

## Growth and Productivity of Three Fig (*Ficus carica* L.) Cultivars Grown Under Upper Egypt Conditions

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**Abstract:** The vegetative growth and vigor as well as yield components and fruit quality of three fig cultivars, two introduced, namely Conadria and Kadota and the local one, Sultani were evaluated under upper Egypt conditions during three successive seasons, 2010, 2011 and 2012. The results of this study could be summarized as follow: There was a great variability in vegetative, vigor growth, yield components and fruit quality of these cultivars. Kadota fig trees cultivar surpassed in vegetative growth and vigor compared to either Conadria or Sultani trees cultivars. Kadota fig trees recorded the highest values of bud burst percentage, leaves number per shoot and annual pruning wood weight, whereas, Conadria fig trees gave the highest leaf area compared with other two cultivars. On other hand, Conadria fig trees cultivar was superior among the rest cultivars in producing the highest fruits number, and heaviest fruit and consequently the heaviest yield/tree. Moreover, Kadota fig cultivar was superior in chemical fruit properties, whereas Sultani fig cultivar had the least fruit quality compared to other two studied cultivars. Concerning the overall numerical evaluation data revealed that, Conadria and Kadota cultivars gained the highest degrees evaluation. It could be arranged these degrees in a descending order as follows 86.7, 81.3 and 52.3 units for Conadria, Kadota and Sultani fig trees cultivars, respectively, under Upper Egypt conditions. On the account of the present findings, it can be recommended to plant Conadria and Kadota fig cultivars under this condition to obtain the high yield with good fruit quality.

**Key words:** Fig, growth, yield components, fruit quality, leaf traits, pruning wood weight.

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### INTRODUCTION

The common fig (*Ficus carica*, L.) family Moraceae, is one of the few deciduous species in the genus. Such species is subtropical and dicotyledonous.

The fig varieties for the commercial production in Egypt were limited and their fruit mature without pollination. Recently, new fig varieties were introduced from California and Italy (Conadria and Kadota). In the evaluation of these foreign in comparison with local cultivars, morphological and physiological studies are very important to identify and select those of the promising characters. Sultani fig variety is the most widely grown. As such, Sultani fig cultivar could be considered the local standard variety in Egypt. Other local cultivars received much less attention in comparison with Sultani cv.

Diredo and Conadria fig cvs had largest vigor followed by Sultani and Black Mission (Badawy, 1990 and Salem, 1996). Theremore, Kadota fig cv is superiority of its vegetative and vigor growth than Conadria, Black Mission and Sultani fig cvs whereas Conadria fig. cultivar surpassed other three fig cultivars in its productivity and fruit quality. Conadria and Kadota cultivars were recorded the high degree evaluation compared with other cultivars (Khamis *et al.*, 2006a,b). Nine fig genotypes were evaluated, some morphological characteristics i.e. tree growth habit, tree vigor and leaf shape. Also, the characteristics of all the fig genotypes were identified. In addition, pomological characteristics, fruit weight ranged between 43.20 to 71.77 g, some other values 46.99 to 65.26 mm of width and 38.23 to 56.87 mm of length, as well as 16.87 to 28.57% of total soluble solids (Simsek, 2009).

The current study was conducted as an attempt to evaluate growth, fruiting and fruit quality of three fig cultivars namely, Sultani, Kadota and Conadria under El-Kawther region condition, Sohag Governorate, Egypt. Such study may be considered as an important step for selecting the promising cultivars and improving the productivity of trees.

### MATERIALS AND METHODS

The current study was conducted in Experimental farm of Sohag Fac. of Agriculture located at El-Kawther region, Sohag Governorate, Egypt, through three successive seasons 2010, 2011 and 2012.

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This experiment was an attempt to evaluate the growth and productivity of one local and two introduced fig cultivars namely, Sultani, Kadota and Conadria under the environmental conditions of Sohag Governorate, Egypt.

