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EFFECT OF IRRIGATION AND ORGANIC FERTILIZATION ON GROWTH AND PRODUCTIVITY OF *Majorana hortensis*, L. IN SANDY SOILS

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ABSTRACT

This investigation was conducted during two successive seasons of 2004 and 2005 at the experimental farm of El-Quassassin Hort. Res. Station, Ismailia Governorate, Egypt, to study the effect of irrigation rates (1610, 3220 or 4876 m^3/fed.) and fertilization treatments (NPK and organic fertilizers) on vegetative growth, volatile oil yield and chemical composition of *Majorana hortensis* L. plant in sandy soil. Application of the high rate of water irrigation (4876 m^3/fed./season) gave the highest values of vegetative characteristic i.e., plant height, fresh and dry weight of herb/plant, dry weight of leaves and stems/plant, the yield of fresh and dry weight of herb per plant and per feddan and chemical composition i.e., volatile oil percentage and N, P or K content as compared with 1610 or 3220 m^3/fed./season water amount irrigation in the three cuttings during the two seasons. Application NPK fertilization treatment (300 , 300 , 100 kg/fed. as ammonium sulphate, calcium superphosphate and potassium sulphate, respectively) surpassed significantly in vegetative characteristics, oil percentage and chemical content when compared with organic fertilization (compost, poultry and cattle manure). On the other side, poultry manure (10 m^3/fed) gave significant increase in the most characteristics under this study when compared to the compost or cattle manure (15 and 20 m^3/fed. respectively) fertilization treatments. Irrigation sweet marjoram plants with drip irrigation system at water amount of 4876 m^3/fed./season gave 14.305 and 4.688 ton per feddan fresh and dry weight of herb, respectively and 2.63 % (dry weight) volatile oil percentage. The maximum contents of Terpinene-4-Ol and Linalool were obtained from the high level of irrigation (4876 m^3/fed/season) combined with cattle manure fertilization treatment. While the high contents of 1,8 Cineole and Limonene were resulted from the high level of irrigation combined with poultry manure fertilization treatment.

INTRODUCTION

Aromatic and medicinal plants are considered essential economic products which occupy a prominent position in several industrial usages and applications, such as pharmaceutical preparations, foods, perfumes and cosmetic. Recently, an increasing interest in the cultivation and production of aromatic and medicinal plants has been recognized in Egypt to cover the increasing demands of the local industries as well as, for export and local proposes.

Sweet marjoram plants (*Majorana hortensis* L.) is considered as an, important medicinal crop in Egypt due to the great area with high production and great uses. The air dried leaves and flowering tops are used as condiment for seasoning soups dressing, stews, poultry and sausage. It is also used as a stimulating in tooth pastes, whooping cough and larynx infections. Marjoram has a mild oregano flavor with of balsam. It is wonderfully aromatic. It is good with veal, beef, lamb, roost poultry, fish,

patas, green veggies, carrots, cauliflower, eggplant, eggs, mushrooms, parsnips, potatoes, squash and tomatoes. Marjoram is a good herb to add to other stimulating herbs for bath. It has mildly antiseptic properties and is a good for the skin. Add a sprig of marjoram to mixed herb tea, and makes an effective home insect repellant. The essential oil is found in glands in the plant leaves extracted commercially by steam or water distillation method (Stary and Jirasek, 1975). The oil was employed quite extensively in many kinds of favours including confectioners, backed foods and condimentary, (Gunther, 1961).

In the recent years, the safe agriculture is one of the main attitudes in the world (El-Kouny, 2002). There is a great attention to increase the cultivated area of sandy soils. These soils suffer from lack of water resource and poor fertility. As such controlling water utilization through determination of the ultimate amount of irrigation water which apply by modern technique such as drip irrigation is objective goal, since it is not much applied for the medicinal and aromatic plants. Moreover, using intense chemical fertilization cause serious problems on human health. The organic fertilizers is utilized for the change of soil texture, supplying nutrients to the growing plants and organic acids, enhancing nutrients uptake as reported by Lampkin (1990), Mohamed and Matter (2001), Badran (2002) and Yousef (2002) and the organic fertilizers consider save for human health.

On such basis, the aim of present study was to investigate the adequate water amounts needs for high production of sweet marjoram plant in sandy soil in addition to compare between the three organic fertilizers for obtaining good production of herb, oil yield and chemical composition of marjoram plants with recommended NPK fertilization.

MATERIALS AND METHODS

The present study was conducted to investigate the effect of irrigation and fertilization treatments on the vegetative growth, volatile yield and the chemical composition of *Majorana hortensis* L. plant.

This investigation was carried out during the two successive seasons of 2004 and 2005 at the Experimental Farm of El-Quassassin Horticultural Research Station, Ismailia Governorate, Agriculture Research Center, Egypt. Table (A) shows the mechanical and chemical analysis of Farm soil.

The marjoram (*Majorana hortensis* L.) seedlings were obtained from the Medicinal and Aromatic Plants Section at El-Kanater El-Khairia, Kalubia Governorate, Horticulture Research Institute, A.R.C. The seedlings were 10 – 15 cm in length, with 10 – 12 leaves and were transplanted on 1st of March in rows (60 cm between rows and 30 cm between plants). The experimental unit was 5.4 m^2, every unit contained three dropper lines with 3 m length. Every experimental unit contained 30 plants (about 22222 plants per feddan).

Table (A): The mechanical and chemical analysis of the experimental soil.

The mechanical analysis		The chemical analysis	
Sand	89.92 %	**Macro elements (ppm)**	
Silt	4.0 %	**Nitrogen**	**81**
Clay	**6.08 %**	**Phosphorus**	**23**
The soil was sandy in texture		**Potassium**	**108**
		Micro elements (ppm)	
Field capacity (F.C.)	**11.20 %**	**Fe**	**2.0**
Welting point (W.P.)	**2.20 %**	**Cu**	**---**
Organic matter	**0.42 %**	**Zn**	**0.26**
pH (1 soil : 2.5 d.w.)	**8.1**	**Mn**	**0.8**
E.C. (mmohs/cm)	**0.21**	**Anion (mq/100 g soil)**	
		Cl^-	**0.5**
		HCO_3	**1.0**
		SO_4	**0.97**
		Cations (mq/100 g soil)	
		Ca^{++}	**1.0**
		Mg^{++}	**0.4**
		Na^+	**0.76**
		K^+	**0.31**
		$CaCO_3$ (meq/100 g soil	**2.6**

Irrigation treatments :

Drip irrigation system was used in this experiment with drippers of 2 liter/hr. discharge for each at 0.5 bar. The amount of applied water irrigation liter/plant and m^3/feddan for every irrigation treatments during the growth period are shown in Table (B)

Table (B): Irrigation treatments and water amount added per plant and per feddan during the plant growth season.

