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RESPONSE OF BASIL PLANTS TO DRIP IRRIGATION RATS AND ORGANIC FERTILIZERS IN SANDY SOIL CONDITIONS

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ABSTRACT

Drip irrigation rates and organic fertilizers influenced the vegetative growth and oil content of sweet basil (Ocimum basilicum L.) plant cultivated in sandy soil, at the Experimental Farm of El-Quassasin Horticultural Research Station, Ismailia Governorate, Egypt, during the two successive seasons of 2005 and 2006. Water irrigation amount at 5096 m^3/fed./season significantly increased the vegetative growth and essential oil yield/plant and feddan as compared with other rates. The poultry manure at 20 m^3/fed. produced the highest values of vegetative growth (plant height, number of branches/plant, leaves/stems ratio, fresh and dry weight of herb/plant and per cut during season and the yield of fresh and dry weight of herb/fed. in the two seasons) as compared with the NPK and organic fertilization treatments. While cattle manure at the rate of 60 m^3/fed. gave the highest essential oil yield/plant and fed. Irrigated basil plants with drip irrigation system at water amount of 5096 m^3/fed./season combined with 20 m^3/fed. poultry manure gave the best results of vegetative growth, while plants watered 5096 m^3/fed./season combined with 60 m^3/fed. cattle manure resulted in the highest essential oil yield/plant and feddan when compared to other combination treatments, in both seasons.

INTRODUCTION

Recently, medicinal and aromatic plants have a major role in agriculture and industry. They are the main source of safety drugs and raw substances used in manufacturing of pharmaceuticals. Some of their components are the nucleus to which the chemical biosynthesis for some important drugs such as cortisone, sex hormones, plasma substitutes and others.

Sweet basil plants (*Ocimum basilicum* L.), Fam. Lamiaceae (Labiatea), should be grown in full sun, in well drained soil. It acts principally on digestive and nervous system, stomach cramps, colic and indigestion. It can be used to prevent nausea and vomiting and help to kill intestinal worms, it has mild sedative action. 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 flavours including confectioners, backed foods and condimentary, (Gunther, 1961).

Many authors have revealed that short irrigation intervals enhanced the vegetative growth and essential oil content. Reffaat and Saleh (1998) found that the sweet basil (*Ocimum basilicum* L.) growth was reduced by increasing intervals of irrigation from 7, 14 to 28 days. The highest yield of essential oil/fed. were obtained from plants received the shortest irrigation interval and vice versa.

Khater *et al* (1996) showed that irrigation intervals every one week had clear effect and significantly increased the plant height and fresh and dry

weight of *Mentha piperita* L. herb. Kandeel (2001) on rosemary (*Rosmarinus officinalis* L.) reported that irrigation every 14 days significantly increased number of branches/plant, fresh weight of both herb and roots/plant and yearly yield of fresh and dry herb/plot compared with intervals of 7 or 21 days. The volatile oil percentage tended to increase by increasing irrigation intervals from 7 to 21 days. However, the highest oil yield was resulted from plants irrigated every 14 days. Yousef (2002) mentioned that increased irrigation rate to 2802 m^3/fed./season (126 L./plant/season) combined with $N_2P_2K_2$, 10, 20, 30 and 40 m^3/fed. poultry manure increased dry inflorescences yield of *Matricaria chamomilla* by 65.81, 83.55, 62.00, 74.67 and 83.26 kg/fed. dry inflorescences, respectively, comparing to 934 m^3/fed./season (42 liter/plant/season).

Organic manuring is a modern approach in agriculture practices that manipulate organic wastes to provides the growing plants with their nutritional requirements without having an undesirable impact on the human health and environment. Using organic manure will reduce the hazards induced by excessive application of chemical fertilizers. It is estimated that only 50 % of the applied nitrogen fertilizers is used by plants, while most of the remainder is lost by either leaching or denitrification. The concentration of the toxic nitrate up to a toxic level is usually prevalent in water reservoirs in the vicinity of heavily fertilized fields. This approach is particularly important in the newly reclaimed lands, where it improve chemical and physical characteristics of the soil and sustain soil fertility to support high crop yield, reported by Lampkin (1990), Mohamed and Matter (2001) and Yousef (2002) and the organic fertilizers consider save for human health.

Several studies were carried out to test the effect of organic manure fertilizers on medicinal and aromatic plants. In this concern, Jacoub (1999) on *Ocimum basilicum* concluded that poultry manure (PM) at 5, 10 and 20 m^3/fed. ; cattle manure (CM) and horse manure (HM) at 20 or 40 m^3/fed. increased plant height than the control. PM at 20 m^3/fed. significantly increased the leaf area, the number of branches/plant, herb fresh and dry yields comparing with the untreated plants. On *Thymus vulgaris* PM at 20 m^3/fed. increased significantly the plant height and number of branches/plant. Herb fresh and dry weights/plant were significantly increased by PM at 20 m^3/fed. and CM at 40 m^3/fed. Similar trend was observed by El-Ghadban (1998) on *Mentha viridis* showed that poultry manure (PM) at 30 m^3/fed. significantly increased the herb fresh and dry yields, followed by cattle manure (CM) at 60 m^3/fed. These treatments were more effective in increasing the plant height and leaf area. Moreover, the same treatments were the best for increasing herb fresh and dry weights of *Origanum majorana*. PM at 20 m^3/fed. and CM at 40 m^3/fed. gave higher leaves fresh weight : stems fresh weight ratio. Sakr (2001) on *Mentha piperita* reported that the best results (in terms of fresh and air dry herb yields, and essential oil yield) were obtained from plants fertilized with chemical fertilization (NPK at 900 kg./fed./season), poultry manure at 20 m^3/fed./season or sheep manure at the rate of 30 m^3/fed./season.

