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EFFECT OF SOME DRIP IRRIGATION AND MULCHING TREATMENTS ON:
1. VEGETATIVE GROWTH AND NUTRITIONAL STATUS OF "ANNA" APPLE TREES GROWN IN NEW RECLAIMED SOILS

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ABSTRACT: ***This investigation was carried out during 2003 and 2004 seasons on 7-years old "Anna" apple trees budded on Malus rootstock grown in loamy sand soil at El-Bostan region, El-Beheira Governorate to study the effect of three drip irrigation rates of 13.584, 10.188 and 6.792 m^3/tree/year (I_1, I_2 and I_3) and two mulching types i.e. black polyethylene (B.B.E.) and dry cut gross beside, bare soil as well as their interaction on vegetative growth, root system growth and nutritional status.***

Black polyethylene mulching treatment was the most effective on keeping soil temperature more higher about 2-4 °C than bare soil and dry cut grass, which reduced it specially at 2 p.m. due to shading of this organic material, while drip irrigation treatments had no significant effect on soil temperature. In addition, raising drip irrigation rate up to 10.188 or 13.584 m^3/tree/year significantly increased soil moisture content. Furthermore, both mulching materials increased the percentage of soil moisture and the effect was pronounced by black P.E. treatment due to reducing evaporation water from soil surface.

Shoot length and diameter, leaf area, leaf dry and specific weights, trunk cross section area as well as average number and fresh weight of fibrous roots were proportionally increased with increasing irrigation rate. Moreover, both mulching materials caused significant increase in these vegetative growth parameters in the two seasons of study.

The application of moderate irrigation rate under black P.E or dry cut grass mulches in (I_2 x black P.E) or (I_2 x cut grass) may be considered the suitable combination treatment in increasing vegetative growth parameters, while applying (I_3 x bare soil) recorded the least values.

Using deficit irrigation rate of I_3 (6.792 m^3/tree/year) led to significant decreased leaf N, P, K, Ca, Mg, Fe, Mn and Zn as well as total chlorophyll contents. On the other hand, leaf free proline content was significantly increased. However, soil mulching extend to increase leaf macro and micro nutrients as well as total chlorophyll contents specially; by dry cut grass.

In both seasons, the maximum values of macro and micro nutrients and total chlorophyll contents in leaves of "Anna apple" trees were obtained with (I_1 x cut grass), (I_1 x black P.E) and (I_2 x cut grass) combination treatments,

respectively without significant differences among them. On the other hand, the minimum values belonged to (I_3 x bare soil) treatment.
Thus, this study recommended Anna apple growers to use moderate drip irrigation rate and soil mulching with dry cut grass in (I_2 x cut grass) which considered the best combination treatment for saving irrigation water and keeping soil moisture which enhanced top and root system growth and improved tree nutritional status under loamy sand soil conditions.
Key words: *apple – drip irrigation – mulching – soil moisture content – vegetative growth – nutritional status*

INTRODUCTION

Anna apple (*Malus domestica*, Borkh) is a summer cultivar has a high productivity and regular bearing, it is considered as a hybrid between "Red Hadassia" and "Golden Delicious" (Reid and Olma, 1972). The area under "Anna" apple cultivation is increased especially in the last few years in the new reclaimed land due to its low chilling requirements (300-350 effective chilling units) and high income return per feddan. It is reached about 65441 feddans in 2005 produced 578249 tons of fruits (according to the statistics of Ministry of Agriculture and Land Reclamation).

Most increase of the new established apple orchards in ARE concentrated in El-Nubaria and new reclaimed regions. In these new cultivated regions, the drip irrigation is the main system used to irrigate apple orchard, since saving the irrigation water is considered one of the main objective in these regions.

Soil mulching as agricultural practice play an important role by conserving soil moisture (Khalifa, 1994), reducing soil erosion, improving soil structure, regulate soil temperature and controlling the weed population (Rao and Pathak, 1998). Also, mulching improving vegetative growth and distribution of roots and their absorption of nutrients (Verma *et al.*, 2005).

The present work was planned to study the possible effects of three irrigation rates and two mulching materials i.e. cut grass and black polyethylene beside, bare soil as control on vegetative growth, root distribution and nutrient uptake of "Anna" apple trees budded on Malus rootstock grown in El-Bostan region. Irrigation and mulching effects on soil temperature and moisture content were also studied.

MATERIALS AND METHODS

The present study was carried out during the two successive seasons of 2003 and 2004 on seven years old "Anna" apple trees budded on Malus rootstock, spaced at 4 m between rows and 3 m within rows (350 trees/fed.) grown at El-Bostan region, El-Beheira Governorate. The tree subjected to cultural practices usually done in this area. The soil orchard is classified as loamy sand, calcareous (18.6% $CaCO_3$) and slightly alkaline (pH = 8.2). Some chemical and physical properties of soil experimental site are presented in

Table (1). The chemical analysis of irrigation water is illustrated in Table (2) according to the study methods described by Black (1983) and Klute (1986).

Table (1): Some chemical and physical properties of the experimental soil.

Soil variable	Soil depth (cm)		
	0-30	30-60	60-90
pH	8.2	8.1	8.2
EC mmhos/cm	1.98	1.24	1.22
OM%	0.97	0.85	0.43
$CaCO_3$ %	18.6	19.3	19.5
Porosity %	65.28	55.47	61.89
Bulk density gm/cm^3	0.92	1.18	1.01
Soluble cations meq/L			
Na^+	4.81	4.26	3.92
K^+	0.62	0.58	0.46
Ca^{++}	9.41	8.27	7.80
Mg^{++}	3.56	2.95	1.42
Soluble anions meq/L			
Cl^-	10.73	9.46	8.15
HCO_3^-	1.75	0.96	1.00
CO_3^{--}	0.00	00.0	0.00
SO_4^{--}	5.92	5.64	4.45
Particle size distribution %			
Sand	87.92	86.71	89.06
Silt	5.63	6.25	4.98
Clay	6.45	7.04	5.96
Textural class	Loamy sand	Loamy sand	Loamy sand

OM: Organic matter

Table (2): Chemical analysis of irrigation water.

pH	EC	Soluble cations meq/L				Soluble anions meq/L			
	mmhos/cm	Na^+	K^+	Ca^{++}	Mg^{++}	Cl^-	HCO_3^-	CO_3^-	SO_4^-
7.9	0.64	1.14	0.72	2.17	2.37	2.54	2.23	0.00	2.54

The treatments used in this study are as follows:

I.Main: irrigation rates:

I_1 = Control irrigation treatment (as done in the farm): each tree received 13.584 m^3 of water/year.