Irrigation time minute/twice every week	Water amount per week (liter/plant)	Water quantity liter/plant/season	Water quantity m^3/feddan/season
30	2	70	1610
60	4	140	3220
90	6	212	4876

Fertilization treatments :

The chemical treatments included nitrogen fertilization was applied at the rate of 300 kg per feddan ammonium sulphate (20.5 % N) as nitrogen source. Phosphorus fertilization was applied at the rate of 300 kg per feddan calcium superphosphate (15.5 % P_2O_5) as phosphorus source. Potassium fertilization was applied at the rate of 100 kg per feddan potassium sulphate (48 – 52 % K_2O) as a source of potassium (El-Gamasy *et al*, 1985).

The organic fertilization treatments as cattle manure (CM) was applied at the rate of 20 m^3 per feddan, poultry manure (PM) was applied at the rate of 10 m^3 per feddan and compost (C) was applied at the amount of 15 m^3 per feddan. The chemical composition of the three types of organic fertilizers are shown in Table (C). The organic fertilizers was obtained from a private farm at El-Quassassin, Ismailia Governorate.

The phosphorus fertilizer and organic fertilizers were added 15 days before transplanting date and covered by sand. While the nitrogen and potassium fertilizers was applied as soil dressing beside drippers. The amount of fertilizer treatments were divided into four equal doses, the first dose was applied after one month from transplanting, whereas, the other three doses were applied after every cutting of herb.

Table (C) : The chemical composition of the cattle manure, poultry manure and compost.

Fertilizer characteristics	Cattle manure (CM)		poultry manure (PM)		compost (C)	
	First season	Second season	First season	Second season	First season	Second season
Weight of 1 m^3 (kg/m^3)	491	470	685	526	570	560
Moisture content (%)	19.50	19.10	16.90	19.60	17.3	15.6
Organic matter (%)	34.20	32.40	45.70	54.60	48.92	43.82
Organic carbon (%)	24.2	20.9	38.2	34.6	27.3	30.9
Total nitrogen (%)	1.82	1.94	3.42	2.96	2.64	2.30
Total phosphorus (%)	0.37	0.42	1.07	0.92	1.65	1.04
Total potassium (%)	0.86	1.09	1.97	2.30	2.53	1.80
C/N ratio (%)	13.3	10.7	11.2	11.7	10.3	13.4
Fe (ppm.)	710.8	932.4	926.8	1457.3	850.6	1071.4
Zn (ppm.)	186.9	259.7	290.3	250.4	267.2	210.3
Mn (ppm.)	187.2	167.4	124.9	170.6	210.4	154.2
Cu (ppm.)	56.7	34.1	92.4	100.2	102.3	76.4
E.C. (mmoh/cm)	6.8	7.5	5.3	4.9	5.2	4.6
pH	7.9	8.1	7.2	7.5	7.2	7.6

The fertilization treatments were applied in the two seasons as follows :

1. NPK (300 – 300 – 100 kg. fertilizer/fed.), according to El-Gamasy *et al* (1985) as control.
2. Cattle manure (CM) at the rate of 20 m^3/fed.
3. Poultry manure (PM) at the rate of 10 m^3/fed.
4. Compost (C) at the rate of 15 m^3/fed.

The plants were harvested as following :-

The first cut on – June 15th
The second cut on – August 15th
The third cut on – November 15th

The experimental design was factorial experiment between irrigation and fertilization in split plots with three replicates. The irrigation treatments were arranged in the main plots, while the fertilization treatments were assigned at random in the sub plots. A guard two lines was left between each two experimental plots to avoid the overlapping infiltration. The data were statistically analyzed according to Steel and Torrie (1960) and L.S.D. at (5% & 1% levels) for comparison the means of different treatments. Essential oil percentage was determined in dry herb according to the British Pharmacopoeia (1963).

RESULTS AND DISCUSSION

1. Plant height

Data in Table (1) show the plant height of sweet marjoram (*Majorana hortensis* L.) as affected by irrigation and fertilization treatments.

As for the effect of irrigation treatments, data indicated that, increasing water irrigation amount from 1610 to 4876 m^3/fed resulted in significant increase in the plant height from 42.8 to 51.8 in the first cut, 38.7 to 43.3 in the second cut and 28.5 to 33.9 in the third cut this during the first season. While, during the second season, the plant height increased from 42.8 to 55.8 in the first cut, 40.6 to 45.8 in the second cut, 29.1 to 35.1 in the third cut.

The obtained increase in plant height was in harmony with several investigators applied different irrigation intervals (Agena, 1966, on *Pelargonium graveolens* L., El-Khyat, 1992, on cumin and Kandeel, 2001, on *Rosmarinus officinalis* L. plant). They reported that, short irrigation interval enhanced the plant height. Moreover, Yousef (2002) on chamomile plant found that, increasing irrigation amount from 934 to 2802 m^3/fed/season resulted in significant increase in plant height.

Concerning the effect of fertilization treatments, data presented in Table (1) show that, application of the organic manure gave significant increase comparing to chemical fertilization that was clear for the second and third cuttings of two seasons.

These results are in harmony with those obtained by El-Ghadban (1998) on *Origanum majorana*, Heikal (2005) on *Thymus vulgaris*, Sakr (2001) on *Mentha piperita* L., Abd El-Raouf (2001) on *Ocimum basilicum* and Hayat Hassan (2007) on rosell plants. They reported that, the NPK and organic fertilizers gave the tallest plant.

As for the interaction between the irrigation and fertilization, it is clear from the data tabulated in Table (1) showed that, the interaction did not show significant effect on plant height in the first and third cuts, while it was significant increase in the second cut during the two seasons.

2. Fresh and dry weight of herb (gm.)/plant :

Data in Tables (2 & 3) show the effect of irrigation and fertilization on fresh and dry weight of herb per plant of *Majorana hortensis* L. plant.

