_1			0.139 A		0.130 A	
	M_1		0.155 C		0.147 B	
	M_2		0.161 B		0.144 C	
	M_3		0.170 A		0.163 A	
		Cont	0.137 E		0.136 D	
		25	0.153 D		0.146 C	
		50	0.165 C		0.157 B	
		75	0.176 B		0.162 A	
		100	0.180 A		0.157 B	
			K_0	K_1	K_0	K_1
	M1	Cont	0.133 s	0.140pqr	0.131r	0.139o
		25	0.147 no	0.159jk	0.142n	0.145m
		50	0.151mn	0.163ij	0.139o	0.161g
		75	0.157kl	0.169gh	0.144m	0.158h
		100	0.155klm	0.171fg	0.147l	0.164f
	M2	Cont	0.135rs	0.143opq	0.129s	0.141n
		25	0.145op	0.153lm	0.137p	0.150k
		50	0.160ijk	0.165hi	0.141n	0.158h
		75	0.171fg	0.183d	0.160g	0.156i
		100	0.175ef	0.180de	0.156i	0.110t
	M3	Cont	0.130s	0.139qr	0.133q	0.142n
		25	0.157kl	0.155klm	0.148l	0.153j
		50	0.172fg	0.180de	0.167e	0.175c
		75	0.178de	0.197b	0.165f	0.188b
		100	0.190c	0.210a	0.170d	0.193a

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**
§ K treatment, K_0= without foliar K application, K_1= with foliar K application
¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg
! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

These results are in accordance with findings of Ibrahim *et al*. (1991) on garlic plants, they illustrated that the largest essential oil yield of Balady cv. were obtained after spraying the plants by 5 kg Zn fed^{-1} + 5kg Mn fed^{-1}, while the best results for Chinese cv. due to doubled the quantity i.e. 10 kg fed^{-1} from each Zn and Mn. Dey and Choudhavi (1980) found that micro-nutrients B, Cu, Mn, Mo, Ni, and Zn increased the total oil content of *Ocimum Sanctum* L. plants. Eid *at al*. (2001) stated that, the highest values of (*Peteroselinum Sativum)* oil percentage were obtained after spraying the plants by Sahara fertilizer (Zn + Fe + Mn) at rate of 4.5g l^{-1}. Mousa *et al*. (2001) found that foliar application of Zn and Fe increased the fixed and volatile oils in nigella seeds. Similar results were also obtained by El-Ghadban (1994) on (*Mentha Viridis* L.) and Mirsa (1995) on (*Mentha arvensis* L.).

Concerning the main effect of different concentrations of (0, 25, 50, 75, and 100g/100L H_2O) foliar spray mixtures the oil percentage gradually increased with increasing the concentration. Generally, there were significant differences between the different fertilizer levels. The highest values of oils percentage were obtained after applying the foliar spray at 75g

(0.176, 0.162%) and at 100g (0.180, 0.157%) in the first and second seasons respectively.

Data presented in Table (9), also illustrated the interaction between K foliar application, nutrients mixtures and concentrations on essential oil percentage. It could be noticed that, the results were better in presence of potassium (K_1) than in control treatment (K_0). The oil percentage was found to slight gradually increase with increasing the level of fertilizer inside each mixture of M_1, M_2 and M_3. Nutrients mixture in M_3 treatments was the superior with K_1 followed by M_2 then M_1. In general there were significant differences in most between treatments. Overall, the heights percentage of essential oil were obtained from applying K (K_2SO_4) with the mixture of M_3 at 75g (0.197, 0.188%) and at 100g (0.210, 0.193%) in the first and second seasons respectively. This results were in the harmony with those found by Bisher *et al*. (1998), They concluded that the highest increase in the fixed and volatile oils of (*Nigela Sativa* L.) were obtained after adding 150 kg fed^{-1} of K_2SO_4 as well as 50 ppm from Zn + Mn + Fe as a foliar spray application.

7. Essential Oil Composition

Data in Table (10) and Figs. (1a and 1b), showed that, there were 10 constituents identified in the essential oil of garlic ‘Aspani’ cultivar by using Gas chromatography-mass spectrum technique (GC-MS). They were di-allyl disulfide (di-propenyl di-sulfide) as major component, the intermediate components were allyl sulfide, methyl allyl tri-sulfide and Allyl tri-sulfide and the rest were minor, Kotb (1991) analyzed the garlic volatile oil by GLC and determined 8 sulfur compounds. Abou Hadid *et al.* (1999) studded the constituents of garlic Chinese cv. with GLC. They found that the main component was dially-di-sulfide and ranged from 28 to 51%.

