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WATER MANAGEMENT FOR APPLE TREES UNDER DRIP IRRIGATION

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ABSTRACT

Four drip irrigation treatments were used in a four years old apple orchard during 1997-1998 season at Khatatba, Menofia Governorate to determine the effect of water amounts on growth, yield, fruit quality and water use efficiency by apple trees. Anna apple trees budded on MM 106 rootstock planted at 3.0x 3.5 m spacing were used in this study. Irrigation treatments were: A= received equal amount to the estimated evapotranspiration for apple trees. B = received amount 25% less than treatment A.C = received amount 25% more than treatment A. D= irrigated according to the usual amount used by the farmers in the area. The main results could be summarized as follows:

1. Increasing the amount of applied water to apple trees enhanced it's growth rate i.e. shoot length, leaf area, tree size and trunk growth for rootstock and scion.
2. Treatment A had the highest fruit setting followed by treatment B while C and D gave the lowest values of fruit set.
3. Applying water more or less than required according to estimated treatment decreased apple productivity significantly as well as yield efficiency.
4. Water requirements for apple trees grown under drip irrigation ranged between 2839 and 5520 m3/fed. The maximum water demand for apple trees was during June, July and August.
5. The highest water consumption efficiency values were obtained from treatments A,B and D.
6. Treatment A had the best fruit quality.

Keywords: Anna apple; irrigation; vegetative growth; yield efficiency

INTRODUCTION

The majority of the apple orchards are concentrated in the newly reclaimed desert areas. Drip irrigation is the most common microirrigation system used in such area. The farmers apply water to their orchards in a manner that they feel it is the best. However, better water management i.e. when to irrigate the amount of water to be applied to increase their yields and at the same time save their water resources.

Salter and Goode (1967) concluded that the daily growth of the trunk and of the fruits was found to be the net result of shrinkage during the day and swelling during the night, when the water loss is small. This daily shrinkage was also used to determine water potential and irrigation needs. Assaf et al, (1975) observed that highest yields, largest fruit size and most vigorous trunk growth were observed when a high water regime (40 and 807. available water in the 0-600 mm and 0-1200 mm layers respectively) was maintained during the shoot growth and fruit development stages. However, at the rest of the season, irrigation was applied when the 0-600 mm layer was at wilting point and the 600-1200 mm layer at 60% available soil water.

Black, (1976) and Levin et al., (1979) pointed out that drip irrigation enables a restricted volume of wetted soil to be maintained with small fluctuations in water tension, and with the development of a dense root system with minimum loss of water and fertilizers by leaching.

Richards and Rowe, (1977) and salomon, (1978) concluded that the use of drip irrigation offer a posiblities of: a) irrigating according to water consumptive use b) maintaining soil water tension close to the optimum available water for the plants c) keeping the desired concentration of nutrients in the root midea d) possibly restricting root volume e) affecting the balance of physiological process such as fruiting and vegetative growth. Assaf et al, (1984) tested six drip irrigation treatments differ in the amount of applied water found that yields, growth, fruit size and crop load were not significantly affected by these treatments. The ratio of crop yield to trunk growth was found to be a reliable measure for crop load and may be useful in studies on the effect of over cropping on alternate bearing and on fruit quality.

Miseha et al, (1993) pointed out that water consumptive use for trees grown under drip irrigation system can be estimated by Modified Penman method (energy balance) on the bases of percentage plant cover. Ali et al, (1998) concluded that seasonal water consumptive use by apple trees ranged from 85.58 to 120.18 cm under different soil moisture levels. Apple roots extract 70% of their moisture needs from the first foot of soil profile. Adequate water supply at the root zone is important in reducing the percentage of fruit shedding or fruit drop.

The present investigation is an attempt to study the water requirements of apple trees grown in new reclaimed sandy soils under drip irrigation system and its effect upon growth, yield and fruit quality.

MATERIALS AND METHODS

The present work was carried out at Khatatba, Menofia Governorate, Egypt in a private farm during the two successive seasons namely 1997 and 1998, to study the effect of applied water on growth, yield and fruit quality of apple trees. The farm is irrigated by drip irrigation sysem from a well which has a good water quality (Ec.= 0.3 mmos/c = 200 ppm). Soil texture is 65.32% sand, 17% silt and 17.68% clay. Soil pH is 7.7 and 7.5 at 30 and 60 cm soil depth respectively. Anna apple trees budded on M.M 106 rootstock were planted in 1994 at 3.0 x 3.5 m spacing. Irrigation treatments were as follows:

A. Irrigated with equal amount to the estimated potential evapotranspiration, and taking into account crop coefficient and percent cover.
B. Irrigated with amount 25% less than that of treatment A.
C. Irrigated with amount 25% more than that of treatment A.
D. Irrigated according to the usual amount used by the farmers (farmer practices).