As for the main effect of irrigation, the data indicate that, the fresh weight of herb did not significantly affect with the irrigation treatments during the first cutting in the first season. While, the main effect indicate that, irrigation significantly increased the fresh and dry weight of herb/plant as irrigation water amount was increased from 1610 to 4876 m^3/fed/season during the second and third cuttings in the two successive seasons. The highest fresh and dry weight was recorded as a result of the highest rate of irrigation (4876 m^3/fed/season) which resulted in 207.8, 236.0 or 172.2 gm/plant, 71.8, 75.3 or 55.4 gm/plant dry weight and 231.3, 223.4 or 153.8 gm/plant fresh weight, 55.1, 79.0 or 50.5 gm/plant dry weight during the first and second season, respectively.

T1-2

T3-4

These results are in agreement with those obtained by Yousef (2002) on chamomile plant, reported that, increasing of water irrigation amount resulted in significant increase in the fresh and dry weight of herb, Kandeel (2001) on *Rosmarinus officinalis* and Agena (1966) on *Plargonium graveolens* found that, shorter irrigation intervals gave increases of fresh and dry weight of herb.

Also, the main effect of fertilization, indicate that, fertilization did not show significant effect during the first cut of the first season, while it was significantly increased the fresh and dry weight of herb, application the chemical fertilization (NPK) treatment significantly surpassed when compared with organic fertilization treatments which resulted 227.9, 188.8 and 194.4 fresh weight, 56.3, 69.6 and 58.1 dry weight during the first season, 242.0 193.6 and 191.3 fresh weight, 51.0, 76.5 and 55.3 dry weight during the second season, in the first, second and third cuttings. On the other side, application the poultry manure was nearly similar as the effect of chemical fertilization (NPK) and resulted in significant increase when compared the compost and cattle manure.

The favorable effect of NPK fertilization are support the minerals nutrient to roots plant and reflected on plant growth and development to, it is play an active role, protein metabolism, helps in osmotic, ionic regulation, functions as a cofactor, or activator for many enzymes of carbohydrates and protein metabolism and increasing of photosynthetic activity (Bidwell, 1974, Fageria *et al,* 1997 and El-Sayed *et al,* 2002 on spearmint and marjoram). Organic fertilizers amount soil properties when they are added to sunny soil they aggregate their particles and increase water holding capacity and nutrient availability this effects on plant growth.

Regarding the effect of the interaction between the irrigation and fertilization on fresh and dry weight, the data indicate that, interaction did not show significant effect in fresh and dry weight during the first cutting in the two seasons and second cutting in the first season. While, it was significant on the fresh and dry weight with second and third cuttings during the two seasons. The maximum values of fresh and dry weight were obtained when applied the moderate or high level of irrigation water amount (3220 or 4876 m^3/fed/season) combined with NPK fertilization or poultry manure at 10 m^3/fed.

3. Dry weight of leaves and stem/plant :

Data in Tables (4 & 5) show the effect of irrigation and fertilization on the dry weight of leaves and stems of marjoram plant during the three cuts of two successive seasons.

The main effect of irrigation, the results did not show significant effect in the first cut during the first season. On the other hand, the irrigation treatments gave significant effect on the leaves and stems in the second and third cuts during the two seasons. However, the plants irrigated with 4876 m^3/fed/season gave the highest weight of leaves and stems as 31.3, 45.1 or 28.7 gm/plant and 21.6, 46.4 or 26.3 gm/plant dry weight of leaves in the two seasons, respectively, and 40.5, 30.2 or 26.7 gm/plant and 35.5, 32.5 or 24.3 gm/plant dry weight of stem in the two seasons during the three cuts, respectively.

Similar results were recorded by Bishr (1972) on marjoram and Hassan *et al,* 1986 on mogat, they showed that, the fresh and dry weight of leaves were significantly increased by decreasing the intervals irrigation, also, Hayat Hassan on roselle.

Also, the main effect of fertilization, show that the dry weight of leaves and stems affected with the fertilization treatments in the second and third cuts during the two seasons. The maximum weight of leaves and stems obtained when NPK was applied in the second and third cuts during the two seasons and resulted in 41.1, 28.9 and 45.5, 28.5 and dry weight of leaves/plant and 28.6, 29.2 and 31.0, 26.8 and dry weight of stem/plant during the first and second seasons, respectively. While, application the poultry manure treatment resulted significant increase in the dry weight of leaves and stems when compared the other organic fertilization treatments.

The obtained results are generally in harmony with those reported by Hanafy (1989) on *Majorana hortensis*, stated that, N and K combination significantly increased dry weight of leaves and stem, Viera *et al* (2002) on *Calendula officinalis* and Hayat Hassan on roselle (2007).

As for the interaction between the irrigation and fertilization treatments, it is clear from the data that, the interaction did not show any significant effect on dry weight of leaves and stems during the first cutting in the two seasons and second cut in the first season. While, in the third cut, the data show significant increase in the dry weight of leaves and stem during the two seasons, the maximum values of dry weight of leaves and stem per plant obtained when applied the treatments of irrigation at 4876 m^3/fed/season combined with NPK fertilization. Also, the second cutting in the second season the data resulted significant increase in the dry weight of leaves and stem.

4. The total yield of fresh and dry weight of herb per plant :

Data of the main effect in Table (6) indicate that, increasing irrigation amount of water from 1610 to 4876 m^3/fed./season resulted in significant increase in the yield of fresh and dry weight of herb per plant of marjoram plant.

As for the main effect of fertilization, the results clear, there was significant increase in the yield of fresh and dry weight of herb per plant due to NPK treatment surpassed significantly organic fertilization treatments and poultry manure treatment gave significantly increase when compared with the other organic fertilization treatments with an increase of 13.9 & 20.8 % fresh weight than compost treatment in the two seasons, respectively, 13.3 & 14.9 % fresh weight than cattle manure in the two seasons, respectively, and dry weight was 25.5 & 26.8 % than compost treatment, in the two seasons, respectively, 7.2 & 8.4 % than poultry manure in the two seasons, respectively.

The increase in fresh and dry weight of herb due to chemical fertilization treatments with NPK are in harmony with El-Gamasy *et al* (1985) on *Majorana hortensis* L. mentioned that, the highest herbage yield was obtained from plants treated with calcium nitrate, calcium super phosphate and potassium sulfate at 300 : 300 : 100 kg/fed. Also, Hanafy (1989) stated that, N and K combination significantly increased of dry weight of herb and dry weight of leaves.

