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Effect of Spacing on Yield and Fruit Quality of Two Pomegranate Cultivars

M.A. BACHA, M.A. AL-HAMADY, M.A. ALY and A.O. ABDULRAHMAN
Plant Production Department, College of Agriculture,
King Saud University, Riyadh, Saudi Arabia

ABSTRACT. Pomegranate seedlings of two cultivars namely, Taiefe and Mellacey were planted in 1989 season at spacing 1 × 2, 2 × 2, 2 × 3 and 5 × 5 m giving densities 5000, 2500, 1670 and 400 trees/ha. Increasing plant density, generally increased yield as kg/m^2, while decreased marketable fruit percentages in 1992 and 1993 seasons. In Mellacey cultivar, no significant difference was found between 2 × 3 m and 5 × 5 m treatments in yield and fruit marketability for both seasons. In Taiefe cultivar, closer plant density (1 × 2 m) increased yield (ton/ha), while decreased the marketable fruit percentage in both seasons. Increasing plant density decreased light intensity percentages measured between, under and inter trees in both cultivars.

Plant density treatments did not statistically affect length, diameter, length to diameter ratio, color degrees, fruit weight and fruit volume for both cultivars. No significant differences were found among all physical fruit properties, except in Taiefe fruit length and in weight of 100 seeds in Mellacey in 1992 season. Plant spacing treatments had inconsistent trend for chemical fruit properties in Taiefe and Mellacey cvs. in both seasons.

Introduction

The search for tree species which provide both high yield and fruit quality products has been one of the main targets in pomegranate cultivation. The high-density system appears to be an efficient system for crops where trees can be produced at relatively low cost and fruited at early age (Chaudra and Govind 1995). Also, high-density system appears to be more easy in soil fumigation, irrigation, weed control, promotes faster growth in height and enhances precocious fruiting. In addition, trees can be planted more closely in a poor than in a good soil. If the soil is poor because it is sallow or of poor water-holding capacity unproductiveness will only be increased by closer spacing (Kuroda *et al.* 1996). Donadio *et al.* (1995) found that, fruit weight and T.S.S. of "Pera" sweet orange significantly affected by spacing, while juice acid percentage in-

creased with increasing planting density. On the other hand, Pastor *et al.* (1993) compared seven plant spacing in olives and found that, yield/ha did not increase greatly at planting densities above 300 trees/ha. The same trend was also found by Stampar *et al.* (1996) on apple. Light intensity was found to decrease more from the upper to the lower part of apple tree, in a triple- or double- row system, that it did in a single row system (Corelli and Sansavini 1989).

The objective of this experiment was to evaluate the effect of several planting- densities in two pomegranate cultivars for their ability to produce fruits with high yield and quality.

Materials and Methods

Taiefe and Mellacey pomegranate (*Punica granatum* L.) were planted in Agricultural Research Experimental Station, College of Agriculture, King Saud University in February, 1989 at four plant spacing 1×2, 2×2, 2×3 and 5×5 m giving densities 5000, 2500, 1670 and 400 trees/ha, respectively. The experiment was designed as a randomized complete block design. Each plant density treatment was a four-plot (each plot was $10 \times 10 m^2$). The planting site, in Derab station was sandy loam. Trees were irrigated with a trickle system. Tress were fertilized annually with compound fertilizers as recommended, and pruned as the vase shape system with three main branches. In 1992 and 1993 seasons, light intensity was measured under, between and inside trees as foot candle percentages from the total light intensity percentage using Panlux electronic Z apparatus in the different planting spacing treatments. At harvest time, weight of fruits per square meter, and weight per hectare and percentage of marketable fruits were determined for each treatment. Samples of fruits (10 fruits) from each tree were collected to determine the physical properties of fruits as length, diameter, length to diameter ratio (fruit shape), average fruit weight and volume, peel and pulp weight, juice volume, color of fruits and weight of 100 seeds. Fruit chemical properties as acidity, TSS, TSS/acid ratio and vitamin C content in juice of fruits were determined according to AOAC (1980).

Results and Discussion

Yield

In Taiefe cultivar, Table (1) showed that, increasing planting density increased yield production as kg/m^2 for two seasons. Spacing at 1×2 m gave the best results for yield (kg/m^2 and ton/ha) as compared with other spacing treatments. The lowest yield obtained from 5×5 m treatment (400 trees/ha), but this treatment had the highest marketable fruits percentage in both seasons. On the other hand, closer planting 1×2 m (5000 trees/ha) produced less percentage of marketable fruits. No significant differences were found between 2×2 m and 2×3 m treatments in yield production during the first season and among 2×2, 2×3 and 5×5 m treatments in marketable fruit percentage in both seasons.

