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NITROGEN FERTILIZER EFFECT ON BASIL AND WATER PRODUCTIVITY UNDER NEW RECLAIMED SOILS CONDITIONS

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ABSTRACT

Water and nitrogen (N) nutrition are two key factors affecting nutrient absorption growth and biomass production of leafy crops. The purpose of this research is to evaluate the influence of N fertilization on basil and water productivity under different irrigation levels in reclaimed sandy soils. Three N fertilization rates F1(100% N), F2 (75% N), and F3 (50% N) of full recommendation and three irrigation levels I1 (80% ETo), I2 (100% ETo), and I3 (120% ETo) were used. The Field experiment was carried out in split plot design at the Experimental Farm of South Tahrir Horticulture Research Station, Behira Governorate during two successive seasons 2016 and 2017.Irrigation and N fertilization levels influenced basil growth parameters, N content and quality of sweet basil plant. Maximum fresh weight (510.83 g plant^{-1}) and essential oil yield (43.98 l fed^{-1}) were attained with 120% ETo treatment and N fertilizer (100% of recommended rate). The essential oil main constituent Linalool content (31.45% - 61.05%) was influenced with irrigation and N fertilizer levels and the highest value was recorded with 120% ETo and N fertilizer (100% of recommended rate. Both irrigation and nitrogen application had significant effects on water consumptive use (WCU) and water productivity (WP).The highest value of WCU (4656 m^{3}fed^{-1}) was attained at 120% of ETo and 100% N, whereas, the lowest value (2446 m^{3}fed^{-1}) was obtained under 80% of ETo with 50% of nitrogen level.The highest WP5.7 kg / m^3 was obtained under80% of ETo and 100% of N. These results were obtained at the first season, with the same trend at second season.

(Key words: Basil (*Ocimum basilicum* L.), nitrogen fertilizer rates, water consumptive use, water productivity)

INTRODUCTION

Basil (*Ocimum basilicum* L.), a member of Lamiaceae family, is an annual plant and is widely used as a vegetable and as aromatic plant. Basil is a well-known and appreciated spice and medicinal plant (Omer *et al.,* 2008).Its leaves contain essential oils of strong aroma. Basil leaves and shoots are used fresh or dried in culinary applications (Ozcan *et al.,* 2005). Basil extracts are used in the manufacturing of cosmetic and pharmaceutical products or bio-pesticides (Pascual-Villalobos and Ballesta-Acosta, 2003).

Water and nitrogen (N) availability remain, globally, the most limiting crop growth factors (Mueller *et al.,* 2012). The additional demand for food by the growing population will require that we increase resource use efficiency of water and N for crops. Without underestimating the role of plant genetics, efficient management of water and N has been identified as crucial for closing the yield gap of main crops (Sinclair and Rufty, 2012). Sustainable intensification of agriculture should rely, therefore, on defining management strategies towards increasing water and N use efficiency. Plant growth is linearly related to water transpiration by the plant (Tanner and Sinclair, 1983). A good crop N nutritional status enhances crop tolerance to drought, and a moderate increase in N supply improves water use efficiency (WUE) in semiarid environments (Cossani *et al.,* 2012). Biomass production is a function of the relationship between N and water availability, and this relationship has been described it as co-limitation (Sadras, 2004). Co-limitation means that the plant growth response to water and N is greater than its response to each factor in isolation, and implies that strategies to maximize plant growth should ensure that both

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resources are equally available. In addition, nitrogen transport in the soil and absorption by roots are water limited. Thus, from the perspective of plant physiology or soil availability it is best to optimize N and water management simultaneously. The degree of plant supply with nitrogen is a major factor regarding yielding and affects the quantity and composition of volatile oils (Daneshian *et al.,* 2009).

Therefore, the present research aimed to evaluate the effects of applying nitrogen rates on water consumptive, water use efficiency and the productivity of basil plants.

MATERIALS AND METHODS

Site description and setup

The experimental site was a newly reclaimed sandy soil at Agricultural Research Station, ARC, El-Behira Governorate. It is situated at an altitude of 6.7m a.s.l. and is intersected by 31°02′N and 30° 28′E. Average of meteorological data from 2013 to 2017 are presented in table 1.

