

Effects of pruning systems on growth, fruit yield and quality traits of three greenhouse-grown bell pepper (*Capsicum annuum* L.) cultivars

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Abstract

Pruning system plays a key role in efficient use of production area inside protected structures. Two experiments were performed to study the effect of pruning systems on vegetative growth, yield and quality traits of three hybrid bell pepper cultivars: 'Pasodoble', 'Lirica' and 'Sondela'. Cultivars were grown under greenhouse conditions in drip fertigated soil culture and plants were pruned leading to one main branch, two and four side branches. Vegetative growth, yield and quality traits were affected by cultivars or pruning systems and their interactions. 'Pasodoble' F₁ yellow cultivar had the highest early and total yields due to the relative rapid fruit set and fruit number. 'Lirica' F₁ yellow cultivar had large fruit size (heavier, longer, wider and thicker pericarp fruits). Meanwhile, 'Sondela' F₁ red cultivar exhibited superior fruit quality (vitamin C, titratable acidity, total soluble solids and total sugars). Pepper plants pruned to one branch resulted in a significant increase in early yield, fruit size and internal fruit quality with a decrease in total fruit yield followed by plants pruned to two branches. However, plants pruned to four branches produced the highest yield, due to higher number of fruits plant⁻¹. The best fruit number and total yield were obtained by pruning 'Pasodoble' F₁ plants to 4 branches. On the other hand, pruning 'Lirica' F₁ plants to one branch improved fruit weight, fruit size and gave thicker flesh width. Regarding to fruit quality traits; 'Sondela' F₁ red pepper, especially under one branch pruning system represented a vital source of vitamin C.

Keywords: Branch pruning; colored pepper; hybrid cultivars; fruit size; fruit flesh thickness; vitamin C.

Abbreviation: Cultivar (cv.); vitamin C (vit. C); titratable acidity (TA); total soluble solids (TSS); total sugars (TS).

Introduction

Bell pepper (*Capsicum annuum*) is among the most grown vegetables in greenhouses worldwide. From a nutritional prospective, bell pepper is rich in vitamins; chiefly, vit. C and provitamin A. Concentrations of vitamin C is ranged from 63 to 243 (mg 100 g⁻¹) depending on fruit colour (Howard et al., 1994). In a survey on content of vitamin C in fruits and vegetables, bell peppers represented the highest fourth out of 42 choices (Frank et al., 2001). A 100 g of edible portion of pepper provides 24 Kcal of energy, 1.3 g of protein, 4.3 g of carbohydrates and 0.3 g of fat (Zende, 2008). Also, it is one of the valuable medicinal plants in pharmaceutical industries, owing to high amounts of health promoting substances, particularly antioxidant, capsaicin and capsantin (Aminifard et al., 2012).

Greenhouse bell pepper cultivars are hybrids that have bell-shaped or blocky-type fruits with varied colors. While green is the most favored color in bell peppers, red and yellow are also preferred with higher price in fresh market. Market shares in USA are about 80%, 10%, and 8% for the three colors, respectively (Frank et al., 2001). Such hybrid cultivars are characterized for high productivity and quality traits.

Pepper plants have a branching habit; therefore, fruit development is controlled by restricting the branching pattern to 1, 2, 3 and 4 main branches. The reasons for pruning bell pepper under greenhouse conditions are to train plant to grow upright in order to facilitate light penetration all over the leaf canopy, improve fruit set and obtain early fruit ripening and high yield of large sized fruits (Jovicich et al., 2004; Zende,