TABLE 1. Effect of plant spacing on light intensity, yield and marketable fruits for Taiefe cultivar in 1992 and 1993 seasons.

Spacing treatments	Light intensity (%)			Yield		Marketable fruits (%)
	between	under	inside	kg/m^2	ton/ha	
1992						
1 × 2 m (5000 trees/ha)	98.3a	5.1b	25.4ab	0.757a	7.57a	58.09b
2 × 2 m (2500 trees/ha)	97.0a	9.1ab	20.5b	0.483ab	4.83ab	67.17ab
2 × 3 m (1670 trees/ha)	94.0a	9.7ab	20.5b	0.150b	1.50b	82.14a
5 × 5 m (400 trees/ha)	100.0a	13.6a	38.7a	0.107b	1.07b	80.00a
1993						
1 × 2 m (5000 trees/ha)	10.3d	2.5b	4.1b	0.973a	9.73a	21.12a
2 × 2 m (2500 trees/ha)	19.8c	2.9b	3.5b	0.780a	7.80a	20.40a
2 × 3 m (1670 trees/ha)	42.4b	9.3a	10.0a	0.890a	8.90a	25.19a
5 × 5 m (400 trees/ha)	100.0a	9.2a	12.5a	0.250b	2.50b	33.63a

*Means not sharing the same letter with columns are significantly different ($P < 0.05$) according to Duncan's multiple range test.

In Mellacey cultivar, data in Table (2) showed that, dense planting increased yield (kg/m^2 and ton/ha) without any significant loss in fruit marketability, while lower planting density (5 × 5 m) gave the lowest values of yield/ha in two seasons (1.7 and 6.7 ton/ha). Mellacey cultivar at (1 × 2 m) 5000 trees/ha significantly produced higher yield kg/m^2 as compared with that in 2 × 3 m in the first season and 5 × 5 m in both seasons. No significant difference was found between 2 × 3 m and 5 × 5 m treatments in yield in both seasons. Also, no significant differences were found in percent fruit marketability among all plant spacing treatments for both seasons.

TABLE 2. Effect of plant spacing on light intensity, yield and marketable fruits for Mellacey cultivar in 1992 and 1993 seasons.

Spacing treatments	Light intensity (%)			Yield		Marketable fruits (%)
	between	under	inside	kg/m^2	ton/ha	
1992						
1 × 2 m (5000 trees/ha)	94.6a	9.9a	30.8b	1.7a	16.7a	77.8a
2 × 2 m (2500 trees/ha)	96.7a	12.5a	28.7b	1.0ab	9.5ab	66.4a
2 × 3 m (1670 trees/ha)	100.0a	11.3a	33.6b	0.6b	6.1b	70.8a
5 × 5 m (400 trees/ha)	100.0a	9.7a	52.3a	0.2b	1.7b	85.7a
1993						
1 × 2 m (5000 trees/ha)	8.5c	4.8b	12.0c	4.2a	42.1a	62.1a
2 × 2 m (2500 trees/ha)	18.3bc	6.6b	10.9c	3.7a	37.1a	65.0a
2 × 3 m (1670 trees/ha)	27.6b	6.0b	26.1b	2.2ab	21.5ab	57.9a
5 × 5 m (400 trees/ha)	100.0a	11.1a	50.0a	0.7b	6.7b	47.9a

*Means not sharing the same letter with columns are significantly different ($P < 0.05$) according to Duncan's multiple range test.

Generally, yield/ha was positively related to the number of trees/ha, while marketable fruit percentage negatively related with number of trees/ha in both cultivars. These results are in line with those obtained by Stampar *et al.* (1996) and Kuroda *et al.* (1996) on apple, Kist and Manica (1995) on pawpaw. They found that increasing plant density increased yield per/ha, whereas, Pastor *et al*. (1993) on olives and Reynolds *et al.* (1995) on vines reported that, yield/ha did not increase greatly with increasing planting densities.

Light Intensity

As for light intensity percentages in Taiefe cultivar, data in Table (1) showed that, no significant differences were observed in light intensity percentages measured between trees in all density treatments in 1992 season, while 400 trees/ha density showed significant differences comparing with other density treatments in 1993 season. Moreover, light intensity under trees, as well as, inside trees decreased significantly with increased plant densities particularly in the second season (Table 1).