T5-6

Yousef (2002) on chamomile plant reported that, application ammonium sulphate, calcium super phosphate and potassium sulphate rate at 300 : 300 : 100 kg/fed. respectively resulted in significant increase in fresh and dry weight of herb.

The positive response of organic fertilization are in harmony with many authors, as El-Ghadban (1998) on *Mentha viridis* L. and *Origanum majorana*, Jacoub Rola (1999) on *Ocimum basilicum* and *Thymus vulgaris* L., El-Sayed *et al* (2002) on spearmint and marjoram plants and Yousef (2002) on *Matricaria chamomilla*, L.

Regarding the effect of interaction between the irrigation and fertilization, it is clear from the data that, the interaction of significant effect on yield of fresh and dry weight of herb per plant in the second season. While it was not significant during the first season the maximum values of the yield 687.2 & 704.9 gm fresh weight per plant in the two seasons, respectively, obtained with application of 3220.0 m^3/fed./season water amount combined with NPK fertilization treatment during the two seasons, respectively, and 226.1 & 216.5 gm dry weight per plant obtained when applied 4876 m^3/fed./season water amount combined with NPK fertilization treatment during the two seasons, respectively.

5. The yield of fresh and dry weight of herb per feddan (ton.) :

The data in Table (7) show the yield of fresh and dry weight of herb of sweet marjoram plant per feddan as affected by the irrigation and fertilization treatments.

The main effect of irrigation, indicate that, increasing water irrigation amount resulted in significant increase in the yield of fresh and dry weight of herb per feddan. The maximum values 13.553 & 13.386 ton. fresh weight were recorded in the two seasons, respectively, by using the higher amount of irrigation water 4876 m^3/fed/season, and 4.453 & 4.062 ton. dry weight were recorded in the two seasons, respectively, by using the same treatment.

The data also indicate that, the main effect of fertilization treatments resulted significant increase in the fresh and dry weight of herb per feddan. The NPK treatment significantly surpassed the other treatments and resulted 13.444 & 13.791 ton. per feddan fresh weight, 4.048 & 4.021 ton. dry weight in the two seasons, respectively.

Concerning the effect of organic fertilization on the yield of fresh and dry weight of herb, application of poultry manure at 10 m^3/fed. resulted in significant increase (12.485 & 12.385 ton. fresh weight and 3.922 & 3.562 ton. dry weight) in the two seasons, respectively, when compared with compost at 15 m^3/fed. and cattle manure at 20 m^3/fed.

The obtained results indicate there was no significant interaction between irrigation and fertilization treatments during the first season, but it was resulted significant increase during the second season, the highest weight of fresh yield of herb were 15.118 & 15.508 ton. per feddan were obtained when applied the moderate rate of irrigation water amount (3220 m^3/fed/season) combined with NPK fertilization treatments and the highest weight of dry yield of herb were 4.975 & 4.762 ton. per feddan were obtained by using the highest rate of irrigation water amount (4867 m^3/fed/season) combined with NPK fertilization treatments during the two successful seasons, respectively.

Application the poultry manure at 10 m^3/fed. when combined with the higher rate of irrigation (4876 m^3/fed./season) gave nearly similar values of the yield of fresh and dry weight of herb (14.305 & 14.107 ton. fresh weight and 4.688 & 4.088 ton. dry weight) per feddan in the two seasons, respectively.

6. Volatile oil percentage :

Results in Table (8) show that, the volatile oil percentage in marjoram dry herb was affected with the irrigation and fertilization treatments. The main effect of irrigation was significant. The maximum values were recorded as a result of highest rate of irrigation (4876 m^3/fed/season) which resulted in 2.90, 2.42 and 2.47 volatile oil percentage in the first, second and third cuts, respectively, during the first season, and 2.54, 2.36 and 2.58 in the first, second and third cuts, respectively, during the second season.

Regarding, the main effect of fertilization on volatile oil percentage in herb, application of NPK resulted high significant increase in the three cuts during the first and second seasons when compared with another fertilization treatments. The organic fertilization treatments, declared that, compost fertilization treatments resulted the less volatile oil content 2.30, 1.77 and 1.99 in the three cuts, respectively, during the first season and 1.96, 1.69 and 1.81 in the three cuts, respectively, during the second season.

Concerning the interaction effect between the irrigation and fertilization treatments, the data show that, the interaction did not show any significant effect on volatile oil percentage of marjoram plant during the two seasons. However, application of the irrigation rate at 4876 m^3/fed/season combined with fertilization treatment resulted the highest values of volatile oil percentage in the three cuttings. During the two seasons. The maximum values was obtained when applied 4876 m^3/fed/season water irrigation amount combined with NPK treatment (3.12, 3.04 and 3.06) in the first season and (2.89, 2.95 and 3.03) in the second season during the three cuttings.

7. Volatile oil constituents :

Volatile oil constituents as determined by gas chromatography was carried out on the chosen treatments in Table (9) which gave the maximum values of volatile oil percentage and the most of characters under this study. By gas chromatography mass spectrometry (GC. Ms) seven compounds were identified ; the main compound were Terpinene-4-01, Limonene, 1,8 Cineol and Linalool.

T7-8

Table (9): Effect of irrigation and fertilization on volatile oil constituents of marjoram plant.

Compounds / Treatments	α-Pinene	β-Pinene	Limonene	1,8 Cineol	γ-Terpinene	Linalool	Terpinene-4-Ol	Unidentified
4876 m^3/fed. + Compost	3.94	9.06	23.41	16.12	5.86	10.64	26.53	4.44
4876 m^3/fed. + Poultry manure	4.63	9.05	26.25	18.13	5.94	7.18	23.71	5.11
4876 m^3/fed. +NPK	3.69	8.62	23.08	17.23	5.56	7.22	27.31	7.29
3220 m^3/fed. + NPK	3.84	8.94	23.58	15.34	5.81	11.15	25.93	5.41
4876 m^3/fed. + cattle manure	1.58	8.60	13.22	12.57	6.70	14.21	33.51	9.61

Data presented in Table (9) showed that, the maximum Terpinene-4-Ol content (33.51 %) was obtained from the high level of irrigation (4876 m^3/fed/season) combined with cattle manure fertilization treatments and the following 27.31 % was obtained the high level of irrigation combined with NPK fertilization treatment, while, the minimum Terpinene-4-01 content (23.71 %) was obtained from the high level of irrigation combined with poultry manure treatment.