The fig tree were about 7-year-old planted according to the square system at 4 meters apart, the soil orchard was calcareous sandy soil (18.8% CaCO<sub>3</sub>), irrigated by using drip system with specific management for fertilization and control of pests and diseases. The trees were winter pruned to equal number of bearing units (20 per tree with six buds).

Six trees of each cultivar nearly uniform in their vigor, size, shape and disease free, were selected. The complete randomized block design was followed with three replicates; each replicate was represented by two trees for each cultivar.

The following parameters were evaluated in all the three fig cultivars.

**1- Tree vigor.** Weight of next winter pruned wood per each tree in (kg) was determined in Jan. of each season on the basis of removed 1-year-old wood. The trees were pruned to leave 20 bearing units of 1-year-old wood each of 6 buds in first, second and third seasons of study.

**2- Bud burst percentage** was calculated according to the following equation:

$$\text{Bud burst \%} = \frac{\text{Number of opened buds per shoot}}{\text{Total number of buds per shoot after winter pruning}} \times 100$$

**3- Number of new current shoots** which sprouted during spring from buds along each bearing unit was also determined.

**4- Ultimate shoots length (cm) and number of leaves/shoot.** Six shoots per tree were tagged to record ultimate shoot length (cm) and number of leaves/shoot at the end of the growing seasons on the last week of Sep.

**5- Leaf area (cm<sup>2</sup>).** On the last week of July, ten mature leaves per tree were randomly sampled. Leaf area was measured according to the following equation outlined by Ahmed and Morsy (1999).

$$\text{Leaf area (cm}^2\text{)} = 0.40 (0.79 \times W^2) + 15.33$$

Where W was the maximum diameter of leaf (cm)

**6- Yield per tree.** The yield per tree (number and weight of fruits) of both “Boni-crop” (picked during May and June) and Main-crop (through June, July and August) were determined. The total number of fruit and their weight/tree/year were calculated.

**7- Fruit quality.** Fruit samples of the “Main-crop” were taken on the last week of July for the three tested cultivars to determine fruit weight (g), fruit length and diameter (cm). Total acidity was estimated as citric acid/100g fruit by titration with NaOH at 0.1N and phenolphthaleine as an indicator according to A.O.A.C. (1975), total soluble solids (TSS) percentage was estimated by using the hand refractometer, TSS/acid ratio was obtained from the values of total soluble solids divided by the values of total acids.

#### **General Evaluation of Tested Cultivars:**

Scoring evaluation of the studied of tested cultivars was calculated through their vegetative growth (bud burst %, wood pruning weight, leaves number and leaf area), yield components (total yield/tree, boni-crop and main-crop) and fruit quality (fruit weight, TSS and TSS/acid ratio). Hundred units were shared between the previous ten characteristics (10 units for each). Within each of these parameters the cultivar that recorded the uppermost values received all the units specified for it. Relative values due to the other tested cultivars were calculated. The following equation was used to determine these characters.

$$\text{Characters score} = \sum \frac{B}{A} \times 10$$

A = The highest value recorded for studied character among all cultivars.

B = Value recorded for the specific character for considered cultivars.

The obtained data were statistically analyzed using the computer MSTAT-C statistical analysis package (Freed *et al.*, 1989), and then LSD test was used to recognize the significance between the treatment means according to the procedure of Snedecor and Cochran (1972).

## **RESULTS AND DISCUSSION**

The evaluation of one local and two introduced fig cultivars grown under Sohag environmental conditions were carried out during three successive growing seasons of 2010, 2011 and 2012. The evaluation included vegetative growth, productivity of trees and fruit quality.