2008). Moreover, pruning is effective in improving air circulation which reduces relative humidity and limits the spread of diseases (Esiyok et al., 1994). Pruning methods vary with different branching habits of *Capsicum* cvs. and under different plant densities (Dasgan and Abak, 2003; Maniutiu et al., 2010). The prime objective of the pruning practice is obtaining proper balance between fruit number and fruit size by improved canopy management. Due to the heavy vegetative growth and fruit load on the colored pepper plants (Shaw and Cantliffe, 2002), shoot pruning is important factor in proper utilization of production area (Maniutiu et al., 2010). Pruning plants to 2, 3 or 4 shoots was reported to be effective in increasing yield and reducing fruit size. Thus, the limitation of shoot number allows the increase in fruit quality (Cebula, 1995). Several studies have reported an increase in fruit yield of sweet pepper with increase in shoot number under soilless media in protected agriculture (Cebula, 1995; Jovicich et al., 2004; Maboko et al., 2012). However, there is little information on the effect of shoot pruning on bell pepper in a soil culture. On the other hand, most of bell pepper cultivars present in Saudi Arabia's markets are newly introduced, which require many investigations focused on cropping methods, characterization with the aim for rapid growth, excellent branching and fast fruit growth under protected agriculture. Therefore, the present study was carried out to clarify the best pruning system on the base of some vital vegetative growth traits, fruit yield and quality of three F₁ colored pepper cvs. grown in the greenhouse soil.

Results and Discussion

Vegetative growth traits

Significant differences were detected among bell pepper cvs. in most studied vegetative growth traits. 'Pasodoble' F₁, generally, showed higher plant height, and heavier leaf fresh and dry weights plant⁻¹ than either 'Sondela' or 'Lirica' F₁ (Fig. 1a, b and c). However, 'Sondela' F₁ reflected higher leaf area plant⁻¹ than others (Fig. 1d). These results were due to the genetic variations among three bell pepper cvs. and their ability for exploiting the environmental factors under greenhouse conditions (Awole et al., 2011).

Pruning systems resulted in significant differences in all vegetative growth traits. Generally, bell pepper plants pruned to one branch were characterized by the tallest stems than those pruned to 2 or 4 branches (Fig. 2a). This might be due to the fact that competition between plants for available water, nutrients and light is less in one branch system than in 2 or 4 branches systems. On the other hand, the heaviest leaf fresh and dry weights, as well as the largest leaf area were obtained by pepper plants pruned to 4 branches, followed by plants pruned to 2 branches (Fig. 2b, c and d). Generally, Jovicich et al., (1999) reported that single-stem plants had longer branches than 2 or 4-stem plants. Whereas, plants with 2 and 4 stems had a greater final plant growth (greater number of leaves and heavier plant dry weight) over single-stem plants (Jovicich et al., 1999).

External fruit quality traits

'Lirica' F₁ showed the highest mean values for both fruit weight and fruit dimension (fruit length and width) than 'Sondela' and 'Pasodoble' F₁ (Fig. 3a, b and c). 'Lirica', also, reflected thicker flesh width, followed by 'Sondela' F₁ (Fig. 3d), owing to heavier and bigger fruits having thicker pericarp. Fruit fresh weight varied from 170 to 195 g (Fig. 3a). This variation was, mostly, represented by larger yellow fruits of 'Lirica' F₁ followed by either the red or the yellow fruits of cultivars 'Sondela' F₁ or 'Pasodoble' F₁, respectively. This result is similar to the finding of Shaw and Cantliffe (2002), who found average fruit weights ranged from 165-212 g in yellow pepper and from 180-207 g in red pepper. Fruit weight of colored bell pepper is an important factor for both export and local vegetable markets. Fruits having 150-200 g weight with 4 lobes are considered as export grade (A), which reflects higher price on the market (Zende, 2008). Also, in local fresh produce markets, consumers prefer colored bell pepper with large fruit size. Thus, 'Lirica' and 'Sondela' F₁ might be considered as superior cvs. and can be chosen for specialty market production.

Significant differences were also detected among pruning systems. Plants pruned to one branch produced heavier, longer and wider fruits with thicker pericarp, followed by plants pruned to 2 branches, rather than those pruned to 4 branches (Fig. 4a, b, c and d). These external quality traits could be attributed to the higher source (mature and photosynthesizing leaves) to sink (growing, metabolizing and storing tissues) ratio (Ambroszczyk et al., 2008a). A sufficient amount of assimilates was available for young fruits in plants with one pruned branch. The opposing case was observed under 2 or 4 pruned branches, where the sink to source ratio was high. Therefore, the availability of assimilates was low, which has directly affected weight, length and breadth of fruits (Zende, 2008).