This study was conducted to compare the effect of conventional chemical NPK fertilization with those of two types of organic manures (poultry and

cattle manures) each with two levels, on the growth and yield of essential oil of basil plants grown in newly reclaimed region, and irrigated at different intervals using drip irrigation system.

MATERIALS AND METHODS

This investigation was carried out during the two successive seasons of 2005 and 2006 at the Experimental Farm of El-Quassassin Horticultural Research Station, Ismailia Governorate, Agricultural Research Center (A.R.C.), Egypt.

The seeds of basil (*Ocimum basilicum* L.) plants were obtained from the Medicinal and Aromatic Plants Section, Horticulture Research Institute, A.R.C., at El-Kanater El-Khairia, Kalubia Governorate. Seeds were planted in the nursery on March 15th in both seasons. The seedlings were transplanted after 45 days in plots of 6 m^2 (5.0 X 1.2 m) which contained the two drip irrigation lines spaced 60 cm apart. Transplanting distance was 25 cm between plants. The drippers (with a discharge of 2 liters/hour) were spaced at 50 cm on the irrigation lines. During and after transplanting, all seedlings were irrigated 2 hours every day at the first week. Then, the plants were watered one time/day (starting 09 : 00 Am) for a duration of 2 hours in each treatment. Standard agricultural practices were followed.

The plants irrigated 84, 42 and 24 times for irrigation intervals treatments (2, 4 and 7 days), respectively, in the two seasons, and the water irrigation amount treatments added per feddan during the plant growing season were shown in Table (B)

The experiment included 15 treatments (3 irrigation rates X 5 fertilization levels) and 3 replicates, which were distributed in split plot using a randomized complete block design. The main plots were the drip irrigation rates (5096, 2744 and 1637 m^3/fed/season), while the fertilization treatments [chemical NPK (400 : 300 : 150 kg/fed. respectively), 10 m^3 poultry manure (PM_{10}), 20 m^3 poultry manure (PM_{20}), 30 m^3 cattle manure (CM_{30}) and 60 m^3 cattle manure (CM_{60})] were the sub-plot.

The mechanical and chemical analysis of soil, and the analysis of organic fertilizers used in this study were done at Water and Soil Lab. (A.R.C.), and the obtained results are shown in Tables (A and C).

The organic fertilizers were added to the soil before transplanting by 15 days and watered until the cultivation. Plants of the chemical fertilization treatment were supplied with ammonium sulphate (20.5 % N), calcium superphosphate (15.5 % P_2O_5) and potassium sulphate (48 % K_2O). Ammonium sulphate (400 kg/fed.) was added as a basal dressing in three doses (100 kg/fed. was added one month after transplanting, then 150 kg/fed. after one month from the first, while the third dose 150 kg/fed. after the first cut). Calcium superphosphate was added at the rate of 300 kg/fed. during soil preparation. While potassium sulphate (150 kg/fed.) was added in two doses (75 kg/fed. for each one), which were added at the same time as the second and third doses of ammonium sulphate.

Plants were cut twice, the first one on August 15th and the second was on October 15th in both seasons, by cutting the vegetative parts of the plants 10 cm above the soil surface.

The following data were recorded in both cuts during the two seasons :

1- Plant height (cm) / cut / season
2- Number of branches / plant / cut / season
3- Leaves / stems ratio / cut / season
4- Fresh and dry weight of herb (g) / plant / cut / season
5- The yield of fresh and dry weight of herb (g) / plant / season
6- The yield of fresh and dry weight of herb (ton) / fed. / season
7- Essential oil percentage and oil yield (ml) / plant / cut / season
8- Essential oil yield (L) / fed. / season

Essential oil percentage was determined in dry herb according to the **British Pharmacopoeia (1963)**.

The statistical analysis was performed for the data using method outlined by **Snedecor and Cochran (1972)**, using L.S.D. at (5% & 1% levels) for comparison the means of different treatments.

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
Field capacity (F.C.)		**Micro elements (ppm)**	
Welting point (W.P.)	11.20 %	**Fe**	2.0
Organic matter	2.20 %	**Cu**	---
pH (1 soil : 2.5 d.w.)	0.42 %	**Zn**	0.26
E.C. (mmohs/cm)	8.1	**Mn**	0.8
	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

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

Irrigation intervals	Irrigated times/season	Water quantities m^2/fed/season
2	**84***	**5096**
4	**42***	**2744**
7	**24***	**1637**

*** In addition to 392 m^3/fed. were added for all treatments during the first week after transplanting.**

Table (C): Analysis of poultry and cattle manures before adding to the experimental soil

Organic fertilizer report	Poultry manure		Cattle manure	
	1st season	2nd season	1st season	2nd season
Weight of m^3(kg)	265	260	332	340
Humidity %	6.9 %	8.70 %	7.6 %	8.0 %
Total nitrogen %	3.35 %	4.16 %	1.29 %	1.18 %
Ammonia, mg/kg	910.1	930.1	1.172	1.273
Nitrate, mg/kg	71.3	75.9	917.0	930.1
Total phosphorus, %	0.4 %	0.7 %	0.29 %	0.68 %
Total potassium, %	2.15 %	1.89 %	1.75 %	1.86 %
Organic matter, %	74.34 %	36.76 %	45.2 %	39.5 %
Organic carbon, %	43.12 %	21.3 %	27.9 %	22.9 %
Ash %	60.1 %	63.2 %	62.3 %	60.5 %
C:N ratio	5.0 : 1	5.1 : 1	18.3 : 1	19.4 : 1
Micro elements mg/kg				
Iron	8342.3	8548.6	25346.0	26163.0
Manganese	196.8	212.5	349.9	327.8
Copper	50.1	41.2	42.9	43.0
Zinc	783.8	792.9	80.3	79.3

