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PRODUCTION OF HYSSOP (*HYSSOPUS OFFICINALIS* L.) PLANT UNDER MARIOUT CONDITIONS - EGYPT

Toaima, Wael I.M.
Department of Medicinal and Aromatic Plants, Desert Research Center, Cairo, Egypt
E-mail: wael.toaima3@gmail.com

Field research was conducted on Hyssop (*Hyssopus officinalis* L.) plants in the Mariout region, North of Egypt during the two successive seasons of 2020 and 2021. The purpose of the study is to determine the optimum space, chemical fertilization, and their interactions on the biomass yield. The research was set compatible to a split-plot design technique. The inter spacing was 30 and 50 cm, while the subplots had chemical fertilization at three levels: full dose NPK, 2/3 NPK, and 1/3 NPK. The used chemical fertilizers (full dose of NPK) were: 450 kg ammonium sulphate (20.5% N) + 300 kg calcium superphosphate (15.5% P_2O_5) + 150 kg potassium sulphate (48% K_2O)/feddan. The results of the two cuts revealed that cultivation at a narrow spacing of 30 cm and adding a full dose of NPK recorded the significant highest production of herb and essential oil yield in the total area. The extracted oil contained pinocamphone (31.61-57.63%) and α-pinene (20.47-49.88%) as principal compounds. Cultivation at 30 cm space and adding the full dose of NPK also improved the pinocamphone concentration in the essential oil better than other treatments.

Keywords: *Hyssopus officinalis*, planting spaces, fertilization, pinocamphone, biomass yield

INTRODUCTION

Hyssopus officinalis L. (English name: Hyssop, Family: Lamiaceae) is one of the most commonly used herbs. Its native range extends from the East Mediterranean to central Asia, where it grows mainly. The Hyssop plant is a brightly colored shrub or subshrub that grows to 30 to 60 cm. The base of the stem is woody, from which several upright branches grow. It has lanceolate, dark green leaves 2 to 2.5 cm long (Fig. 1). Plants produce pink or blue fragrant flowers (Balick, 2014).

In the realm of herbal medicine, Hyssop is regarded as possessing properties that are calming, expectorant, and cough-suppressant. It has an old history of use in traditional medicine, improving circulation and treating various ailments, including coughing and sore throats. Hyssop has a stimulating effect on the digestive system. Aromatic Hyssop leaves are a condiment that gives the food a harsh taste and a minty scent. Beekeepers use the plant's nectar to manufacture rich scented honey. The volatile oil is utilized in cosmetic industries. Its essential oil contains pinene, pinocamphone, isopinocamphone, and other terpenoids that are common active ingredients (Gardner, 2014 and Norman, 2015).

The yield and the active ingredients that medicinal and aromatic plants produce are extremely sensitive to the agronomic practices used, which are the primary factors in determining production and quality. The most crucial aspects are the number of plants cultivated and chemical fertilization.

It is highly fundamental to have a high planting density per unit area. Spacing the plants closer together can achieve a higher herb yield per area. Wider spacing, however, can result in a higher herb yield per plant. This could be because wider-spaced plants have the opportunity to increase metabolite synthesis, which promotes growth with more stems and roots (Stewart and Globig, 2011; Mohr and Schopfer, 2012 and Hamed et al., 2017).

Nitrogen, phosphorus, and potassium, abbreviated as NPK, are the primary components of most commercial fertilizers. Each of these necessary nutrients play an important role in the nutrition of medicinal and aromatic plants and is required for producing maximum yield with high active constituents (Toaima, 2005; Drutu et al., 2014; Gholamreza et al., 2015; Jain, 2017 and Hamed, 2018).

Egypt has moved into newly reclaimed lands in the desert to expand the cultivation of medicinal and aromatic plants to increase the quantity of production and quality characteristics following international standards. In recent years, Egypt's exports of herbs and spices have had to be supplemented by the cultivation of new medicinal and aromatic plant species for the country to keep up with demand in global markets. Hyssop is an example of a recently introduced plant. However, more research needs to be found on their production in the country.