Some physical and chemical properties of the experimental site are shown in table 2. Chemical and physical soil analyses were conducted by the standard methods described by (Tan, 1996). Chemical analysis of the irrigation water indicated that electrical conductivity (EC) was 0.50 (dS/m) at 25 ºC and pH value was 7.55 (Page *et al.,*1982).

Field experiment

Basil (*Ocimum basilicum* L.) seedlings (15–20 cm in length, with 10–12 leaves) were obtained from the Farm of Medicinal and Aromatic Plants Department and were transplanted 25 cm a part on 15th of April for each season. Nitrogen levels were 100% (F1), 75%(F2) and 50% (F3) N kg fed^{-1} of the recommendation dose and were added in the form of ammonium sulphate (20.6% N) and represent (100%, 75% and 50% of the recommended dose). Fertilization with calcium superphosphate (15.5% P_2O_5) was added during soil preparation. Potassium was supplementary in the form of potassium sulphate (48% K_2O). Both potassium and phosphorus were added at recommended dose.

Irrigation water was applied each three days by using drip irrigation system. It was a surface drip including an irrigation pump (50 hp) connected to sand and screen filters he conveying pipeline system consists of a 63 mm PVC main line connected to 50.8 mm PVC sub-main line. The drip lateral lines of 16 mm diameter are connected to the sub-main line. Each lateral line is 20 m long and spaced at 0.7 m on the sub-main and is equipped with build-in emitters of 2 l h^{-1} discharge rate spaced at 0.3 m on the lateral lines.The irrigation water treatments were: 80 %ETo (I1), 100%ETo (I2), 120%ETo (I3).

The plants were harvested twice in each growing season. The first was done on 1st July during the flowering stage, again, on 1st August. Each time all the above ground plant parts were cut at the height 10 cm. When harvesting, there were determined yield of herb and there were also collected plant material samples to be subjected to laboratory analyses. The extraction of the essential oil was carried out according to Guenther, (1961) on the basis of the herb fresh weight at the laboratory of Cultivation and Production of Medicinal and Aromatic Plants, Agricultural Research Centre (ARC), Dokki, Cairo, Egypt.

Studied characters

Vegetative growth and yield parameters:

At each harvest, Plant samples were randomly collected from all treatments, plant height (cm), number of branches, fresh and dry weight of herb (g $plant^{-1}$)were recorded for the two cuts during both seasons.

Chemical analysis:

- Oil yield (l fed^{-1})
- Gas Liquid Chromatography (GLC): The volatile oil obtained from the fresh leaves was analyzed in Laboratory of Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, (ARC) using Ds Chrom 6200 Gas Chromatograph apparatus, fitted with capillary column BPX-5, 5 phenyl (equiv.) polysillphenylene-siloxane 30 x 0.25 mm ID x 0.25l film. Temperature program ramp increase rate of 10°C/min from 70°C to 200°C. Flow rates of gases were nitrogen at 1 ml/min, hydrogen at 30 ml/min and 330 ml / min for air Detector and injector temperatures were 300°C and 250°C respectively. The identification of the different constituents was achieved by comparing their retention times with those of the authentic samples.
- Determination of total nitrogen element in sweet basil leaves using the modified micro-Kjeldahl method according to Anonymous (1990).

Crop water relation parameters

Water consumptive use (WCU):

Water consumptive use or actual evapotranspiration (ETc) values were calculated for each irrigation using the following formula (Israelsen and Hansen, 1962)

$$WCU = \sum_{i=1}^{i=4} (Q2 - Q1)/100 * Bd * D$$

Where: WCU : Seasonal water consumptive use (cm), Q_2:Soil moisture content after irrigation (on mass basis, %),Q_1; Soil moisture content before irrigation (on mass basis, %),Bd; Soil bulk density (g/cm^3),D : Depth of soil layer (15 cm each), and i : Number of soil layer.Soil moisture content was gravimetrically determined in soil samples taken from consecutive depths of 15 cm down to 60 cm. Soil samples were collected just before each irrigation, 48 hours after irrigation and at harvest time.

Crop water productivity (WP):

Crop Water Productivity is defined as crop yield $unit^{-1}$ applied irrigation water that is looking into the efficient use of applied irrigation water (Zhang, 2003) and is given as follow:

WP=Yield (kg/fed.) / AIW (m3 water applied/fed)

Statistical analysis:

Statistical analysis all data were statistically analyzed according to the technique of analysis of variance (ANOVA) procedures for strip-plot design with three replicates. The main plots were irrigation treatments and the sub-plots were assigned to the nitrogen fertilizer rates as published by Gomez and Gomez, (1984). Means of the treatment were compared by the least significant difference (LSD) at 5% level of significance as developed by Waller and Duncan (1969).