RESULTS AND DISCUSSION

I. Vegetative growth

1. Plant height

Data recorded in Table (1) show that, irrigation treatments significantly affected growth of basil plants in most cases. In general, water irrigation amount of 5096 m^3/fed./season gave mostly the tallest plants in comparison with the other treatments in the two cuts of the two seasons. Differences were found to be highly significant in this respect.

Concerning the effect of fertilization treatments, data presented in Table (1) state that, using organic manure stimulated elongation of basil plants as the 20 m^3/fed. poultry manure produced the tallest plants followed by 60 m^3/fed. cattle manure in most cases.

As for the interaction treatments (I X F), it was found that 20 m^3/fed. of poultry manure at any water irrigation amounts showed the highest significant stimulation in the plant height. The tallest plants were produced under irrigation water of 5096 m^3/fed./season and 20 m^3/fed. poultry manure. However, 60 m^3/fed. cattle manure with water irrigation amount of 2744 m^3/fed./season gave mostly significant stimulation in this respect.

2. Number of branches / plant

Data presented in Table (2) indicate that, in the first season water irrigation amount at 5096 m^3/fed./season treatment resulted in significant more branches than any irrigation treatments. This general trend was confirmed in the second season.

The results also demonstrate that poultry manure resulted in the highest number of branches in the two cuts during the two seasons. Poultry manure at the rate of 20 m^3/fed. had highly significant effect on the branching of basil plants in comparison with NPK in the two cuts of the two seasons and with

other treatments in the two cuts of the second season. Furthermore, there were highly significant increases between 60 m^3/fed. cattle manure and NPK in the first cut in the first season and in the second cut during the two seasons.

Regarding the effect of the interaction between irrigation and fertilization treatments, it was clear that, the results gave significant increases of number of branches. The combined treatments between all water irrigation amounts and 20 m^3/fed. poultry manure gave the highest number of branches followed by all irrigation intervals + 60 m^3/fed. cattle manure in both cuts during both seasons. The treatment of irrigation with 5096 m^3/fed./season of water + 20 m^3/fed. poultry manure followed by 5096 m^3/fed./season irrigation water + 60 m^3/fed. cattle manure gave the highest results in most cases and have a significant differences comparing with NPK + all water irrigation amounts in the second cut during the second season.

3. Leaves / stems ratio

Results in Table (3) emphasize that, increasing water irrigation amount to 5096 m^3/fed./season resulted an increase in leaves/stems ratio. The obtained data showed significant differences in the first cut during both seasons. On the other hand, these treatments had no significant effect in the second cut during the two seasons, but the plants irrigated with water irrigation amount at 5096 m^3/fed./season gave the highest leaves/stems ratio compared to the other amounts.

Among the three types of fertilizers, poultry manure appear to be the most favorable in term of percentage between the weight of leaves and stems (leaves/stems ratio). It is also clear that, 20 m^3/fed. poultry manure resulted in highly significant values in this respect in most cases when compared to NPK treatment. No significant differences were recorded in case of the 2 rates of cattle manure comparing with NPK treatment, in both seasons.

Regarding the interaction treatments (I X F) on leaves/stems ratio, it is clear from the data in Table (3) that, there was an increase in response to the treatment of water irrigation amount at 5096 m^3/fed./season + 20 m^3/fed. poultry manure comparing with the same irrigation treatment + NPK in most cases. This treatment was significant in the first cut in the first season

4. Fresh and dry weights of herb/plant/cut

Data in Tables (4 & 5) show the fresh and dry weights of basil plants as affected by water irrigation amounts, fertilization and their combinations. As for the effect of water irrigation amount treatments, data indicate that increasing the amount of water irrigation resulted in highly significant increase in the fresh and dry weights of herb. The maximum values 260.5 and 371.7 gm/plant of fresh herb were recorded in the 1^{st} and 2^{nd} cuts in the first season, and 337.3 and 428.9 gm/plant in both cuts in the second season, respectively, when irrigating plants with 5096 m^3/fed./season. Data of herb dry weight followed nearly similar trend of fresh weight. The maximum values recorded in both cuts were 54.6 and 74.3 gm herb dry weight/plant under 5096 m^3/fed./season water irrigation amount in the first season, and in the second season they were 51.6 and 85.8 gm dry weight/plant.

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It's evident from the results in Tables (4 & 5) that the fresh and dry weights of herb in both seasons show increase with using the organic fertilizers instead of chemical NPK. The maximum fresh weight of herb was obtained from the treatment of 20 m^3/fed. poultry manure followed by the treatment of 60 m^3/fed. cattle manure in both cuts during the two seasons. The recorded results show that the fresh weight of herb had a highly significant increase with adding 20 m^3/fed. poultry manure by more than 40.1 & 14.1 % in 1st & 2nd cuts during the first season and 20.3 & 13.0 % in both cuts in the second season respectively as compared with NPK treatment. While using cattle manure at the rate of 60 m^3/fed., the data recorded also highly significant increases in 1st & 2nd season in the second cut and in the first cut during the second season, while it tabulated significant increase in the first cut at the first season, compared to NPK treatment. These increments were 14.7 & 9.6 % in the first and second cuts during the first season, furthermore, they were 11.6 & 5.9 % in 1st & 2nd cuts in the second season.