However, the maximum Limonene content (26.25 %) was resulted from the high level of irrigation combined with poultry manure treatment, while, the minimum Limonene content (13.22 %) was obtained from the high level of irrigation combined with cattle manure treatment.

Also, the maximum 1,8 Cineole content (18.13 %) was resulted from the high level of irrigation combined with poultry manure treatment, while, the minimum 1,8 Cineole (12.57 %) was obtained from the high level of irrigation combined with cattle manure treatment.

Regarding, Linalool content, the maximum value (14.21 %) was obtained from the high level of irrigation combined with cattle manure treatment, while, the minimum value (7.18 %) was resulted from the high level of irrigation combined with poultry manure treatment.

8. Macro elements percentage of herb :

8.1. Nitrogen :

The results in Table (10) show that, the nitrogen content in the herb of marjoram plant was affected with the irrigation and fertilization treatments. The main effect of irrigation recorded significant increase by increasing the water amount of irrigation from 1610 to 4876 m^3/fed./season. Application the high rate gave the maximum values of nitrogen content 2.60 and 2.69 in the two seasons, respectively. The main effect of fertilization treatments resulted in significant increase in nitrogen percentage with chemical fertilization (NPK) treatment which significantly surpassed the organic fertilization treatments. On the other side, the cattle manure fertilization treatment gave significant increase when compared to poultry manure and compost fertilization treatments.

T10

As for the interaction between the irrigation and fertilization treatments, the data showed significant increase in nitrogen percentage of marjoram herb according to the increasing rates of irrigation and fertilization during the two successive seasons.

8.2. Phosphorus :

Data in Table (10) show the main effect of irrigation and fertilization on phosphorus percentage was significantly increased by increasing the water amount of irrigation. The maximum values of phosphorus percentage 0.347 and 0.415 was obtained the high rate of water irrigation amount (4876 m^3/fed./season) during the two seasons, respectively.

As for the main effect of fertilization, the data indicate that, applied NPK treatment resulted heigh significant increase and poultry manure gave the highest phosphorus content in herb when compared with compost or cattle manure treatments in the two seasons.

The interaction effect between the irrigation and fertilization treatments did not show significant effect on the phosphorus percentage in herb of marjoram plant in the two successive seasons.

8.3. Potassium :

The data in Table (10) show the potassium percentage as affected by irrigation and fertilization. The results of irrigation main effect indicate parallel significant increase in potassium percentage as irrigation rate increased from 1610 to 4876 m^3/fed./season. Hence the maximum potassium content in herb (1.99 and 2.09) was obtained by application of 4876 m^3/fed./season in the two seasons, respectively.

Considering the main effect of fertilization, the data clear that, application of NPK treatment resulted in significant increase in potassium content (1.98 and 2.04) in the two seasons, respectively, but application poultry manure surpassed compost or cattle manure.

As for the effect of interaction, the data clear significant interaction which indicate that, the maximum potassium content (2.22 and 2.04) was recorded for the highest irrigation rate (4876 m^3/fed./season) combined with NPK treatment, respectively, during the two seasons.

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تأثير الرى والتسميد على النمو وإنتاجية نبات البردقوش فى الأراضى الرملية

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هذا البحث تم فى موسمين زراعيين ناجحين فى ٢٠٠٤ – ٢٠٠٥ فى المزرعة البحثية لمحطة بحوث البساتين بالقصاصين – محافظة الإسماعيلية – مصر ، لدراسة تأثير معدلات الرى (١٦١٠ ، ٣٢٢٠ , ٤٨٧٦ م٣/فدان/موسم) ومعاملات التسميد (ن ، فو ، بو وأسمدة عضوية) على النمو الخضرى ومحصول الزيت والمكونات الكيميائية لنبات البردقوش فى الأراضى الرملية .

وجد أنه بإستخدام المعدل العالى للرى (٤٨٧٦ م٣/فدان/موسم) فإنه يعطى أعلى قيم من الصفات الخضرية مثل طول النبات والوزن الطازج والجاف للعشب للنبات والوزن الجاف للأوراق والسيقان والمحصول من الوزن الطازج والجاف من العشب لكل من النبات والفدان ، وكذلك المكونات الكيميائية مثل النسبة المئوية للزيت والمحتوى من ن ، فو ، بو وذلك عند مقارنة هذه المعاملة بمعاملات الرى الأخرى ١٦١٠ ، ٣٢٢٠ م٣/فدان/موسم فى الثلاث حشّات أثناء الموسمين .

معاملة التسميد بـ (ن فو بو) أعطت تفوقاً معنوياً للصفات الخضرية ونسبة الزيت والمكونات الكيميائية عند مقارنتها مع التسميد العضوى المستخدم وهو (كمبوست – مخلفات الدواجن – مخلفات المواشى).

وعلى جانب آخر عند مقارنة التسميد بسماد الدواجن مع الأسمدة العضوية الأخرى فإنه أعطى زيادة فى معظم الصفات تحت الدراسة .

وعند رى نباتات البردقوش بكمية من مياه قدرها ٤٨٧٦ م٣/فدان/موسم تحت نظام الرى بالتنقيط مقترنة بتسميد بسماد الدواجن بمعدل ١٠ م٣/فدان فإنه يعطى ١٤,٣٠٥ طن محصول عشب طازج و ٤,٦٨٨ طن محصول عشب جاف للفدان فى العام ، وكذلك نسبة زيت طيار قدرها ٢,٦٣% .

أعلى محتوى من التربينول-٤-١٠ والليناليول تم الحصول عليها من معاملة المستوى العالى من الرى (٤٨٧٦ م٣/فدان/موسم) المتحد مع معاملة سماد المواشى . بينما المحتوى العالى من ١,٨ سينيول والليمونين قد نتج من المستوى العالى من الرى مع معاملة سماد الدواجن .