From the previous results, it seems, the main effects of K and different mixtures of foliar spray application (M_1, M_2 and M_3) as well as the main effect of the different concentrations of fertilizers (0, 25, 50, 75 and 100g/100L H_2O) on the percentage of the volatile oil constituents showed the same trend with volatile oil percentage i.e. potassium fertilization significantly increased the essential constituents percentage. Also there were differences between the percentage of the constituents resulted from adding different mixtures of M_1, M_2 and M_3. As for the main effect of different levels of foliar spray application could be also notes that, the percentage of essential oil constituents slight progressively increased by increasing the concentrations of fertilizers.

As for the, effect of interaction between K application and different mixtures of fertilizers (M_1, M_2 and M_3) and its concentrations (0, 25, 50, 75 and 100g/100 L H_2O) there were significant increases in most cases in comparison to control treatment.

Table 10. Effects of K, Mg and micronutrients mixtures and concentrations on the oil constituents of garlic during the winter season of 2000/2001.

K§ Treat	Mixt¶	Conc!	Allyl-sulfide	Methyl allyl-di-sulfide	Di-methyl tri-sulfide	Di-propenyl di-sulfide	Methyl allyl tri-sulfide	Di-methyl tetra-sulfide	Allyl tri-sulfide	Methyl allyl tetra-sulfide	Allyl thio-phene	Allyl tetra-sulfide
			%									
K_0			8.18 B	1.10 B	0.98 A	22.89 B	10.74 B	0.51 A	10.54 A	0.90 B	0.54 B	0.89 B
K_1			11.31 A	2.13 A	1.03 A	25.82 A	13.49 A	0.67 A	14.53 A	1.14 A	0.70 A	1.10 A
	M_1		8.78 C	1.88 A	1.10 A	24.84 A	12.28 A	0.53 B	12.87 B	1.00 B	0.56 B	0.94 C
	M_2		10.61 A	1.96 A	0.97 B	24.49 A	12.39 A	0.63 A	13.94 A	1.31 A	0.64 A	1.06 A
	M_3		9.84 B	1.90 A	0.94 B	23.73 A	11.68 B	0.60A	12.47 B	1.03 B	0.64 A	0.99 B
		Cont	9.07 C	1.43 D	0.93 B	21.71 C	10.32 B	0.44 D	9.93 C	0.87 C	0.51 D	0.84 D
		25	9.58 BC	1.67 C	0.94 B	23.99 B	12.54 A	0.41 D	13.84AB	1.03 B	0.58 C	0.91 C
		50	9.44 BC	2.09 B	1.22 A	25.01 B	12.00 A	0.70 B	13.80AB	1.08 B	0.68 B	1.01B
		75	10.98 A	2.27 A	0.77 C	26.90 A	12.89 A	0.64 C	13.44 B	1.31 A	0.72 A	1.18 A
		100	9.64 B	2.13 AB	1.17 A	24.15 B	12.84 A	0.74 A	14.44 A	1.28 A	0.57 C	1.05 B
K_0	**M_1**	Cont	7.33jkl	1.39 lm	0.91jkl	21.90hi	9.83jkl	0.41no	9.33ijl	0.80ij	0.37p	0.82j-o
		25	6.85kl	1.52klm	0.98h-l	26.12c-f	12.33e-i	0.06q	11.89fgh	0.80ij	0.55klm	0.83j-n
		50	8.33ij	1.68h.m	1.21cde	25.05d-h	10.22i-l	0.53h-l	9.00ijk	0.95g-j	0.58i-l	0.89i-m
		75	7.96ijk	2.26c-f	0.37no	23.50f-i	13.12c-g	0.61e-h	10.85ghi	0.89hij	0.57jkl	0.75mno
		100	8.04ijk	2.11c-g	0.93jkl	21.74hi	13.02c-g	0.58f-l	10.16hij	0.91hij	0.49mn	0.94h-l
	M_2	Cont	7.38jkl	1.35lm	0.91jkl	21.53hi	9.83jkl	0.45l-o	8.77jk	0.85ij	0.41op	0.74mno
		25	6.53l	1.59i-m	1.03g-j	24.42e-i	12.03f-j	0.56h-k	13.49ef	0.83ij	0.41op	0.75mno
		50	9.13ghi	1.84f-k	1.11e-h	22.15ghi	12.33d-i	0.66def	12.37fg	1.01e-i	0.63g-j	0.97g-j
		75	10.12efg	1.75g-l	0.97i-l	25.51d-g	9.98jkl	0.65d-g	13.52ef	1.24de	0.88ab	1.08c-h