### **1- Vegetative Growth:**

Data present in Tables (1 & 2) described the vigor and vegetative growth parameters of three investigated fig tree cultivars during 2010, 2011 and 2012 seasons. It is obvious from the data that, the results took similar

trend during the three studied seasons. Data showed great varied in vegetative characteristics, i.e. bud burst percentage, shoots number per tree, shoot length and shoot thickness, as well as weight of annual pruning wood/tree, leaves number/tree and leaf area. Individual parameter of them might be used separately as an index for tree vigor of tested fig cultivar, especially, annual pruning wood weight, where it is the end result of tree activity through the previous season as food materials can be stored in all part of tree during summer and fall remain stored until the following spring. Each parameter could have an effect on or be influenced by another one or more. Accordingly, Kadota fig tree cultivar had the largest vigor followed by both Conadria and Sultani cultivars during the three studied seasons. Kadota fig trees had the highest values of bud burst percentage, shoots number pr tree and leaves number and hence the heaviest pruning wood weight compared to other two cultivars. On other hand, Conadria trees had the highest values of shoot thickness and leaf area, whereas, Sultani fig trees recorded the highest values of shoot length compared to other studied cultivars. The greatest vigorous fig was accompanied by the highest weight of winter pruned wood/tree. Contrarily, the less vigor cultivar was accompanied by the least amount of winter pruned wood/tree.

The recorded these parameters for Kadota cultivar were (41.58%, 191.1 shoot, 129.5 cm, 3.89 cm, 9.473 kg, 20.80 leaf and 394.9 cm<sup>2</sup> as an average of the three studied seasons) for bud burst percentage, shoots number, shoot length, shoot thickness, pruning wood weight, leaves number and leaf area, respectively. The corresponding of these parameters for Conadria and Sultani fig cultivars were (27.27%, 121.4 shoot, 124.5 cm, 4.23 cm, 6.772 kg, 14.53 leaf and 508.30 cm<sup>2</sup>) and (22.89%, 131.9 shoot, 156.7 cm, 2.91 cm, 6.463 kg, 15.73 leaf and 426.2 cm<sup>2</sup> as an average of three studied seasons), respectively.

The increment percentage of annual pruned wood weight/Kadota tree over Conadria and Sultani trees were (39.88 and 46.57% as an average the three studied seasons), respectively.

Thus is can be concluded that Conadria trees more stout than other two studied fig cultivars in its vegetative growth and vigor. Such findings emphasized that fact the growth and vigor of trees depended on cultivar, environmental conditions and agricultural practices.

The above results were confirmed by Rokba *et al.* (1985), Badawy (1990), Salem (1996) and Khamis *et al.* (2006a). They found that Kadota and Conadria trees had the largest vigor than Sultani fig trees.

## **2- Yield and its Components:**

In this regard, yield expressed either weight (kg) or number of fruits produced per shoot and tree for both boni and main crops were investigated fruiting measurements.

Data presented in Tables (3 & 4) show the fruits number of boni and main crops and consequently the total fruits number/tree, as well as the yield (kg) for boni and main crops and hence the final yield/tree for some fig cultivars in 2010, 2011 and 2012 seasons.

It is worth to mention that results reached almost similarly during three studied seasons. Such data in previously tables resulted the superiority of Conadria fig cultivar regarding their higher yield expressed as number and weight harvested fruits per tree followed in a descending order by Kadota cultivar. The least number and weight of total fruits/tree was found in Sultani fig cultivar during the three studied seasons. The obtained total number of fruits per tree was (169.67, 411.1 and 535.67 fruit as an average of the three studied seasons) for Sultani, Kadota and Conadria fig trees, respectively. The increment percentage of Conadria number fruits over Kadota and Sultani number fruits were (30.24 and 215.67% as an average of the three studied seasons), respectively. Also, it could be seen that the yield/tree was equivalent to number of fruits per tree. So, the corresponding yield/tree was attained (5.00, 14.33 and 24.58 kg/tree as an average of three studied seasons), respectively. As well as, the increment percentage of yield/Conadria tree over Kadota and Sultani trees was (71.53 and 491.6% as an average of the three studied seasons), respectively. Moreover, data showed that Conadria cultivar gave highest boni crop than other two studied cultivars, as either the number of fruits or yield weight/tree. On other hand, Sultani fig cultivar gave the least number and weight of yield/tree compared other two studied cultivar.