RESULTS AND DISCUSSION

Vegetative growth and yield parameters

The vegetative growth and yield parameters of sweet basil plants were significantly affected by irrigation levels and N fertilizer rates and their interaction in terms of plant height, number of branches plant^{-1}, fresh and dry weight plant^{-1} (g) during two successive seasons and presented in table 3. A profound influence of irrigation levels and N rates in increasing the vegetative growth and yield characters of sweet basil plants was well evidenced in the present study. The statistical analysis of results showed that, the irrigation treatment 120% of ETo (I3) recorded the highest values of plant height and number of branches plant^{-1} compared to the other irrigation treatments ETo 100% (I2) and 80% (I1) in the two experimental seasons as shown in table 3. Data also showed that the average values of vegetative growth and yield parameters increased with increasing the amount of irrigation water according to the order I3>I2>I1. However, there were no significant differences among irrigation treatments on fresh weight, dry weight and yield parameters during the first cut of the first season (Table 3).

Nitrogen fertilizer rates also significantly influenced vegetative growth and yield parameters of sweet basil plants (Tables 3). Generally, increasing fertilizer rates progressively increased plant growth and yield. Basil plants that received the highest N (100%) resulted in higher values compared to other fertilizer levels (75% and 50 %). This agreed with the results of Zheljazkov *et al.,* (2008) and Kandil *et al.* (2009). Similarly, Beisiada and Kus (2010) stated that sweet basil was positively affected by N doses and the highest yields were recorded at the dose of 250 kg N ha^{-1}. Nitrogen plays a most important role in various physiological processes. It imparts dark-green color in plants, promotes vegetative growth and development. Furthermore, application of nitrogen fertilizer increased the uptake and accumulation of other nutrients such as phosphorus and potassium (Baranauskiene *et al.,* 2003). However, deficiency of nitrogen decreases leaf CO_2 assimilation capacity, net photosynthesis rate, transpiration rate, stomatal conductance and the concentration of total chlorophyll of plants (von Caemmerer and Farquhar, 1981).

Results also revealed that, the interaction between the two factors under study on growth and yield characters was significant. The highest values were obtained in plants irrigated at 120% ETo and fertilized with the highest rate of N (100%). The heaviest plants were 525 g plant^{-1} as a fresh weight and 116 g plant^{-1} as a dry weight and were recorded in the second cut of the first season. While, minimum mean values of 87.1 g plant^{-1} as a fresh weight and 19.29 g plant^{-1} as a dry weight were obtained in plants irrigated at 80% of ETo amount of water and fertilized with the lowest rate of N (50%), these values were recorded in the first cut of the second season. The current results can be explained by the fact that at irrigation water amount of 80% ETo, nitrogen fertilizer was not absorbed in the sufficient amount required for optimum growth. This indicates that, sweet basil plant can produce optimum yield when receiving water and N fertilizer at optimum levels.

The improvement of sweet basil plants vegetative growth with increasing levels of irrigation could be attributed to favorable moisture conditions maintained throughout the crop growth period. Closely related results were reported by Ekren *et al.* (2012) and Pejiæ *et al.* (2017). Under higher moisture supply, the crop covered the ground faster and developed sufficient photosynthetic area for maximum utilization of solar radiation (Singh, 2002). A significant reduction in growth parameters might be due to the fact that, the plant response under water shortage is by closing the stomata and this leads to a decrease in the uptake of carbon dioxide, thus reducing the carbon assimilation rate of the plant. Water stress cause a reduction in growth through a decrease in cytokine in transport from roots to shoots and/or an increase in leaf abscisic acid; these changes in hormone balance cause changes in cell wall extensibility and therefore growth (Blackman and Davies, 1985). Furthermore, water stress restricts the ability of the plants to reduce and assimilate nitrogen, due to the inhibition of the activities of enzymes involved in nitrogen metabolism. The cytosolic NADH nitrate reductase, the first enzyme in the pathway of nitrate assimilation, is one of the enzymes which its activity was declined in water-stressed leaves of several species (Singh *et al.,* 2001).