I_2 = Moderate irrigation treatment: each tree received 10.188 m^3 of water/year (75% from the control).

I_3 = Deficit irrigation treatment: each tree received 6.792 m^3 of water/year (50% from the control.

The irrigation rates I_1, I_2 and I_3 were performed by using two JR line for each row of the trees with internal emitters each 50 cm as well as

disannulled, one/four and half of them to get 12, 9 and 6 emitters/tree, respectively. Each emitter discharge is 4 L/ha.

The quantity of irrigation water applied to each "Anna" apple trees and per feddan (m^3) in the different irrigation treatments during each of growing seasons were showed in Table (3).

Table (3): The quantity of irrigation water applied to each "Anna" apple trees (litters) and per feddan (m^3) in the different irrigation treatments during each growing season.

Months	No. of irrigation /month	Time of each irrigation (hours)	Irrigation treatment L/tree		
			I_1	I_2	I_3
Jan.	4	1	192	144	96
Feb.	10	1	480	360	240
Mar.	10	2	960	720	480
Apr.	10	2.50	1200	900	600
May	15	2.50	1800	1350	900
Jun.	15	3	2160	1620	1080
Jul.	15	3	2160	1620	1080
Aug.	15	2.50	1800	1350	900
Sept.	10	2.50	1200	900	600
Oct.	10	1.50	960	720	480
Nov.	10	1	480	360	240
Dec.	4	1	192	144	96
Total amount/tree/year (m^3)	-	-	6.792	10.188	13.584
Total irrigation water/ fed./year (m^3)	-	-	2377.2	3565.8	4754.4

I_1 =12 emitters/tree, I_2 = 9 emitters/tree and I_3 = 6 emitters/tree
Emitter discharge is 4 L/ha

II. Sub: Mulching treatments:

1. Black polyethylene sheets with 60 micron thickness as inorganic material.
2. Cut grass in 10 cm depth as organic material.
3. Bare soil (control).

Black P.E or dry cut grass was used in two mulching treatments, with a bare soil as control. Both mulching treatments were applied on both sides of the tree line, from the trunk to the point under the periphery of the tree. The mulching area was about 27 m^2 for each replicate. Mulching materials were applied on March, 1st until the end of November of the two years of study.

Eighty one uniform trees were selected and divided into three blocks. Each block had three main plots, each main plot divided into three sub-plots of three trees. The main factor treatments (3 irrigation rates) were arranged in the main plots while, the submain factor treatments (both mulching types plus bare soil) were arranged in the sub plots in nine (3 irrigation x 3 mulching) combination treatments. The experimental treatments were

arranged in a complete randomized block split plot design with three replication in each and three trees per each replicate (3 replicate x 3 trees).

Measurements and determinations:

1. Soil temperature and moisture content:

Soil temperature at 10 cm, depth was measured by mercury in glass thermometer in each replicate. Average temperature for three days on July 10, 11 and 12 in both years was calculated. In addition, soil samples were taken at (0-20), (20-40) and (40-60) cm, depth to determine average soil moisture content as percent on dry weight basis, 24 and 48 hours after each irrigation in July of both years.

2. Vegetative growth parameters:

Four main branches, in different direction on each tree were labeled. All current shoots developed on these branches in spring were used for measuring vegetative growth parameters i.e. shoot length (cm) shoot diameter (cm) and leaf area (cm^2) by Li-Core 3100 Areameter. Leaves were dried and weighted to get leaf dry weight (gm) and then leaf specific weight (LSW) was calculated as (mg/cm^2) according to Hunt (1989) also, seasonal increment in TCSA cm^2 was calculated.

3. Root growth and distribution:

Fibrous roots density was determined in soil samples taken in November of both seasons at (0-30), (30-60) and (60-90) cm, depth by soil auger at 130-150 cm from tree trunk horizontally in four directions. Fibrous roots less than 2 mm in diameter from each sample were cleaned, counted and their fresh weight was determined as gm/hole (1750.80 cm^3 or 1.628 kg soil) according to methods described by (Cahoon *et al.*, 1959 and Ford, 1962).

4. Chemical determinations:

a. Leaf macro and micronutrients:

Fifty mature mid-shoot leaves in mid August of both seasons were collected at random, washed three times with tap water, then washed again by distilled water. Sampling were oven dried at 70°C to constant weight, ground and digested with H_2O_2 and H_2SO_4 for the determination of leaf mineral contents. Nitrogen was estimated by micro-kjeldahl gunning methods (A.O.A.C., 1990). Phosphorus was determined with a colourimetric method as described by Snell and Snell (1968). Potassium was determined by flame photometer E.E.L., Model (Jackson, 1967). Calcium, magnesium, iron, zinc and manganese were determined by Parking-Elmer Atomic absorption spectrophotometer model 2380 AL, according to Jackson and Ulish (1959) and Yoshida *et al.* (1972). All macro-elements were expressed as percent, while micro-elements were expressed as (ppm) on dry weight basis.

b. Leaf total chlorophyll content:

Leaf total chlorophyll content (SPAD) value was determined by using a Portable Minolta Chlorophyll Meter (Model SPAD-501). Leaf samples collected in mid-June and the reading was taken at the middle of leaf blade according to Murquard and Timptons (1987).

c. Leaf free proline content:

Fully expanded leaves were sampled in first August of both 2003 and 2004 seasons. Approximately 0.5 gm of fresh leaf sample was homogenized in 10 ml of 3% sulphosalicylic acid and the homogenate filtered through Whatman No. 2 filter paper, then free proline was extracted in the filtrate using acid non hydrine and glacial acetic acid. the absorbency of the supernatant was recorded using a spectrophotometer at 520 nm wave length and the concentration was estimating from standard curve as µmole/gm fresh weight according to Bates *et al.* (1973).

