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# EVALUATION OF DIFFERENT FLOODING IRRIGATION METHODS IN VALENCIA ORANGE ORCHARDS UNDER KAFR EL-SHEIKH CONDITIONS

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## ABSTRACT

A field experiment was carried out during two successive growing seasons (2000 and 2001) to evaluate the different flooding irrigation methods (Basin, Ring-shaped, Basin furrow and Border strip irrigation) of "Valencia" orange orchards under Kafr El-Sheikh conditions.

The obtained results indicated that, tree vegetative growth as indexed by shoot length and number, leaf area, dry weigh and dry weight percent, tree height, canopy width, trunk diameter, and trunk cross sectional area ($cm^2$) and canopy volume ($m^3$/ tree), was larger on trees irrigated with Border strip irrigation method than those of trees irrigated with Basin or other irrigation methods.

Moreover, trees irrigated with Border strip irrigation method had the greatest fruit yield (71.47 and 68.32 kg/tree/year) and tree yield efficiency (fruit weight 3.11 and 2.83 kg/$m^3$ of canopy or yield per TCSA 1.62 and 1.53 kg/$cm^2$) than those of trees irrigated with Basin or other irrigation methods. Also, these trees gave the highest fruit number/ tree compared with other irrigation methods.

The highest values of fruit weight, total soluble solids percentage (TSS%), TSS / acid ratio, and the lowest value of acidity % was found under Border strip irrig. method compared to the other treatments. However, vitamin C content and peel thickness were not significantly affected by different irrigation methods.

Leaf N, Ca and Mg contents were slightly affected by different flooding irrigation methods. Meanwhile, leaf P, K, Fe, Mn and Zn contents were significantly affected by adopted method, and the highest average values of the previous elements were found under Border strip irrigation method.

Thus, it could be concluded that Border strip irrigation method was the better method for Valencia orange orchard under Kafr El-Sheikh conditions.

**Keywords:** citrus irrigation, vegetative growth, yield, yield efficiency, fruit quality and leaf mineral content.

## INTRODUCTION

Citriculture is the most important fruit production among the Egyptian horticulture. According to 1998 statistics, citrus acreage in Egypt represents approximately 39% of the total area of fruit trees. It is about 340443 feddans from which 3426 feddans are grown in Kafr El-Sheikh Governorate. At the same time few studies on the effect of irrigation methods and water relations of citrus has been done at Kafr El-Sheikh Governorate (Abd El-Metaal, 1990; Khalifa, 1994; Dawood, *et al*., 2001 and Khalifa, *et al.,* 2001).

On the other hand, in Egypt, the cultivated area depends entirely on the limited quantity of irrigation water, brought by River Nile. Flooding irrigation (Basin, Ring-shaped, Basin furrow and Border strip irrigation) is still the main irrigation method in Egypt especially in North Delta, thus, ideal use of this method is essential. The present work was carried out to study the effect of different flooding irrigation methods on vegetative growth, yield, yield

efficiency, fruit quality and leaf mineral content of Valencia orange under Kafr El-Sheikh conditions.

## MATERIALS AND METHODS

Field experiments were conducted during the 2000 and 2001seasons to investigate the effect of different methods of flooding irrigation (Basin, Ring-shaped, Basin furrow and Border strip irrigations) on vegetative growth, yield, yield efficiency, fruit quality and leaf mineral content of "Valencia" orange trees (*Citrus sinensis*) under Kafr El-Sheikh conditions.

**The following parameters were determined:**

**Plant and soil:** The trees were 15 years old, 3.0 m height, budded on sour orange rootstock, planted at 5 x 5 m and grown in the Agrarian reform orchard at Shino, Kafr El-Sheikh Governorate. All trees received the regular fertilization and horticulture practices as recommended by the Ministry of Agriculture, Egypt.

Soil samples were taken before the experiment from around trees under the canopy for each irrigation method using auger method at five successive depths: 0-20, 20-40, 40-60 and 60-90 cm. EC in soil paste extract and soil-pH in 1: 5 soil water extract were determined in different samples for each irrigation method according to Black (1965). Concentration of total-N, available-P and -K of soil depths were determined according to Jackson (1958). DTPA-extractable (Fe, Zn, Cu, Ni and Cd) were determined using an atomic absorption spectrophotometer according to Lindsay and Norvell (1978).

