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Performance of Two Fig Cultivars Grown under Different Planting Densities

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Abstract. The effect of plant density on two fig cultivars, namely Napolitana and Wazeri was evaluated. Trees were planted at 2500, 1670, 400 trees/ha for Napolitana and 5000, 2500, 400 trees/ha for Wazeri cultivars. Trees were evaluated at the 4th and 5th years from planting. After 4 years, there were no significant differences in length and diameter of the main branches with increasing planting density, while after 5 years the diameter of main branches decreased significantly with increasing planting density as compared with 400 trees/ha treatment in both cultivars. No significant differences were observed after 4 years from planting in trunk diameter with increasing planting densities, while it decreased with increasing the planting density after 5 years in both cultivars. The high-planting density (2500 and 5000 trees/ha for Napoltina and Wazeri cultivar, respectively) decreased the light intensity in both cultivars. Leaf area index increased with increasing planting densities in the two cultivars, while leaf area decreased with increasing planting density in Napolitana cultivar. After 5 years, the cumulative yield was 47.8 and 107.1 t/ha for high-density planting (2500 and 5000 trees/ha) compared with 10.1 and 6.5 t/ha for the normal density (400 trees/ha) in Napolitana and Wazeri cultivars, respectively. The fruit size and total soluble solids increased by increasing density, while other physical and chemical properties were not affected with increasing planting density in both cultivars. These results suggested that the effect of density on tree growth and yield depends on cultivar as well as tree age.

Introduction

During the last two decades, intensive orchard systems have received increased attention. The high planting-density appears to be an efficient system where fruit trees can be produced at relatively low cost and fruited at early age. Also, high-density system is considered as an ideal system for managing trees in fruit breeding programs because they would have a rapid advance of plants from seed to fruiting, increase genetic gain per year and minimize nongenetic variation among trees [1]. Many investigators studied the effects of plant density on vegetative growth, yield and fruit quality of different fruit species. In fig, Storey and Condit and Amen and Amen [2;3] reported that physical fruit properties were increased at the higher trees densities, while chemical fruit properties

were decreased. Also, Gvozdenovic and Manastirac and Wagenmakers [4,5] in pear and Kim *et al.*, Mika and Krawiec and Stampar *et al.* [6-9] in apple reported that yields varied, depending on cultivar and planting density, while trunk growth and leaf area increased with trees density. As well as, in peach Abrahao *et al.* and Kim *et al.* [10,11] and in pawpaw, Kist and Manica [12] found that increasing tree density reduced trunk circumference and increased early yields. On the other hand, Reynolds *et al.* [13,14] stated that vine spacing had a limited influence on reproductive yield and fruit composition.

The objectives of this experiment were to examine the relationship between planting densities and tree performance of two fig cultivars grown in Riyadh region.

Materials and Methods

Seedlings from Napolitana and Wazeri fig cultivars (*Ficus carica L.*) were planted in 1989 at the Agricultural and Research Experimental Station, College of Agriculture, King Saud University. The soil was sandy loam. Irrigation, fertilization and pest control practices were carried out for all plant spacing according to cultural practices in the field. The layout of this experiment was randomized complete block design containing three treatments and five blocks for each fig cultivar according to Steel and Torrei [15, p.327].

The plant spacings were as follows for Napolitana cultivar:

2 x 2 m (2500 trees/ha)
2 x 3 m (1670 trees/ha)
5 x 5 m (400 trees/ha)

and as follows for Wazeri cultivar:

1 x 2 m (5000 trees/ha)
2 x 2 m (2500 trees/ha)
5 x 5 m (400 trees/ha)

Trees of the two cultivars were pruned as the vase - shape system with three main branches. After 4 and 5 years from planting (1993 and 1994 seasons) length and diameter of the main branches(4 and 5 years) were determined in May in both seasons for the two cultivars. Trunk diameter was measured in August 1993 and 1994 seasons at 30 cm above soil surface. Leaf area was examined by portable area meter LI-COR model LI-3000A No. PAM 1671, then leaf area index was calculated using the following equation: leaf area / land area. Light intensity was measured as foot candle (fc) using Panlux electronic Z apparatus in the different plant spacing treatments.

At ripening stage, fruits were harvested from each tree, average fruit weight (50 fruits) was recorded and then yield/tree, yield/ha were calculated in both seasons. A fruit sample (20 fruits) for each tree was collected randomly at harvest time to determine the fruit physical and chemical properties. Fruit size, length, diameter, length to diameter ratio, TSS and acidity were determined in both fig cultivars in the different plant spacings according to A.O.A.C. methods [16, pp. 642-667].