Data of the herb dry weight behaved in the same manner as the fresh weight. So, the treatment of 20 m^3/fed. poultry manure had a highly significant increase in the dry weight of herb compared to NPK treatment. These increases were 56.8 & 14.0 % for the 1st & 2nd cuts in the first season, while in the second season they were 20.2 & 13.0 % over than NPK treatment in the first and second cuts, respectively. Concerning the effect of cattle manure, there was highly significant effect for 60 m^3/fed. treatment compared to NPK. The increment were 16.5 & 9.6 % in 1st & 2nd cuts in the first season and 7.6 & 6.0 % over NPK treatment in the first and second cuts during 2nd season. It was observed that, 20 m^3/fed. poultry manure gave the maximum effect in this respect.

Regarding the interaction treatments (I X F), data presented in Table (4) indicate that, the treatment of water irrigation amount at 5096 m^3/fed./season + 20 m^3/fed. poultry manure resulted in the heaviest fresh weight of herb/plant and had highly significant differences when compared with the same treatment of water irrigation amount + NPK. This treatment recorded increases in the fresh herb by more than 43.7 & 35.1 % in the 1st & 2nd cuts in the first season, and 20.5 & 18.4 % in both cuts during 2nd season, respectively. Whereas, the treatment of water irrigation amount of 5096 m^3/fed./season + 60 m^3/fed. cattle manure gave mostly highly significant increase in the fresh weight of herb when compared with the combined treatment of water irrigation amount at 5096 m^3/fed./season + NPK in 1st and 2nd cuts during the first season and in the second cut in the second season, while there is non significant effect in the first cut during the second season. These increases were 19.0 & 30.9 % in 1st & 2nd cuts in the first season, and 0.8 & 14.6 % in both cuts during the second season.

Concerning the dry weight of herb/plant the results in Table (5) point out that, all water irrigation amounts combined with 20 m^3/fed. poultry manure had a positive effect. Also, it is clear that, the differences between these treatments and all water irrigation amounts + NPK were highly significant in both cuts during the two seasons. The values recorded increments over than NPK + 5096 m^3/fed./season water irrigation treatment by about 64.6 & 35.1 % in the first and second cuts in the first season, and 19.0 & 18.4 % in 1st & 2nd

cuts during the second season. It could be observed in the same Table that, water irrigation amount at 5096 m^3/fed./season with cattle manure at the rate of 60 m^3/fed. had highly significant effect on the dry weight compared with all irrigation amounts + NPK in the second cut during both seasons. The values in case of the treatment of 5096 m^3/fed./season water irrigation amount + 60 m^3/fed. cattle manure were higher than those of 5096 m^3/fed./season + NPK by about 13.6 & 5.5 % in 1st & 2nd seasons in the first cut, and 31.0 & 14.6 % in both seasons in the second cut, respectively.

5. Yield of herb

With respect to the yield of fresh and dry herb/plant during the whole season, data in Table (6) indicate that, water irrigation amount at 5096 m^3/fed./season gave highly significant differences when compared with the rest of water irrigation amounts. In the same trend, the treatment of 20 m^3/fed. poultry manure followed by 60 m^3/fed. cattle manure had highly significant effect when compared with NPK treatment. Furthermore, the combined treatment of water irrigation amount at 5096 m^3/fed./season + 20 m^3/fed. poultry manure followed by water irrigation amount at 5096 m^3/fed./season + 60 m^3/fed. cattle manure gave the highest results and had highly significant increases when compared with the treatment of water irrigation amount at 5096 m^3/fed./season + NPK.

Data of the main factor in Table (7) indicate that, increasing the water irrigation amount resulted in the high significantly increase in the yield of herb/fed. The maximum fresh yield (15.173 and 18.405 ton/fed.) and dry yield (3.094 and 3.298 ton/fed.) were obtained from the highest amount of irrigation (5096 m^3/fed./season) for the two seasons, respectively.

Data in Table (7) also show that, plants receiving poultry manure at the rate of 20 m^3/fed. produced highly significant yield of herb followed by 60 m^3/fed. cattle manure in the two seasons than those treated with the other treatments. 20 m^3/fed. poultry manure yielded 16.283 and 18.128 ton/fed. fresh yield of herb, and 3.461 and 3.474 ton/fed. dry herb, in the two seasons, respectively. In the same trend, cattle manure at the rate of 60 m^3/fed. gave 14.811 & 16.904 ton/fed. fresh yield of herb, and 2.992 & 3.198 ton/fed. dry yield of herb during the two seasons respectively.

As for the interaction between irrigation and fertilization treatments, it was found that, highly significant differences in fresh and dry yield of basil herb occurred between plants treated with different combinations of water irrigation amounts and kinds of fertilizers. In general, it could be concluded that, plants supplied with 20 m^3/fed. poultry manure gave the largest yield when they were irrigated with water irrigation amount at 5096 m^3/fed./season in both seasons. These yields were 19.24 & 21.824 ton/fed. as fresh yield of basil herb and 4.083 & 3.869 ton/fed. as dry yield of herb for the two seasons, respectively. Concerning the plants fertilized with cattle manure at the rate of 60 m^3/fed. and watered with 5096 m^3/fed./season yielded 17.448 & 19.76 ton/fed. of fresh herb and 3.418 & 3.602 ton/fed. dry yield of herb for the two seasons, respectively.