**Table (1): Main chemical properties of the experimental soil before starting the treatments.**

| Soil depth cm | Soil pH (1:5) | EC* Ds / m | Macro elements, % | | | Available micro elements, ppm | | | | | Soil texture |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total N | Avail. P | Avail. K | Fe | Zn | Cu | Ni | Cd | |
| 0-20 | 8.23 | 1.99 | 0.150 | 0.0172 | 0.0912 | 6.01 | 3.32 | 0.16 | 1.12 | 0.113 | Clayey loam |
| 20-40 | 8.12 | 1.67 | 0.091 | 0.0151 | 0.0812 | 5.12 | 3.23 | 0.30 | 1.01 | 0.016 | Clayey loam |
| 40-60 | 8.20 | 1.48 | 0.060 | 0.0040 | 0.061 | 4.43 | 1.55 | 0.15 | 0.53 | 0.061 | Sandy loam |
| 60-90 | 8.13 | 1.22 | 0.051 | 0.0012 | 0.0522 | 4.12 | 1.66 | 0.17 | 0.61 | 0.081 | Sandy loam |

***Were determined in soil paste extract.**

**Some weather observations:** Some weather observations (2000 and 2001) were recorded as well as, the total effective heat (F$^{o}$) is presented in table (2).

**Table (2): Some climatologically parameters of Sakha Agriculture Research Station and total effective heat.**

| year | Total effective heat (F$^{o}$) | Relative humidity /day | Wind velocity (km/hr) | Solar radiation | | Pan evaporation (mm/day) | Rain (mm/day) |
|---|---|---|---|---|---|---|---|
| | | | | Rimco (day) | Gunn (day) | | |
| 2000 | 4419.56 | 62.54 | 5.77 | 439.41 | 17.21 | 0.592 | 0.322 |
| 2001 | 5110.12 | 60.38 | 5.24 | 412.15 | 16.24 | 0.581 | 0.228 |

**Vegetative growth:** Four main branches on each tree in different directions were labeled. All shoots on these branches in the growing cycles were counted and measured, then the average length / shoot was calculated. Also, sixty mature leaves per replicate were taken at the end of August and November 2000 and

2001, respectively (Embleton *et al*., 1983). Leaf area was measured as $cm^2$ according to Singh and Snyder (1984).

Leaf samples were cleaned with damp cloth, and then washed with redistilled water. Dry weight was estimated after being oven–dried at 65 – $70^0$ C to a constant weight and leaf dry weight percent was calculated. Tree height, width and trunk diameter (cm) 15 cm above the bud union was measured in Nov. of each season. Then, trunk cross sectional area (TCSA $cm^2$) was also calculated. Canopy volume ($m^3$) was calculated by formula: $HD^2$ X 0.5236 where H = tree height and D= tree diameter as indicated by Turrel (1946).

**Yield:** Yield was recorded at harvest time in both seasons (April, 20011 and 2002) on an individual tree basis and was expressed as total fruit number and kilograms per tree, and tree yield efficiency (fruit weight $kg/m^3$ of canopy or yield per TCSA $kg/cm^2$) was calculated.

**Fruit quality:** At harvest time 20 mature fruits were randomly collected from the individual trees under each irrigation method for determining (TSS%, Acidity %, Vit. C, fresh weight (g) and peel thickness according to A.O.A.C. (1975).

**Leaf mineral composition:** Leaf samples were collected from non-fruiting terminals of spring and summer cycles growth at the end of August and November of each season (Embleton *et al*., 1983). The samples were cleaned with damp cloth and washed three times with redistilled water. The leaves were dried at $60^oC$ till constant weight and ground in porcelain morter and subjected to chemical analysis using wet aching method according to Snell and Snell (1967). Leaf mineral composition (N, P, K, Ca, Mg, Fe, Mn and Zn) was determined as described by Jackson (1958).

**Statistical analysis:** The experiment was performed in a complete randomized block design with 4 replicates. Each replicate for each irrigation method contained 4 uniform trees of Valencia orange trees, which providing about 60% of tree ground cover. Guard rows were maintained for each treatment. All data were subjected to statistical analysis according to Steel and Torrie (1982).