Results and Discussion

Vegetative growth

Within 5 years from planting, spacing had no effect on length of main branches, while diameter of the main branches and trunk circumference were significantly affected by spacing in Napolitana and Wazeri cultivars. Dense planting decreased the trunk circumference in both cultivars. The spacing of 2x2m (2500 trees/ha) produced higher length of main branches for the two cultivars and produced medium trunk circumference (Table 1). Kim *et al.* [6,11] stated that as density increased, the trunk circumference was reduced, but trunk cross- sectional area increased on apple and peach. At the same time, Stampar *et al.* [8,9] found that trunk growth of four apple cultivars increased with densities up to 5400 trees/ha and decreased at densities above 6000 trees/ha. In nectarine, Loreti *et al.* [17], in orange, Roberto *et al.* [18] and in pawpaw, Kist and Manica [12] found that spacing had no effect on trunk growth.

Table 1. Effect of plant density on some vegetative growth characteristics for two fig cultivars in 1993 and 1994 seasons

Plant densities	Length of main branches(cm)			Diameter of main branches(cm)			Trunk circumference(cm)		
	1993	1994	mean	1993	1994	mean	1993	1994	mean
				Napolitana					
2500 trees/ha (2x2m)	212.3a	183.3a	197.8	3.8a	4.1b	4.0	7.1a	9.3b	8.2
1670 trees/ha (2x3m)	215.3a	145.0a	180.2	3.9a	4.1b	4.0	7.0a	9.2b	8.1
400 trees/ha(5x5m)	201.6a	164.6a	183.1	3.9a	4.9a	4.4	7.2a	11.2a	9.2
				Wazeri					
5000 trees/ha (1x2m)	133.3a	134.3a	133.8	3.7a	4.3b	4.0	6.2a	7.7b	7.0
2500 trees/ha (2x2m)	164.0a	136.3a	150.8	4.3a	4.6b	4.5	7.3a	9.6a	8.4
400 trees/ha (5x5m)	136.0a	107.3a	121.7	3.9a	5.5a	4.7	7.1a	9.8a	8.5

* Means followed by the same letter within a column in each cultivar are not significantly different ($P<0.05$) according to Duncan's multiple range test.

In Wazeri cultivar, data in Table 2 shows that with increasing planting densities up to 5000 trees/ha, leaf area and leaf area index increased in both seasons. Leaf area index gave the same trend for Napolitana cultivar. The highest leaf area was obtained from 2 x 3 m (1670 trees/ha) treatment after 4 years, while 2 x 2 m (2500 trees/ha) treatment gave the same results after 5 years in Napolitana cultivar (Table 2). Results observed by Wagenmakers [5] in pear and Loreti *et al.* [17] in nectarine revealed that leaf area decreased with increasing density, while Stampar *et al.* [8,9] on four apple cultivars found that leaf area/ha increased with increasing density and depended on the previous years yield.

Table 2. Effect of plant density on leaf area, leaf area index and light intensity for two fig cultivars in 1993 and 1994 seasons

Plant densities	Leaf area (cm^2)			Leaf area index			Light intensity (foot candle)		
	1993	1994	mean	1993	1994	mean	1993	1994	mean
				Napolitana					
2500 trees/ha (2x2m)	352.0b	293.6a	309.3	4.1a	8.4a	6.3	1.0a	1.0c	1.0
1670 trees/ha (2x3m)	498.2a	254.0a	371.6	3.6a	5.1b	4.3	1.1a	1.3b	1.2
400 trees/ha (5x5m)	401.4b	289.3a	345.4	0.9b	1.6c	1.2	1.1a	1.6a	1.4
				Wazeri					
5000 trees/ha (1x2m)	343.0a	258.6a	300.8	15.9a	19.8a	17.8	0.8a	1.1a	1.0
2500 trees/ha (2x2m)	322.8b	234.3a	278.3	8.8b	10.0b	9.2	1.1b	0.9b	1.0
400 trees/ha (5x5m)	202.8b	198.6b	200.7	0.7c	1.9c	1.3	1.2c	1.4b	1.3

*Means followed by the same letter within a column in each cultivar are not significantly different ($P<0.05$) according to Duncan's multiple range test.

Light intensity (as foot candle), data in Table 2 showed that with increasing planting densities at 2500 trees/ha for Napolitana cultivar and at 5000 trees/ha for Wazeri cultivar, light intensity significantly decreased as compared with that in the lower density (400 trees/ha) after 5 years from planting. The same trend was found by Corelli and Sansavini [19] in apple and by Wagenmakers [5] in pear. They found that trees in 3-row and 4-row beds tended to transmit less light than trees in single row.

Yield

Fruit weight was not affected by plant density in both cultivars in 1993 and 1994 seasons. Cumulative yields as an average for the two seasons varied depending on cultivar and planting density from 6.0 t/ha (400trees/ha) to 30.8 t/ha (2500trees/ha) in Napolitana cultivar and from 5.1 t/ha (400 trees/ha) to72.2 t/ha (5000trees/ha) in Wazeri cultivar (Table 3). The results were somewhat in agreement with those obtained by Kim *et al.* [6], Mika and Krawiec [7], Stampar *et al.* [8,9] on apple, Jankovic [20] on quince, and Kim *et al.* [21] on pear.