Chemical analysis

Essential oil yield (l fed^{-1})

Data presented in Table 4indicated that amounts of irrigation water, nitrogen fertilizer rates and their interactions had a positive effect on essential oil yield (l/ fed.). Application of the highest amount of irrigation water significantly increased the biomass and consequently also the oil yield of sweet basil in both seasons.

Similar increases in herb essential oil percentage and yield as a result of irrigation treatments were reported in some species such as *Salvia officinalis* (L.) and *Mentha arvensis* (L.) (El-Fiky *et al.,* 2006; Dasha *et al,* 2006). Unlike, Ekren *et al*, (2012) who reported that decreasing the amounts of irrigation water increased the concentration of sweet basil oil.

Fertilization with the highest rate of N (100%) resulted in the maximum mean values of essential oil yield and was obtained in the second cut of the second season as shown in table 4. Minimum mean values were obtained in the first cut of the first season with the lowest N fertilizer rate. The interaction between the two factors significantly affected the oil yield fed^{-1}. in the two seasons (Table 4). Generally, the best results of sweet basil essential oil yield fed^{-1}. were obtained in plants received the highest amount of water (120% ETo) and fertilized with the highest rate of N (100%). The highest values of essential oil yields were 42.87 and 35.97 l fed^{-1}. obtained in the second cut during both seasons. Increases in essential oil yield as influenced by nitrogen fertilizer application were also reported by Kandil *et al.* (2009). Conversely, Singh (2002) found that sweet basil oil content and quality were not influenced by nitrogen and irrigation regime.

Therefore, the obtained results ensure the positive effects of irrigation and nitrogen fertilizer application in adequate amounts on enhancing oil yield.

Esential oil composition:

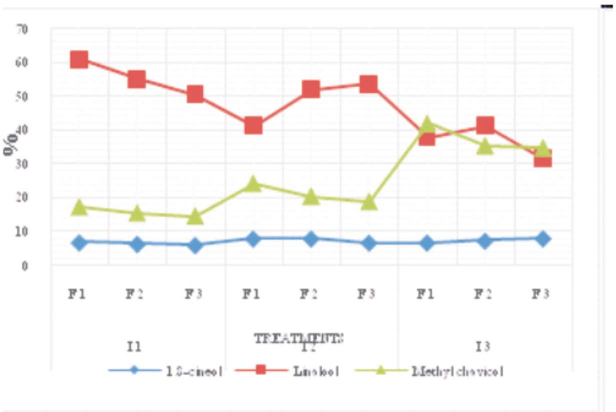

Figure 1. Effect of different irrigation levels (I) and nitrogen fertilization rates (F) on essential oil main constituents of sweet basil plants

The qualitative composition of sweet basil essential oil revealed that the main components of the essential oil were linalool, methyl chavicol and 1,8-cineole and comprised more than 80% of the essential oil composition as shown in Fig. 1.These results are in agreement with other studies which showed that linalool was the main constituent in sweet basil oil as reported by Gharib (2006). According to Simon *et al.* (1999) the Egyptian basil is very similar to the European, characterized by linalool and methyl chavicol as the major oil constituents and belonged to the linalool-rich type. The linalool content ranged from 31.45% to 61.05%, and was largely dependent on the applied amounts of water and nitrogen fertilizer rates. The highest percentage of linalool (61.05%) was obtained when plants received the highest amount of irrigation water (120% ETo) and nitrogen fertilizer rate (100%). A decrease in the amounts of water up to 80% ETo and nitrogen fertilizer rate up to 50% of recommended dose resulted in a reduction in the linalool percentage to 31.45%. Methyl chavicol content (14.44%- 41.88%) was also influenced by different irrigation levels and nitrogen fertilizer rates. Maximum values of this component resulted from plants irrigated with the lowest amount of water (80% ETo) and highest N (100%). The content of 1,8-cineole ranged between 6.04% in plants received the highest irrigation level (120% ETo) with the lowest N (50%) and 8.03% in plants received the lowest irrigation level (120% ETo) with the lowest N (50%).

Changes in the composition of essential oils as a result of exposing plants to different water levels have also been reported for parsley (Petropoulos *et al.,* 2008). Moreover, El-Fiky *et al.*(2006) mentioned that some components of *Salvia officinalis*L. essential oil reached the highest values with 120% ETo irrigation treatment, while other components were utmost at 80% ETo irrigation treatment.