Yield attributes

There were significant differences among bell pepper cvs. in fruit number, early and total fruit yield (Table 1). 'Pasodoble' F₁ was found to be superior in fruit number than others. 'Pasodoble' F₁ is the tallest cv. (Fig. 1) with more growing points (nodes). This finding is in harmony with Awole et al. (2011), who reported that plants tend to have more growing points (nodes) in taller varieties. Also, 'Pasodoble' F₁ produced the highest early and total fruit yield, greater than for 'Lirica' and 'Sondela' F₁. The increasing percentages in both early and total fruit yield (t ha⁻¹) of 'Pasodoble' F₁ were (17.64-23.29%) and (18.66-14.44%) for the first season and (9.36-18.39%) and (16.68-10.52%) for the second season, in comparison with 'Lirica' and 'Sondela' F₁, in that order. The highest yield of 'Pasodoble' F₁ could be mainly due to the highest mean value of fruit number (Table 1). Plants pruned to one branch resulted in a significant increase in early fruit yield (Table 2), due to a sufficient amount of assimilates from vegetative to reproductive parts. The highest early fruit yield ranged between 16.2 to 16.5 t ha⁻¹ for a single branch pruned plants. The percentage of increases were 16.57 to 113.14% in the first season and between 14.68 to 107.91% in the second season, in comparison with 2 and 4 branches pruning systems. On the other hand, plants pruned to 4 branches gave the highest number of fruits, as compared with other pruning systems. This finding might explain on the basis that fruit abortion is linearly decreased with increasing growth rate of the vegetative parts (Marcelis et al., 2004). Plants pruned to 4 branches generated higher total fruit yield (84.79 and 85.43 t ha⁻¹). The relative percentage of increase was 20.78 to 70.69%, in the first season and 18.92 to 83.33%, in the second season, in comparison with 2 and one branch pruning systems. As branch number increased, total fruit yield was higher. An increased number of branches produced more fruits plant⁻¹, which might lead to the production of further yield per unit area and higher total fruit yield. Jovicich et al. (1999) and Maboko et al. (2012) also observed similar results when bell pepper plants were pruned to 4 branches. In general, the obtained results recorded moderate to wide range in total yield between cvs. (63.265-75.340 t ha⁻¹) and between pruning systems (46.600-85.431 t ha⁻¹), respectively. These results agreed with the findings of Ambroszczyk et al. (2007) and Ambroszczyk et al. (2008a), who found a wide range of total fruit yield in eggplant based on cvs., pruning systems and growth conditions.

Internal fruit quality traits

Significant differences were found in fruit chemical composition among the three bell pepper cvs. The red bell pepper cv. 'Sondela' F₁, had the highest levels of vitamin C, TA, TSS and TS in comparison with yellow cultivars 'Lirica' and 'Pasodoble' F₁ (Table 1). Bell pepper cvs. used in this study contained a higher level of vitamin C content than other reported pepper cvs., which ranged from 63 to 243 (mg 100 g⁻¹) based on the fruit color of cvs (Howard et al., 1994; Frank et al., 2001). The values of vitamin C found in the 'Lirica' and 'Pasodoble' F₁ yellow pepper (208-226 mg 100 g⁻¹) was higher than that detected in yellow bell pepper 'Zarco HS' cv. (188 mg 100 g⁻¹) (Antoniali et al., 2007). On the other hand, red cultivar 'Sondela' F₁ exhibited the highest value of vitamin C (225.2-234.3 mg 100 g⁻¹), indicating that this cv. represents a vital source for vitamin C. Red pepper is considered as one of the vegetable crops with the highest content of vitamin C among other important plant foods like broccoli and spinach (Lee and Kader, 2000).

Table 1. Fruit yield component and fruit quality traits of bell pepper cultivars during 2009/2010 and 2010/2011 growing seasons.