The experiment includes 16 apple rows, four rows for each treatment. Every four rows having their own value to be able to control the amount of applied water in each treatment. Each row consist 16 trees i.e 64 trees were tested in every treatment. This means that 256 apple trees were envolved in this study (as in the following drawing).

Treatments A, B, and C were irrigated by two laterals per row and 6 drippers for each tree i.e 3 emitters at each side.

This pattern ensure a good wetted area around the tree. However, treatment D, one lateral per row was used and each tree have 3 drippers. (The same as the farm follows). The emitter is said to be a self- componsate one with a constant discharge of 4 L/hour. Irrigation water was applied daily in two equal doses for all months except those months of tree dormancy (November, December and January). Fertilizers were added by injection through irrigation water at the rate of Table (1), according to the recommended doses.

Table (1). Amount of applied fertilizers:

Months	Ammonium nitrate Kg./ fed.	Potassium sulfate Kg./ fed.	Phosphoric acid Liter/fed
January	9.600	4.800	0.960
February	19.200	9.600	1.920
March	28.800	14.400	2.880
April	19.200	38.400	3.840
May	19.200	38.400	3.840
June	24.000	48.000	4.800
July	48.000	14.400	-
August	48.000	14.400	-
September	38.400	11.520	-

For winter culture: The following fertilizers were added:

October	**120 Kg./ fed Ammonium sulfate**
November	**80 Kg./ fed Potassium sulfate**
December	**300 Kg./ fed Super phosphate**
	30 Kg./ fed Magnesium sulfate

A complete randomized block design was used with three replication and three sub replications i.e Nine trees were chosen for each treatment (three trees in each replicate). This means that 36 trees for data collection.

Data Collected.

I. Apple -tree growth.

a- **Shoot Length.** Ten shoots per tree were tagged as soon as growth has been started, length and diameter were periodically measured during the season.

b. **Leaf area.** At the end of July, leaf samples from the middle of tagged shoots were taken for the determination of leaf area using leaf area meter (CD 2001 U.S.A).

C. **Tree dimensions.** Canopy dimension was measured at the beginning and at the end of the season i.e starting from November 1997. Tree size was calculated according to the formula mentioned by Westwood (1978):

$$4/3 = \Pi\pi a^2 b$$

Where: Π= 3.14, a = ½ major axis and B = ½ miner axis

D = **Trunk circumference** The circumference of each trunk for rootstock and scion was measured by a tape at fixed point i.e. below and above union (10 cm), at the beginning of the experiment and at the end of each season under study (Feb. 1997, Nov. 1997 and 1998). Data will be presented as cross section area.

II. Fruit setting and yield.

A- **Fruit setting percentage.** Total number of flowers at blooming stage were determined in 30 shoots randomly from each tree. Then, after month, number of fruits were computed and recorded to calculate fruit setting.

B-.**Yield.** At harvest time, number and weight of apple fruits were determined in each selected tree for yield data.

C- **Yield efficiency.** Yield efficiency was calculated according to the following equation as described by Schechter, et al (1991).

$$\text{Yield efficiency} = \frac{\text{Fruit yield in grams}}{\text{Trunk cross-sectional area cm}^2}$$

III. Fruit Quality .

Samples of fruits were collected from each tree for the determination of fruit characteristics which include the following :

A. Physical properties: Fruit size, weight and fruit dimensions (diameter, length and circumference in cm,) were determined. Also, skin color was estimated by matching with color chart according to Robert, 1938.

Firmness of fruits was estimated using penetrometer.

B. Chemical Properties : Total soluble solids, and juice acidity according to A.O. A.C. (1965) were determined and recorded.

IV. Water Relations.

a. Water Requirements:

The amount of applied water for each tree was calculated according to the following equation

$Q = q_e \times N \times T$ - Liter/tree

Where

q = amount of irrigation water per tree in liters.

q_e = emitter discharge L./hr.

N = Number of emitters/ tree

T = Time operation for each irrigation in hr.

The sum of applied water per month is the monthly water requirements from which seasonal water requirements is obtained.

B. Determination of irrigation needs (Treatment A). Modified Penman method has been used for estimating potential evapotransperation (ETP) Doorenbos and Pruitt, (1973), Results reported by Gad EL-Rab et al,. (1993) for Nubaria area was used in this study.

For calculating actual evapotranspiration Et_c by orchard crops the following equation was applied.