In general, Conadria cultivar was superior among the rest cultivars in inducing the largest fruit number and the heaviest yield/tree. Such increment in the yield/tree of Conadria and Kadota cultivars mainly due to increase the number of fruits/tree as a result of improving the bud burst percentage and flowering. This is a good evidence for the importance of leaf surface expansion in enhancing growth and fruiting potentiality since the important role them in accelerating carbohydrate and protein synthesis and movement which aids in encouraging cell division and development of meristematic tissues. In additional, the increment Conadria yield since the increasing of fruits number due to a good balance between vegetative growth and fruiting potentiality in alter to the later (Tables 1 and 2).

These results were confirmed with the findings of Rokba *et al.*, 1985; Badawy, 1990; Salem, 1996 and Khamis *et al.*, 2006b.

**Table 1:** Bud burst %, shoot number/tree and length and thickness of shoots for the three fig trees cultivars during 2010, 2011 and 2012 seasons.

Characters	Bud burst %				Shoot number/tree				Shoot length (cm)				Shoot thickness (cm)				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	
Season→ ↓Cultivar																	
Sultani	22.92	22.87	22.90	22.89	124.9	138.9	131.9	131.9	153.5	159.9	156.7	156.7	2.86	2.97	2.90	2.91	
Kadota	41.99	41.16	41.58	41.58	180.5	201.7	191.1	191.1	123.6	135.4	129.5	129.5	3.81	3.92	3.94	3.89	
Conadria	26.88	27.64	27.29	27.27	114.8	127.9	121.4	121.4	123.2	125.8	124.5	124.5	4.16	4.25	4.28	4.23	
L.S.D.	1.02	1.49	0.83	0.45	5.2	5.8	4.8	2.1	2.9	2.6	2.7	1.1	0.11	0.12	0.09	0.05	

**Table 2:** Leaves number, Leaf area and annual pruning wood weight/tree of the three fig trees cultivars during 2010, 2011 and 2012 seasons.

Characters	Leaves number/shoot				Leaf area (cm <sup>2</sup> )				Pruning wood weight/tree (kg)				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	
Season→ ↓Cultivar													
Sultani	16.47	14.96	15.76	15.73	453.7	398.1	426.9	426.2	6.197	6.727	6.467	6.463	
Kadota	21.06	20.21	21.14	20.80	397.0	392.6	395.2	394.9	9.020	9.930	9.470	9.473	
Conadria	14.88	14.28	14.43	14.53	503.3	512.9	508.7	508.3	6.713	6.857	6.747	6.772	
L.S.D.	0.31	0.34	0.28	0.14	30.0	56.5	50.9	26.2	0.238	0.290	0.234	0.112	

**Table 3:** Fruits number/tree of boni, main and total crop for the three fig trees cultivars during 2010, 2011 and 2012 seasons.

Characters	No. of fruits/tree (boni-crop)				No. of fruits/tree (main-crop)				Total fruits number/tree				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	
Season→ ↓Cultivar													
Sultani	2.93	2.80	3.03	2.92	182.20	152.30	165.80	166.77	185.10	155.10	168.80	169.67	
Kadota	11.43	14.53	13.07	13.01	322.00	473.70	398.50	398.07	333.50	488.20	411.60	411.10	
Conadria	22.80	24.73	23.97	23.83	446.70	575.60	513.30	511.87	469.50	600.30	537.20	535.67	
L.S.D.	2.14	2.80	1.93	0.92	11.7	36.6	10.6	9.2	12.3	34.8	9.7	8.8	

**Table 4:** Yield/tree (kg) of boni, main and total crop for the three fig trees cultivars during 2010, 2011 and 2012 seasons.