Pepper cultivars	Fruit number plant ⁻¹	Early fruit yield (t ha ⁻¹)	Total fruit yield (t ha ⁻¹)	Vit. C (mg 100 g ⁻¹ f.w.)	TA (g 100 g ⁻¹ f.w.)	TSS (%)	TS (% f.w.)
First season (2009/2010)							
Lirica	14.5 c	12.009 b	63.494 c	217.3 b	0.300 b	6.5 b	6.4 b
Sondela	15.6 b	11.459 c	65.835 b	225.2 a	0.313 a	6.9 a	6.7 a
Pasodoble	16.8 a	14.128 a	75.340 a	208.3 c	0.287 c	6.3 c	6.2 c
Second season (2010/2011)							
Lirica	13.5 c	12.850 b	63.265 c	226.6 b	0.309 b	6.6 b	6.3 b
Sondela	14.6 b	11.870 c	66.792 b	234.3 a	0.320 a	7.0 a	6.6 a
Pasodoble	16.5 a	14.053 a	73.817 a	215.7 c	0.293 c	6.4 c	5.9 c

Means followed by the same letter in each season are insignificantly different at 0.05 level.

Table 2. Fruit yield component and fruit quality traits as affected by pruning systems during 2009/2010 and 2010/2011 growing seasons.

Pruning systems	Fruit number plant ⁻¹	Early fruit yield (t ha ⁻¹)	Total fruit yield (t ha ⁻¹)	Vit. C (mg 100 g ⁻¹ f.w.)	TA (g 100 g ⁻¹ f.w.)	TSS (%)	TS (% f.w.)
First season (2009/2010)							
One branch	8.3 c	16.156 a	49.675 c	234.8 a	0.388 a	7.8 a	7.28 a
2 branches	14.9 b	13.859 b	70.202 b	216.8 b	0.273 b	6.5 b	6.43 b
4 branches	23.8 a	7.580 c	84.792 a	199.2 c	0.237 c	5.5 c	5.50 c
Second season (2010/2011)							
One branch	8.0 c	16.479 a	46.600 c	241.0 a	0.392 a	7.5 a	7.0 a
2 branches	14.0 b	14.369 b	71.842 b	224.7 b	0.270 b	6.6 b	6.4 b
4 branches	22.6 a	7.926 c	85.431 a	210.8 c	0.261 c	5.9 c	5.5 c

Means followed by the same letter in each season are insignificantly different at 0.05 level.