The study aims to find the best Hyssop cultivation practices on reclaimed lands. Thus, this investigation examines the relationships between yield and some agronomic factors, such as planting density and chemical fertilization, and how those factors interact.

MATERIALS AND METHODS

The investigation was conducted at the Experimental Field of the Desert Research Center in the Mariout region (30˚ 59′ 57.12″ N and 29˚ 46′ 59.16″ E), Alexandria Governorate. The trial was performed throughout the two successive seasons of 2020 and 2021. The area's soil physical characteristics were sand = 59.00%, silt = 27.50%, clay = 13.50%, and soil texture = sandy loam. The soil chemical properties were pH = 8.40, organic matter = 0.14%, E.C. = 2304 ppm, and $CaCO_3$ = 25.75%. Irrigated water had an E.C. of 375 ppm.

The seeds of Hyssop were imported from Gavrish Seeds Company, Moscow, Russia. In both seasons, seeds were planted on January 1st in a greenhouse. On March 1st, the uniform seedlings with 4-5 leaf pairs were transplanted into the open field, where they will continue to grow. Drip irrigation was used, with rows spaced 75 cm apart. All the recommended agriculture procedures for Hyssop were adhered to throughout the production stages.

In a split-plot experiment, three replicates with six treatments were used. The main plots contained 30 and 50 cm planting spaces (18667 and 11200 plants/feddan, respectively), while the subplots had chemical fertilization at three levels: NPK, 2/3 NPK, and 1/3 NPK. The used chemical fertilizers (full dose of NPK) were 450 kg ammonium sulphate (20.5% N) + 300 kg calcium superphosphate (15.5% P_2O_5) + 150 kg potassium sulphate (48% K_2O)/feddan. The ammonium sulphate and potassium sulphate were applied in two doses. The first was given 30 days after cultivation, and the second was added after the first harvest. Before planting, a single amount of calcium superphosphate was added with compost manure at 10 m^3/feddan.

Two successive harvests of the flowering herb were performed on 30th June and 10th October. It was cut 10 cm above the soil, leaving two branches for growth again. ANOVA analyzed all the data (Snedecor and Cochran, 1982), and LSD tested mean differences at 0.05. At harvest, the following readings were collected: plant height (cm), fresh herb weight (g/plant), dry herb weight (g/plant), fresh herb yield (ton/feddan), and dry herb yield (ton/feddan) were all growth and yield traits.

Some quality indicators were determined as essential oil percentage in the air-dried herb by hydrodistillation (British Pharmacopoeia, 1963), essential oil yield per plant (ml), and this was calculated as follows: oil percentage × herb dry weight per plant/100, essential oil yield per feddan (liter) and this was estimated as follows: essential oil yield per plant × number of plants per feddan, and GC-MS analysis of oil was achieved by Gas Chromatography-Mass Spectrometry instrument at the Laboratory of Medicinal and Aromatic Plants, National Research Center, Egypt with the following specifications. Device: a TRACE GC Ultra Gas Chromatograph (THERMO Scientific Corp., USA) coupled with a THERMO mass spectrometer detector (ISQ Single Quadrupole Mass Spectrometer). The GC-MS system had a TR-5MS column (30 m x 0.32 mm i.d., 0.25 μm film thickness). Analyses were conducted using helium as carrier gas at a flow rate of 1.3 ml/min at a split ratio of 1:10 and the following temperature program: 80°C for 1 min; rising at 4°C/min to 300°C and held for 1 min. The injector and detector were held at 220 and 200°C, respectively. Diluted samples (1:10 hexane, v/v) of 1 μL of the mixtures were continuously injected. Mass spectra were obtained by electron ionization (EI) at 70 eV, using a spectral range of m/z 40-450. Identification of the compounds depended on both comparison of the retention times with those of authentic samples and computer matching against commercial and libraries mass spectra built up from pure substances (Massada, 1976; National Committee for Clinical Laboratory Standards, 2002; Adams, 2007 and Babushok et al., 2011).