In Mellacey cultivar, Table (2) showed that, no significant differences were found between and under trees among spacing treatments in 1992 season. Light intensity percentages inside trees were 30.8, 28.7, 33.6 and 52.3 for 1 × 2 m, 2 × 2 m, 2 × 3 m and 5 × 5 m treatments, respectively. In both seasons 5 × 5 m (400trees/ha) gave the highest percentage of light intensity inside trees than in other plant densities treatments.

Generally, data revealed that, with increasing plant density for two pomegranate cultivars, light intensity percentages decreased in between, under and inside trees. Corelli and Sansavini (1989) stated that light intensity was decrease more from the upper to the lower part of apple trees, in a triple-or double-row system, than it did in a single row system.

Physical Fruit Properties

Fruit physical properties as affected by plant spacing treatments in two pomegranate cultivars are illustrated in Tables (3 - 6). In Taiefe cultivar, fruit shape and color percentage were not significantly affected by tree spacing treatments in both seasons. Weight of 100 seeds increased with increasing densities in the first season, while no differences were found in the second season (Table 3). Fruit weight and volume were not affected by spacing in 1992 season, while spacing 1 × 2 m was significantly higher than 5 × 5 m in 1993 season (Table 5). Taiefe cv. at 2 × 2 m produced the highest pulp and peel weight and juice volume in both seasons.

In Mellacey cultivar, there were no significant differences in length, diameter, length/diameter ratio of fruits (fruit shape) and color percentages in both seasons. Weight of 100 seeds was significantly higher in 1 × 2, 2 × 2 and 2 × 3 m in 1992 season (Table 4). No significant differences were obtained in fruit weight and fruit volume as affected by plant spacing treatments in both seasons. Lower spacing generally reduced pulp and peel weight and juice volume in both seasons, and these reductions were not statistically significant (Table 6). Jankovic (1987) on quince found that, the higher planting density reduced the mean fruit weight, while Stampar *et al.* (1996) on apple noticed that, mean fruit weight was not affected by plant density. Also, Amen and Amen (1987) in Sultani fig trees, reported that fruit diameter was greater at the higher trees density.

TABLE 3. Effect of plant spacing on fruit shape, fruit color and weight of seeds for Taiefe cultivar in 1992 and 1993 seasons.

Spacing treatments	Fruit length (cm)	Fruit diameter (cm)	L / D (fruit shape)	Color (%)	Weight of 100 seeds (gm)
1992					
1 × 2 m (5000 trees/ha)	7.12ab	7.75a	0.92a	50.00a	66.60a
2 × 2 m (2500 trees/ha)	7.56a	8.32a	0.91a	33.33a	66.10a
2 × 3 m (1670 trees/ha)	7.14ab	7.87a	0.91a	40.00a	63.40a
5 × 5 m (400 trees/ha)	7.08b	7.79a	0.91a	40.00a	42.70b
1993					
1 × 2 m (5000 trees/ha)	8.41a	8.94a	0.94a	43.30a	38.60a
2 × 2 m (2500 trees/ha)	8.07a	8.80a	0.94a	46.70a	37.20a
2 × 3 m (1670 trees/ha)	8.06a	8.70a	0.93a	33.30a	39.60a
5 × 5 m (400 trees/ha)	7.51a	8.01a	0.92a	43.30a	35.30a

*Means not sharing the same letter with columns are significantly different ($P < 0.05$) according to Duncan's multiple range test.

TABLE 4. Effect of plant spacing on fruit shape, fruit color and weight of seeds for Mellacey cultivar in 1992 and 1993 seasons.

Spacing treatments	Fruit length (cm)	Fruit diameter (cm)	L / D (fruit shape)	Color (%)	Weight of 100 seeds (gm)
1992					
1 × 2 m (5000 trees/ha)	7.75a	8.77a	0.88a	66.60a	69.30a
2 × 2 m (2500 trees/ha)	7.12a	8.23a	0.87a	60.00a	66.30ab
2 × 3 m (1670 trees/ha)	7.22a	8.14a	0.89a	70.00a	58.40ab
5 × 5 m (400 trees/ha)	7.03a	8.06a	0.87a	60.00a	55.60b
1993					
1 × 2 m (5000 trees/ha)	8.38a	9.08a	0.92a	70.00a	32.60a
2 × 2 m (2500 trees/ha)	8.11a	9.17a	0.88a	63.30a	31.00a
2 × 3 m (1670 trees/ha)	8.36a	9.31a	0.89a	63.30a	32.20a
5 × 5 m (400 trees/ha)	8.35a	8.99a	0.93a	73.30a	30.70a

*Means not sharing the same letter with columns are significantly different ($P < 0.05$) according to Duncan's multiple range test.