II. Oil yield

1. Oil percentage

It was observed from Table (8) that, oil percentage of basil plants was affected by water irrigation amounts, fertilization and their interactions. As for the effect of water irrigation amounts, data clear that, the maximum value of oil percentage was found with irrigated plants with 5096 m^3/fed./season. However, differences between water irrigation amounts were not significant in the 1st cut of the 1st season, while its recorded highly significant effects in the two cuts during the second season..

In the same Table, data reveal that, plants fertilized with 60 m^3/fed. cattle manure gave higher values of oil percentage in most cases.

Also, data clearly indicate that, the combined treatment of water irrigation amount at 5096 m^3/fed./season + 60 m^3/fed. cattle manure gave the highest values with highly significant increases of oil percentage comparing with the other combination treatments. These finding hold true in both cuts, during the two seasons.

2. Essential oil yield (ml) / plant

It is evident from the results in Table (9) that, increasing the water irrigation amounts resulted an increase in oil yield (ml)/plant. The obtained data show highly significant increase between water irrigation amount at 5096 m^3/fed./season and other treatments in all cuts during both seasons.

Among the fertilization treatments, cattle manure (60 m^3/fed.) appear to be the most favorable one for the production of the highest oil yield (ml) / plant.

Concerning the interaction treatments (I X F), it is evident from the data in Table (9) that, there was a highly significant difference in oil yield (ml)/plant in response to the treatment of water irrigation amount at 5096 m^3/fed./season + 60 m^3/fed. cattle manure comparing to the same irrigation treatment level with NPK and 20 m^3/fed. poultry manure, in most cases. Results obtained in the second season followed nearly the same trend as the first one.

3. Essential oil yield (L.) / fed.

Data in Table (10) show the oil yield (L.)/fed. as affected by water irrigation amounts, fertilization and their combinations. With regard to the effect of irrigation treatments, data indicate that, the maximum values 20.71 and 26.74 L/fed. with highly significant differences were recorded in first and second seasons, respectively, with irrigating plants with 5096 m^3/fed./season.

Regarding the effect of fertilization treatments, cattle manure resulted in highly significant oil yield (L.)/fed. The recorded data show that, oil yield/fed. had highly significant increase with adding 60 m^3/fed. cattle manure by (23.33 and 31.17 L/fed.), for the 1st and 2nd season, respectively.

With respect to the combination treatments (I X F), data tabulated in Table (10) state that, the treatment of water irrigation amount at 5096 m^3/fed./season + 60 m^3/fed. cattle manure resulted in highest oil yield (L.)/fed. and had highly significant differences when compared with the other treatments. This treatment yielded 35.56 and 39.2 L/fed. in the first and second seasons, respectively.

Conclusion

From the above results, relatively largest irrigation amount (5096 m^3/fed./season) appeared to be more beneficial for growth and productivity of herb and oil yield of basil plants. Similar trend was observed by Khater *et al* (1996) on *Mentha piperita* L. and Reffaat and Saleh (1998) on *Ocimum basilicum* L.

Among the three types of fertilizers that were tested, poultry manure at 20 m^3/fed. followed by 60 m^3/fed. cattle manure were the most effective in increasing the vegetative growth. While, 60 m^3/fed. cattle manure resulted in better oil yield/plant and feddan. These finding go parallel with those of El-Ghadban (1998) on *Mentha viridis* and *Origanum majorana*, Jacoub (1999) on *Ocimum basilicum* and *Thymus vulgaris* and Sakr (2001) on *Mentha piperita* L plants.

From these conclusion the following may be recommended:

* Using the combined treatment of water irrigation amount at 5096 m^3/fed./season + 20 m^3/fed. poultry manure or 60 m^3/fed. cattle manure to get highest yield of fresh and dry weight of herb/fed.

* Using the interaction treatment of water irrigation amount at 5096 m^3/fed./season + 60 m^3/fed. cattle manure to yield the highest oil yield/fed.

This very important in the new reclaimed arid and semi-arid region where the soil is very poor from nutrition and irrigated with a new irrigation systems.

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إستجابة نباتات الريحان لمعدلات الرى بالتنقيط والأسمدة العضوية تحت ظروف الأرض الرملية

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لقد كان لكل من معدلات الرى بالتنقيط والأسمدة العضوية تأثير على النمو الخضرى ومحتوى الزيت فى نباتات الريحان الحلو المنزرعة فى الأرض الرملية بالمزرعة التجريبية لمحطة بحوث البساتين بالقصاصين (محافظة الإسماعيلية) خلال موسمى 2005 – 2006 . وقد أدت معاملة الرى بكمية من مياه الرى بمعدل 5096 م^3/فدان إلى زيادة معنوية فى النمو الخضرى ومحصول الزيت / نبات وللفدان بالمقارنة بباقى المعاملات .

وأعطت معاملة سماد الدواجن بمعدل 20 م^3/ف أعلى القيم فى النمو الخضرى (طول النبات ، عدد الأفرع/نبات ، نسبة الأوراق/السيقان ، الوزن الطازج والجاف للعشب / نبات/حشة وخلال الموسم ومحصول العشب الطازج والجاف/فدان) عند كل حشة خلال الموسمين بالمقارنة بالتسميد الكيماوى (ن ، فو ، بو) وباقى معاملات التسميد العضوى . بينما سماد المواشى بمعدل 60 م^3/ف أعطى أعلى محصول للزيت (لتر) / نبات و للفدان.