Fig. (1). *Hyssopus officinalis* plants.

RESULTS AND DISCUSSION

1. Growth and Yield Parameters

The impacts of planting spaces on growth parameters are displayed in Tables (1-3). Fresh and dry herb weights per plant were significantly higher in the 50 cm planting space than in the 30 cm space, which had lower values. The 50 cm detections were as follows: 277.11 and 277.18 g, and 117.52 and 117.11 g for the first and second cuts, respectively. In inverse, the narrow space, 30 cm treatment, offered the best results regarding fresh and dry herb yields per feddan (Tables 4 and 5). In that order, these measures were 3.79 and 2.87 tons, and 1.75 and 1.40 tons for the first and second harvests, correspondingly.

Concerning chemical fertilization, by gradually increasing the amount of NPK, the growth metrics of plant height, fresh herb weight, and dry herb weight per plant increased. The full dose of fertilization produced significantly higher values than any other rate. Its measurements were 64.73 and 38.17 cm; 364.84 and 283.50 g; and 157.39 and 143.61 g for the first and second cuts, respectively. In contrast, plants fertilized with 1/3 NPK recorded the lowest growth features (Tables 1-3). Likewise, increasing NPK amounts caused significant increments in fresh and dry herbs yield per feddan. In that order, those findings were 5.09 and 3.91 tons and 2.21 and 2.01 tons (Tables 4 and 5).

The interaction between planting distances and chemical fertilization on the growth is shown in Tables (1-3). It was found that the highest NPK level combined with cultivation at a wide spacing of 50 cm gave the significant maximum plant height and fresh and dry herb weights per plant. These records were 68.56 and 40.56 cm, 463.11 and 370.78 g, and 194.67 and 181.22 g, correspondingly. On the other hand, there were no significant differences between growing plants close together, at 30 cm apart, and giving them the highest NPK rate, and growing them wide apart, at 50 cm, and giving them the most NPK amount in fresh and dry weights per feddan.

Table (1). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* height as cm (mean values of the two successive seasons).

Treatments	**1st cut**				**2nd cut**			
Spacing	**Fertilization**				**Fertilization**			
	1/3 NPK	**2/3 NPK**	**NPK**	**Mean**	**1/3 NPK**	**2/3 NPK**	**NPK**	**Mean**
30 cm	53.67	57.00	60.89	57.17	27.00	32.67	35.78	31.82
50 cm	42.56	51.22	68.56	54.11	32.67	34.22	40.56	35.82
Mean	48.12	54.11	64.73		29.84	33.45	38.17	
LSD 5%								
Spacing	4.19				2.13			
Fertilization	5.12				2.61			
Interaction	7.25				3.68			

Table (2). Effect of plant spacing, chemical fertilization, and their interaction on fresh *Hyssopus officinalis* herb weight as g/plant (mean values of the two successive seasons).

Treatments	**1st cut**				**2nd cut**			
Spacing	**Fertilization**				**Fertilization**			
	1/3 NPK	**2/3 NPK**	**NPK**	**Mean**	**1/3 NPK**	**2/3 NPK**	**NPK**	**Mean**
30 cm	158.44	183.67	266.56	202.89	94.44	170.11	196.22	153.59
50 cm	167.33	200.89	463.11	277.11	128.44	182.33	370.78	227.18
Mean	162.89	192.28	364.84		111.44	176.22	283.5	
LSD 5%								
Spacing	29.52				25.90			
Fertilization	36.33				31.73			
Interaction	51.13				44.87			

Table (3). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* dry herb weight as g/plant (mean values of the two successive seasons).