## RESULTS AND DISCUSSION

**Vegetative growth:** Data concerning the effects of the different flooding irrigation (Basin, Ring-shaped, Basin furrow and Border strip irrigation) methods on vegetative growth of “Valencia” orange trees under Kafr El-Sheikh conditions are presented in Table (3). It is clear that, the measured vegetative growth parameters of “Valencia” orange trees as indexed by shoot length and number, leaf area, dry weigh and dry weight percent, tree height, canopy width, trunk diameter, and trunk cross sectional area ($cm^2$) and

canopy volume ($m^3$/tree), was significantly larger on trees irrigated with Border strip irrigation method than those of trees irrigated with Basin and other irrigation methods. This was true for the two studied seasons. The highest increase may be due to that Border strip irrigation method enhanced the mean values of water use efficiency (WUE) of "Washington Navel " orange trees, soil moisture depletion from the upper two feet (0-60 cm) of soil profile, (Khalifa *et al.,* 2001). Also, it was found that, Border strip irrigation method had the majority of fibrous root density, moreover, typical fibrous root distribution at (0-60 cm depth), enhanced some leaf mineral contents, decreased weeds density and had the lowest value of perennials and annual weeds and improved soil EC and the availability of some soil nutrient elements of "Washington Navel" orange trees, (Dawood *et al*., 2001).

These results are in agreement with those reported by Abd El-Messih (1977) and Abd El-Metaal (1990).

**Table (3): Vegetative growth of Valencia orange trees as affected by different flooding irrigation methods.**

| Irrigation methods | Shoot | | Leaf | | | Tree | | |
|---|---|---|---|---|---|---|---|---|
| | length (cm) | No | Area ($cm^2$) | D.W (mg) | D.W % | Height (m) | Width (m) | T.D (cm) |
| First season, 2000 | | | | | | | | |
| Basin irrig. | 10.8 | 7.63 | 22.6 | 198.4 | 42.7 | 3.16 | 3.38 | 7.17 |
| Ring-shaped irrig. | 11.6 | 8.38 | 23.1 | 203.7 | 43.2 | 3.22 | 3.51 | 7.29 |
| Basin furrow irrig. | 12.5 | 8.99 | 23.8 | 208.6 | 43.6 | 3.26 | 3.56 | 7.36 |
| Border-strip irrig. | 13.9 | 9.58 | 24.2 | 218.7 | 44.1 | 3.31 | 3.64 | 7.61 |
| L.S.D. at 5% | 0.79 | 0.53 | 0.96 | 14.4 | 0.59 | 0.08 | 0.09 | 0.14 |
| Second season, 2001 | | | | | | | | |
| Basin irrig. | 10.6 | 7.02 | 22.7 | 194.9 | 42.3 | 3.19 | 3.41 | 7.22 |
| Ring-shaped irrig. | 11.5 | 7.48 | 23.1 | 198.6 | 42.8 | 3.38 | 3.49 | 7.31 |
| Basin furrow irrig. | 12.16 | 8.01 | 23.8 | 204.5 | 43.2 | 3.46 | 3.57 | 7.46 |
| Border-strip irrig. | 13.8 | 8.69 | 24.4 | 214.8 | 43.8 | 3.68 | 73.66 | 7.69 |
| L.S.D. at 5% | 0.72 | 0.78 | 1.4 | 17.9 | 0.56 | 0.04 | 0.11 | 0.14 |

**No = number** **D.W = dry weight** **T.D = trunk diameter**

**Yield and yield efficiency:** With regard to the effect of different flooding irrigation methods (Basin, Ring-shaped, Basin furrow and Border strip irrigation) on "Valencia" orange trees yield and yield efficiency (Table 4), it is obvious that trees irrigated with Border strip irrigation method produced the highest yields expressed as kilograms of "Valencia" orange fruits than those of trees irrigated with Basin and other irrigation methods and were found to be 71.47 and 68.32 kg/tree in the two seasons, respectively. Also, these trees had the most yield efficiency measured as kilograms of fruit / $m^3$ of tree canopy volume or kilograms of fruit / $cm^2$ of trunk cross-sectional area (TCSA) and were found to be 3.11 and 2.83 kg/ $m^3$ of tree canopy volume in the two seasons respectively, and 1.62 and 1.53 kg/ $cm^2$ of (TCSA) in the two seasons, respectively.