$Et_c = K_c \times Et_p$

Where :

Et_p = potential evapotransperation in mm/day

Et_c = estimated crops evapotransperation mm/day

K_c - crops coefficient

for apple archard, the K_c values are published by Ali et al,. (1998).

Ground cover percent was taken into account where Keller and Karmeli (1974) equation was applied:

$$K_r = \frac{G.C.}{0.85} \quad \text{or 1 which is the smallest}$$

K_r = Reduction factor

G.C. = Ground cover percent

The ground cover percent in this experiment had been estimated to be 60%.

Also, irrigation efficiency and emitter flow variation is taken into consideration when calculating water requirements under drip irrigation. (Irrigation efficiency for drip= 90% while emitter flow variation equal to 5%). Then, the obtained values were multiplied by 4.2 (each mm of water depth for feddan = $4.2m^3$). and dried by 400 to obtain water dose per tree per day. The values were corrected to the nearest to liters to be applicable in the field concretions.

C - Water use efficiency:

Water use efficiency was calculated for each treatment according to the following formula :

$$W.U.S. = \frac{\text{Apple yield per tree in kg.}}{\text{Seasonal water applied per tree.}}$$

Data were analyzed statistically according to Snedecor and Cochran, (1990) in each season and L.S.D. was used for comparison between means of each treatment.

RESULTS AND DISCUSSION

I. Apple tree Growth :

The growth of apple tree under different irrigation treatments is expressed as shoot length, leaf area, tree size and trunk cross section.

One. Shoot Length .

Figure (1) represents the effect of applied water by drip irrigation method on shoot length during the study period. Results clearly indicate that shoot length increased by time from March up to November. This pattern of growth in apple trees was found to be the same in both seasons 1997 and 1998. As for the effect of irrigation treatments, results illustrated in Fig. (I) reveal that farmer practices treatment produced the lowest values of shoot length and as the amount of applied water increased shoot length increased. In other words, treatment C had the highest shoot length followed by treatment A and treatment B. This trend could be related to water availability for apple trees. Also, treatments A, B, and C, the trees were irrigated by two lateral i.e. in both sides of the tree. This type provides a good and uniform wetted area around the tree compared with the control treatment (farmer practices) which was irrigated by single lateral or at one side only. In this respect, Levin et ak (1979) showed that soil water and root system distribution in an apple tree extended over a large volume when trikle irrigation were applied twice weekly with 8 Liter /hr emitter discharge rate rather than every day or once a week with 4 L//hr rate.

Winter, (1974) concluded that plant with limited water supply is smaller than one with unlimited water Organ development is often slower in water stressed plants.

B. Leaf area.

Leaf area of apple trees as affected by irrigation treatments in 1997 and 1998 season is shown in Fig. (II). Results indicate that generally, the treatment A had the highest leaf area compared with other irrigation treatment. However treatments B, C or D are similar in their leaf area but less than those obtained from treatment A. In other words, less water or applying more water than that required (estimated by potential E,T.) reduced leaf area per tree. Such results may be due to leaf drop as a matter of either excess or less water than that required. In this connection, Winter (1974) concluded that plants which have been subjected to drought and then watered, the old leaves die off and are replaced by the rapid expansion of younger leaves and the development of more young leaves at the apex.

C. Tree size.

The increase in apple tree growth (size) as a function of applied water is presented in Table (2) . Results indicate that tree dimensions increased by advancing tree age from 1.5 up 3.8 m^3 or about 50 to 65% of its volume in two seasons. The differences between irrigation treatments were found to be significant in both seasons under study. The highest increase in tree size was recorded for treatments A and C. Such results may prove that water supply is important for the growth rate of apple trees, while on the contrary of that treatment B and D were less. These treatments had the lowest increase in tree size and showed a decrease in tree growth in the second year compared with the first season. The explanation of such results could be related to that those trees suffer from water stress in their growth cycle or received water less than required. These findings are obvious in treatment D (farmer practices) which received water 35% less than that applied in treatment A. In this respect Kramer (1980) concluded that water stress caused a reduction in cell target which is the most important reasons for reduced plant size.

D. Trunk Growth.

Trunk growth was studied in the two seasons as the increase rootstock and scion circumference in each growth cycle and expressed as cross- sectional area (Table 2). Results clearly indicate that trunk growth was affected significantly by the amount of applied water. Treatment A and C showed a higher growth rate of trunk and that was found to be clear in scion cross sectional area. However, B and D irrigation treatment were the lowest in this respect. In other words, increasing the amount of applied water gave a significant increase in trunk growth. The highest relative growth rate of trunk cross sectional area was attained in the first seasons in all irrigation treatments. This is mainly due to the growth rate in tree trunk which is relatively lower by advancing tree age.