Treatments	1st cut				2nd cut			
Spacing	Fertilization				Fertilization			
	1/3 NPK	2/3 NPK	NPK	Mean	1/3 NPK	2/3 NPK	NPK	Mean
30 cm	77.22	84.11	120.11	93.81	60.22	96.89	106.00	87.70
50 cm	67.44	90.44	194.67	117.52	75.00	95.11	181.22	117.11
Mean	72.33	87.28	157.39		67.61	96.00	143.61	
LSD 5%								
Spacing	12.53				11.13			
Fertilization	15.34				13.63			
Interaction	21.69				19.27			

Table (4). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* fresh herb yield as ton/feddan (mean values of the two successive seasons).

Treatments	1st cut				2nd cut			
Spacing	Fertilization				Fertilization			
	1/3 NPK	2/3 NPK	NPK	Mean	1/3 NPK	2/3 NPK	NPK	Mean
30 cm	2.96	3.43	4.98	3.79	1.76	3.18	3.66	2.87
50 cm	1.87	2.25	5.19	3.10	1.44	2.04	4.15	2.54
Mean	2.42	2.84	5.09		1.60	2.61	3.91	
LSD 5 %								
Spacing	0.49				0.31			
Fertilization	0.60				0.50			
Interaction	0.84				0.71			

Table (5). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* dry herb yield as ton/feddan (mean values of the two successive seasons).

Treatments	1st cut				2nd cut			
Spacing	Fertilization				Fertilization			
	1/3 NPK	2/3 NPK	NPK	Mean	1/3 NPK	2/3 NPK	NPK	Mean
30 cm	1.44	1.57	2.24	1.75	1.12	1.09	1.98	1.40
50 cm	0.76	1.01	2.18	1.32	0.84	1.07	2.03	1.31
Mean	1.10	1.29	2.21		0.98	1.08	2.01	
LSD 5 %								
Spacing	0.39				0.09			
Fertilization	0.48				0.21			
Interaction	0.69				0.30			

2. Quality Parameters

The results in Tables (6-8) show the influence of growing space on essential oil measurements. The highest essential oil percentage and oil yield per feddan were found by cultivation at a closer distance of 30 cm than others. These estimates, correspondingly, were 0.40 and 0.51%, and 7.27 and 8.53 l concerning the first and second cuts. While planting at 50 cm, essential oil percentage and oil yield per feddan decreased.

Regarding chemical fertilization, Tables (7 and 8) demonstrate that fertilization enhanced quality as the highest level of NPK produced the maximum essential oil yield per plant and feddan. In the same order, these quantities were 0.59 and 0.58 ml and 8.78 and 8.74 l for the first and second cuts. In this regard, 1/3 of NPK had the lowest stats.

Furthermore, the interaction of the preceding factors had a significant impact on essential oil attributes. The cultivation at a closer distance of 30 cm and basal dressing with the highest amount of NPK resulted in the highest essential oil percentage and oil yield per feddan. These values were 0.48 and 0.57%, and 10.83 and 11.20 l, respectively, for the first and second cuts. Variations in cultivation at 30 or 50 cm combined with the full dose of NPK, on the other hand, were not significant for volatile oil yield per plant in both harvests.

The extracted essential oils were primarily composed of pinocamphone (31.61-57.63%) and α-pinene (20.47-49.88%) (Table 9). The interaction of treatments influenced the oil composition. Only Hyssop essential oil contains more than 5% of pinocamphone than any other oil, and pinocamphone is the molecule responsible for its flavor and aroma. Planting in a limited space of 30 cm and using the highest NPK levels improved oil quality by increasing pinocamphone content more than other treatments. This could be attributed to increased secondary metabolites in these treatments' oil. The values were 57.63 and 56.76% for 30 cm with 2/3 NPK and 30 cm with NPK, respectively. On the other hand, plants in a wide space with any fertilization level had a lower percentage of pinocamphone (Fig. 2). These results are in harmony with the findings of Figueredo et al. (2012) and Zawislak (2016) on *Hyssopus officinalis*.

Table (6). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* essential oil percentage (mean values of the two successive seasons).