Characters	Yield/tree (kg), boni-crop				Yield/tree (kg), main-crop				Total yield/tree (kg)				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	
Season→ ↓Cultivar													
Sultani	0.083	0.093	0.093	0.090	4.800	5.020	4.910	4.910	4.880	5.110	5.000	5.000	
Kadota	0.400	0.520	0.460	0.460	11.130	16.620	13.870	13.870	11.530	17.140	14.330	14.330	
Conadria	1.040	1.150	1.100	1.097	20.300	26.650	23.480	23.480	21.340	27.800	24.580	24.570	
L.S.D.	0.093	0.088	0.093	0.038	0.480	0.890	0.340	0.190	0.140	0.100	0.120	0.060	

### 3 – Fruit Quality:

#### A- Fruit Physical Characteristics:

Data presented in Table (5) indicated that Conadria trees gave the heaviest significantly fruit weight (in the main crop), whereas the lightest significantly one was recorded on Sultani trees and the intermediate fruit weight recorded on Kadota trees. The obtained fruit weight was (29.56, 34.80 and 45.82 g as an average of the three studied seasons) of Sultani, Kadota and Conadria cultivars, respectively. The increment percentage of Conadria fruit weight was (55.01 and 31.67% as an average the studied seasons) compared to Sultani and Kadota fruits, respectively.

Comparing the length, diameter and shape index of the three studied fruit cultivars, it could be concluded from, Table (5) that the length and diameter of fruits took a similar trend of the fruit weight, where the Conadria fruits recorded the highest values of length and diameter. However, the Sultani fruits recorded the least values of such traits. On other hand, Kadota fruit had the highest significantly shape index of fruits. The obtained fruit length was (3.82, 5.09 and 5.55 cm as an average the three studied seasons) of Sultani, Kadota and Conadria fruits, respectively. The corresponding fruit diameter and fruit shape index were (4.06, 4.50 & 5.20 cm) and (0.95, 1.13 and 1.07), respectively.

#### B – Fruit Chemical Constituents:

Data presented in Table (6) indicated that Kadota fruits of (main crop) had the highest significantly values of the reducing sugars and total soluble solids and the least significantly values of total acidity (as citric acid), hence increased total soluble solids/acid ratio compared to other two studied fruits. Contrary, Sultani fruits had a significantly decreased in reducing sugars, total soluble solids and total soluble solids/acid ratio and significantly increased in total acidity. However, the intermediate values of such fruit traits recorded of Conadria fruits. The chemical constituents of Kadota fruits were (18.32%, 25.80%, 0.123% and 209.5 as an average the three studied seasons) for reducing sugars, total soluble solids, acidity and total soluble solids/acid ratio, respectively. The corresponding these values of Conadria and Sultani fruits were (18.15%, 24.64%, 0.197% and 125.4) and (14.66%, 20.33%, 0.206% and 98.9), respectively. Hence, the increment percentage of Kadota fruit TSS/acid ratio was (111.62 and 67.07% as an average of the three studied seasons) over the Sultani and Conadria fruits, respectively.

In general, it can be concluded that Conadria cultivar surpassed other two fig cultivars in its fruit weight and size, whereas, Kadota cultivar surpassed in its fruit eating quality. Such results may be due to improving the leaf area surface expansion, induce an increasing in fruit growth rate and advanced their ripening since a better supply of food material (carbohydrates) that are manufactured in the leaves.

The findings emphasized that fact the growth, vigor and productivity of trees depended on cultivar, environmental conditions and agricultural practices. These results are in line with those reported by Krezdorn and Adriance (1961), Rokba *et al.* (1985), Badawy (1990), Salem (1996), Khamis *et al.* (2006b) and Simsek (2009). They concluded from their studies that the fruit weight and size of fig is generally classified to large,

medium or small as well as fruit chemical constituents is great variability. Additionally, Conadria and Kadota cultivars surpassed in their fruit quality than Sultani cultivar.