The effect of nitrogen fertilizer rates on sweet basil oil composition was confirmed by other studies. For instance, Zheljazkov *et al.* (2008) found that the highest content of linalool was obtained with the medium rates of nitrogen fertilizer. Also, Daneshian *et al.* (2009) mentioned that linalool content ranged from57.93% in the 100 kg N ha^{-1} application to 61.10% in the control and 150 kg N ha^{-1}. The composition of essential oil is influenced by the genetics and cultivation conditions such as climate, plant density and use of fertilizers (Baranauskiene *et al.,*., 2003). Nitrogen also has an influence on the synthesis of some enzymes responsible for the biosynthesis of essential oils (Nurzyńska- Wierdak, 2013).

Basil leaves nitrogen contents (N%):

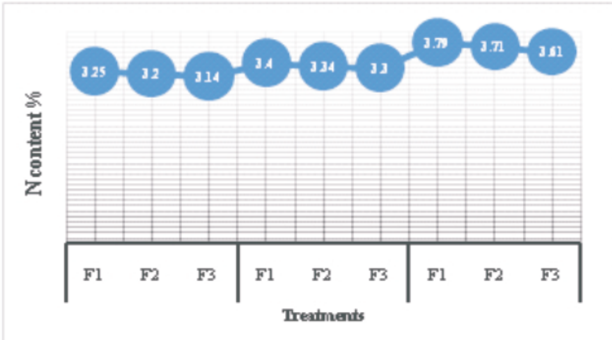

Figure 2. Nitrogen contents (%) in sweet basil lea*ves*

The N contents of sweet basil leaves affected by N fertilization rate under irrigation levels which are shown in fig. 2. Nitrogen content varied from 3.14% to 3.79 %.It is noticed that nutrient content of basil plant leaves was decreased with decreasing both N fertilization rate and decreased irrigation level. In terms of interaction effect, it was observed that N nutritional content in plant leaves was significantly affected by combination of both N fertilization rates and irrigation levels. N nutritional content recorded higher values in 120 % of Eto of irrigation treatment under full N (100%) than the counterparts under lower N fertilization rates of either 75% or 50% with 100% EToor 80% ETo.

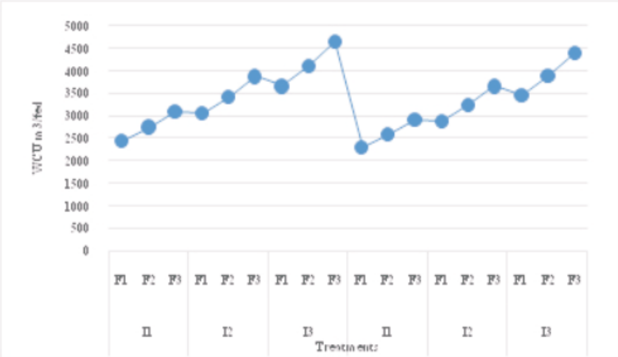

Figure 3. Effect of irrigation treatments and nitrogen fertilizer on WCU of basil in the 1st and 2nd seasons

The increase in N contents in sweet basil plant may be due to the availability of adequate amounts of N in the soil solution. The obtained results are in agreement with those of Cirillo *et al*. (2014) who reported that water stress caused a decrease in macronutrient concentration of Bougainvillea genotypes in response to an increase in water stress. When water inside the plant declines below a threshold level, stomata close which causes a decrease in transpiration resulting in a reduction in water transport through the plant, which affects the roots' ability to absorb water and nutrients. Since the transport of macronutrients to the plant roots occurs via diffusion, low soil moisture content will reduce nutrient uptake (Mackay and Barber, 1985).Nitrogen fertilizer rates also had a positive effect on NPK contents of sweet basil plant. Increasing N fertilizer rates progressively increased NPK contents. Similar results were reported for *Zingiber officinalis* (Singh *et al*., 2016).