All obtained data were subjected to statistical analysis according to Snedecor and Cochran (1990) and the least significant differences L.S.D. test at 0.05 were used for compared between averages.

RESULTS AND DISCUSSION

Effect of drip irrigation rate (I), mulching type (M) and their interaction (I x M) on:

I. Soil temperature (°C):

Data presented in Table (4) showed that, soil temperature reached the maximum values at 2 p.m then, reduced to minimum at 8 p.m. however, under drip irrigation condition, soil temperature at 8 a.m, 2 p.m, and 8 p.m. were not significantly influenced with irrigation treatments in both seasons. Such results are in line with those obtained by Srivastava *et al.* (1984). Meanwhile, El-Henawy (2006) indicated that soil temperature were higher under drip irrigation treatments than that under surface irrigation one.

Concerning, the impact of mulching treatments, the obtained data revealed that, soil temperature reading under black polyethylene mulch were always higher than under dry cut grass or bare soil (unmulch). It could be concluded that, block P.E was more effective on keeping soil temperature higher than bare soil and dry cut grass as organic mulching material by about 2-4°C and the differences among all treatment were significant in both 2003 and 2004 seasons. Mulching with black P.E maintained continuously higher temperature as it intercepts more solar addition (Thakur *et al.*, 1993). These findings are supported by those obtained by Neislon *et al.* (1986), Diaz-Perez and Batal (2002) and Zeerban (2004). Meanwhile, soil temperature reading under dry cut grass were always lower at 8 a.m, 2 p.m or 8 p.m as compared to bare soil or under black P.E. This reduction in soil temperature resulted

under dry cut grass could be due to shading effect of this organic material. Similar observation on thermal control by organic mulches have been reported by Zayan (1994), Chattopadhyay and Patra (1997), Rao and Pathak (1998) and Zeerban (2004).

Table (4): Effect of drip irrigation and mulching treatments and their interaction on soil temperature (°C) and moisture content (%) in 2003 and 2004 seasons.

Treatments		Av. soil temperature (°C)						Soil moisture %			
Irrig.	Mulching	8 a.m		2 p.m		8 p.m		24 (HAI)*		48 (HAI)*	
rate	type	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
I_1	Bare soil	28.5	29.3	31.5	32.6	29.8	30.7	20.77	20.61	14.33	13.80
	Cut grass	27.4	28.1	28.7	29.5	27.7	29.0	25.98	24.89	16.93	16.52
	Black P.E.	29.9	30.3	33.5	35.7	31.8	33.6	27.53	26.38	17.58	17.29
I_2	Bare soil	28.4	29.4	31.1	32.5	30.3	31.0	19.46	19.10	13.16	12.83
	Cut grass	27.1	28.2	29.0	30.1	28.4	29.1	23.59	23.72	16.29	15.77
	Black P.E.	29.8	30.6	33.7	35.2	31.7	33.5	25.65	25.22	18.01	16.73
I_3	Bare soil	28.6	29.8	31.6	33.0	30.5	31.9	18.21	17.41	12.79	11.96
	Cut grass	27.7	28.6	29.5	30.7	28.2	29.8	21.04	20.99	15.22	14.61
	Black P.E.	30.2	30.3	34.2	35.9	31.6	33.1	22.79	22.32	16.18	15.16
L.S.D. 0.05		0.44	0.71	3.29	3.73	0.66	0.85	1.619	2.720	1.130	0.817
Average	I_1	28.6	29.2	31.2	32.6	29.8	31.1	24.76	23.96	16.28	15.87
	I_2	28.4	29.4	31.3	32.6	30.1	31.2	22.90	22.68	15.82	15.11
	I_3	28.8	29.6	31.8	33.2	30.1	31.6	20.68	20.24	14.73	13.91
L.S.D. 0.05		N.S	N.S	N.S	N.S	N.S	N.S	1.091	2.432	0.611	0.468
Average	Bare soil	28.5	29.5	31.4	32.7	30.2	31.2	19.48	19.04	13.43	12.86
	Cut grass	27.4	28.3	29.1	30.1	28.1	29.3	23.54	23.20	16.15	15.63
	Black P.E.	30.0	30.4	33.8	35.6	31.7	33.4	25.32	24.64	17.26	16.39
L.S.D. 0.05		0.27	0.23	1.08	1.72	0.33	0.32	0.885	1.005	0.694	0.491

I_1, I_2 and I_3 = 13.584, 10.188 and 6.792 m^3 irrigation water/tree/year, respectively.
Soil mulching material was applied on March, 1st in both seasons.
HAI: Hours after irrigation.

However, the most important data were disclosed by the interaction (I x M) which were significantly in both seasons. Maximum soil temperature always belonged to (I_1 x black P.E), (I_2 x black P.E) and (I_3 x black P.E) combination treatments without significant differences among them. So, most of the effect was due the usage of black P.E, while, the least values obtained with (I_1 x cut grass), (I_2 x cut grass) and (I_3 x cut grass) combination treatments.

2. Soil moisture content:

As shown in Table (4), it is clear that, soil moisture % at 24 or 48 hours after drip irrigation were gradually decreased by reducing drip irrigation rate from 13.584 or 10.188 to 6.792 m^3/tree/year. The least moisture percentages belonged to lower irrigation rate (I_3) while, maximum soil moisture content recorded with higher (I_1) and moderate (I_2) irrigation rates without significant differences between them, except at 24 hours after irrigation in the first season. These results are in harmony with those of El-Henawy (2006).

It is noticeable from data in Table (4) that the two mulching treatments increased the percentage of soil moisture at 24 and 48 hours after drip irrigation as compared to bare soil (unmulched). Moreover, the differences between black P.E or dry cut grass mulching treatments and bare soil were always significant in both seasons. In addition, black P.E was more effective on increasing soil moisture content than cut grass. Both mulch materials specially black P.E., conserved soil moisture content by reducing the evaporation rate from the soil surface. Therefore, mulched soil gave the chance for apple tree to absorb more water by roots than bare soil (unmulched). Similar results were obtained by Mbagwu (1991), Zayan (1991), Khalifa (1994), Rao and Pathak (1998) and Zeerban (2004). They found that, various mulching treatments showed remarkable influence on moisture retention at all stages of sampling.