In the view of growth measurements of apple trees, it can be concluded that the amount of applied water proves to be one of the chief constrains on the growth of apple trees. Increasing water supply or applying water to apple trees on the bases of evapotransperation rate enhanced its growth rate. However, when trees received water less than that level, its growth may be retarded or reduced.

II Apple yield :

a. Fruit setting % :

Fruit setting of apple trees under different level of applied water is presented in Table (3). Treatment A showed the highest values of fruit setting following by the treatments B. However, treatment C and D had the, lowest values of fruit setting. This trend revealed that increasing the amount of applied water result in a significant increase in fruit setting. The only exception of that is treatment C which recived water 25% more than treatment A but had lower values of fruit setting. Such reduction in fruit setting was found to be significant.

The previous results may indicate that excess water or decreasing applied water caused an increase in fruit drop through out fruit development. Therefore, applying water according to the rate of evapotranspeiration increased the retained fruits on apple trees. In other words, adequate water supply at the root zone is very important in increasing fruit setting or reducing fruit shedding (fruit drop). These results are in agreement with those reported by George and Nissen (1988) and Ali et al (1998) who concluded that adequate soil moisture is very important in increasing fruit setting by apple trees. More water stored in the root zone or soil moisture stress reduced fruit set in apple trees. Also, Simons (1963) by anatomical studies found that lack of soil water accompanied by high temperature hastened the abscission zone development in apple fruits.

B. Fruit number and weight/tree.

Apple fruit yield as number and weight tree as well as yield/ feddan under different irrigation treatments in the two seasons is presented in Tables (3 & 4). Analysis of variance showed that amount of applied water had a significant effect upon apple tree productivity. The maximum fruit yield either in number or weight was gained from treatment A followed by treatment C.

However, the lowest yield was recorded from treatment B and D which received the less amount of applied water. The increase in yield (number or weight/tree) from treatment A was found to be significant compared with other irrigation treatments B, C and D. These results indicate that apple tree yield is manily related to the amount of applied water (Fig. 111). Such results could be detected from the gradual decrease in fruit yield observed in treatments B and D comparing with A.

In these treatments the amount of applied water decreased in a descending order A > B > D and the decrease in yield had the same order A> B> D. It is worthy to mention that the decrease in fruit yield of apple trees observed from treatment (received water 25% more than A), could be described to more drop in fruits by excess water (20.7% fruit set). These results may demonstrate that better water management or applied water for apple trees increased the productivity of such crop. In other words, either more or less amount of applied water than that required according to crop evapo transpiration decreased apple productivity (Table 4). Also, the use of two laterals at each side of the tree seemed to be more suitable and ensure uniform distribution of water around the root such conditions have a role on increasing tree productivity (differences in yield between treatment A and farmer practices reached 0.9 Tons/fed). These results are in full agreement with those reported by Ali et al (1998) who concluded that adequate water supply for apple trees is an important factor for maximizing its production. Benporatll and Greenblat (1994) found that increased yield of apple trees could be realized by irrigation at the high level of water.

As for yield efficiency (apple tree yield in gm/ cross section area of rootstock in cm2), results clearly indicate that it was lower in the first season than second one. Irrigating apple trees by optimum level i.e. treatment A, had the highest yield efficiency in both seasons. Increasing or decreasing the amount of applied water than the optimum level decreased the values of yield efficiency.

III. Water Requirements.

Monthly and seasonal water requirements by apple trees under the four irrigation treatments are presented in Table (5). Results clearly indicate that seasonal water requirements ranged between 2839 and 5520 m3/fed. depending on the amount applied to the trees. Monthly rates were low at the beginning of the growing season (January and February) when the tree canopy was not established yet. There after a gradual increase was observed as the tree canopy increased. Thus, monthly rates recorded its maximum during June, July and August which represent the period of maximum water demand by apple tree. Then a decline in monthly water requirement accrued as the plants growing to the period of dormancy.

It was found that the farmers apply water less than that required Fig

1+2+3

2

3

4

5

according to evapotransperation rates by about 35% (water applied in treatment A). Such decrease in applied water by the farmers resulted in decreasing their yield by about 34.6% . These results may demonstrate that apple fruit yield stood parallel to amount of applied water.

The use of one lateral per tree seemed to be not sufficient for distributing water more uniformly around the roots of the tree. This could be detected from treatment B which received water very close to treatment D but out yielded it by 12.5%.