Table (1): Effect of Irrigation and fertilization on the plant height (cm) of marjoram plants of three cuts during the two seasons of 2005 and 2006

Fertilization (B)	1st Cut					2nd Cut					3rd Cut				
	NPK	Compost	Poultry manure	Cattle manure	$Mean_A$	NPK	Compost	Poultry manure	Cattle manure	$Mean_A$	NPK	Compost	Poultry manure	Cattle manure	$Mean_A$
Irrigation (A)	1st season														
1610 m^3/fed.	44.0	39.7	41.0	46.7	42.8	37.3	39.7	38.0	39.7	38.7	24.0	31.0	26.7	32.3	28.5
3220 m^3/fed.	53.3	50.3	55.7	54.3	53.4	38.7	38.3	43.0	45.7	41.4	31.7	31.3	33.7	33.7	32.6
4876 m^3/fed.	49.7	48.7	58.0	51.0	51.8	42.0	39.3	44.0	47.7	43.3	32.3	34.7	33.0	35.7	33.9
$Mean_B$	49.0	46.2	51.6	50.7		39.3	39.1	41.7	44.3		29.3	32.3	31.1	33.9	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	5.9	NS		NS		NS	1.6		2.8		4.0	2.5		NS	
LSD at 1%	NS	NS		NS		NS	2.2		3.8		NS	3.4		NS	
	2nd season														
1610 m^3/fed.	44.3	39.3	41.0	46.7	42.8	44.3	38.3	40.0	39.7	40.6	34.0	29.0	24.3	29.0	29.1
3220 m^3/fed.	58.0	50.7	54.7	53.3	54.2	49.3	39.3	43.0	48.3	45.0	34.3	27.0	33.7	33.7	32.2
4876 m^3/fed.	62.0	49.3	57.7	54.3	55.8	51.0	39.3	42.7	50.0	45.8	40.3	29.3	35.0	35.7	35.1
$Mean_B$	54.8	46.4	51.1	51.4		48.2	39.0	41.9	46.0		36.2	28.4	31.0	32.8	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	3.0	3.2		NS		NS	1.8		3.2		1.6	2.5		4.2	
LSD at 1%	4.9	4.3		NS		NS	2.5		4.4		2.6	3.4		NS	

Table (2): Effect of Irrigation and fertilization on the fresh weight of herb (gm)/plant of marjoram plants of three cuts during the two seasons of 2005 and 2006

Fertilization (B)	1st Cut					2nd Cut					3rd Cut				
	NPK	Compost	Poultry manure	Cattle manure	$Mean_A$	NPK	Compost	Poultry manure	Cattle manure	$Mean_A$	NPK	Compost	Poultry manure	Cattle manure	$Mean_A$
Irrigation (A)	1st season														
1610 m^3/fed.	192.0	182.7	200.7	183.3	189.7	116.3	95.0	100.7	108.7	105.2	174.2	95.0	153.7	76.5	124.9
3220 m^3/fed.	267.7	219.0	228.3	215.3	232.6	217.3	192.0	222.3	217.7	212.3	202.2	126.4	146.5	131.8	151.7
4876 m^3/fed.	224.0	234.0	170.3	203.0	207.8	232.7	215.7	267.7	228.7	236.0	206.9	132.0	212.2	137.8	172.2
$Mean_B$	227.9	211.9	199.8	200.6		188.8	167.6	196.8	184.8		194.4	117.8	170.8	115.4	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	NS	NS		NS		8.7	16.0		NS		25.4	15.4		26.7	
LSD at 1%	NS	NS		NS		14.4	22.0		NS		NS	21.1		NS	
	2nd season														
1610 m^3/fed.	194.7	173.3	191.0	171.7	182.7	120.0	95.7	108.0	111.3	108.8	164.2	92.7	143.7	73.2	118.5
3220 m^3/fed.	275.0	216.0	230.0	224.7	236.4	219.0	169.0	230.0	203.0	205.3	210.9	118.1	144.5	122.5	149.0
4876 m^3/fed.	256.3	217.7	225.7	225.3	231.3	241.7	198.7	243.3	210.0	223.4	198.9	117.0	172.2	127.1	153.8
$Mean_B$	242.0	202.3	215.6	207.2		193.6	154.4	193.9	174.8		191.3	109.2	153.5	107.6	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	27.5	16.2		NS		8.1	10.9		18.9		11.9	10.5		18.2	
LSD at 1%	NS	22.2		NS		13.5	14.9		NS		19.8	14.4		25.0	

Table (3): Effect of Irrigation and fertilization on the dry weight of herb (gm)/plant of marjoram plants of three cuts during the two seasons of 2005 and 2006

Fertilization (B)	1st Cut					2nd Cut					3rd Cut				
	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$
Irrigation (A)	1st season														
1610 m^3/fed.	42.7	34.1	55.9	47.8	45.1	55.2	34.7	42.1	41.9	43.5	41.3	32.1	40.5	32.8	36.7
3220 m^3/fed.	55.7	75.0	62.6	61.1	63.6	71.9	43.8	70.1	59.5	61.3	59.1	41.6	52.3	52.4	51.4
4876 m^3/fed.	70.5	66.4	79.3	70.8	71.8	81.8	59.0	81.6	78.0	75.3	73.8	39.9	52.2	55.6	55.4
Mean$_B$	56.3	58.5	65.9	59.9		69.6	45.8	64.6	59.8		58.1	37.9	48.3	46.9	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	15.7	NS		NS		14.4	3.6		NS		5.6	3.4		6.0	
LSD at 1%	NS	NS		NS		NS	4.9		NS		9.3	4.7		8.2	
	2nd season														
1610 m^3/fed.	39.8	33.8	37.7	33.9	36.3	59.1	37.8	42.8	45.2	46.2	46.3	28.6	40.1	29.1	36.0
3220 m^3/fed.	52.1	48.3	50.8	52.7	51.0	81.0	46.9	78.8	62.2	67.2	53.5	34.5	49.8	41.3	44.8
4876 m^3/fed.	61.0	53.0	52.4	54.3	55.1	89.4	61.6	83.2	82.0	79.0	66.1	38.7	50.2	47.0	50.5
Mean$_B$	51.0	44.9	47.0	47.0		76.5	48.8	68.2	63.1		55.3	33.9	46.7	39.2	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	3.4	3.7		NS		3.5	3.2		5.5		3.1	2.8		4.9	
LSD at 1%	5.7	5.0		NS		5.9	4.4		7.6		5.2	3.9		NS	