A similar trend was observed in the second season and may be due to the greatest vegetative growth attained by Border strip irrigation method under the experimental conditions (Tables 3 and 4) which produced the highest values of fruit weight, the highest average fruits No/tree, fruit weight/tree, and the total yield per fed. (Khalifa *et al.,* 2001). These results are

in agreement with those reported by Abd El-Messih (1977); Abd El-Metaal (1990); El-Nokrashy *et al*. (1966); Roth *et al*. (1995); Dawood *et al.* (2001) and Khalifa *et al*.(2001).

**Table (4): Tree canopy volume, trunk cross sectional area, yield and tree yield efficiency of Valencia orange trees as affected by different flooding irrigation methods.**

| Irrigation methods | yield | | canopy volume ($m^3$) | Tree yield efficiency (kg/ $m^3$) | TCSA | Yield per TCSA (kg/ $cm^2$) |
|---|---|---|---|---|---|---|
| | Kg/ tree | No/ tree | | | | |
| First season, 2000 | | | | | | |
| Basin irrig. | 46.39 | 281.3 | 18.90 | 2.45 | 40.49 | 1.15 |
| Ring-shaped irrig. | 54.47 | 322.5 | 20.77 | 2.62 | 41.74 | 1.30 |
| Basin furrow irrig. | 63.56 | 366.6 | 21.63 | 2.94 | 42.54 | 1.49 |
| Border-strip irrig. | 71.47 | 397.8 | 22.96 | 3.11 | 44.06 | 1.62 |
| L.S.D. at 5% | 3.72 | 13.6 | 1.32 | 0.17 | 1.09 | 0.14 |
| Second season, 2001 | | | | | | |
| Basin irrig. | 44.86 | 269.8 | 19.42 | 2.31 | 40.94 | 1.10 |
| Ring-shaped irrig. | 52.13 | 307.2 | 21.56 | 2.42 | 41.97 | 1.24 |
| Basin furrow irrig. | 58.63 | 335.8 | 22.57 | 2.60 | 43.71 | 1.34 |
| Border-strip irrig. | 68.32 | 380.4 | 24.15 | 2.83 | 44.53 | 1.53 |
| L.S.D. at 5% | 3.56 | 13.9 | 1.69 | 0.18 | 1.32 | 0.12 |

**TCSA= trunk cross sectional area**

**Fruit quality**: Regarding fruit quality of “Valencia” orange trees, data in Table (5) indicated that Border strip irrigation method gave a higher average fruit weight (197.7 g), followed by Basin furrow irrigation (173.3 g) and Ring-shaped irrigation (168.9 g), while Basin irrigation method gave a lower average fruit weight (164.6 g) in the two seasons.

Data about TSS %, Acidity % and TSS/acid ratio of fruit juice as affected by methods of irrigation, Table (5) show that, the highest values of TSS and TSS/acid ratio and the lowest acidity % were recorded for Border strip irrigation method and were found to be (11.69%, 10.44 and 1.12%, respectively. While, the lowest values of TSS%, TSS/acid ratio and the highest acidity % were obtained under Basin irrigation method and are found to be 11.23, 8.77 and 1.28%, respectively.

On the other hand, Vit. C content and peel thickness are not significantly affected by different methods of irrigation, although values of V.C content slightly increased under Border strip irrigation method in comparison with the other treatments. Similar results were obtained by El-Nokrashy *et al*. (1966b), Abd El-Messih *et al*. (1977) and Abd El-Metaal (1990), who found that values of TSS, Vit. C content, TSS/acid ratio of Washington Navel orange were decreased and acidity % increased by decreasing number of irrigation. On the other hand, Brown *et al*. (1974), Constantin *et al*. (1975), and Peng Yong Hong (1998) stated that peel thickness, TSS/acid ratio and vitamin C content of fruit juice were not affected by irrigations methods.