It can be concluded that for estimating water requirements by trees grown under drip irrigation, potential evapotransperation could be determined by any method and multiplied by crop coefficient. Also, the percent of crop cover must be taken into consideration as well as irrigation efficiency. In this respect, Mishea et al (1993) concluded that water consumption use for trees grown under drip irrigation system can be estimated by modified Penman method (energy balance) on the bases of percentage plant cover .

Water use efficiency :

Water use efficiency is defined as the equation of marketable crop yield produced per unit area over the amount of applied water to produce such yield. This term has been used to evaluate different agronomic practices with respect to water used. Water use efficiency can be increased by increasing crop production or by decreasing the amount of applied water. Water use efficiency by apple trees expressed as Kg fruit yield per fed./ unit of applied water in m3 is presented in Table (5). Results clearly indicate that the values were higher in the second season compared with the first one. This trend is mainly due to higher yield production in the second season than the first. Regarding the effect of applied water on water use efficiency, results indicate that the values obtained from treatments A, B and D are about the same. In other words, decreasing the amount of applied water did result in a similar decrease in fruit yield which finally gave similar values of water use efficiency. On the contrary, treatment C had lower values of water use efficiency. Such trend could be ascribed to that increasing applied water did not cause an increase in fruit yield but decreased it. The decrease in yield observed in this treatment may be due to fruit drop caused by excess of applied water. Therefore, it can be concluded that for maximizing water use efficiency by apple trees, water should be applied on the basis of evapotransperation rates by a crop. In this connection, Ali et al (1998) concluded that for increasing water use efficiency values by apple trees, irrigation water should be practiced at moderate soil moisture stress i.e 40% depletion in available water.

IV. Fruit Quality

a. Physical Properties.

Fruit quality of apple tree parameters i.e fruit weight, size, diameter, length, circumference and firmness as affected by applied water in the two seasons is presented in Table (6). Results indicated that fruit weight and size were not affected by water doses and the differences were found to be in significant. However, fruit diameter, length and circumference were responded to the amount of applied water. The highest values were gained from treatment A and B while treatment D had the least figures in this respect. The differences between A and B and treatment D were found to be significant. Such results prove that irrigation water must be applied at optimum level for increasing fruit characters. In this respect, Ali et al (1998) concluded that the highest values of fruit characters were gained from the most level of soil moisture.

As for firmness, results showed that treatment C had the lowest value and treatment B and D gave the highest firmness figures while treatment A produce values in between . Such results may prove that the amount of applied water affect firmness. In other words, increasing applied water did result in significant decrease in firmness and vice versa. These results are in full agreement with those resparted by Ali et al (1998) who concluded that fruits produced under dry conditions was higher in the values of firmness.

b. Chemical properties.

Total soluble solids in the juce were higher in treatments A, B and C while treatment D had the lowest values of T.S.S. This trend reveal that decreasing the amount of applied water caused a reduction in T.S.S. on delaying the ripping of apple fruits and the reverse trend was found to be true. The contrary of T.S.S. was juice acidity. Increasing the amount of applied water resulted in a significant decrease in juice acidity. These results reveal that fruit quality of apple trees was found to be better under optimum water supply than under stress or water deficit conditions. Such findings could be detected when total soluble solids acidity ratio were calculated (Table 7). Higher ratio values indicate better quality than lower values. It seems that treatment D or farmer practices produce low fruit quality than treatment A and C. These results prove that apple fruit quality could be improved by applying water at optimum level. In this respect, Ramos et at (1994) found that both fruit size decreased with water strees whereas soluble solids (T.S.S) and acidity increased.

Table 7 present the color of fruit for different treatments of irrigation. In both seasons, treatment A showed a best red color, while treatments C and D showed a lowest red color. These findings were in agreement with those of Bootsma (1986).

6+7

REFERENCES

Ali, M.A.; M.M. Mohmoud and A.Y. Salib. (1998). Effect of soil moisture stress on apple trees. Egypt. J. Agric. Res., 76 (4) 1565-1583.

A.O.A.C. (1965) . Association of official analytical chemists; afficial methods of analysis published by A.D.A.C Washington. D.C. USA.

Assaf, R.; L. Levin and B.Bravdo. (1975). Effect of irrigation regimes on trunk and fruit growth rates, quality and yield of apple trees. J. Hort. Sci., 50, 481-493.

______;______ and ______. (1984). Effect of drip irrigation on the the yield and quality of Golden Delicious and Jonathan apples. J. Hort. Sci., 59 (4): 493-499.

Benporatll, A. and Y. Greenblat. (1994). Effect of antitranspirants onyield and fruit size apriot grown under different water regimes. Hort. Abst., 64.