Crop water relation

Water Consumptive use (WCU)

Data shown in figure 3 indicated that WCU under irrigation treatments in the first season values ranged between 2446 m^3 fed^{-1} and 4656 m^3 fed^{-1}. The highest value 4656 m^3 fed^{-1} was attained with 1.20 of ETo and 100% N, whereas, lowest value was 2446 m^3 fed^{-1} under 0.80 of ETo with 50% N, the same trend was achieved in the second season. The results also indicated that WCU values were higher in 2017 growing season than 2016 growing season, which can also be attributed to the differences in climatic parameters and consequently. Hain and Zou (2009) revealed that total water consumption and water consumption rate were significantly impacted by different fertilization and increased with application of chemical fertilizer and organic manure, They also concluded that soil water supply buffered and regulated soil water condition, and played an important role on guaranteeing crop yield; fertilizer application, can enhance soil water supply, increase crop yield and water use efficiency, especially organic manure application.

Water productivity (WP)

Both irrigation and nitrogen application had significant effects on water productivity. Crop water productivity is a quantitative term used to define the relationship between crop produced and the amount of water involved in crop production. Achieving greater water productivity became the primary challenge for scientists in agriculture. This should include the employment of techniques and practices that deliver more accurate supply of water to crops (Tariq *et al.,* 2003).The highest water productivity in the first growing season was obtained at irrigation amount of 0.80 of ETo with 100% N by 5.7, 5.4 and 3.3 kg/m^3, respectively figure (4). Regarding to the second growing season, the same trend was observed. Goswami and Sarkar (2007) also observed either decreased or non significant change in water productivity at higher levels of irrigation. Moreover, the higher water productivity at higher nitrogen doses was mainly due to higher grain yield of crops with similar water use at higher nitrogen doses. These results are in agreement with Pandey *et al.* (2001).

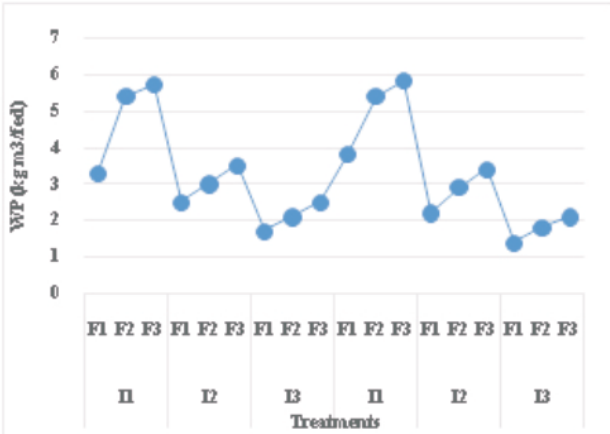

Figure 4. Water productivity under the adopted treatments in two growing seasons

Table 1. Average of meteorological data from 2013 to 2017 at the experimental site in 2016 and 2017 growing seasons

Months	SRAD	TMAX	TMIN	WS	TD	ETo
April	25.2	29.6	13.9	3.4	5.3	7.1
May	27.6	33.7	17.2	3.3	8.2	8.2
June	29.5	37.3	20.2	3.4	12.2	9.3
July	28.4	37.9	21.7	3.3	15.4	9.0
August	26.4	38.1	22.4	3.0	16.1	8.3

Where: TMAX, TMIN: mean of maximum and minimum temperatures °C; mean of WS: wind speed (m sec^{-1});Td: mean of temperature dew (%); SRAD: solar radiation (cal/cm^2/day). ETo: evapotransipiration (mm $month^{-1}$) was calculated by BISm by (Snyder *et al.,* 2004).(Data were obtained from the agro meteorological Unit at SWERI, ARC).

Table 2. Some soil physical and chemical properties of the experimental site soil properties

Soil depth (cm)	Particle size distribution			
	Sand%	Silt%	Clay%	Texture
0 – 30	90.75	3.75	5.50	Sandy
30 – 60	90.25	3.95	5.80	sandy

Soluble cations

Soil depth (cm)	Ca^{++} meq L^{-1}	Mg^{++} meq L^{-1}	Na^{+} meq L^{-1}	K^{+}meq L^{-1}
0-30	1.23	0.54	1.56	0.17
30-60	1.25	0.49	1.61	0.15

Soluble anions

Soil depth (cm)	CO^{-3} meq L^{-1}	HCO^{-3}meq L^{-1}	Cl^{-}meq L^{-1}	SO^{-4} meq L-1
0-30	0.00	1.10	1.73	0.67
30-60	0.00	1.07	1.74	0.69

Soil depth (cm)	Bulk density mg/m^3	Field capacity %w/w	Permanent wilting point %w/w	Available water %	pH (1:2.5)	EC (dsm^{-1})
0-30	1.58	11.25	5.45	5.8	9.13	0.35
30-60	1.76	9.35	4.6	4.75	9.38	0.30