Table 3. Effect of plant density on fruit weight and yield for two fig cultivars in 1993 and 1994 seasons

Plant densities	Mean fruit weight(gm)			Yield per tree(Kg)			Yield per hectar(t/ha)		
	1993	1994	mean	1993	1994	mean	1993	1994	mean
					Napolitana				
2500 trees/ha (2x2m)	26.4a	32.3a	29.4	5.5a	19.1b	12.3	13.7a	47.8a	30.8
1670 trees/ha (2x3m)	24.1a	32.9a	28.5	4.4a	21.5b	13.0	7.4b	35.9b	21.7
400 trees/ha (5x5m)	23.5a	33.7a	28.6	4.7a	25.3a	15.0	1.9c	10.1c	6.0
					Wazeri				
5000 trees/ha (1x2m)	16.6a	15.1a	15.9	7.5b	21.4b	14.5	37.4a	107.1a	72.2
2500 trees/ha (2x2m)	17.4a	18.4a	17.9	15.3a	29.4a	22.4	38.2a	73.5b	55.9
400 trees/ha (5x5m)	16.0a	15.6a	15.8	9.3ab	16.3b	12.8	3.4b	6.5c	5.1

*Means followed by the same letter within a column in each cultivar are not significantly different ($P<0.05$) according to Duncan's multiple range test.

Fruit weight per square meter increased, generally, with increasing density for the two fig cultivars. The highest yield was obtained from 2x2 m (2500 trees/ha) and 1x2 m (5000 trees/ha) treatments (3.07 kg/m^2 and 7.22 kg/m^2) for Napolitana and Wazeri cultivars, respectively. On the other hand, yield per tree and yield per hectar was significantly affected by spacing in both cultivars. The same trend was found by Abrahao *et al.* [10] on peach, Mika and Krawiec [7] and Stampar *et al.* [8,9] on apple. They reported that yield per hectar increased with increasing plant density, while Pastor *et al.* [22] on olives found that yield/ha did not increase greatly at planting densities above 300 trees/ha. Alekseeva [23] reported that dense peach planting depressed the yield.

Increasing of plant density from 1670 trees/ha to 2500 trees/ha had no significant effect on yield per tree in Napolitana cultivar in 1994 season, while increasing of plant density from 2500 trees/ha to 5000 trees/ha decreased the yield per tree significantly in Wazeri cultivar in both seasons.

As for the two fig cultivars, dense planting increased yield per hectar. The differences were statistically significant between 1670 trees/ha and 2500 trees/ha treatments in Napolitana cultivar in both seasons. Wazeri cultivar at 5000 trees/ha produced the same yield per hectar as those planted at 2500 trees/ha in 1993 season, but in 1994 the closer planting produced significantly higher yield per hectar as compared with that in the two other densities. Thus, Wazeri cultivar was considered to show promise, because of its high yield at closer plant densities (Table 3).

Fruit properties

The results of physical properties of Napolitana and Wazeri fruits show that after 4 years from planting fruit size of Napolitana cultivar increased significantly with the increase in the plant density, while in Wazeri cv. there was no difference. After 5 years no differences were noted in both cultivars. Also, spacing had no effects on fruit length

and diameter in 1993 and 1994 seasons (Table 4). The same trend was also observed for fruit shape (length to diameter ratio) in Napolitana cultivar. Amen and Amen [3] found that fig fruit diameter was greater at the higher trees density (168/feddan), while Kim *et al.* [6] noted no effect for fruit apple volume by increasing tree density.

Table 4. Effect of plant density on some physical properties for two fig cultivars in1993 and 1994 seasons

Plant densities	Fruit size (cm^3)			Fruit length (cm)			Fruit diameter (cm)			L/D ratio		
	1993	1994	mean	1993	1994	mean	1993	1994	mean	1993	1994	mean
						Napolitana						
2500trees/ha(2x2m)	36.0a	42.0a	39.0	3.5a	3.5a	3.4	4.4a	4.7a	4.6	0.8a	0.7a	0.8
1670trees/ha(2x3m)	30.5ab	42.0a	36.3	3.8a	3.8a	3.8	3.8a	4.7a	4.3	1.0a	0.8a	0.9
400trees/ha(5x5m)	26.5b	41.0a	34.1	3.3a	3.8a	3.6	3.8a	5.1a	4.5	0.9a	0.7a	0.8
						Wazeri						
5000trees/ha(1x2m)	23.6a	22.8a	23.2	3.2a	3.3a	3.3	3.5a	3.6a	3.6	0.9b	0.9a	0.9
2500trees/ha(2x2m)	22.5a	26.7a	23.9	3.3a	3.4a	3.4	2.9a	3.8a	3.4	1.1a	0.9a	1.0
400trees/ha(5x5m)	21.1a	26.7a	23.9	3.2a	3.4a	3.3	3.0a	3.6a	3.3	1.1ab	1.0a	1.0

*Means followed by the same letter within a column in each cultivar are not significantly different ($P<0.05$) according to Duncan's multiple range test.