**Table (5): Fruit quality of Valencia orange trees as affected by different flooding irrigation methods.**

| Methods of irrigation | Fruit quality | | | | | |
|---|---|---|---|---|---|---|
| | Fruit weight (g.) | TSS % | Acidity % | TSS/ acid. | Vit. C mg/100 L | Peel thickness |
| First season, 2000 | | | | | | |
| Basin irrig. | 164.6 | 11.23 | 1.28 | 8.77 | 42.36 | 3.52 |
| Ring-shaped irrig. | 168.9 | 11.49 | 1.20 | 9.58 | 42.58 | 3.46 |
| Basin furrow irrig. | 173.3 | 11.56 | 1.16 | 9.97 | 42.83 | 3.41 |
| Border strip irrig. | 179.7 | 11.69 | 1.12 | 10.44 | 42.92 | 3.39 |
| L.S.D at 5% | 3.8 | 0.25 | 0.06 | 0.18 | N.S | N.S |
| Second season, 2001 | | | | | | |
| Basin irrig. | 166.3 | 11.02 | 1.26 | 8.75 | 41.69 | 3.54 |
| Ring-shaped irrig. | 169.7 | 11.26 | 1.19 | 9.46 | 41.96 | 3.48 |
| Basin furrow irrig. | 174.6 | 11.38 | 1.17 | 9.73 | 42.07 | 3.42 |
| Border strip irrig. | 179.6 | 11.49 | 1.11 | 10.35 | 42.18 | 3.41 |
| L.S.D at 5% | 3.4 | 0.23 | 0.05 | 0.16 | N.S | N.S |

The same trend was observed in the second season and the data are in agreement with those reported by Abd El-Messih (1977); Abd El-Metaal (1990); El-Nokrashy *et al*. (1966b); Roth *et al*. (1995); Dawood *et al.* (2001) and Khalifa *et al*. (2001).

**Leaf mineral composition:** Data in Table (6) show that in both growing seasons, leaf N, Ca and Mg contents were not significantly affected by different methods of irrigation. However, the highest values of the previous elements were detected with Border strip irrigation method and found to be 2.58, 3.76 and 0. 0.443% for N, Ca and Mg in the first season, respectively. While, the lowest values of N, Ca and Mg elements were detected under Basin irrigation method and found to be 2.32, 3.62 and 0.424 % in the first season, respectively.

With respect to the leaf content of P, K, Fe, Mn and Zn elements as influenced by different irrigation methods, data in Table (6) indicate that in both growing seasons, the leaf composition of the above mentioned elements were affected significantly by the methods of irrigation. In this regard, the highest values of P (0.164%), K (1.36%), Fe (161.4ppm), Mn (41.56 ppm) and Zn (24.47 ppm) in the first season respectively, were obtained under Border strip irrigation method compared to the other treatments of irrigation. While, the lowest values of leaf minerals were detected under Basin irrigation method and found to be 0.134%, 1.16%, 126.4 ppm, 31.91 ppm and 18.25 ppm for P, K, Fe, Mn and Zn in the first season, respectively.

Similar trend was observed in the second season. Results obtained by Swellem (1986) who, indicated that leaf content of N tended to increase by increasing soil moisture levels, while leaf-P content was negatively correlated. On the other hand, Roth *et al*. (1995) reported that effects of irrigation methods (Trickle, Basin, Sprinkler and traditional Border-flood irrigations) on leaf concentrations of N, Fe, Zn, Mn and Ca were minimal. Also, Tomita (1972) stated that P and Ca contents of the spring leaves increased by irrigation, while leaf contents of K and Mg were reduced.

**Table (6): Leaf mineral content of Navel orange trees* as affected by different flooding irrigation methods.**

| Irrigation methods | Macro elements, % | | | | | Micro-elements (ppm) | | |
|---|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | Fe | Mn | Zn |
| First season, 1999 | | | | | | | | |
| Basin irrigation | 2.32 | 0.134 | 1.16 | 3.62 | 0.424 | 126.4 | 31.91 | 18.26 |
| Ring-shaped irrigation | 2.41 | 0.151 | 1.21 | 3.67 | 0.436 | 135.6 | 34.83 | 19.94 |
| Basin furrow irrigation | 2.53 | 0.159 | 1.29 | 3.72 | 0.440 | 147.8 | 36.72 | 21.34 |
| Border strip irrigation | 2.58 | 0.164 | 1.36 | 3.76 | 0.443 | 161.4 | 41.56 | 24.47 |
| L.S.D. at 5% | N.S | 0.019 | 0.032 | N.S | N.S | 12.21 | 3.36 | 2.64 |
| Second season, 2000 | | | | | | | | |
| Basin irrigation | 2.23 | 0.133 | 1.09 | 3.52 | 0.419 | 121.8 | 23.43 | 19.32 |
| Ring-shaped irrigation | 2.29 | 0.141 | 1.18 | 3.54 | 0.426 | 131.6 | 27.26 | 19.89 |
| Basin furrow irrigation | 2.31 | 0.152 | 1.29 | 3.56 | 0.427 | 136.4 | 33.63 | 21.57 |
| Border strip irrigation | 2.42 | 0.17 | 1.34 | 3.58 | 0.429 | 148.3 | 38.84 | 22.69 |
| L.S.D. at 5% | N.S | 0.016 | 0.031 | N.S | N.S | 11.34 | 3.22 | 3.08 |