Black, J.D.F. (1976). Trickle irrigation - a review. Hort. Abst. 46, 1-7, 69-74.

Bootsma, J.H. (1986). Ijsselmeer polders. Research Garden news cultural measures for Elstar. Fruitteelt 76 (10): 294 (CF.Hort Abst., 57(3) : 178, 1987).

Doorenbos, J. and W.O. Pruitt. (1973). Guidelines for predicting crop water requirments. F.A.O. Irrigation and drainage, P. 24.

Gad El-Rab, G.M.; W.I. Miseha and N.G. Ainer, (1993). Potential evopotranspirstion estimation at Nobaria Area. 4th conf. Of Agriculture Development, Ain Shams Univ.

George, A.P. and R.J. Nissen. (1988). The effects of temperature, vapour pressure deficit and soil moisture stress on growth, flowering and fruit set of custerd apple (Annona cherimola Annona squamosa) African pride. Scientia-Hort. 1988, 34 (3/4):183-191.

Kramer, P.J. (1980). Plant and soil water relationships TATA McGraw. Hill Publisher Camp. LT.D. New Delhi (PP. 480).

Keller, J. and D. Karmeli. (1974). Trickle irrigation design parameters. Trans. Asae (W.S.) 17(4): 678-784.

Levin, I.; R.Assaf and B.A. Bravdo. (1979). Soil moisture and root distribution in an apple archard irrigated by tricklers. Plant and Soil, 52: 31- 40.

Miseha, W.I.; M.A. Sherif and A.T.A. Moustafa (1993). Water requirements of some orchard trees under drip irrigation. Egypt J. Appl. Sci, 8 (10): 267-278.

Ramos, DE.; SA. Weinbaum; KL, Shackel; LJ. Schwankl; EJ. Mitcham; FG. Mitchell; RG. Snyder; G. Mayer; G. McGourty and D. Sugar. (1994). Influence of tree water status and canopy position an fruit size and quality of Bartlett pears. Sixth international symposium on pear growing, Medford, Oregon, USA 1214 July 1993. (Acta. Hort. 1994, 367, 192-200)

Richards, D. and S.R.N. Rowe (1977). Effects of root restriction root pruning and 6- benzylamino- purine on the growth of peach seedlings, Annals of Botany, 41: 729-40.

Robert, F.W. (1938). Colour- Chart of Royal Horticultural society, issued by the British colour council in collaboration with the Royal Horticultural

Society. London- Part I & II.

Salter, P.J. and J.E. Goode. (1967). Crop responses to water at different stages of growth. Res. Rev. Commw. Bur. Hort. E. Malling No.2.

Salomon, E. (1978). Induction of dwarfing and early cropping through root treatments in citrus. Acta Horticulturae, 65: 147.

Schechter, L.; Elfving, D.C. and T.T.A. Proctor. (1991). Rootstock affects vegetative growth characteristics and productivity of Delicious apple, Hortsience, 26 (9): 1145-1148.

Simons, R.K. (1963). Anatomical studies of apple fruit abscission in relation to irrigation Amer. Soc. Hort. Sci. Proc., 83: 77-87

Snedecor, G. W. and W.G. Cochran (1990). Statistical methods. 7th . The Iowa state, Univ. Press. Ames. Iowa. USA. P. 593.

Westwood, M.N. (1978). Temperatre zone pomology. W.H. Freeman Company San Fransisco. USA. P.P 428.

Winter, E.J. (1974): Waters, Soil and the plant. The Macmillan Press LTD., London and Basing stock (PP. 141).

المقننات المائية لأشجار التفاح تحت نظام الرى بالتنقيط

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طبقت 4 معاملات رى بالتنقيط على اشجار تفاح عمرها 4 سنوات خلال موسمى 1997-1998 فى منطقة الخطاطبة - محافظة المنوفية - لتحديد تأثير كميات مياه الرى على كل من : النمو - المحصول - صفات الثمار ، وكذلك كفاءة استخدام المياه على اشجار التفاح الأنا.

استخدمت اشجار تفاح الآنا المطعومة على مالنج مرتون 106 المطعومة على مالنج مرتون 106 (م م 106) - والمنزرعة على مسافات 3×5ر3 متر - وكانت معاملات الرى هى :-

أ - كميات المياة المستخدمة مساوية لتقدير البخر النتح لأشجار التفاح .

ب - كميات المياه المستخدمة أقل بنسبة 25% عن المعاملة أ.

ج - كميات المياة المستخدمة تزيد بنسبة 25% عن المعاملة أ.

د - كميات المياه المستخدمة مثل الكميات التى اعتاد المزارعون استخدامها فى هذه المنطقة .