TABLE 5. Effect of plant spacing on fruit weight and volume, weight of peel and pulp for Taiefe cultivar in 1992 and 1993 seasons.

Spacing treatments	Fruit weight (gm)	Fruit volume (cm^3)	Peel weight (gm)	Pulp weight (gm)	Juice volume (cm^3)
1992					
1 × 2 m (5000 trees/ha)	244.8a	254.7a	108.2a	135.0ab	99.9a
2 × 2 m (2500 trees/ha)	275.8a	293.2a	119.7a	153.1a	98.3a
2 × 3 m (1670 trees/ha)	247.5a	259.0a	96.5ab	143.7ab	94.7a
5 × 5 m (400 trees/ha)	241.1a	226.0a	74.6b	107.0b	60.0b
1993					
1 × 2 m (5000 trees/ha)	341.0a	352.3a	151.0a	190.3a	129.3a
2 × 2 m (2500 trees/ha)	339.0a	356.0a	142.3a	197.7a	148.7a
2 × 3 m (1670 trees/ha)	332.0b	343.7a	139.3a	193.0a	123.3a
5 × 5 m (400 trees/ha)	225.0b	213.0b	141.0a	144.3a	147.7a

*Means not sharing the same letter with columns are significantly different ($P < 0.05$) according to Duncan's multiple range test.

TABLE 6. Effect of plant spacing on fruit weight and volume, weight of peel and pulp for Mellacey cultivar in 1992 and 1993 seasons.

Spacing treatments	Fruit weight (gm)	Fruit volume (cm^3)	Peel weight (gm)	Pulp weight (gm)	Juice volume (cm^3)
1992					
1 × 2 m (5000 trees/ha)	318.7a	330.4a	129.7a	182.5a	116.8a
2 × 2 m (2500 trees/ha)	264.8a	266.1a	110.5a	146.5a	97.3a
2 × 3 m (1670 trees/ha)	263.5a	277.7a	113.3a	152.3a	92.7a
5 × 5 m (400 trees/ha)	251.9a	259.3a	97.9a	148.9a	96.0a
1993					
1 × 2 m (5000 trees/ha)	394.0a	417.3a	151.3a	243.0a	145.3a
2 × 2 m (2500 trees/ha)	359.7a	389.0a	152.3a	207.3a	133.7a
2 × 3 m (1670 trees/ha)	408.7a	436.3a	174.7a	232.7a	157.3a
5 × 5 m (400 trees/ha)	361.7a	390.0a	147.0a	214.7a	144.3a

*Means not sharing the same letter with columns are significantly different ($P < 0.05$) according to Duncan's multiple range test.

Chemical Fruit Properties

Data in Tables (7 and 8) revealed that, there were no significant differences in TSS and vitamin C content with spacing for two cultivars in 1992 season. The highest acidity percentages and lowest TSS/acid ratio were obtained at spacing of 5 × 5 m in Taiefe

cv. in both seasons. Spacing 1 × 2 m and 2 × 2 m produced fruits with 4.95 and 3.73 mg/100 ml juice Vit. C in 1993 season, respectively (Table 7).

In Mellacey cv., no significant differences were found in all chemical fruit properties under study for two seasons. Spacing 2 × 2 m and 2 × 3 m gave 5.61 and 3.34 mg/100 ml juice Vit. C in 1993 season, respectively. Generally, the effect of plant spacing treatments on fruit chemical properties for two cvs. slightly cleared (Table 8). The same trend was found by several authors such as, Amen and Amen (1987) on apple and Ogata (1989) and Krawiec (1995) on sour cherry.

TABLE 7. Effect of plant spacing on acidity, T.S.S., T.S.S./acid ratio and vitamin C. for fruits of Taiefe cultivar in 1992 and 1993 seasons.

Spacing treatments	Acidity (%)	T.S.S. (%)	T.S.S. / acid ratio	Vit. C mg / 100 ml. juice
1992				
1 × 2 m (5000 trees/ha)	0.81b	15.20a	19.70a	1.14a
2 × 2 m (2500 trees/ha)	0.85b	15.60a	18.60ab	1.26a
2 × 3 m (1670 trees/ha)	1.04ab	15.70a	16.10ab	1.55a
5 × 5 m (400 trees/ha)	1.45a	14.80a	10.60b	0.98a
1993				
1 × 2 m (5000 trees/ha)	0.70a	13.73ab	20.50a	4.95a
2 × 2 m (2500 trees/ha)	1.08a	14.30a	14.20a	3.73ab
2 × 3 m (1670 trees/ha)	0.86a	13.70ab	17.20a	2.51ab
5 × 5 m (400 trees/ha)	1.26a	13.60b	13.00a	1.27b

*Means not sharing the same letter with columns are significantly different (P< 0.05) according to Duncan's multiple range test.