Table (4): Effect of Irrigation and fertilization on the dry weight of leaves (gm)/plant of marjoram plants of three cuts during the two seasons of 2005 and 2006

Fertilization (B)	1st Cut					2nd Cut					3rd Cut				
	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$
Irrigation (A)	1st season														
1610 m^3/fed.	18.0	14.2	25.7	23.7	20.4	36.0	21.0	24.2	25.4	26.6	21.3	16.6	17.5	16.2	17.9
3220 m^3/fed.	24.2	33.2	25.9	26.4	27.4	42.0	27.0	43.4	36.4	37.2	31.6	22.5	26.2	30.2	27.6
4876 m^3/fed.	30.4	27.3	34.7	32.8	31.3	45.1	37.8	48.9	48.4	45.1	33.8	18.7	28.7	33.6	28.7
Mean$_B$	24.2	24.9	28.8	27.6		41.1	28.6	38.8	36.7		28.9	19.2	24.2	26.6	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	NS	NS		NS		9.2	5.5		NS		3.4	3.1		5.4	
LSD at 1%	NS	NS		NS		NS	7.5		NS		5.6	4.3		NS	
	2nd season														
1610 m^3/fed.	18.9	17.2	18.2	16.0	17.6	37.3	22.7	25.8	27.2	28.3	24.6	15.6	18.8	15.5	18.6
3220 m^3/fed.	21.3	20.9	21.4	21.9	21.4	48.8	29.5	50.8	37.8	41.7	29.0	18.6	24.9	23.9	24.1
4876 m^3/fed.	23.7	20.5	20.4	21.7	21.6	50.5	38.2	48.2	49.4	46.6	31.8	20.0	26.3	27.0	26.3
Mean$_B$	21.3	19.5	20.0	19.9		45.5	30.1	41.6	38.1		28.5	18.1	23.3	22.1	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	1.9	NS		NS		4.4	2.9		5.1		2.3	2.0		NS	
LSD at 1%	3.2	NS		NS		7.3	4.0		6.9		3.9	2.8		NS	

Table (5): Effect of Irrigation and fertilization on the dry weight of stem/plant of marjoram plants of three cuts during the two seasons of 2005 and 2006

Fertilization (B)	1st Cut					2nd Cut					3rd Cut				
	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compos	Poultry manure	Cattle manure	Mean$_A$
Irrigation (A)	1st season														
1610 m^3/fed.	24.7	19.9	30.2	24.0	24.7	19.2	13.7	17.9	16.5	16.8	20.0	15.5	22.9	16.6	18.8
3220 m^3/fed.	31.5	41.8	36.7	34.7	36.2	29.9	16.8	26.7	23.1	24.1	27.5	19.2	26.1	22.2	23.8
4876 m^3/fed.	40.1	39.1	44.6	38.0	40.5	36.7	21.8	32.7	29.6	30.2	40.0	21.2	23.5	22.1	26.7
Mean$_B$	32.1	33.6	37.2	32.3		28.6	17.4	25.8	23.1		29.2	18.6	24.2	20.3	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	6.8	NS		NS		2.6	2.7		NS		4.3	2.8		4.9	
LSD at 1%	11.3	NS		NS		4.3	3.8		NS		NS	3.9		6.7	
	2nd season														
1610 m^3/fed.	20.9	16.7	19.5	17.9	18.8	21.8	15.1	16.9	18.0	18.0	21.6	13.0	21.3	13.6	17.4
3220 m^3/fed.	30.7	27.5	29.4	30.8	29.6	32.2	17.5	28.0	24.4	25.5	24.5	15.8	24.9	17.5	20.7
4876 m^3/fed.	37.3	32.1	32.0	32.6	33.5	38.9	23.4	35.0	32.6	32.5	34.3	18.7	23.9	20.1	24.3
Mean$_B$	29.7	25.3	27.0	27.1		31.0	18.7	26.6	25.0		26.8	15.9	23.4	17.1	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	3.4	NS		NS		2.5	2.0		3.5		2.1	1.8		3.1	
LSD at 1%	5.6	NS		NS		4.1	2.8		4.8		3.4	2.5		4.3	

Table (6): Effect of Irrigation and fertilization on the total yield of the fresh and dry weight of marjoram herb (gm) per plant per season during the two seasons of 2005 and 2006

Fertilization (B)	Fresh weight of herb/plant/season					Dry weight of herb/plant/season				
Irrigation (A	NPK	Compost	Poultry manure	Cattle manur	Mean$_A$	NPK	Compost	Poultry manure	Cattle manur	Mean$_A$
	First season									
1610 m^3/fed.	482.5	372.7	455.1	368.5	419.7	139.2	100.9	138.5	122.5	125.3
3220 m^3/fed.	687.2	537.4	597.2	564.8	596.7	186.7	160.4	184.9	174.4	176.6
4876 m^3/fed.	663.5	583.9	650.2	568.8	616.6	226.1	165.9	213.1	204.5	202.4
Mean$_B$	611.1	498.0	567.5	500.7		184.0	142.4	178.8	166.7	
	A	B		AB		A	B		AB	
LSD at 5%	106.4	50.4		NS		20.5	11.0		NS	
LSD at 1%	NS	69.1		NS		34.0	15.1		NS	
	Second season									
1610 m^3/fed.	478.9	361.7	442.7	356.2	409.9	145.2	100.2	120.6	108.3	118.6
3220 m^3/fed.	704.9	503.1	604.9	550.2	590.8	186.5	129.7	179.3	156.2	163.0
4876 m^3/fed.	696.9	533.3	641.2	562.4	608.5	216.5	153.0	185.8	183.3	184.6
Mean$_B$	626.9	466.0	562.9	489.6		182.7	127.6	161.9	149.3	
	A	B		AB		A	B		AB	
LSD at 5%	26.8	17.9		31.0		4.0	5.2		8.9	
LSD at 1%	44.4	24.5		NS		6.6	7.1		12.2	

Table (7): Effect of Irrigation and fertilization on the yield of the fresh and dry weight of marjoram herb (ton) per feddan per season during the two seasons of 2005 and 2006