رى نباتات الريحان الرى بمعدل 5096 م^3/فدان مياه رى بالإضافة إلى التسميد بسماد الدواجن بمعدل 20 م^3/ف أعطى أفضل النتائج بالنسبة للنمو الخضرى ، بينما النباتات التى سمدت بسماد المواشى بمعدل 60 م^3/ف ورويت بمعدل 5096 م^3/فدان مياه رى أنتجت أعلى محصول من الزيت العطرى / نبات وللفدان بمقارنتها بباقى المعاملات ، وذلك فى الموسمين .

Table (1): Effect of water irrigation amount, fertilizers and their interaction treatments on plant height (cm) of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	50.5	48.5	52.3	47.0	48.0	49.3	62.0	61.3	65.7	58.7	61.3	61.8
2744 m^3/fed/season	48.5	47.0	51.0	49.7	50.0	49.3	55.3	54.0	62.0	57.7	61.0	58.0
1637 m^3/fed/season	47.3	46.3	50.0	44.0	46.7	46.3	58.3	48.0	61.7	52.3	60.3	56.1
M_F	48.8	47.3	51.1	46.9	48.2		58.5	54.4	63.1	56.2	60.9	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	1.0		0.8		1.3		1.2		1.6		2.8	
L.S.D. at 1%	1.6		1.0		1.8		1.9		2.2		3.8	
	Second season											
5096 m^3/fed/season	53.0	52.3	55.0	51.3	52.0	52.7	67.0	62.0	89.3	52.7	74.0	69.0
2744 m^3/fed/season	49.3	45.3	52.3	48.3	52.0	49.4	66.3	60.0	85.3	51.3	72.7	67.1
1637 m^3/fed/season	48.0	47.3	50.7	47.7	48.0	48.3	65.0	53.3	75.0	50.7	72.0	63.2
M_F	50.1	48.3	52.7	49.1	50.7		66.1	58.4	83.2	51.6	72.9	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.8		1.0		1.8		0.7		0.8		1.4	
L.S.D. at 1%	1.4		1.4		2.4		1.1		1.1		1.8	

Table (2): Effect of water irrigation amount, fertilizers and their interaction treatments on number of branches of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	12.0	12.7	15.0	13.0	14.0	13.3	14.0	13.3	15.7	13.0	14.7	14.1
2744 m^3/fed/season	11.3	11.7	14.0	12.0	13.3	12.5	10.7	9.7	12.3	10.7	11.3	10.9
1637 m^3/fed/season	10.7	11.0	13.7	12.3	13.0	12.1	9.3	8.7	11.7	8.0	11.3	9.8
M_F	11.3	11.8	14.2	12.4	13.4		11.3	10.6	13.2	10.6	12.4	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.69		0.91		NS		0.86		0.65		NS	
L.S.D. at 1%	NS		1.24		NS		1.43		0.89		NS	
	Second season											
5096 m^3/fed/season	17.0	14.3	20.7	13.3	16.7	16.4	15.3	14.3	24.0	13.0	18.0	16.9
2744 m^3/fed/season	16.3	15.3	18.3	13.0	16.0	15.8	13.7	11.0	21.3	12.0	16.0	14.8
1637 m^3/fed/season	14.7	13.0	14.7	11.7	14.0	13.6	12.3	11.0	19.7	12.0	15.3	14.1
M_F	16.0	14.2	17.9	12.7	15.6		13.8	12.1	21.7	12.3	16.4	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	2.03		1.41		NS		1.04		0.67		1.15	
L.S.D. at 1%	NS		1.91		NS		1.73		0.90		NS	

PM_{10} & PM_{20} : Poultry manure at 10 & 20 m^3
CM_{30} & CM_{60} : Cattle manure at 30 & 60 m^3
I : Irrigation treatments
F : Fertilization treatments

Table (3): Effect of water irrigation amount, fertilizers and their interaction treatments on the leaf/stem ratio of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	2.95	3.44	3.46	2.22	2.48	2.91	2.98	2.76	3.46	2.25	2.91	2.87
2744 m^3/fed/season	1.98	2.06	2.62	2.43	2.55	2.33	2.69	2.48	2.09	2.72	2.87	2.77
1637 m^3/fed/season	2.54	2.25	2.90	1.67	2.44	2.36	2.47	2.5	3.00	2.32	2.41	2.54
M_F	2.42	2.58	2.99	2.11	2.49		2.71	2.58	3.18	2.43	2.73	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.38		0.29		0.21		NS		0.25		NS	
L.S.D. at 1%	NS		0.40		0.69		NS		0.40		NS	
	Second season											
5096 m^3/fed/season	2.26	2.50	2.67	2.21	2.54	2.44	2.29	1.65	2.86	1.78	2.00	2.12
2744 m^3/fed/season	2.25	2.33	2.54	1.64	2.06	2.16	1.44	2.18	2.50	1.77	1.97	1.97
1637 m^3/fed/season	1.24	1.85	1.88	1.82	1.79	1.72	2.05	1.44	2.11	1.70	1.80	1.82
M_F	1.92	2.23	2.36	1.89	2.13		1.93	1.76	2.49	1.75	1.92	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.28		0.24		0.42		NS		NS		NS	
L.S.D. at 1%	0.47		0.33		NS		NS		NS		NS	