TABLE 8. Effect of plant spacing on acidity, T.S.S., T.S.S. / acid ratio and vitamin C. for fruits of Mellacey cultivar in 1992 and 1993 seasons.

Spacing treatments	Acidity (%)	T.S.S. (%)	T.S.S. / acid ratio	Vit. C mg / 100 ml. juice
1992				
1 × 2 m (5000 trees/ha)	1.11a	15.30a	13.98a	1.83a
2 × 2 m (2500 trees/ha)	1.09a	15.30a	14.29a	1.26a
2 × 3 m (1670 trees/ha)	0.94a	15.73a	18.65a	2.07a
5 × 5 m (400 trees/ha)	1.42a	14.17a	10.83a	1.95a
1993				
1 × 2 m (5000 trees/ha)	1.43a	13.90a	10.17a	2.88a
2 × 2 m (2500 trees/ha)	1.27a	13.50a	10.72a	5.61a
2 × 3 m (1670 trees/ha)	1.46a	14.10a	11.47a	3.34a
5 × 5 m (400 trees/ha)	1.58a	13.30a	8.50a	1.39a

*Means not sharing the same letter with columns are significantly different (P< 0.05) according to Duncan's multiple range test.

According to the above mentioned results it can be concluded that, the lower plant spacing treatments gave a higher yield production and lower percentages of marketable fruits comparing with higher plant spacing treatments in the two cultivars. Also, Mellacey cv., generally appears a more promising cultivar under closer densities than Taiefe cultivar.

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تـأثيــر مسافــات الزراعــة على المحصــول وجـودة الثمـار في صنفـين من الرمــان

محمد علي باشة ، مصطفى عاطف الحمادي
محمود أحمد علي و عبد السلام عثمان عبد الرحمن
قسم الإنتاج النباتي ، كلية الزراعة ، جامعة الملك سعود
الريـــاض - المملكة العربية السعودية

المستـخلص . زرعت شـتـلات من صنفين من الرمـان همـا الطائفي والمليسي في موسم ١٩٨٩ على مسافات زراعة ١×٢م ، ٢×٢م ، ٢×٣م و ٥×٥م (تعطي كثافات نباتية ٥٠٠٠ ، ٢٥٠٠ ، ١٦٧٠ ، ٤٠٠ شجرة للهكتار) . وقد أدت زيادة كثافة الأشجار إلى زيادة في كمية المحصول بالكيلوجرام لكل متر مربع ، بينما أدت إلى خفض النسبة المئوية للثمار القابلة للاستهلاك في صنفي الطائفي والمليسي في كلا الموسمين . أدت زيادة كـثـافـة النبـاتات في الصنف الطائفي إلى زيادة المحـصـول (طن/ هكتار) بينما قللت النسبة المئوية للثمار القابلة للاستهلاك في كلا الموسمين . المعاملتين ٢×٣م و ٥×٥م لم تعطى فروق معنوية في كـمية المحصول ونسبة الثمـار القابلة للاستهلاك في صنف المليسي في كلا موسمي الدراسة . وفي صنف الطائفي أدت مسافة الزراعة (١×٢) إلى زيادة المحصول (طن/ هكتار) بينما قللت النسبة المئوية للثمار القابلة للاستهلاك في كلا الموسمين . أدت زيادة كثافة الأشجار إلى خفض النسبة المئوية لشدة الإضاءة المقاسة بين وتحت وداخل الأشجار في كلا الصنفين .

وأظهرت النتائج أيضًا أن معاملات مسافات الزراعة لم تؤدي إلى وجود أي فروق معنوية في طول ، قطر ، نسبة الطول/ القطر (شكل الثمرة) ، درجة تلوين الثمار ، متوسط وزن الثمرة وحجم الثمرة ووزن ١٠٠ بذرة في كلا الصنفين مع وجود بعض الاختلافات . حيث وجدت اختلافات معنوية بالنسبة لطول الثمرة في صنف الطائفي ، و وزن

١٠٠ بذرة في صنفي الطائفي والمليسي في موسم ١٩٩٢ . كما لم تظهر الصفات الكيميائية للثمار أي تأثير محدد الاتجاه نتيجة للمعاملات المستخدمة في كلا الصنفين وفي موسمي الدراسة .