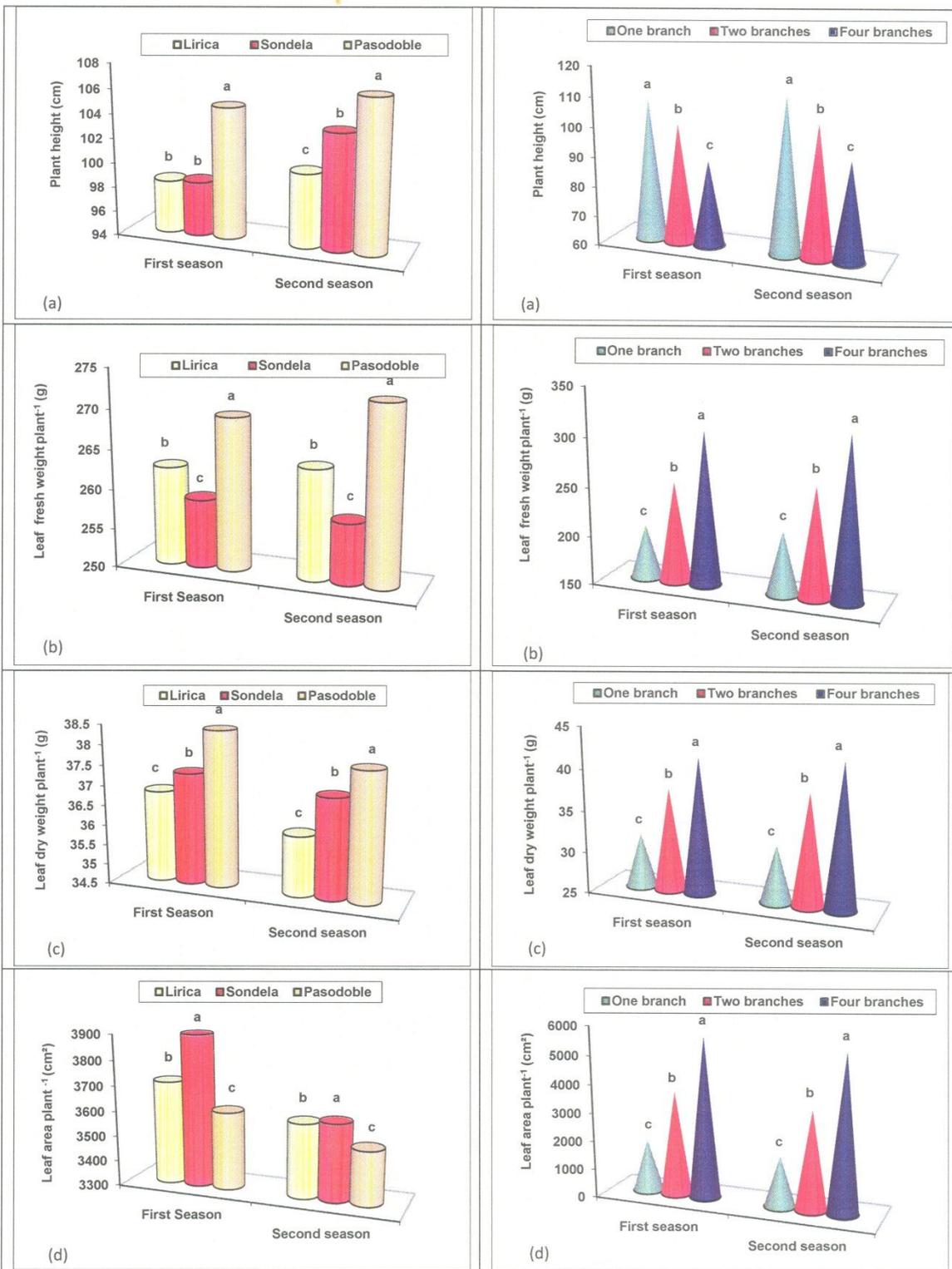


Fig. 1. Vegetative growth traits of bell pepper cultivars: (a) plant height, (b) leaf fresh weight plant⁻¹, (c) leaf dry weight plant⁻¹ and (d) leaf area plant⁻¹ during 2009/2010 and 2010/2011 growing seasons.

Fig. 2. Vegetative growth traits as affected by pruning systems: (a) plant height, (b) leaf fresh weight plant⁻¹, (c) leaf dry weight plant⁻¹ and (d) leaf area plant⁻¹ during 2009/2010 and 2010/2011 growing seasons.

Significant differences were also recorded among pruning systems on fruit chemical composition. The highest values of vitamin C, TA, TSS and TS were detected with plants pruned to one branch, followed by plants pruned to 2 branches (Table 2). The lowest contents of these traits were observed in plants pruned to 4 branches, which might be as a result of poor light interception by the leaf canopy. A similar finding was obtained by Ambroszczyk et al. (2008b), who stated that high assimilate supply was connected with better light conditions in plants pruned to a lesser number of branches. The single-shoot plants produce fruits with better quality because of high available assimilates, as suggested by Ambroszczyk et al. (2008a; b).