ويمكن تلخيص اهم النتائج كمايلى :

1 - أدت زيادة كميات المياه المستخدمة الى زيادة فى معدل النمو أى أطوال النموات - مساحة الورقة - حجم الشجر - نمو الجزع - (الأصل والطعم).

2 - أعطت المعاملة أ اعلى نسبة عقد يليها المعاملة ب - بينما اعطت المعاملتان جـ ، د اقل قيم لنسب العقد.

3 - استخدام كميات مياه اعلى أو أقل بنسبة 25% من كميات المياه المضافة فى المعاملة أ قلل من الانتاج وكذلك من الكفاءة الانتاجية .

4 - تراوحت احتياجات المياه لاشجار التفاح تحت نظام الرى بالتنقيط بين 2839 5520 متر3/ للفدان - وكانت اعلى احتياجات للمياه شهور يونيو - يوليو - اغسطس.

5 - كانت اعلى كفاءة لاستخدام المياه من المعاملات أ ، ب ، د .

6 - أعطت المعاملة أ أحسن جودة ثمار .

J. Agric. Sci. Mansoura Univ., 25 (6): 3641 - 3658, 2000.

Table (5) . Monthly and seasonal water requirements by apple trees under different irrigation treatments.

Treat	Item.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total M3
Estimated Requirements	Polential Et. Mm/day	2.55	3.36	3.94	5.47	6.48	6.74	6.94	6.57	6.29	4.69	3.06	2.17	
	ETp x K_c	1.10	1.44	2.32	3.66	4.47	5.06	5.21	4.93	4.28	3.19	-	-	
	Et_p x K_c x G.C.	0.78	1.02	1.65	2.60	3.17	3.59	3.70	3.50	3.04	2.26	-		
	Et_c x efficiency	0.92	1.20	1.94	3.06	3.73	4.22	4.35	4.12	3.58	2.66	-	-	
	W.R. m^3/ mont	119.8	141.1	252.6	385.6	485.6	531.7	566.8	536.4	451.1	346.3	-	-	3817.0
	Liter /tree/day	9.7	12.6	20.4	32.1	39.2	44.3	45.7	43.3	37.6	27.9	-	-	9.54
A	Water Applied m^3/fed/Month	124	224	372	480	496	600	620	620	480	372	24	-	4412
	Liter/tree/ day	10	20	30	40	40	50	50	50	40	30	-	-	11.03
B	Water applied m3/fed/month	124	112	248	360	372	480	496	496	360	248	8	-	3304
	Liter/tree/ day	10	10	20	30	30	40	40	40	30	20	-	-	8.26
C	Water applied M^3/fed./ Month	124	336	496	600	620	720	744	744	600	596	40	-	5520
	Liter/tree/ day	10	30	40	50	50	60	60	60	50	40	-	-	13.8
D	Water applied M^3/fed/Month	111.6	111.6	297.6	288	297.6	384	396	396	192	198.4	80	76.8	2839.6
	Kiter/tree/ day	9	9	24	24	24	32	32	32	16	16	-	-	17.0

K_c = crop coefficient G.C. = Ground cover Et_c = crop evapotransperation W.R.= Water Requirements

Table (2) . Effect of applied water on tree size and trunk cross section in cm2 (for rootstock and scion).

Treatment	Item	Tree size in m^3				Trunk sectional area cm^2 Rootstock				Trunck sectrional area cm^2 Scion			
		March 1997	Nov. 1997	Nov. 1998	Mean	March 1997	Nov. 1997	Nov. 1998	Mean	March 1997	Nov. 1997	Nov. 1998	Mean
A	A. value	1.48	2.75	4.14		25.2	38.6	53.9		17.1	27.0	36.4	
	Increase	1.27	1.39		1.33	13.40	15.30		14.35	9.90	9.40		9.7
	R.increase %	85.8	50.5		65.2	53.2	39.6		46.4	57.9	34.8		46.4
B	A. value	1.54	2.43	3.56		28.3	34.9	40.6		21.8	29.1	38.2	
	Increase	0.84	1.13		0.99	6.60	5.70		6.15	7.3	9.1		8.2
	R.increase %	54.5	46.5		50.5	23.3	16.3		19.8	33.5	31.3		32.4
C	A. value	1.53	3.01	4.07		28.3	38.5	53.5		14.6	30.3	40.5	
	Increase	1.48	1.06		1.27	10.2	15.0		12.6	10.7	10.2		10.5
	R.increase %	96.7	35.2		66.0	36.0	39.0		37.5	54.6	33.7		44.2
D	A. value	1.41	2.79	3.30		25.4	36.5	46.0		19.6	26.3	30.3	
	Increase	1.38	0.51		0.95	11.10	9.50		10.3	6.7	4.0		5.4
	R.increase %	97.9	18.3		58.1	43.7	26.0		34.9	34.2	15.2		24.7
L.S.D. at 0.05		0.31	0.39			2.46	1.17			2.09	3.7		