The interaction (I x M) was significant in both seasons. The best combination treatment was (I_2 x black P.E) and/or (I_2 x cut grass) which seemed to be beneficial in saving irrigation water and keeping moisture in drip irrigated apple rows to an optimum level in new reclaimed areas.

3. Vegetative growth parameters:

a. Shoot and leaf growth parameters:

The obtained data in Table (5) show shoot and leaf parameters of "Anna" apple trees as affected by drip irrigation rate (I), mulching treatment (M) and their interaction (I x M) in 2003 and 2004 seasons. It is clear that, shoot length and diameter (cm), area per leaf (cm^2) and individual leaf dry weight (gm) as well as leaf specific weight (mg/cm^2) were significantly increased by raising drip irrigation rate up to 10.188 or 13.584 m^3/tree/year. The highest values were obtained by application of I_1 (13.584 m^3/tree/year) while, the least values induced by deficit irrigation rate (I_3) 6.792 m^3/tree/year. This reduction in tree growth under water stress condition could be attributed to lower photoysnthetic rate and stomatal conductance (Mpelascoka *et al.*, 2001). In this respect, Atkinson *et al.* (2000) said that, drought stress induced an increase in root abscicis acid (ABA) production and transportation to the shoot. The increase in ABA could be expected to reduce shoot growth and leaf expansion of "Queen Cox" apple trees. These results are in line with those obtained by Fathi (1999a) on "LeCont" pear trees, Shahein *et al.* (2002) on "Anna" apple trees and Abd El-Messeih and El-Gendy (2004a) on "Canino" apricot trees. They found that, shoot and leaf growth were significantly reduced under the low drip irrigation rates.

Regarding the effect of mulching treatments on shoot and leaf growth parameters, it is clear that, both black P.E and dry cut grass treatments significantly increased shoot length, diameter and leaf area as well as leaf dry and specific weights compared to bare soil in both seasons. Moreover, black polyethylene mulch was more effective in increasing shoot and leaf growth. Also, dry cut grass mulch has increased the shoot and leaf growth too but to

a less degree than black P.E. mulch. The positive effect of soil mulching treatments on improving shoot and leaf growth of "Anna" apple trees might be due to its effects on soil temperature and moisture content as shown in Table (4), which enhanced root growth and increased nutrients uptake via the roots. These finding are in full agreement with those obtained by Hifny *et al.* (1994) and Zeerban (2004) on grapevines and Zayan *et al.* (1994) and Pande *et al.* (2005) on apple trees. However, the interaction (I x M) was significant in both 2003 and 2004 seasons and the highest values of shoot and leaf growth parameters came from high and moderate irrigation rates under both black P.E. and cut grass mulches in (I_1 x black PE), (I x cut grass), (I_2 x black P.E) and (I_2 x cut grass) combination treatments and the differences among of them were unsignificant. So, (I_2 x cut grass) considered the suitable combination treatment for improving shoot and leaf growth of "Anna" apple trees due to saving irrigation water by using moderate rate (I_2) as well as abundant, cheapness and benefits of applying cut grass as organic material to the soil after mulching period.

Table (5): Effect of drip irrigation and mulching treatments and their interaction on vegetative growth of "Anna": apple trees in 2003 and 2004 seasons.

Treatments		Shoot length (cm)		Shoot diameter (cm)		Leaf area (cm^2)		Leaf dry wt. (gm)		L.S.W. * (mg/cm^2)		TCSA-increase (cm^2)	
Irrig. rate	Mulching type	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
I_1	Bare soil	40.43	41.88	0.72	0.70	34.36	35.62	0.361	0.385	10.50	10.81	24.53	25.27
	Cut grass	45.78	47.51	0.90	0.87	42.58	43.51	0.475	0.502	11.16	11.54	34.92	30.45
	Black P.E.	46.93	48.22	0.93	0.90	44.20	45.35	0.495	0.520	11.21	11.47	36.93	31.73
I_2	Bare soil	35.42	36.09	0.71	0.64	33.40	34.55	0.329	0.349	9.85	10.11	20.89	15.90
	Cut grass	41.61	42.33	0.84	0.83	38.26	39.37	0.411	0.433	10.74	11.00	25.36	22.36
	Black P.E.	42.74	43.86	0.82	0.86	41.17	42.45	0.454	0.482	11.03	11.36	27.86	21.86
I_3	Bare soil	25.22	27.18	0.60	0.58	26.95	28.10	0.254	0.273	9.42	9.72	15.01	13.29
	Cut grass	31.14	31.72	0.65	0.62	31.78	32.94	0.323	0.345	10.17	10.48	17.93	12.63
	Black P.E.	32.02	32.66	0.67	0.65	32.83	33.97	0.336	0.358	10.24	10.55	17.93	14.62
L.S.D. 0.05		6.191	4.057	0.056	0.040	4.027	3.995	0.0362	0.0348	0.448	0.454	6.71	7.02
Average	I_1	44.38	45.87	0.85	0.83	40.38	41.49	0.444	0.469	10.96	11.27	32.06	29.15
	I_2	39.91	40.76	0.79	0.78	37.61	38.79	0.398	0.421	10.54	10.82	24.70	20.04
	I_3	29.46	30.52	0.64	0.62	30.52	31.67	0.304	0.325	9.94	10.25	16.96	13.52
L.S.D. 0.05		5.502	1.543	0.046	0.010	2.421	2.716	0.0168	0.0226	0.295	0.404	1.68	5.96
Average	Bare soil	33.69	35.05	0.68	0.64	31.57	32.73	0.315	0.336	9.92	10.21	20.14	18.15
	Cut grass	39.51	40.52	0.80	0.77	37.54	38.61	0.403	0.427	10.69	11.01	26.00	21.82
	Black P.E.	40.55	41.58	0.81	0.80	39.40	40.59	0.428	0.453	10.83	11.13	27.51	22.74
L.S.D. 0.05		2.330	2.689	0.026	0.027	2.371	2.195	0.0232	0.0197	0.251	0.171	4.62	2.97