Interaction effect

In general, results revealed clear significant differences among bell pepper cultivars and pruning systems in various fruit yield and quality traits (Table 3). For instance, pruning 'Lirica' F₁ plants to a single branch resulted in significantly higher fruit fresh weight and thicker fruit flesh, in comparison with 2 or 4 branches systems. For pericarp thickness trait, significant differences between yellow and red pepper F₁ cultivars are imperative in postharvest handling point under different pruning systems. For instance, thicker pericarp generates a heavier fruit. Hence, less fruit may be needed to fill a 5-kg shipping container, or thin pericarp may fracture easier during handling (Shaw and Cantliffe, 2002). Single branch pruning system of 'Pasodoble' F₁ plants produced the highest early fruit yield due to the fast fruit set of this cultivar joined with availability of more sunlight and better aeration under this pruning system. Moreover, 'Pasodoble' F₁ plants with 4 pruned branches generated a higher number of fruits, as well as higher total fruit yield, as compared to other cultivars under different pruning systems. However, 'Sondela' F₁ red recorded the highest fruit quality, in terms of vitamin C, particularly with pruned plants to one branch over than other two pruning systems (Table 3). This result might be explained on the basis that the amount and intensity of light during the growing season have a clear effect on increasing the vitamin C formation (Lee and Kader, 2000).

Materials and methods

The study was conducted during 2009/2010 and 2010/2011 seasons under greenhouse conditions at the Agricultural Research and Experimental Station, in Dirab near Riyadh, Saudi Arabia (24° 39' N, 46° 44' E).

Plant materials

Three bell pepper F₁ hybrid cultivars of indeterminate growth habit; 'Pasodoble', (yellow fruits), 'Lirica' (yellow fruits) and 'Sondela' (red fruits) (RIJK ZWAAN company, Netherlands) were used. Seeds were germinated in seedling trays on 29th August 2009 and 20th August 2010 in a controlled environment of 25 ± 1°C day/18 ± 1°C night temperatures. Six-week-old seedlings, with healthy and uniform size and 3-4 true leaves were transplanted into soil in a fibreglass greenhouse. Physical and chemical properties of the soil are shown in Table 4. A drip irrigation system was used for irrigation and fertilization. For each season 700 kg N, 280 kg P₂O₅ and 800 kg K₂O ha⁻¹ fertilizers were applied and the amount of water applied was 6000 m³ ha⁻¹ (Ibrahim, 2009). The air temperature in the greenhouse was maintained at 26 ± 1°C during the day and 19 ± 1°C during the night and relative humidity was 75 ± 2% overall the growing season.

Harvesting started 80 days after transplanting and continued periodically, depending on ripening of fruits.

Experimental design

The treatments were arranged in a split plot system in a randomized complete block design with four replications. Pepper cultivars were assigned to the main plots and pruning systems were randomly organized in the sub-plots. The sub-plot area was 8 m², which comprised of 20 plants. Planting distance was 40 and 100 cm between plants and lines, respectively.

Pruning systems

To encourage initial vegetative growth, the first crown flower and second order flowers were pulled from the plants of the three cultivars in all treatments. Lateral shoots and flowers, just above the cotyledonary node, were also removed. Based on number of branches, the pruning system was applied to form a plant structure of 1, 2 and 4 main branches. When pruning a main branch, only the flower on the branch node and its nearby leaf were left. After 21 days from transplanting, at 2 weeks intervals, all side branches were removed on the main branches to enhance upward growth and fruiting on trained main branches only. In addition, older leaves were removed from the lower parts of stems to allow for more air circulation and light within the canopy. For supporting growing pepper plants, they were led with strings tied to transversal wires, 2.5 m above the ground.

Data recorded

At 50% flowering, five plants from each sub-plot were randomly sampled to record plant height, leaf area with a Portable Area Meter (LI-COR model 3000A), leaf fresh weight and leaf dry weight. Data on fruit traits, fruit yield and its components were recorded throughout the fruiting period. Data included fruit number plant⁻¹, fruit fresh weight plant⁻¹. Fruit length, fruit width and fruit flesh thickness was also measured using a digital caliper. The sum of all harvests comprised the total fruit yield (ton ha⁻¹), while that of the first five harvests was considered as the early fruit yield (ton ha⁻¹). Five fruit samples, derived from five plants from each sub-plot were collected during the full fruiting period and used to determine fruit chemical composition as follows; from the homogenized fruit juice, vitamin C (mg 100 g⁻¹ f.w., as ascorbic acid) was determined by titration of homogenate pepper cv. samples (which were diluted in 3% meta-phosphoric acid and 8% acetic acid solution) using 2,6 Dichlorophenol-indophenol solution that was standardized in a solution of ascorbic acid with a known concentration (Patane et al., 2011). Titratable acidity (TA, g 100 g⁻¹ f.w. as malic acid) was determined using 10 g of fruit flesh ground in a blender and homogenized with 90 mL of distilled water. The samples were potentiometric titration with 0.1 M L⁻¹ NaOH as a standardized titration solution up to pH 8.1