Data in Table 5 revealed that there were no significant differences in TSS and acidity percentages with spacing for the two cultivars in both seasons. These results are in agreement with those obtained by Krawiec [24] on sour cherry, and Ogata [25] on apple. They found that there were no significant differences in the quality of fruits planted at different densities. On the other hand, Amen and Amen [3] found that TSS and total sugars decreased with increasing tree density, but total acidity was not affected in fig fruits.

Table 5. Effect of plant density on TSS and acidity percentages for two fig cultivars in 1993 and 1994 seasons

Plant denities	TSS (%)			Acidity (%)		
	1993	1994	mean	1993	1994	mean
			Napolitana			
2500trees/ha(2x2m)	28.2a	27.0a	27.6	0.22a	0.24a	0.23
1670trees/ha(2x3m)	25.7a	27.6a	26.7	0.27a	0.21a	0.24
400trees/ha(5x5m)	29.5a	22.0a	25.8	0.20a	0.23a	0.22
			Wazeri			
5000trees/ha(1x2m)	30.1a	26.8a	28.5	0.26a	0.17a	0.22
2500trees/ha(2x2m)	28.5a	29.2a	28.9	0.29a	0.23a	0.26
400trees/ha(5x5m)	24.4b	27.8a	26.1	0.25a	0.24a	0.25

* Means followed by the same letter within a column in each cultivar are not significantly different ($P<0.05$) according to Duncan's multiple range test.

According to the above mentioned data, spacing has a great influence on yield and vegetative growth. Wazeri cultivar appears a positive relationship between growth and fruiting. This cultivar considered a promising cv. because of its high yielding under closer plant densities(5000 trees/ha). Also, the results indicated that the effects of densities on tree growth and yield depend on cultivar as well as tree age.

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سلوك صنفين من التين تحت كثافات نباتية مختلفة

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ملخص البحث. تمت دراسة تأثير كثافات مختلفة لأشجار صنفين من التين هما نابولتين ووزيري.حيث زرعت الأشجار بكثافات ٤٠٠ ، ١٦٧٠ ، ٢٥٠٠ شجرة/هكتار للصنف نابولتين ٤٠٠ ، ٢٥٠٠ ، ٥٠٠٠ شجرة/هكتار للصنف وزيري. أجري تقييم للأشجار في العام الرابع والخامس من الزراعة. وقد أظهرت النتائج أنه بعد خمس سنوات من الزراعة فإن زيادة كثافة الأشجار لم تعط أى فروق معنوية في طول وقطر الأفرع الرئيسية في صنفي التين تحت الدراسة. وبعد أربع سنوات من الزراعة، لم تلاحظ أي فروق معنوية في قطر الجذع مع زيادة كثافة الأشجار، بينما انخفضت مع زيادة كثافة الأشجار بعد خمس سنوات من الزراعة في كلا الصنفين.أدت كثافة الأشجار العالية (٢٥٠٠ ، ٥٠٠٠شجرة/هكتار في صنف النابولتين والوزيري، على التوالي) إلى خفض شدة الإضاءة بين الأشجار، كما أدت زيادة كثافة الأشجار إلى زيادة معامل المساحة الورقية في صنفي التين، بينما أدت إلى انخفاض المساحة الورقية في النابولتين. وبعد خمس سنوات من الزراعة كان المحصول التراكمي ٤٧,٨ ، ١٠٧,١ طن/هكتار لمعاملتي زراعة الأشجار الكثيفة (٢٥٠٠ ، ٥٠٠٠شجرة/هكتار) مقارنة بـ ٦,٥ ، ١٠,١ طن/هكتار لمعاملة زراعة الأشجار بالكثافة العادية (٤٠٠شجرة/هكتار) لصنفي التين نابولتين ووزيري على التوالي.

كما وجد أن متوسط حجم الثمرة والمواد الصلبة الكلية قد حدثت بها زيادة بزيادة كثافة الأشجار، بينما لم تتأثر باقي الصفات الطبيعية والكيميائية الأخرى بزيادة كثافة الأشجار في كلا الصنفين. ويتضح من هذه النتائج أن تأثير كثافة الأشجار على النمو الخضري وكمية وجودة المحصول تعتمد على الصنف، وكذلك على عمر الأشجار.