I_1, I_2 and I_3 = 13.584, 10.188 and 6.792 m^3 irrigation water/tree/year, respectively.
Soil mulching material was applied on March, 1st in both seasons.
* L.S.W. = Leaf specific weight.

b.Trunk cross section area (TCSA) increase (cm^2):

Data in Table (5) cleared that, TCSA-increase (cm^2) of Anna apple trees take the same trend as with shoot and leaf growth parameters as affected with drip irrigation and mulching treatments as well as their interaction. It was markedly decreased by reducing drip irrigation rate from 13.584 to 6.792 m^3/tree/year. Similar findings are in harmony with those reported by Shahein *et al.* (2002) and Abd El-Messeih and El-Gendy (2004a). who, mentioned that upper rate of drip irrigation induced significantly high TSCA-increase than other treatments. Meanwhile, soil mulching with black P.E or dry cut grass recorded largest TCSA-increase as compared to unmulched treatment (bare soil). This result is mainly due to regulation of soil temperature, increasing available soil moisture and improving nutrient uptake (Thakur *et al.*, 1997). Moreover, highest increase in TCSA (cm^2), came from high irrigation rate (I_1) under soil mulching with black P.E or dry cut grass in (I_1 x Black P.E) or (I_1 x cut grass) interaction whereas, the least increase produced by (I_3 x bare sol) interaction. This hold was true in both seasons.

c. Root growth parameters:

Data in Table (6) showed the average number and fresh weight (gm/hole) of the fibrous roots of "Anna" apple trees at (0-30), (30-60) and (60-90), cm soil depth as affected by drip irrigation rate (I), mulching type (M) and their interaction (I x M) during 2003 and 004 seasons.

The obtained data exhibited that, average number and fresh weight (gm) of fibrous roots were decreased by increasing depth from soil surface up to (60-90) cm, depth. In addition, more fibrous roots with heavy fresh weights were produced at the surface soil layer (0-30) cm, depth compared to deeper soil one (60-90) cm, depth in both seasons.

The data also revealed that, average number and fresh weight of fiborus roots at all soil depths were significantly decreased with decreasing of drip irrigation rates from 13.584 to 6.792 m^3/tree/year. The highest values were recorded by I_1 (13.584 m^3/tree/year) while, the lowest values were obtained by I_3 (6.792 m^3/tree/year) in the two seasons. This reduction in root density and fresh weight under soil drought conditions could be attributed to decreasing the uptake of water and nutrients vla the roots. Moreover, the shortage of water supply caused death of more roots. The above mentioned results are in accordance with those obtained by Ruggiero (1991), Fathi (1996b), El-Sanhoury (2003) and El-Henawy (2006). They found that root density and fresh weight were significantly decreased by reducing irrigation rate. Moreover, Hussein (1998) indicated that, irrigation increased root density of "Anna" apple trees.

Table (6): Effect of drip irrigation and mulching treatments and their interaction on number and fresh weight of fibrous roots of "Anna" apple trees in 2003 and 2004 seasons.

Treatments		Av. number of roots*						Av. root fresh wt. (gm/hole)					
Irrig. rate	Mulching type	0-30 cm depth		30-60 cm depth		60-90 cm depth		0-30 cm depth		30-60 cm depth		60-90 cm depth	
		2003	2004	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
I_1	Bare soil	49.8	49.7	21.0	23.8	5.5	5.5	1.793	1.789	0.861	0.976	0.261	0.259
	Cut grass	57.0	58.3	25.2	27.5	6.3	6.5	2.166	2.215	1.058	1.159	0.302	0.312
	Black P.E.	52.5	55.2	23.7	26.3	5.8	6.2	2.048	2.153	1.019	1.131	0.284	0.304
I_2	Bare soil	36.5	39.0	17.5	18.7	4.2	4.7	1.387	1.445	0.718	0.767	0.197	0.221
	Cut grass	51.7	57.5	22.3	24.8	5.7	6.3	1.861	2.185	0.937	1.042	0.274	0.315
	Black P.E.	48.2	56.8	20.8	23.2	5.3	6.0	1.879	12.152	0.894	0.998	0.259	0.294
I_3	Bare soil	31.2	34.3	13.7	15.8	3.5	3.8	1.154	1.269	0.562	0.648	0.165	0.179
	Cut grass	39.5	43.8	18.8	19.7	4.3	4.8	1.423	1.664	0.789	0.827	0.206	0.230
	Black P.E.	41.3	44.7	19.2	21.3	4.5	5.0	1.446	1.699	0.826	0.895	0.221	0.242
L.S.D. 0.05		5.64	3.21	2.73	2.55	1.02	1.21	0.361	0.360	0.129	0.163	0.045	0.034
Average	I_1	53.1	54.4	23.3	25.9	5.9	6.1	2.002	2.052	0.979	1.089	0.282	0.292
	I_2	45.5	50.1	20.2	22.2	5.1	5.7	1.709	1.927	0.850	0.936	0.243	0.277
	I_3	40.7	40.9	17.2	18.9	4.1	4.5	1.341	1.544	0.726	0.790	0.197	0.217
L.S.D. 0.05		2.94	2.35	1.59	1.08	0.80	1.04	0.296	0.258	0.076	0.114	0.038	0.021
Average	Bare soil	39.2	41.0	17.4	19.4	4.4	4.7	1.445	1.501	0.714	0.797	0.208	0.220
	Cut grass	49.4	53.2	22.1	24.0	5.4	5.9	1.817	2.021	0.928	1.009	0.261	0.286
	Black P.E.	47.3	51.2	21.2	23.6	5.2	5.7	1.791	2.001	0.913	1.008	0.255	0.280
L.S.D. 0.05		3.50	1.66	1.62	1.66	0.48	0.50	0.162	0.191	0.077	0.088	0.020	0.020

I_1, I_2 and I_3 = 13.584, 10.188 and 6.792 m^3 irrigation water/tree/year, respectively.
Soil mulching material was applied on March, 1st in both seasons.
* The average number of fibrous roots in hole (1570.80 cm^3 or 1.628 kg soil).