Table 3. Effect of N fertilization rates and different irrigation levels on vegetative growth parameters of sweet basil plants in two growing seasons

Treatments	Plant height (cm)											
	1st season								2nd season			
	1st cut				2nd cut				1st cut			
	I1	I2	I3	Mean	I1	I2	I3	Mean	I1	I2	I3	Mean
F1	60.44	64	65.94	63.46	69.11	70.44	72.77	71.61	59.88	61.11	63.77	61.59
F2	52.83	55.11	61.56	56.5	67.88	70.66	71	69.85	51.88	55	61	55.96
F3	50.56	52.89	54.89	52.78	63.44	64	68.44	65.29	49.34	53.86	57.66	53.62
Mean	54.61	57.33	60.8		66.81	68.37	70.74		53.7	56.66	60.81	
LSD at 0.05		I= 3.16				I= 1.77				I= 1.15		
		F= 2.47				F= 1.32				F= 1.07		
		I x F= 3.51				I x F= 1.79				I x F= 1.93		
	Number of branches plant^{-1}											
F1	16	19.22	21.22	17.61	50.56	54	63.56	56.04	12.99	14.89	16.76	14.88
F2	12.33	13.66	17.67	14.55	39.11	44.78	51.11	45	11.23	12.22	14	12.48
F3	11.44	12.56	13	12.33	29.11	31.78	44.77	35.22	10.55	11.33	13.34	11.74
Mean	13.26	15.15	17.3		39.59	43.52	53.15		11.59	12.81	14.7	
LSD at 0.05		I= 2.83				I= 7.18				I= 2.03		
		F= 2.46				F=7.40				F= 1.91		
		I x F= 3.54				I x F= 12.41				I x F= 3.44		
	Fresh weight (g) plant^{-1}											
F1	235	243.4	275.6	251.3	268.8	361.9	525	385.2	161.8	195.7	259.5	205.7
F2	158.3	182.5	228.3	189.7	218.8	273.3	454.4	315.5	100.2	169.8	213.8	161.3
F3	99.35	149.7	174.3	124.5	169.44	194.44	205	189.63	87.1	123.5	190.8	133.8
Mean	164.2	191.9	226.1		219	276.5	394.8		116.39	163	221.4	
LSD at 0.05		I= 14.02				I= 41.47				I= 16.96		
		F= 18.53				F= 33.08				F= 23.24		
		I x F= 26.11				I x F= 80.99				I x F= 37.78		
	Dry weight (g) plant^{-1}											
F1	39.44	57.29	61.34	52.69	76.78	95.44	116.22	96.15	40.2	45.03	53.65	46.29
F2	33.61	34	49.42	39.01	47.11	57.89	74.39	59.8	28.29	32.77	42.03	34.36
F3	27.78	30.54	31.56	29.96	40.83	42.33	43.78	42.31	19.29	28.89	34.69	27.62
Mean	33.61	40.61	47.44		61.95	65.22	78.13		29.26	35.56	43.46	
LSD at 0.05		I= 3.61				I= 12.18				I= 3.74		
		F= 4.64				F= 11.78				F= 2.64		
		I x F= 5.98				I x F= 22.32				I x F= 5.13		

Table 4. Effect of nitrogen fertilization rates and different irrigation levels on oil yield (l/fed) of sweet basil plants in two growing seasons.

Treatments	Essential oil yield (l) fed^{-1}										
	1st season								2nd season		
	1st cut				**2nd cut**				**1st cut**		
	I1	I2	I3	Mean	I1	I2	I3	Mean	I1	I2	I
F1	8.42	10.75	19.98	13.05	20.84	28.65	42.87	30.78	12.54	15.5	21
F2	5.5	7.1	13.64	8.75	16.06	20.5	35.97	24.18	7.77	13.59	17
F3	3.23	5.37	10.9	6.5	11.01	12.64	13.55	12.4	7.19	9.82	15
Mean	5.72	7.74	14.84		15.97	20.6	30.8		9.17	12.97	17
LSD at 0.05	I= 0.13 F= 0.12 I x F= 0.28				I= 1.05 F= 1.45 I x F= 2.15				I= 1.94 F= 1.93 I x F= 3.95		

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