**Table 5:** Some of physical fruit traits for the three fig cultivars during 2010, 2011 and 2012 seasons.

Characters	Fruit weight (gm)				Fruit height (cm)				Fruit diameter (cm)				Fruit shape index (H/D)				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	
Season→ ↓Cultivar																	
Sultani	26.30	32.82	29.56	29.56	3.50	4.14	3.82	3.82	4.01	4.11	4.06	4.06	0.88	0.99	0.98	0.95	
Kadota	34.53	35.07	34.80	34.80	4.97	5.20	5.09	5.08	4.40	4.60	4.50	4.50	1.12	1.13	1.13	1.13	
Conadria	45.44	46.29	45.74	45.82	5.40	5.70	5.55	5.55	5.14	5.26	5.21	5.20	1.05	1.08	1.07	1.07	
L.S.D.	1.48	0.98	0.58	0.43	0.34	0.40	0.23	0.11	0.18	0.15	0.11	0.06	0.04	0.05	0.05	0.03	

**Table 6:** Fruit chemical constituents for the three fig cultivars during 2010, 2011 and 2012 seasons.

Characters	Reducing sugar %				T.S.S. %				Acidity %				TSS/acid ratio				
	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	2010	2011	2012	Mean	
Season→ ↓Cultivar																	
Sultani	14.34	14.91	14.73	14.66	20.00	20.65	20.33	20.33	0.207	0.203	0.207	0.206	96.8	101.6	98.4	98.9	
Kadota	18.00	18.56	18.40	18.32	25.40	26.20	25.80	25.80	0.123	0.123	0.123	0.123	206.3	212.8	209.5	209.5	
Conadria	17.92	18.40	18.13	18.15	24.13	25.15	24.64	24.64	0.197	0.195	0.199	0.197	122.8	128.0	125.4	125.4	
L.S.D.	0.06	0.11	0.12	0.05	0.12	0.08	0.10	0.05	0.019	0.012	0.021	0.08	19.8	17.2	2.08	8.9	

### General Evaluation of Three Fig Cultivar:

It is quite evident from Table (7) that general evaluation of some fig trees cultivars as an average of three studied seasons. Obtained data according to vegetative growth, yield and fruit quality emphasized the pre-mentioned trends, where the Conadria cultivar gained the highest recorded scores (86.74 units) such cultivar recorded similar values according to vegetative growth and yield/tree (31.2 & 30 units), respectively.

Contrarily, Sultani cultivar recorded the least total score (52.26 units). It could be arranged these scores in an ascending order as follows 52.26, 81.29 and 86.74 units for Sultani, Kadota and Conadria fig cultivars, respectively. These findings might be due to both of the Kadota and Conadria trees had a good vegetative growth and vigor (37.77 & 31.2 units), consequently improve the final yield (15.93 & 30.0 units) and fruit quality (27.59 & 25.54 units). Such improvement was previously explained.

**Table 7:** General evaluation of the three fig cultivars for growth, yield and fruit quality as an average of the three studied seasons.

Characters	Vegetative growth					Yield components				Fruit quality				Grand total	
	Bud burst %	Pruning wood weight	Leaves no/ shoot	Leaf area	Total	Boni-crop	Main-crop	Total yield/ tree	Total	Fruit weight	TSS %	TSS/acid ratio	Total		
Season→ ↓Cultivar															
	10	10	10	10	40	10	10	10	30	10	10	10	30		
Sultani	5.5	6.82	7.56	8.38	28.26	0.82	2.09	2.04	4.95	6.45	7.88	4.72	19.0	52.26	
Kadota	10.0	10.0	10.0	7.77	37.77	4.19	5.91	5.83	15.93	7.59	10.0	10.0	27.59	81.29	
Conadria	6.6	7.15	6.98	10.0	31.2	10.0	10.0	10.0	30.0	10.0	9.55	5.99	25.54	86.74	

These results emphasized the importance role of growth and vigor of trees to obtain the high yield, in addition to improve the fruit quality. Generally, it may be concluded that where both Kadota and Conadria trees gained the highest scores, hence, must be planted these fig tree cultivars to obtain the high yield with good fruit quality under this area condition. Furthermore, the best one is Conadria trees since the highly production.

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