Treatments	**1st cut**				**2nd cut**			
Spacing	**Fertilization**				**Fertilization**			
	1/3 NPK	**2/3 NPK**	**NPK**	**Mean**	**1/3 NPK**	**2/3 NPK**	**NPK**	**Mean**
30 cm	0.32	0.40	0.48	0.40	0.46	0.50	0.57	0.51
50 cm	0.38	0.35	0.31	0.35	0.46	0.44	0.31	0.40
Mean	0.35	0.38	0.40		0.46	0.47	0.44	
LSD 5%								
Spacing	0.01				0.01			
Fertilization	0.01				0.01			
Interaction	0.02				0.01			

Table (7). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* essential oil yield/plant as ml (mean values of the two successive seasons).

Treatments	1st cut				2nd cut			
Spacing	Fertilization				Fertilization			
	1/3 NPK	2/3 NPK	NPK	Mean	1/3 NPK	2/3 NPK	NPK	Mean
30 cm	0.25	0.34	0.58	0.39	0.28	0.49	0.60	0.46
50 cm	0.26	0.32	0.60	0.39	0.35	0.42	0.56	0.44
Mean	0.26	0.33	0.59		0.32	0.46	0.58	
LSD 5%								
Spacing	0.05				0.06			
Fertilization	0.06				0.07			
Interaction	0.08				0.10			

Table (8). Effect of plant spacing, chemical fertilization, and their interaction on *Hyssopus officinalis* essential oil yield/feddan as l (mean values of the two successive seasons).

Treatments	1st cut				2nd cut			
Spacing	Fertilization				Fertilization			
	1/3 NPK	2/3 NPK	NPK	Mean	1/3 NPK	2/3 NPK	NPK	Mean
30 cm	4.67	6.35	10.83	7.28	5.23	9.15	11.20	8.53
50 cm	2.91	3.58	6.72	4.40	3.92	4.70	6.27	4.96
Mean	3.79	4.97	8.78		4.58	6.93	8.74	
LSD 5%								
Spacing	0.80				0.86			
Fertilization	0.98				1.05			
Interaction	1.38				1.49			

Table (9). Effect of interaction on *Hyssopus officinalis* essential oil composition.

R.T.	Compound	30 cm + 1/3 NPK	30 cm + 2/3 NPK	30 cm + NPK	50 cm + 1/3 NPK	50 cm + 2/3 NPK	50 cm + NPK
3.78	2-Thujene	0.86	0.36	0.57	0.29	0.45	0.71
4.25	Camphene	-	-	0.11	18.34	-	0.16
4.64	α-Phellandrene	3.66	7.74	3.03	2.46	7.72	6.25
4.75	α-Pinene	21.84	20.47	27.02	23.23	29.52	49.88
5.03	1-Octen-3-ol	0.63	-	-	0.17	0.16	-
5.49	α-Terpinene	0.77	-	-	-	0.06	-
5.74	D-Limonene	1.05	0.46	0.67	-	0.73	1.14
5.81	Trans-sabinene hydrate	1.65	0.86	-	-	-	-
6.04	α-Ocimene	-	-	0.94	0.10	-	-
6.34	γ-Terpinene	1.97	-	0.26		-	0.21
6.82	Terpineol	2.49	0.26	0.71	0.13	0.25	0.39

Table (9). Cont.