Table 3. Interaction effect among bell pepper cultivars and pruning systems on fruit, yield and quality traits during 2009/2010 and 2010/2011 growing seasons.

Pruning systems	Bell pepper cultivars	Fruit weight plant ⁻¹ (g)	Fruit Thickness (mm)	Fruit Number plant ⁻¹	Early Yield (t ha ⁻¹)	Total yield (t ha ⁻¹)	Vit. C (mg100 g ⁻¹ f.w.)
First season (2009/2010)							
One branch	Lirica	232.3 a	8.4 a	8.0 g	15.611 b	44.656 h	235.0 b
	Sondela	209.5 b	7.7 ab	8.3 g	14.546 d	42.287 i	245.8 a
	Pasodoble	198.5 c	7.2 bc	8.6 fg	18.311 a	62.081 g	223.5 c
2 branches	Lirica	192.5 d	7.6 b	14.0 ef	13.410 e	62.662 f	217.5 d
	Sondela	185.0 e	7.1 bc	15.0 de	13.168 e	72.087 e	226.0 c
	Pasodoble	177.5 f	6.7 bc	15.7 d	15.001 c	75.856 d	207.0 e
4 branches	Lirica	154.3 g	6.6 bcd	21.6 c	7.005 g	83.162 b	199.5 g
	Sondela	147.5 h	5.9 de	23.6 b	6.661 h	83.131 c	203.8 f
	Pasodoble	134.0 i	5.3 e	26.1 a	9.074 f	88.081 a	194.3 h
Second season (2010/2011)							
One branch	Lirica	227.3 a	8.1 a	7.9 f	16.425 b	45.081 h	244.3 b
	Sondela	208.8 b	7.6 ab	7.6 f	15.541 c	43.362 i	254.0 a
	Pasodoble	179.5 d	6.9 cd	8.5 f	17.470 a	51.356 g	224.8 d
2 branches	Lirica	180.3 d	7.6 ab	13.4 e	14.558 d	62.369 f	223.8 d
	Sondela	196.8 d	7.3 bc	13.7 e	13.196 e	71.631 e	232.5 c
	Pasodoble	197.0 c	7.1 bcd	15.1 d	15.353 c	81.525 d	217.8 e
4 branches	Lirica	155.8 e	6.6 d	19.3 c	7.568 g	82.344 c	211.8 f
	Sondela	137.8 f	5.7 e	22.7 b	6.872 h	85.381 b	216.3 e
	Pasodoble	135.0 g	5.3 e	25.9 a	9.336 f	88.569 a	204.5 g

Means followed by the same letters in each season are insignificantly different at 0.05 level.

Table 4. Physical and chemical properties of experimental soil during the seasons of 2009/2010 and 2010/2011.

Season	Soil texture			EC (dS m ⁻¹)	pH	Elements concentration (meq L ⁻¹)								
	Sand	Silt	Clay			N	P	K ⁺	Ca ⁺⁺	Mg ⁺⁺	Na ⁺	SO ₄ ⁻⁻	HCO ₃ ⁻	Cl ⁻
2009/2010	90.2	2.0	7.8	1.88	8.11	0.62	0.05	1.02	11.1	3.2	4.7	15.0	2.1	4.3
2010/2011	88.3	5.0	6.7	2.39	8.08	0.71	0.07	1.46	12.1	4.0	12.0	21.5	2.4	9.9