Table (4): Effect of water irrigation amount, fertilizers and their interaction treatments on fresh weight of herb (gm)/plant of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	247.0	159.7	355.0	246.7	294.0	260.5	330.7	273.3	446.7	375.0	433.0	371.7
2744 m^3/fed/season	191.0	182.3	235.0	226.7	228.0	212.6	333.3	246.0	394.7	329.3	364.7	333.6
1637 m^3/fed/season	166.0	137.7	256.0	133.0	170.3	172.6	393.7	282.7	365.3	274.7	361.7	335.6
M_F	201.3	159.9	282.0	202.1	230.8		352.6	267.3	402.2	326.3	386.5	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	24.9		22.3		38.6		22.0		17.6		30.5	
L.S.D. at 1%	41.3		30.2		52.3		NS		23.8		41.3	
	Second season											
5096 m^3/fed/season	338.3	304.0	407.7	295.7	341.0	337.3	421.0	318.0	498.3	424.7	482.3	428.9
2744 m^3/fed/season	237.3	178.7	240.3	228.0	265.3	229.9	423.0	322.3	444.7	371.0	411.3	394.5
1637 m^3/fed/season	156.3	197.7	232.7	176.3	211.0	194.8	379.0	290.7	439.0	317.7	402.0	365.7
M_F	244.0	226.8	293.6	233.3	272.4		407.7	310.3	460.7	371.1	431.9	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	13.0		14.6		25.2		14.8		7.9		13.8	
L.S.D. at 1%	21.6		19.7		34.2		24.5		10.8		18.6	

Table (5): Effect of water irrigation amount, fertilizers and their interaction treatments on dry weight of herb (gm)/plant of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	49.1	32.3	80.8	54.8	55.8	54.6	66.1	54.7	89.3	75.0	86.6	74.3
2744 m^3/fed/season	39.4	40.7	50.5	48.2	49.8	45.7	66.7	49.2	78.9	65.9	72.9	66.7
1637 m^3/fed/season	33.7	30.7	60.0	30.3	36.6	38.3	78.7	56.3	73.1	54.9	72.3	67.1
M_F	40.7	34.6	63.8	44.4	47.4		70.5	53.4	80.4	65.3	77.3	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	3.5		3.9		6.8		4.2		3.8		6.5	
L.S.D. at 1%	5.0		5.3		9.2		NS		5.1		8.9	
	Second season											
5096 m^3/fed/season	50.8	45.6	60.9	46.9	53.6	51.6	84.2	63.6	99.7	84.9	96.5	85.8
2744 m^3/fed/season	47.1	32.3	50.6	42.7	49.1	44.4	84.6	64.5	88.9	74.2	82.3	78.9
1637 m^3/fed/season	32.8	37.3	45.7	32.3	38.0	37.2	75.8	58.1	87.8	63.5	80.4	73.1
M_F	43.6	38.4	52.4	40.6	46.9		81.5	62.1	92.1	74.2	86.4	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	2.9		3.2		5.6		3.0		1.6		2.8	
L.S.D. at 1%	4.9		4.3		7.5		5.0		2.2		3.8	

PM_{10} & PM_{20} : Poultry manure at 10 & 20 m^3
CM_{30} & CM_{60} : Cattle manure at 30 & 60 m^3
I : Irrigation treatments
F : Fertilization treatments

Table (6): Effect of water irrigation amount, fertilizers and their interaction treatments on the yield of herb (g)/plant/season of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First season						Second season					
	Fresh weight of herb (g)/plant/season											
5096 m^3/fed/season	543.7	433.0	801.7	621.7	727.0	625.4	759.3	622.0	909.3	720.3	823.3	766.9
2744 m^3/fed/season	524.3	428.3	629.7	556.0	592.3	546.1	660.3	501.0	685.0	599.0	676.7	624.4
1637 m^3/fed/season	559.7	420.3	604.0	407.7	532.0	504.7	535.3	488.3	671.7	494.0	613.0	560.5
M_F	542.6	427.2	678.4	528.4	617.1		651.7	537.1	755.3	604.4	704.3	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	19.2		35.7		61.9		26.2		10.6		18.4	
L.S.D. at 1%	31.9		48.4		83.9		43.4		14.4		24.9	
	Dry weight of herb (g)/plant/season											
5096 m^3/fed/season	115.2	87.0	170.1	129.8	142.2	128.9	135.0	109.2	161.2	131.5	150.1	137.4
2744 m^3/fed/season	106.1	89.9	129.4	114.0	122.7	112.4	131.0	96.8	139.5	122.9	131.3	124.3
1637 m^3/fed/season	112.4	87.1	133.1	85.3	108.9	105.4	108.6	95.5	133.5	95.8	118.4	110.3
M_F	111.2	87.99	144.2	109.7	124.6		124.9	100.5	144.7	116.8	133.3	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	3.9		5.3		9.2		5.7		4.7		8.1	
L.S.D. at 1%	6.4		7.2		12.5		9.5		6.3		11.0	