As for the effect of soil mulching treatments, data further revealed that, both mulching treatments significantly increased the average number and fresh weight of the fibrous roots of "Anna" apple trees at (0-30), (30-60) and (60-90) cm, soil depth as compared with the control (bare soil). Furthermore, dry cut grass treatment produced the highest values descendingly followed by black P.E. treatment without significantly differences between them except for the average number of fibrous roots at (0-30) cm in the second season. The differences were significant when compared to the control in both seasons. The positive effect of soil mulching treatments on root distribution determined as number and fresh weight of the fibrous roots may be due to regulation of soil temperature and its conserved soil moisture which in turn, tended to enhance root growth of "Anna" apple trees. These findings are in line with those obtained by Zayan (1991) on "Washington Navel" orange trees, Thakur *et al.* (1997) on "Red Delicious" apple trees and Zeerban (2004) on "Thompson seedless" grapevines. They found that, soil mulching treatments significantly increased fresh weight and the average number of fibrous roots grown under the mulched area.

Concerning the interaction between drip irrigation rates and mulching treatments (I x M) the data of Table (6) indicated that, such interaction had significant effect on average number and fresh weight of fibrous roots at different soil depths in 2003 and 2004 seasons. Maximum values were

produced with (I_1 x cut grass), (I_1 x black P.E), (I_2 x cut grass) and (I_2 x Black P.E) interactions while the minimum values were obtained with (I_3 x Bare soil) interaction. Thus, using moderate drip irrigation rate with 10.188 m^3/tree/year under soil mulched with dry cut grass in (I_2 x cut grass) combination treatment is considered the suitable one for improving root growth of "Anna" apple trees.

4. Leaf mineral contents:

Data of macro (N, P, K, Ca and Mg) and micro (Fe, Mn and Zn) nutrients as affected by irrigation rate, mulching treatments and their interaction are presented in Tables (7 and 8).

With respect to drip irrigation treatments, the data indicated that, decreasing irrigation rate resulted in significant reduction leaf N, P, K, Cu, Mg, Fe, Mn and Zn contents and the effect of all irrigation treatments could be arranged as follow: I_1 > I_2 > I_3. The differences among the three tested irrigation rates were always significant in 2003 and 2004 seasons. These results may be led to the conclusion that nutrient uptake was retarded under water stress conditions where the roots failed to absorb and accumulate valuable nutrient elements. Furthermore, depletion of soil moisture level caused a reduction in leaf mineral contents due to reduced active rooting as an indirect influence (Abd El-Messeih and El-Gendy, 2004b). Similar results were obtained by Pacholack (1986), Hussein (1998) and Fathi (1999a), they indicated that, irrigation tend to increase leaf mineral contents.

Table (7): Effect of drip irrigation and mulching treatments and their interaction on leaf macronutrients (%) of "Anna' apple trees in 2003 and 2004 seasons.

Treatments		Macronutrients % on D.W.t									
Irrig. rate	Mulching type	N		P		K		Ca		Mg	
		2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
I_1	Bare soil	2.40	2.33	0.26	0.25	1.51	1.53	1.26	1.28	0.35	0.37
	Cut grass	2.47	2.53	0.30	0.34	1.68	1.71	1.34	1.36	0.42	0.44
	Black P.E.	2.53	2.60	0.28	0.31	1.67	1.69	1.32	1.34	0.39	0.41
I_2	Bare soil	2.07	2.20	0.23	0.24	1.38	1.41	1.15	1.16	0.32	0.32
	Cut grass	2.33	2.40	0.28	0.30	1.66	1.69	1.32	1.33	0.37	0.40
	Black P.E.	2.40	2.47	0.27	0.27	1.64	1.65	1.29	1.31	0.36	0.39
I_3	Bare soil	1.93	1.93	0.18	0.19	1.22	1.26	1.13	1.08	0.28	0.29
	Cut grass	2.00	2.27	0.24	0.24	1.41	1.43	1.21	1.22	0.33	0.35
	Black P.E.	2.13	2.33	0.21	0.23	1.39	1.412	1.18	1.19	0.32	0.33
L.S.D. 0.05		0.250	0.248	0.056	0.058	0.097	0.068	0.086	0.056	0.052	0.040
Average	I_1	2.47	2.49	0.28	0.30	1.62	1.64	1.31	1.33	0.39	0.41
	I_2	2.27	2.36	0.26	0.27	1.56	1.58	1.25	1.27	0.35	0.37
	I_3	2.02	2.18	0.21	0.22	1.34	1.37	1.17	1.16	0.31	0.32
L.S.D. 0.05		0.161	0.108	0.051	0.054	0.089	0.054	0.073	0.037	0.051	0.031
Average	Bare soil	2.13	2.15	0.22	0.23	1.37	1.40	1.18	1.17	0.32	0.33
	Cut grass	2.27	2.40	0.27	0.29	1.58	1.61	1.29	1.30	0.37	0.40
	Black P.E.	2.35	2.47	0.25	0.27	1.57	1.59	1.26	1.28	0.36	0.38
L.S.D. 0.05		0.143	0.161	0.020	0.018	0.032	0.032	0.036	0.031	0.010	0.019

I_1, I_2 and I_3 =13.584, 10.188 and 6.792 m^3 irrigation water/tree/year, respectively.
Soil mulching material was applied on March, 1st in both seasons.

According to leaf analysis presented in Tables (7 and 8) it is clear that, leaf N, P, K, Ca, Mg, Fe, Mn and Zn were increased by both black P.E and dry cut grass mulching treatments in most cases as compared with bare soil and the differences between each of them and the control were significant in both seasons. The highest values of leaf, P, K, Ca, Mg, Fe, Mn and Zn-contents were belonged to dry cut grass mulching treatment, while, the highest values of leaf N-content were belonged to black P.E mulching treatment during 2003 and 2004 seasons. These findings were supported by those obtained by Neilsen *et al.* (1986), Zayan *et al.* (1994) and Thakur *et al.* (1997) on apple trees and Zeerban (2004) on grapevines they mentioned that, soil mulching treatment increased leaf mineral contents, specially soil mulching with organic materials, which gave better effect than polyethylene mulching one. These results may be attributed to the mulching effect on improving root growth and its respiration rate due to modifying soil temperature and moisture content, which in turn, created a suitable condition for soil microorganisms. These modifications in soil condition may be responsible for increasing nutrients absorption via roots. The interaction (I x M) was significant meaning the importance of drip irrigation and mulching treatments in influencing leaf mineral content. The highest values of leaf N, P, K, Ca, Mg, Fe, Mn and Zn-contents belonged to (I_1 x cut grass), (I_1 x black P.E) and (I_2 x cut grass) and the differences among them were always unsignificant.