Fertilization (B)	Fresh weight of herb/fed./season					Dry weight of herb/fed./season				
Irrigation (A)	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$
	First season									
1610 m^3/fed.	10.616	8.199	10.011	8.108	9.233	3.062	2.220	3.047	2.694	2.756
3220 m^3/fed.	15.118	11.823	13.138	12.426	13.126	4.108	3.530	4.069	3.837	3.886
4876 m^3/fed.	14.598	12.796	14.305	12.513	13.553	4.975	3.649	4.688	4.499	4.453
Mean$_B$	13.444	10.939	12.485	11.016		4.048	3.133	3.935	3.677	
	A	B		AB		A	B		AB	
LSD at 5%	2.339	1.103		NS		0.451	0.243		NS	
LSD at 1%	NS	1.512		NS		0.747	0.332		NS	
	Second season									
1610 m^3/fed.	10.535	7.957	9.740	7.836	9.017	3.195	2.205	2.653	2.382	2.609
3220 m^3/fed.	15.508	11.067	13.307	12.104	12.997	4.104	2.854	3.945	3.436	3.585
4876 m^3/fed.	15.331	11.733	14.107	12.374	13.386	4.762	3.365	4.088	4.033	4.062
Mean$_B$	13.791	10.252	12.385	10.771		4.021	2.808	3.562	3.284	
	A	B		AB		A	B		AB	
LSD at 5%	0.589	0.394		0.682		0.088	0.113		0.196	
LSD at 1%	0.977	0.539		NS		0.146	0.155		0.268	

Table (8): Effect of Irrigation and fertilization on the volatile oil percentage/dry weight plant of marjoram plants of three cuts during the two seasons of 2005 and 2006

Fertilization (B)	1st Cut					2nd Cut					3rd Cut				
	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$	NPK	Compost	Poultry manure	Cattle manure	Mean$_A$
Irrigation (A)	1st season														
1610 m^3/fed.	2.44	1.70	2.28	2.23	2.16	2.20	1.37	1.81	1.66	1.76	2.48	1.93	2.21	2.02	2.16
3220 m^3/fed.	2.92	2.37	2.79	2.59	2.67	2.72	2.00	2.30	2.09	2.28	2.91	2.04	2.34	2.28	2.39
4876 m^3/fed.	3.12	2.83	2.88	2.76	2.90	3.04	1.96	2.50	2.17	2.42	3.06	2.00	2.51	2.32	2.47
Mean$_B$	2.83	2.30	2.65	2.53		2.65	1.77	2.20	1.97		2.82	1.99	2.35	2.21	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	0.25	0.15		NS		0.19	0.15		NS		NS	0.17		NS	
LSD at 1%	0.41	0.21		NS		0.32	0.21		NS		NS	0.24		NS	
	2nd season														
1610 m^3/fed.	2.65	1.67	1.91	1.72	2.00	2.64	1.51	1.60	1.59	1.84	2.72	1.49	2.30	2.28	2.20
3220 m^3/fed.	2.86	1.95	2.10	2.12	2.26	2.82	1.78	1.88	1.88	2.09	2.68	1.75	2.28	2.34	2.26
4876 m^3/fed.	2.89	2.25	2.44	2.58	2.54	2.95	1.77	2.19	2.53	2.36	3.03	2.20	2.46	2.62	2.58
Mean$_B$	2.80	1.96	2.15	2.14		2.80	1.69	1.89	2.00		2.81	1.81	2.35	2.42	
	A	B		AB		A	B		AB		A	B		AB	
LSD at 5%	0.13	0.17		NS		0.08	0.18		0.31		NS	0.15		NS	
LSD at 1%	0.22	0.24		NS		0.13	0.24		NS		NS	0.21		NS	

Table (10): Effect of Irrigation and fertilization on the macro elements percentage of marjoram plants during the two seasons of 2005 and 2006

Fertilization (B)	Nitrogen					Phosphorus					Potassium				
	NPK	Compost	Poultry manure	Cattle manure	Mean A	NPK	Compost	Poultry manure	Cattle manure	Mean A	NPK	Compost	Poultry manure	Cattle manure	Mean A
Irrigation (A)	**1st season**														
1610 m³/fed.	2.45	1.86	2.20	2.56	2.27	0.323	0.180	0.250	0.230	0.246	1.82	1.61	1.75	1.71	1.72
3220 m³/fed.	2.96	2.09	2.61	2.60	2.56	0.427	0.283	0.343	0.240	0.323	1.91	1.68	1.82	1.72	1.78
4876 m³/fed.	3.23	2.28	2.28	2.62	2.60	0.483	0.263	0.353	0.287	0.347	2.22	1.78	2.06	1.89	1.99
Mean B	2.88	2.08	2.36	2.59		0.411	0.242	0.316	0.252		1.98	1.69	1.88	1.77	
	A	**B**		**AB**		**A**	**B**		**AB**		**A**	**B**		**AB**	
LSD at 5%	**0.18**	**0.08**		**0.13**		**0.054**	**0.072**		**NS**		**0.06**	**0.03**		**0.05**	
LSD at 1%	**NS**	**0.11**		**0.18**		**NS**	**0.098**		**NS**		**0.09**	**0.04**		**0.07**	
	2nd season														
1610 m³/fed.	**2.76**	**1.88**	**2.38**	**2.71**	**2.43**	**0.327**	**0.220**	**0.283**	**0.233**	**0.266**	**1.82**	**1.62**	**1.73**	**1.71**	**1.72**
3220 m³/fed.	**3.01**	**2.27**	**2.61**	**2.51**	**2.60**	**0.480**	**0.310**	**0.413**	**0.340**	**0.386**	**1.98**	**1.82**	**1.91**	**1.82**	**1.88**
4876 m³/fed.	**3.24**	**2.28**	**2.62**	**2.64**	**2.69**	**0.543**	**0.330**	**0.433**	**0.353**	**0.415**	**2.31**	**1.88**	**2.21**	**1.95**	**2.09**
Mean B	**3.00**	**2.14**	**2.54**	**2.62**		**0.450**	**0.287**	**0.377**	**0.309**		**2.04**	**1.77**	**1.95**	**1.83**	
	A	**B**		**AB**		**A**	**B**		**AB**		**A**	**B**		**AB**	
LSD at 5%	**0.08**	**0.05**		**0.09**		**0.054**	**0.026**		**NS**		**0.04**	**0.03**		**0.05**	
LSD at 1%	**0.13**	**0.07**		**0.13**		**0.089**	**0.035**		**NS**		**0.07**	**0.04**		**0.07**	