		100	9.09ghi	2.03d-h	1.24cd	22.16ghi	11.08g-k	0.60fgh	11.88fgh	1.42cd	0.45no	1.02e-l
	M_3	Cont	7.21jkl	1.29 m	0.88l	21.37i	9.95jkl	0.41no	9.72ijk	o-h	0.39op	0.80l-o
		25	7.32jkl	1.28m	0.88l	22.03ghi	8.77l	0.60fgh	7.95k	0.79ij	0.55klm	0.96h-k
		50	8.08ijk	1.52klm	1.17c-f	22.11ghi	9.60kl	0.47lmn	9.44ijk	0.87ij	0.65j-m	1.15cde
		75	10.31efg	2.01d-j	1.13d-g	22.08ghi	9.33kl	0.49j-n	10.11hij	1.17efg	0.61g-k	0.73no
		100	8.99ghi	1.90e-k	0.97i-l	21.61hi	9.75jkl	0.57g-j	9.69ijk	0.92hij	0.52lmn	0.92i-l
K_1	**M_1**	Cont	10.97def	1.31m	0.89kl	22.02ghi	10.32i-l	0.41no	10.65g-j	0.93g-j	0.62g-k	0.89i-m
		25	11.20cde	1.31m	1.46b	23.45f-i	14.11a-f	0.82c	15.57cd	0.99f-j	0.77cde	1.12c-g
		50	8.38hjk	2.52bc	1.50b	24.50e-i	10.65h-l	0.94b	11.1ghi	0.75j	0.81bc	0.67o
		75	12.54b	2.43bcd	0.44n	32.02a	13.21c-g	0.44mno	16.17cd	0.89hij	0.65f-i	1.46b
		100	6.18l	2.32b-e	2.35a	28.11bcd	16.04a	0.59fgh	18.51a	1.87a	0.22q	1.03d-l
	M_2	Cont	10.68ef	1.59j-m	0.98h-l	21.57hi	10.96g-l	0.48k-n	10.13hij	0.87ij	0.59h-l	0.81k-o
		25	13.33ab	2.28cde	0.27o	25.09d-h	13.40b-f	0.11p	18.34a	1.86a	0.57jkl	0.99f-i
		50	13.08ab	1.96e-j	1.28c	29.11abc	14.14a-f	0.90bc	17.16abc	1.68ab	0.72def	1.16cde
		75	14.30a	2.72ab	0.65m	30.14ab	15.70ab	0.72d	14.81de	1.78ab	0.93a	1.90a
		100	12.50bc	2.52bc	1.25cd	23.18f-l	14.42a-e	1.13a	18.92a	1.57bc	0.84bc	1.18cd
	M_3	Cont	10.87ef	1.67h.m	1.02g-k	21.87hi	11.03g-l	0.50i-m	11.00ghi	0.93g-j	0.68fg	0.99f-i
		25	12.22bcd	2.02d-i	1.02g-j	22.85f-i	14.63a-d	0.37o	15.82cd	0.83 ij	0.66fgh	0.79l-o
		50	9.66fgh	3.01a	1.00h-l	27.16b-e	15.04abc	0.69de	18.30ab	1.21def	0.79cd	1.20c
		75	10.68ef	2.43bcd	1.08f-i	28.16bcd	16.01a	0.94b	15.16de	1.67ab	0.71ef	1.13c-f
		100	13.03ab	1.91e-k	0.26o	28.10bcd	12.71d-h	0.97b	17.48abc	0.99f-j	0.92a	1.23c

***Values marked with the same letter (s) are statistically similar using Duncan's multiple range test at p= 0.05. Uppercase letter (s) indicate differences between main effects, and lowercase letter(s) indicate differences within interaction of each character.**

§ K treatment, K_0= without foliar K application, K_1= with foliar K application

¶ Mixtures, M_1 = Fe +Zn + Mn, M_2 = Fe +Zn + Mn + Cu, M_3 = Fe +Zn + Mn + Cu +Mg

! Concentrations, Control, 25, 50, 75, 100 gm / 100 L H_2O.

fig1a

fig1b

These results seemed to agree the findings of Park *et al*. (1998) on garlic. They reported that, the application of K_2SO_4 increased the content of S-containing aromatic compounds by 2 to 3 times when compared with the application of KCl. El-Massry *et al*. (1993) concluded that, the major constituents marjoram oil which, are responsible of its quality (Cineole and $\propto$-terpineol) were improved after spraying the plant with micronutrients (Zn +Fe +Mn) at 150 ppm. Eid and Ahmed (2001) on parsleys plants (*petroselinum sativum*) showed that, there was a significant effect on the constituents of volatile oil (*limonene, terpene*) cymine and *caryo phellene* due to spraying the plants with Sahara fertilizer (Zn +Fe + Mn).