6.89	p-Mentha-1,4(8)-diene	0.29	-	0.08	-	-	0.09
7.41	α-Linalool	0.94	0.60	0.50	1.18	2.21	0.27
8.01	1-Methyl-4-(methylethyl)-(E)-2-cyclohexenol	0.19	-		-	-	-
8.38	2-(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethanol	5.35	4.74	2.44	4.29	5.06	5.07
8.73	Pinocamphone	49.38	57.63	56.76	43.65	49.96	31.61
9.22	p-Menth-1-en-4-ol	3.52	-	0.38	-	-	0.11
9.52	Myrtenal	0.20	0.21	0.31	-	0.16	-
9.66	2-Pinen-10-ol	-	-	1.99	-	-	-
11.17	2,4,6-Trimethyldecane	-	-	-	-	0.05	-
12.66	Nerol acetate	-	-	-	-	0.10	0.05
13.09	α-Bourbonene	-	0.29	0.49	0.17	0.42	0.48
13.86	Caryophyllene	0.47	0.27	0.59	0.51	0.68	0.93
14.61	Humulene	0.30	0.75	0.34	0.39	0.43	0.59
15.11	Germacrene D	0.32	0.28	0.46	0.57	0.42	0.60
15.38	Elemene	0.61	0.77	0.75	1.02	0.47	0.39
15.95	Cadina-1,3,5-triene	-	-	0.07	-	-	-
16.62	Hedycaryol	1.43	1.01	1.05	1.73	0.59	0.54
17.18	Caryophyllene oxide	0.28	-	0.28	-	0.17	-
17.19	Spathulenol	0.25	0.26		0.31	-	0.27
17.41	Ledene oxide-(II)	-	-	-	-	-	0.06
18.16	Eudesmol	-	-	0.08	0.11	-	-
18.66	Eudesm-4(14)-en-11-ol	0.36	0.36	0.12	0.44	0.12	0.20
24.90	Behenic alcohol	0.22	0.33	-	-	-	-
29.08	Ethyl iso-allocholate	-	0.42	-	0.25	-	-
Total identified components		99.03	98.07	100.00	99.34	99.73	100.00
Total hydrocarbon compounds		32.14	31.39	35.38	47.08	40.95	61.43
Total oxygenated compounds		66.89	66.68	64.62	52.26	58.78	38.57

R.T. = Retention time

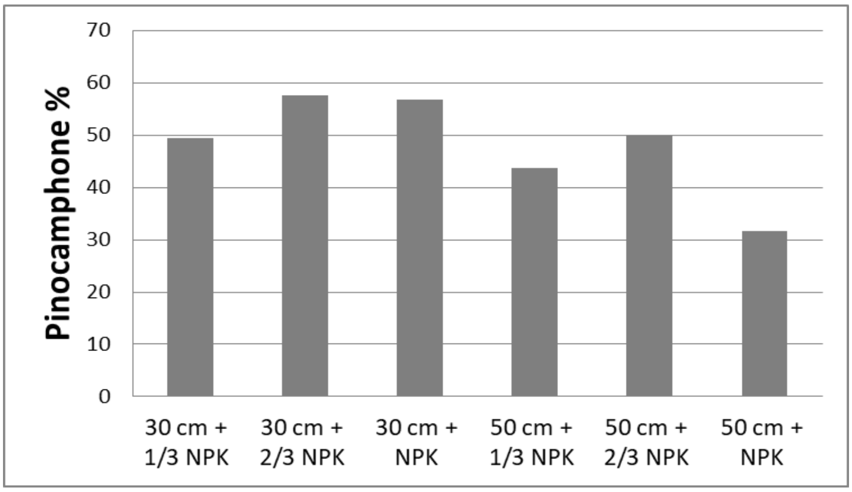

Fig. (2). Effect of treatments on pinocamphone content of *Hyssopus officinalis* essential oil.

Based on the results of the experiment, the parameters for superior treatment of the maximum quantity of chemical fertilization and cultivation in 30 cm could be summarized as follows for the first and second cuts, respectively:

- Fresh herb yield per feddan (4.98 and 3.66 tons).
- Dry herb yield per feddan (2.24 and 1.98 tons).
- Essential oil percentage (0.48 and 0.57%).
- Essential oil yield per feddan (10.83 and 11.20 l).
- Also, essential oil contains 56.76% of pinocamphone.