Table (7): Effect of water irrigation amount, fertilizers and their interaction treatments on the yield of fresh and dry weight of herb (ton)/fed./season of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	Fresh weight of herb						Dry weight of herb					
	First season											
5096 m^3/fed/season	13.864	10.392	19.240	14.920	17.448	15.173	2.766	2.088	4.083	3.116	3.418	3.094
2744 m^3/fed/season	12.584	10.280	15.112	13.344	14.216	13.107	2.545	2.158	3.106	2.737	2.945	2.698
1637 m^3/fed/season	13.432	10.088	14.496	9.784	12.768	12.114	2.699	2.090	3.195	2.047	2.614	2.529
M_F	13.293	10.253	16.283	12.683	14.811		2.670	2.112	3.461	2.633	2.992	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.442		0.770		1.334		0.091		0.127		0.220	
L.S.D. at 1%	0.733		1.044		1.808		0.150		0.172		0.298	
	Second season											
5096 m^3/fed/season	18.224	14.928	21.824	17.288	19.760	18.405	3.240	2.621	3.869	3.157	3.602	3.298
2744 m^3/fed/season	15.848	12.024	16.440	14.376	16.240	14.986	3.144	2.323	3.349	2.807	3.152	2.955
1637 m^3/fed/season	12.848	11.720	16.120	11.856	14.712	13.451	2.606	2.291	3.203	2.299	2.842	2.648
M_F	15.640	12.891	18.128	14.507	16.904		2.997	2.412	3.474	2.754	3.198	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.628		0.254		0.439		0.120		0.097		0.169	
L.S.D. at 1%	1.042		0.344		0.596		0.199		0.132		0.228	

Table (8): Effect of water irrigation amount, fertilizers and their interaction treatments on essential oil percentage of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	0.42	0.31	0.37	0.52	0.84	0.49	0.70	0.52	0.39	0.57	0.92	0.62
2744 m^3/fed/season	0.64	0.50	0.38	0.35	0.55	0.49	0.63	0.67	0.32	0.48	0.57	0.53
1637 m^3/fed/season	0.65	0.36	0.69	0.50	0.41	0.52	0.68	0.39	0.72	0.55	0.52	0.57
M_F	0.57	0.39	0.48	0.46	0.60		0.67	0.53	0.48	0.53	0.67	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	NS		0.04		0.08		0.05		0.05		0.09	
L.S.D. at 1%	NS		0.06		0.10		NS		0.07		0.13	
	Second season											
5096 m^3/fed/season	0.61	0.50	0.54	0.53	0.88	0.61	0.88	0.71	0.55	0.57	0.96	0.73
2744 m^3/fed/season	0.67	0.53	0.64	0.56	0.69	0.62	0.67	0.69	0.58	0.69	0.70	0.67
1637 m^3/fed/season	0.75	0.62	0.70	0.69	0.88	0.73	0.79	0.65	0.72	0.75	0.85	0.75
M_F	0.68	0.55	0.62	0.59	0.82		0.78	0.68	0.62	0.67	0.83	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.05		0.03		0.05		0.03		0.05		0.09	
L.S.D. at 1%	0.08		0.04		0.07		0.05		0.07		0.13	

Table (9): Effect of water irrigation amount, fertilizers and their interaction treatments on essential oil yield (ml)/plant of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First cut						Second cut					
	First season											
5096 m^3/fed/season	0.21	0.10	0.31	0.29	0.47	0.28	0.47	0.29	0.36	0.43	0.80	0.47
2744 m^3/fed/season	0.26	0.21	0.20	0.17	0.28	0.23	0.43	0.34	0.25	0.32	0.42	0.35
1637 m^3/fed/season	0.23	0.11	0.42	0.16	0.15	0.22	0.55	0.22	0.53	0.31	0.38	0.40
M_F	0.23	0.14	0.31	0.21	0.30		0.48	0.28	0.38	0.35	0.53	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.03		0.04		0.08		0.03		0.04		0.08	
L.S.D. at 1%	NS		0.06		0.10		0.05		0.06		0.10	
	Second season											
5096 m^3/fed/season	0.31	0.23	0.33	0.25	0.47	0.32	0.75	0.45	0.56	0.49	0.93	0.64
2744 m^3/fed/season	0.31	0.17	0.32	0.24	0.34	0.28	0.57	0.45	0.51	0.52	0.58	0.53
1637 m^3/fed/season	0.25	0.23	0.32	0.23	0.34	0.27	0.60	0.38	0.64	0.48	0.68	0.56
M_F	0.29	0.21	0.32	0.24	0.38		0.64	0.43	0.57	0.49	0.73	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.01		0.03		0.05		0.03		0.04		0.08	
L.S.D. at 1%	0.02		0.04		0.06		0.05		0.06		0.10	

PM_{10} & PM_{20} : Poultry manure at 10 & 20 m^3
CM_{30} & CM_{60} : Cattle manure at 30 & 60 m^3
I : Irrigation treatments
F : Fertilization treatments

Table (10): Effect of water irrigation amount, fertilizers and their interaction treatments on the yield of essential oil yield (L.)/fed. of basil plants during the two seasons of 2005 and 2006.

(F) Fertilization treatments / Water irrigation amount (I)	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I	NPK	PM_{10}	PM_{20}	CM_{30}	CM_{60}	M_I
	First season						Second season					
	Yield of oil (L.)/fed./season											
5096 m^3/fed/season	19.13	11.01	17.67	20.16	35.56	20.71	30.01	18.95	24.92	20.63	39.20	26.74
2744 m^3/fed/season	19.23	15.40	12.60	13.91	19.60	16.15	24.55	17.36	23.43	21.19	25.67	22.44
1637 m^3/fed/season	21.65	9.43	26.60	13.07	14.84	17.12	23.80	17.27	26.79	19.69	28.65	23.24
M_F	20.00	11.95	18.96	15.71	23.33		26.12	17.86	25.04	20.50	31.17	
	I		F		IXF		I		F		IXF	
L.S.D. at 5%	0.55		1.70		2.94		0.84		1.40		2.43	
L.S.D. at 1%	0.92		2.30		3.98		1.40		1.90		3.30	