CONCLUSION

The good formality of garlic plants in growth and essential oil percentage and quality was more pronounced with applying M_3 at high rate (100g) in presence K (K_1) might be attributed to: firstly, in general foliar spray application technique is considered a practical way to supply macro- and micro-elements could avoid the soil environmental factors and result in rapid absorption. Secondly, The superiority of M_3 at high level (100g) as well as K (K_2SO_4) might be due to its rich composition of different nutrients, under poor sandy soil conditions, plays directly or indirectly an important role in affecting the growth and plant performance resulted in increased bulbs yield quantity and quality of volatile oil.

REFERENCES

Abd El-Hamed, A.M. (1997). Influence of sulpher application and some micronutrients on growth and productivity of garlic (*Allium sativum* L.) Monofiya J. Agric. Res., 22(2): 445-458.

Abou-Hadid, A.F.; M.Z. El-Shinawy and E.A. Omar (1999). Cultivation of garlic in nutrient film techniqe (NFT). Egyptian J. Hort.. 25:(3): 271-280 (c.a. Hort. Abst. 69 (6): 6530, 2000).

Atanasove, S.; I. Salavov; D. Korssva; R. Decheva and N. Gargova (1979). Application of single and compound mineral fertilizers to peppermint. Dni, Nawk, 16(1): 61-65 (Hort. Abst. 50:6530, 1980).

Bennett, F.W. (1993). Plant nutrition utilization and diagnostic plant symptoms. In: Nutrient Deficiencies and Toxicities in Crop Plants. The American phytopathological Society, Minnesota, USA.

Bianchini, F. and F. Corbetta (1977). Health plants of the world. News Week books, New York. P. 32-186.

Bisher, G.A.A.; I.M.A. Harridy;l M.E. Khattb and M.Th. M.A. Soliman (1998). Improving of *Nigella sativa* L. growth, yield, volatile oil and fixed oil by potassium fertilization and some microelements. J, Agric. Sci. Mansoura Univ., 23(6): 2667-2678.

British Pharmacopeia (1968). Determination of essential oil in drugs. Publ. By the pharmaceutical press. London, W.C.I.

Campbell, J. D. and L .V. Gusta (1966). The response of carrots and onions to micronutrients on an organic soil in Manitoba. Cand. J. Plant Sci., 46: 419 - 423. (Hort. Abst. 37: 1084, 1967).

Cooke, G.W. (1975). Timing and placing of fertilizer dressings. In Fertilizing for Maximum Yield. Second Edition. Fletcher and son Ltd, Norwich, GB.

Dey, B.B. and M.A. Choudhari (1984a). Effect of plant developmental stage and some micronutrients on essintial oil and eugenol content in *Ocimum sanctum* L. Determination of eugenol by Folinciocalted regent. Ind. Perfumer, 24(4): 199-203. (Hort. Abst. 52(4): 4181, 1985).

Dey, B.B. and M.A. Choudhari (1984b). Effect of application of N, P nd K on growth and yield of essential oil and eugenol in *Ocimum sanctum* L. Pafi. J. 6(1): 20-24 (Hort. Abst. 55: 6351, 1985).

Eid, I.M. and Sh. K. Ahmed (2001). Effect of foliar nutrition (Sahara) spray on the growth and active ingredients of *Petroselinum sativum*. J. Agric. Sci. Mansoura Univ., 26(11): 7149-7164.

El-Ghadban, E. A. E. (1994). The effect of some trace elements on growth and oil yield of spearmint (*Mentha virids* L.). M.Sc. Thesis, Fac. Agric. Cairo Univ.

El-Habbasha, K. M. and A. G. Behairy(1977). Response of onion (*Allium cepa*, L.) to foliar application of gibbrillic acid and some micro-elements. Zeitschrift Fur Acker- und Pflanzenbau, 144 (3): 209 -214.

El-Masry, M.H. and J.E. Simon (1996). Effect of potassium rates on hydroponically growth peppermint (*Menth piperita* L.) Menofiya J. Agric. Res., 21(6): 1469-1483.