The positive role of adding the highest level of chemical fertilization (450 kg ammonium sulphate + 300 kg calcium superphosphate + 150 kg potassium sulphate) besides cultivation in a narrow distance of 30 cm could be attributed to several reasons as follows: Nitrogen is a macronutrient required for plant activity and an essential component of amino acids. Amino acids are the fundamental components of proteins and enzymes found in plants. Nitrogen is also a component of the chlorophyll molecule, enabling the plant to harness the sun's energy through photosynthesis, which drives plant growth and crop yield. Phosphorus is essential for producing ATP, which functions as the "energy unit" in plant cells. As a result, all plants require phosphorus to maintain an optimal level of health and vitality. Potassium is a vital component for plant development. This substance is a macronutrient. It is involved in the activation of enzymes within the plant. Potassium helps control how often stomata open and close, which governs how water vapor, oxygen, and carbon dioxide move in and out of the plant (Jain, 2017).

A higher herb yield can be obtained from a given area if the plants are spaced closer together. However, wider spacing can result in more herb output per plant because plants have the option to increase metabolite synthesis, which encourages development with more woody stems than leaves and, as a result, lower essential oil when compared to closer spacing (Stewart and Globig, 2011 and Mohr and Schopfer, 2012).

The influences of chemical fertilization and planting density on biomass and essential oil yield of Hyssop plants were in the same line as demonstrated by Khazaie et al. (2008), Zawiślak (2011), Biouki et al. (2014), Drutu et al. (2014), Gholamreza et al. (2015) and Sharifi et al. (2015).

CONCLUSION

It was found that the Hyssop plants would produce the most if the seedlings were cultivated 30 cm inside the row and chemical fertilizers were used at a rate of 450 kg ammonium sulphate (20.5% N) + 300 kg calcium superphosphate (15.5% P_2O_5) + 150 kg potassium sulphate (48% K_2O)/feddan. The ammonium sulphate and potassium sulphate should be given in two doses. The first dose should be supplied 30 days after the transplant, and the second should be given after the first cut. At the same time, a single amount of calcium superphosphate should be added before planting.

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إنتاج نبات الهيسوب تحت ظروف مريوط ـ مصر

وائل إسماعيل محمد طعيمة
قسم النباتات الطبية والعطرية، مركز بحوث الصحراء، المطرية، القاهرة، مصر

تم إجراء تجربة حقلية على نباتات الهيسوب في منطقة مريوط، شمال مصر. كان الغرض دراسة تأثيرات مسافات الزراعة والتسميد الكيماوي وتفاعلهم على المحصول. تم استخدام تصميم القطع المنشقة للقيام بهذا العمل. اشتملت القطع الرئيسية على مسافات زراعة ٣٠ و٥٠ سم بينما اشتملت القطع المنشقة على التسميد الكيماوي بثلاث مستويات: جرعة كاملة ن فو بو، ٣/٢ ن فو بو، ٣/١ ن فو بو. وكانت الأسمدة الكيماوية المستخدمة (الجرعة الكاملة من ن فو بو): ٤٥٠ كجم سلفات نشادر (٢٠.٥٪ ن) + ٣٠٠ كجم سوبر فوسفات الكالسيوم (١٥.٥٪ فو٢أ٥) + ١٥٠ كجم سلفات بوتاسيوم (٤٨٪ بو٢أ). أظهرت نتائج الجمعتين (الحشتين) أن الزراعة على مسافة ضيقة ٣٠ سم وإضافة الجرعة الكاملة من ن فو بو قد سجلت أعلى إنتاج معنوى لمحصول العشب والزيت الطيار في المساحة الكلية. اشتمل الزيت المستخلص على البينوكامفون (٣١.٦١–٥٧.٦٣٪) والفا بينين (٢٠.٤٧-٤٩.٨٨٪) كمركبات رئيسية. أيضًا أدت الزراعة على مسافة ٣٠ سم وإضافة الجرعة الكاملة من ن فو بو إلى تحسين تركيز البينوكامفون في الزيت الطيار بشكل أفضل من المعاملات الأخرى.