*** Leaves of spring and autumn flushes**

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# تقييم طرق الرى بالغمر المختلفة لبساتين البرتقال الفالنشيا تحت ظروف منطقة كفرالشيخ

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أجريت تجربة حقلية خلال موسمى ٢٠٠٠ ، ٢٠٠١ فى مزرعة موالح بقرية شنو ـ محافظة كفرالشيخ بهدف تقييم طرق الرى بالغمر المختلفة فى بساتين البرتقال الفالنشيا تحت ظروف محافظة كفرالشيخ. **وكانت معاملات الرى كالتالى:**

١ - طريقة الرى فى أحواض Basin irrigation
٢ - طريقة الرى فى حلقات Ring-shaped irrigation
٣ - طريقة الرى فى مصاطب Basin furrow irrigation
٤ - طريقة الرى فى البواكى العمياء Border strip irrigation

**وقد أوضحت النتائج المتحصل عليها ما يلى:**

- **النمو الخضرى:** أظهر النمو الخضرى {ممثلا فى طول وعدد النموات / فرع ,المساحة الورقية والوزن الجاف لها , والنسبة المئوية للوزن الجاف ,ارتفاع الشجرة وقطر النمو الخضرى لها, وكذلك قطر ساق الشجرة ومساحة مقطعة , أيضا حجم الشجرة (م٣/ شجرة)} قيما أكبر على الأشجار التى رويت بطريقة البواكى العمياء بالمقارنة بالأشجار التى رويت بطريقة الأحواض وطرق الرى الأخرى.

- **المحصول:** أعطت الأشجار التى رويت بطريقة البواكى العمياء أكبر محصول (٧١,٤٧ ، ٦٨,٣٢ كجم / شجرة / سنة فى الموسمين على التوالى) وكانت الكفاءة المحصولية لأشجار البرتقال الفالنشيا أعلا باستخدام هذه الطريقة (٣,١١ , ٢,٨٣ كجم / م٣ من المجموع الخضرى أو ١,٦٢ , ١,٥٣ كجم / سم٢ من مساحة جذع الشجرة فى الموسمين على التوالى).

- **صفات جودة الثمار:** باستخدام طريقة الرى بالبواكى العمياء أمكن الحصول على أعلى وزن للثمار والمواد الصلبة الذائبة (TSS%) ، ونسبة المواد الصلبة الذائبة / الحموضة وأقل نسبة للحموضة مقارنة بالطرق الأخرى للرى إلا أن قيم فيتامين C وكذلك سمك القشرة لم يتأثرا معنويا بطرق الرى المختلفة خلال موسمى الدراسة.

- **المحتوى المعدنى للأوراق**: فى كلا الموسمين لم يتأثر محتوى الأوراق من النتروجين والكالسيوم معنويا بطرق الرى المختلفة. بينما تأثر معنويا كلا من الفوسفور والبوتاسيوم والحديد والمنجنيز والزنك وقد وجدت أكبر القيم للعناصر السابقة موجودة فى أوراق البرتقال الفالنشيا تحت نظام الرى بالبواكى العمياء.

مما سبق يمكن التوصية بأن طريقة الرى بالبواكى العمياء كأحد طرق الرى بالغمر هى أنسب طريقة لرى بساتين البرتقال الفالنشيا تحت ظروف منطقة كفرالشيخ لما لها أكبر الأثر فى زيادة المحصول وزيادة النمو الخضرى للأشجار وكذا صفات الثمار الناتجة من حيث وزن الثمرة ومحتوى عصير الثمار من المواد الصلبة الذائبة.