El-Msry, M.H.; .A. Sadek and El-S. Gamal (1993). Effect of some micronutrients on marjoram plants grown on sandy soil of South-l-Tahrir. Menofiya J. Agric. Res., 18(1): 415-428.

FAO. (1980). Soil and plant analysis as basis of fertilizer recommendations. Cottenie, A. Soils bulletin No.38 (2). Rome.

Farid. M.L. (1979). Effect of chemical fertilization on mint production (*Mentha viridis* L.). M. Sc. Thesis, Fac. Agric. Cairo Univ.

Follett, R.H.; L.S. Murphy and R.L. Danahue (1981). Fertilizers and Soil Amendments. Prentice-Hall, Englewood Cliffs, NJ, USA.

Foy, C.D.; H.W. Webb and J.E. Jones (1981). Adaptation of cotton genotypes to an acid, manganese toxic soil. Agron. J., 73:107-111.

Freed, R.D. (1988). MSTAT-C: A microcomputer program for the design, management, and analysis of agronomic research experiments. Michigan State Univ. USA.

Gallagher, P. A. (1969). Onions-first - recorded zinc deficiency in crop production here. Fm. Res News. 10: 74. (c.a. Hort . Abst. 40: 1223, 1970).

Gomez, C, A. and A. A.Gomez (1983). Statistical Procedure for Agricultural Research (2nd Edition). An International Rice Research Institute Book. A Wiley-Inter-science.

Guenther, E. (1961). Oil of Tagetes The essential oils. D. Van. Westrand Company Inc. New York.

Gunther, Z. and S. Joseph (1978). Hand book series in chromatography. CRC, IC.

Heftman, E. (1967). Chromatography. Reinhold Pup. Corp. New York.

Ibrahim, D.M.; A.R. Ahmed and A.M. Abdel-Hameid (1991). Influence of zinc and manganese fertilization treatments on bulb, components and chemical composition of Balady and Chines garlic cultivars. Zagazig J. Agric. Res., 18(2):516-528

Ismail, R.H.A. (1995). Response of garlic to some nutrients under calcareous soil condition. M.Sc. Thesis, Fac. of Agric., Cairo Univ.

Katyal, T.C. and N.S. Randhawa (1983). Micro-nutrients. FAO. Fertilizer and plant nutrition bulletin. P.82.

Klute, A. (Ed.) (1986). Methods of Soil Analysis. Part 1. Book series No. 9. American Soc. of Agron. and Soil Sci. Soc. America, Madison, Wisconsin, USA.

Kotb, Sh. (1994). Post-harvest studies on garlic (*Allium sativum* L.) chemical composition of garlic oil. Egypt J. Agric. Res.,72(2): 507-524.

Lewis, W. and F.E. Lewis (1977). Medical botany (plants affecting man’s health). (C.F. Kotb, 1994)

Mengle, K. and E. A. Kirkby (1987). Principles of Plant Nutrition. 4th Ed., International Potash Institute. Bern. Switzerland.

Misra, A. (1995). Critical manganese levels for Jpanese mint (*Mentha arvensis* L.) grown in nutrient solution. J. Essential Oil Res., 7(1): 57-62 (C.A. Hort. Abst. 65(6): 5362).

Mousa, G.T.; I.H. El-Sallami and K.L. Ali (2001). Response of Nigella sativa L. to foliar application of gibberellic cid, benzyladenine, iron and zinc. Assuit J. Agric. Sci., 32(2): 206-218.

Page, A.L. (Ed.) (1982). Methods of Soil Analysis. Part 2. Book series No 9. American Soc. of Agron. and Soil Sci. Soc. Am. Madison, Wisconsin. USA.

Park, H.J.; Kim, U. Kang and K. Park (1998). Effect of sulfur and potassium sulfate application on yields and volatile compounds by garlic (*Allium sativum* L.) varieties. Hortic. Abs. J., 68(11):779

Pillei, F. (1967). "Crop Nutrition". Geyasingh, P.S. Asia. Publishing house Bombay, India.

Sharma, 0. P.; U. K. Kohli and B. S. Mehta (1988). Effect of GAS and multiplex spray on the yield and quality of *garlic (Allium sativum* L.). Agricultural Science Digest, India. 1988, 8 (I): 37-39.

Stoll, A. and E. Seebeck (1950). Specific constituents oil of garlic, Scentia pharm, 18:610.