Table (8): Effect of drip irrigation and mulching treatments and their interaction on leaf macronutrients, total chlorophyll and free proline contents of "Anna' apple trees in 2003 and 2004 seasons.

Treatments		Micronutrients (ppm) on D.t.						Total chl. (SPAD)		Free proline µ males/grm f.wt.	
Irrig.	Mulching	Fe		Mn		Zn					
rate	type	2003	2004	2003	2004	2003	2004	2003	2004	2003	2004
I_1	Bare soil	112.0	113.7	48.7	49.8	18.2	19.6	50.2	50.9	0.32	0.34
	Cut grass	124.8	126.0	55.2	56.6	23.7	25.6	55.1	55.6	0.28	0.30
	Black P.E.	121.6	124.2	53.9	54.8	22.4	24.8	55.8	56.8	0.27	0.28
I_2	Bare soil	101.9	105.4	46.6	48.6	16.7	18.3	50.5	49.8	0.36	0.38
	Cut grass	119.7	122.8	52.0	51.5	21.9	22.1	53.1	53.5	0.33	0.33
	Black P.E.	116.4	115.3	49.6	50.2	20.8	21.7	53.3	55.1	0.33	0.34
I_3	Bare soil	87.5	89.1	42.4	41.7	12.3	11.8	46.2	47.1	0.49	0.50
	Cut grass	102.4	104.5	44.1	46.3	17.6	18.5	49.7	49.5	0.43	0.44
	Black P.E.	99.2	101.9	43.8	45.0	16.9	17.4	50.2	51.0	0.41	0.42
L.S.D. 0.05		12.25	15.68	6.10	6.08	4.68	3.37	1.72	1.37	0.035	0.043
Average	I_1	119.5	121.3	52.6	53.7	21.4	23.1	53.7	54.1	0.29	0.31
	I_2	112.7	114.5	49.4	50.1	19.8	20.7	52.3	52.8	0.34	0.35
	I_3	96.4	98.5	43.4	44.3	15.6	15.9	48.9	49.2	0.44	0.45
L.S.D. 0.05		8.22	10.56	4.27	4.87	3.50	2.11	1.39	0.98	0.024	0.032
Average	Bare soil	100.5	102.7	45.9	46.7	15.7	16.6	49.0	49.3	0.39	0.41
	Cut grass	115.6	117.8	50.4	51.5	21.1	21.9	52.6	52.9	0.35	0.36
	Black P.E.	112.4	113.8	49.1	50.0	20.0	21.3	53.1	54.3	0.34	0.35
L.S.D. 0.05		6.79	8.67	3.28	2.84	2.37	1.94	0.80	0.73	0.019	0.022

I_1, I_2 and I_3 =13.584, 10.188 and 6.792 m^3 irrigation water/tree/year, respectively.
Soil mulching material was applied on March, 1st in both seasons.

This reflect the importance of soil cover more than water regime. Meanwhile, adding 6.792 m^3 irrigated water to unmulched tree in (I_3 x bare soil) combination treatment showed the least values. Wherefore, moderate irrigation level 10.188 m^3/tree under dry cut grass mulch in (I_2 x cut grass) interaction considered the most suitable treatment because it not only keeping optimum soil moisture level but also improved vegetative growth and increasing leaf mineral content, (Tables 2 and 8).

5. Leaf chlorophyll content:

As shown in Table (8) it is clear that, total chlorophyll content in leaves of Anna apple trees grown under high irrigation treatment (I_1) was highest discendingly followed by I_2 and I_3, respectively. The differences among them were significant in 1st and 2nd seasons. Moreover, the data recorded significantly increased in leaf total chlorophyll content under black P.E. or dry cut grass mulching treatment in both seasons. These results revealed a positive correlation between soil moisture level and leaf chlorophyll content. This increment in total chlorophyll content could be attributed to increasing of the macronutrients uptake, especially N and Mg via the as a consequence of improved soil moisture under irrigation and mulching condition. Mengle and Kirkby (1982) reported that N and Mg element are necessary for chlorophyll synthesis. Data of macronutrients in Table (7) supported this explanation. Similar results were obtained by Abd El-Messeih and El-Gendy (2004b) who found that, decreasing the amount of irrigation water caused a significant decrease in leaf total chlorophyll. In addition, Zayan *et al.* (1991) and Zeerban (2004) mentioned that, highest leaf chlorophyll content were obtained by soil mulched with black P.E or some organic materials. Concerning the interaction (I x M), the data revealed that, such interaction had a significant effect on total chlorophyll content in leaves of "Anna" apple trees and the maximum values was produced when irrigated with high rate under black P.E or dry cut grass mulching in (I_1 x black P.E) and (I_1 x cut grass) combination treatments without significant differences between them in both seasons. While the minimum values was obtained by unmulched trees when irrigated with deficit level in (I_3 x bare soil) combination treatment.