Irrigation Treatments
A = Irrigated according to ET. **B = Irrigated 25% less than A**
C = Irrigated 25% more than A. **D = Farmer practices.**

Table 3: Effect of applied water on fruit set %, number and weight of apple fruits/ tree and yield efficiency

Irrigation Treatments	Fruits set %			Tree yield						Yield Efficiency (*)		
				No. of fruits /tree			Weight of fruits/ Tree					
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
A	25.53	28.73	27.13	178.9	319.0	249.0	19.57	34.17	26.87	507	634	571
B	21.57	25.47	23.52	105.9	269.1	187.5	11.78	27.80	19.79	338	604	471
C	18.53	19.90	19.22	116.1	284.0	200.1	13.20	29.97	21.59	343	560	452
D	19.23	22.23	20.73	110.8	194.4	152.6	14.63	20.53	17.58	401	441	424
L.S.D. at 0.05	1.75	1.04	1.20	12.3	17.1	13.1	3.76	3.81	3.07	-	-	-

(*) Yield Efficiency = $\frac{\textbf{Yield of tree in gm.}}{\textbf{Trunk cross section area in cm2}}$

Table 4: Effect of applied water on fruit yield of apple trees (ton / fed.) and water use efficiency (Kg. Fruit yield /m3).

Irrigation Treatments	Apple fruit yield Tons/fed.			Relative increase in yield (*)			Water use Efficiency Kg. /m3 applied water		
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
A	7.828	13.668	10.748	133.98	166.4	152.8	1.774	3.098	2.436
B	4.712	11.120	7.916	80.5	135.4	112.6	1.426	3.366	2.396
C	5.280	11.988	8.634	90.2	146.0	122.8	0.957	2.172	1.565
D	5.852	8.212	7.032	100	100	100	2.061	2.893	2.477
L.S.D. 0.05	1.504	1.524	1.228	-	-	-	-	-	-

Irrigation treatment :
A = Water applied = 4412 m3/fed.
B = Water applied = 3304 m3/fed.
C = Water applied = 5520 m3/fed.
D = Water appied = 2839 m3/fed.
(*) Relative increase over farmer practices.

Table (6): Effect of applied water on fruit quality of apple trees (a- physical properties)

Treatments	Fruit weight In gm.			Fruit size In cm3			Fruit Diameter in cm			Fruit Length in cm			Fruit circ. in cm			Firmness Pound/in2		
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean
A	109.7	106.8	108.3	127.1	114.7	120.9	6.5	6.3	6.4	6.7	6.7	6.7	20.1	19.4	19.8	20.2	20.6	20.4
B	111.3	103.1	107.2	125.1	112.3	118.7	6.4	6.3	6.4	6.7	6.6	6.7	19.9	18.9	19.4	22.4	22.2	22.3
C	111.7	105.5	108.6	120.3	110.5	115.4	6.2	6.0	6.1	6.5	6.7	6.6	18.7	18.5	18.6	18.3	19.0	18.7
D	104.8	10.43	104.6	117.1	105.4	111.3	6.2	6.2	6.2	6.3	6.3	6.3	19.0	18.5	18.8	21.9	21.3	21.6
L.S.D.at 0.05	N.S.	N.S	N.S	N.S	N.S	N.S	0.3	0.2	0.2	0.2	0.3	0.2	0.5	N.S	0.6	0.9	N.S	0.8

Table (7) Effect of applied water on fruit quality of apple trees (b- Chemical properties)

Irrigation Treatment	T.S.S.			Acidity			T.S.S. Acidity Ratio			Skin Colour	
	1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	1997	1998
A	13.0	12.3	12.7	0.332	0.315	0.324	39.16	39.05	39.11	Delft Rose 020	Delft rose 020
B	13.0	12.9	13.0	0.386	0.350	0.368	33.68	36.86	35.27	Delft rose 020.1	Delft rose 020/1
C	12.4	12.9	12.7	0.304	0.301	0.303	40.79	42.86	41.83	Delft rose 020/2	Delft rose 020/2
D	12.0	11.6	11.8	0.403	0.422	0.413	29.78	27.49	28.64	Delft rose 020/2	Delt rose 020/2
L.S.D.0.05	0.4	0.9	0.6	0.20	0.04	0.035					