Tisdale, S.L.; W.L. Nelson and J.D. Beaton (1985). Soil Fertility and Fertilizers. 4th Ed. MacMillan, New York, USA.

Tukey, H.B.; S.H. Wittwer and M. J. Bukovac (1962). The uptake and loss of materials by leaves and other above ground plant parts with special referance to plant nutrition. Nutrient uptake of plants, 4 International symposium, Agrochimica Pisa, Florenz, p. 384-413.

Watt, J.M. and M.G. Brandwijk (1962). Medical and poisonous plants of Thouthern and Eastern Africa.(C.F. Abd El-Hamed, 1997)

Westerman, R.L. (Ed.). (1990). Soil Testing and Plant Analysis. Third edition, Soil Sci. Soc. Am. Book series No. 3. Soil Sci. Soc. Am. Madison, Wisconsin USA.

تأثير الرش الورقي بالبوتاسيوم و الماغنسيوم و العناصر الصغرى على محصول و جودة و مكونات الزيت الطيار للثوم المنزرع بالأراضي الرملية

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نفذت تجربتان حقليتان على محصول الثوم – الصنف الأسباني – تحت ظروف الأراضي الرملية المستصلحة حديثاً والمروية بنظام الري بالتنقيط بالمزرعة البحثية لمركز البحوث الزراعية بقرية علي مبارك – البستان – منطقة النوبارية وذلك خلال موسمي شتاء عامي ١٩٩٩/٢٠٠٠ ، ٢٠٠٠/٢٠٠١. كان الهدف من البحث دراسة تأثير الرش الورقي بالبوتاسيوم مع مخاليط مختلفة من العناصر الصغرى و الماغنسيوم {M_1(Fe+zn+Mn), M_2 (M_1+Cu), M_3 (M_2+Mg)} و ذلك بتركيزات (صفر و ٢٥ و ٥٠ و ٧٥ و ١٠٠ جم/١٠٠ لتر ماء على الثوم الأسباني من حيث النمو و الإنتاجية و الجودة و على تركيز العناصر الكبرى والصغرى بالأوراق و الأبصال و نسبة و مكونات الزيت الطيار بالأبصال.

و قد أظهرت نتائج الدراسة أن التأثير المنفرد لعوامل الدراسة (البوتاسيوم ، مخاليط العناصر و تركيزات الرش) و كذلك التفاعل فيما بينها أعطى تأثيراً معنوياً على الصفات المدروسة مثل صفات النمو الخضري (طول النبات و عدد الأوراق و المساحة الورقية) و المحصول و مكوناته (الوزن الطازج للأبصال وعدد و وزن الفصوص و محصول الأبصال) و مواصفات الأبصال (قطر العنق و قطر البصلة و نسبة تكوين الأبصال و النسبة المئوية للأملاح الصلبة الكلية و المادة الجافة). و قد أوضحت النتائج إن الرش الورقي بالبوتاسيوم و الخليط M_3 خاصة مع التركيز العالي (١٠٠ جم/ ١٠٠ لتر ماء قد أدى إلى تحسين و زيادة معظم الصفات المدروسة.

تأثرت تركيزات العناصر (نتروجين ، فوسفور ، بوتاسيوم ، ماغنسيوم ، حديد ، زنك ، منجنيز ، نحاس) في الأوراق و الفصوص معنوياً بالتفاعل المتبادل بين عوامل الدراسة الثلاثة و كانت افضل النتائج في و جود الرش بالبوتاسيوم مع الخليط M_3 ثم يليه M_2 و أخيرا M_1 و كانت أفضل التركيزات ١٠٠ جم/ ١٠٠ لتر ماء.

تدرجت زيادة النسبة المئوية للزيت الطيار في فصوص الثوم الأسباني مع زيادة التركز داخل كل خليط لتصل إلى أفضل زيادة مع التركيز المرتفع (١٠٠ جم/ ١٠٠ لتر ماء) في الخليط M_3 في وجود البوتاسيوم. و قد أمكن التعرف على ١٠ مكونات للزيت الطيار باستخدام التحليل الكروماتوجرافي بجهاز (GC-MS) و قد أدى الرش بكبريتات البوتاسيوم إلى زيادة معنوية في النسبة المئوية لمكونات الزيت ، و ظهرت فروق معنوية مع أضافه الخليط M_3 ثم يليه M_2 و أخيرا M_1 و مع زيادة التركيز. و قد تدرجت النتائج بزيادة طفيفة في النسبة المئوية لمكونات الزيت ولكنها تباينت طبقاً للمكونات المختلفة.