6. Leaf free proline:

It is clear from the data in Table (8) that, leaf free proline content of "Anna" apple trees was significantly high under deficit irrigation treatment (I_3) followed by I_2 and I_1, respectively, during 2003 and 2004 seasons. This result means that water stress under deficit irrigation rate led to increase hydrolysis of proteins and stimulate the biothynthesis and accumulation of free amino acid proline in leaves. These findings are in harmony with those of Fathi *et al.* (1999) who indicated water stress is associated with wilting which causes an increase of non-protein proline formation. Such negative correlation between

the irrigation rate and free proline content was also noticed by Zayan *et al.* (2002) on grapevines and El-Sanhoury (2003) and Abd El-Masseih and El-Gendy (2004b) on apricot trees. Concerning the effect of mulching treatments the data presented in Table (8) revealed that, proline content was significantly decreased by both black P.E and dry cut grass mulching treatments and its more pronounced in leaves of unmulched trees. These results mean that mulching treatment reduced water stress and decreased accumulation of proline. This conclusion agrees with results of Levitt (1980). With respect to the interaction (I x M), the data clarified that, the interaction was significant in both seasons and the highest values of free proline content produced in leaves of unmulched trees under deficit irrigation rate in (I_3 x bare soil) interaction. Whereas, the least values recorded with (I_1 x black P.E) or (I_1 x cut grass) interaction.

CONCLUSION

It could be concluded that, for irrigating "Anna" apple trees planted on loamy sand soil at El-Bostan area using the drip irrigation system with 10.188 m^3 and soil mulching with dry cut grass in (I_2 x cut grass) which considerable the best combination treatment for saving irrigation water and keeping soil moisture in root zone to an optimum level which improved shoot and root growth as well as increased leaf mineral and total chlorophyll contents.

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تأثير بعض معاملات الرى بالتنقيط وتغطية التربة على:

١- النمو الخضرى والحالة الغذائية لأشجار التفاح صنف آنا النامية فى الأراضى حديثة الاستصلاح

جهاد بشرى يوسف ميخائيل

قسم بحوث الفاكهة المتساقطة الأوراق ــ معهد بحوث البساتين ــ مركز البحوث الزراعية ــ الجيزه ــ مصر

الملخص العربى

أجريت هذه الدراسة فى موسمى ٢٠٠٣ ، ٢٠٠٤م على أشجار تفاح صنف "آنـا" عمرهـا سـبعة سنوات ومطعومة على أصل المالس ونامية فى تربة طميية رملية بمنطقة البستان بمحافظـة البحيـرة والهدف من هذا البحث هو دراسة تأثير ثلاث معاملات رى بـالتنقيط وهـى ١٣,٥٨٤ ، ١٠,١٨٨ ، ٦,٧٩٢م^{٣}/شجرة/سنة (رى$_{١}$ ، رى$_{٢}$ ، رى$_{٣}$) ومعاملتين لتغطية التربة وهما التغطية بالبلاستيك الأسود والحشائش المقطوعة الجافة بجانب التربة العارية والتفاعل بينهما على النمو الخضرى ونمو المجموع الجذرى والحالة الغذائية وقد خلص البحث الى:

تعتبر معاملة التغطية بالبلاستيك الأسود الأكثر تأثيرا فى الحفاظ على درجة حـرارة التربـة أعلـى بحوالى ٢-٤°م من معاملتى التربة العارية والتغطية بالحشائش المقطوعة والتى تخفض درجة حـرارة التربة خاصة الساعة الثانية بعد الظهر نتيجة لتأثير التظليل لهذه المادة العضوية بينما لـم يظهـر أى تأثير لمعاملات الرى بالتنقيط على درجة حرارة التربة. بالإضافة إلى ذلك فإن زيادة معدل الرى بالتنقيط حتى ١٠,١٨٨ أو ١٣,٥٨٤م^{٣}/شجرة/سنة أدت إلى زيادة معنوية فى المحتوى الرطوبى للتربـة كمـا أدت كلا من مادتى التغطية إلى زيادة نسبة رطوبة التربة كما يزداد هذا التأثير مـع معاملـة التغطيـة بالبلاستيك الأسود نتيجة لتقليل بخر الماء من سطح التربة.

أظهرت النتائج أن طول وقطر النموات والمساحة الورقية والوزن الجاف والوزن النوعى للورقـة ومساحة مقطع الجذع بالإضافة إلى متوسط عدد جذور الامتصاص ووزنها الطازج كانـت فـى زيـادة متناسبة مع زيادة معدل الرى. علاوة على ذلك فإن كلا من مادتى التغطية أدت إلى زيادة مقاييس النمو الخضرى فى كل من سنتى الدراسة.

أوضحت النتائج أن الرى بالمعدل المتوسط مع تغطية سطح التربة بالبلاستيك الأسود أو الحشائش المقطوعة الجافة فى (رى٢ × بلاستيك أسود) أو (رى٢ × حشائش مقطوعة) والتى تعتبر أفضل معاملة فى زيادة مقاييس النمو الخضرى بينما تعطى المعاملة (رى٣ × تربة عارية) أقل القيم.

أدى استخدام معدل الرى المنخفض رى٢ (٦,٧٩٢ م٣/شجرة/سنة) إلى نقص معنوى فى محتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم والكالسيوم والماغنسيوم والحديد والمنجنيز والزنك والكلوروفيل الكلى وعلى العكس من ذلك فإن محتوى الأوراق من البرولين الحر قد زاد ، بينما تغطيه سطح التربة تؤدى إلى زيادة محتوى الأوراق من العناصر الكبرى والصغرى والكلوروفيل الكلى خاصة عند التغطية بالحشائش المقطوعة.

بينت النتائج أن استخدام المعاملات المركبة (رى١ × بلاستيك أسود) ، (رى١ × حشائش مقطوعة)، (رى٢ × حشائش مقطوعة) أعطت أعلى قيم فى محتوى أوراق التفاح صنف "آنا" من العناصر الصغرى والكبرى والكلوروفيل الكلى على التوالى بدون فروق معنوية بينهم ومن جهة أخرى فإن أقل القيم تتبع المعاملة (رى٣ × تربة عارية) فى كلا الموسمين.

لذلك توصى هذه الدراسة مزارعى التفاح صنف "آنا" باستخدام معدل الرى المتوسط مع تغطية سطح التربة بالحشائش المقطوعة الجافة فى المعاملة المركبة (رى٢ × حشائش مقطوعة) والتى تعتبر أفضل معاملة لتوفير ماء الرى والحفاظ على رطوبة التربة مما يزيد من نمو المجموع الخضرى والجذرى ويحسن من الحالة الغذائية للأشجار تحت ظروف الأراضى الطميية الرملية.