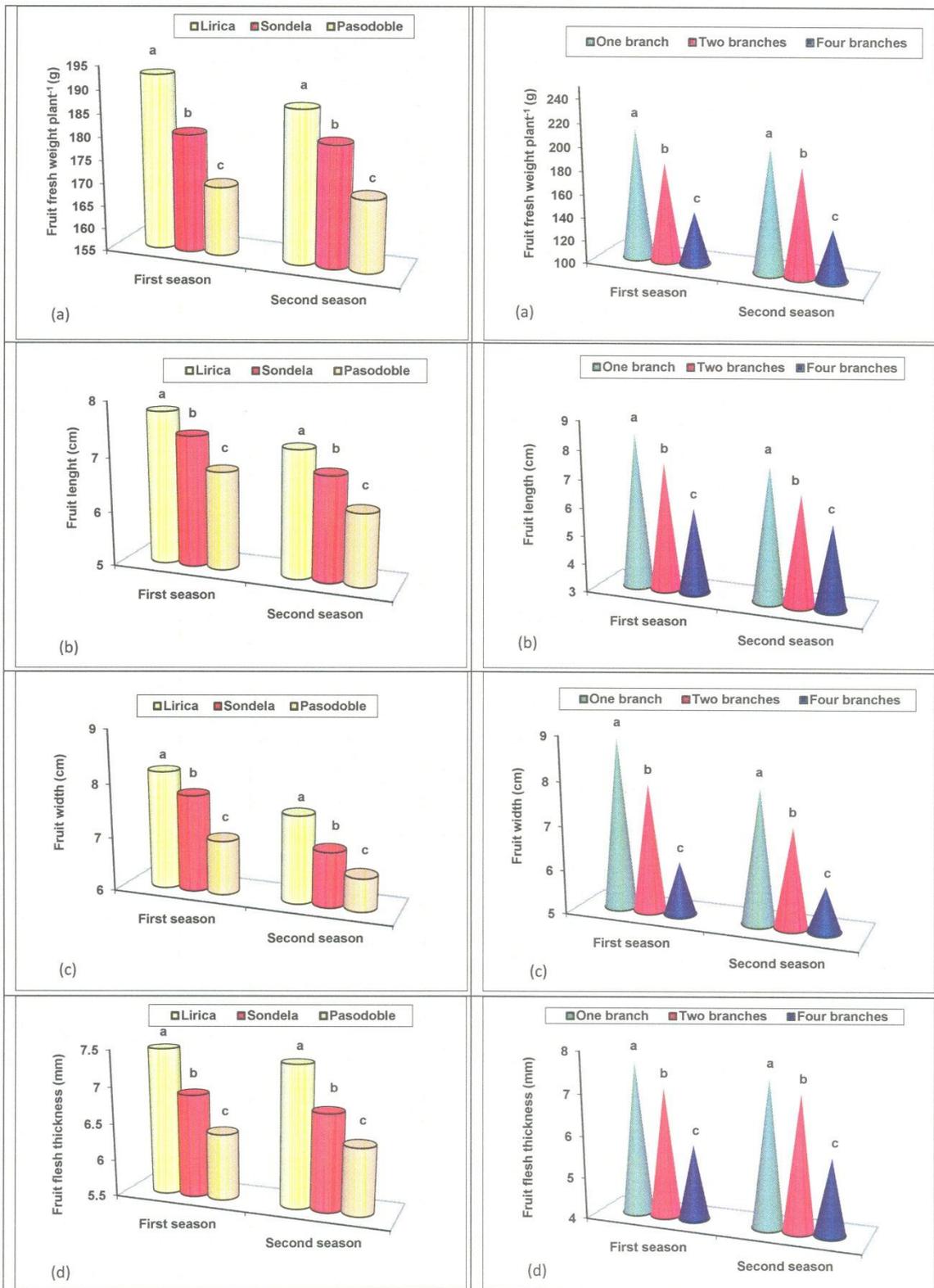


Fig. 3. External fruit quality traits of bell pepper cultivars: (a) fruit fresh weight plant⁻¹, (b) fruit length, (c) fruit width and (d) fruit flesh thickness during 2009/2010 and 2010/2011 growing seasons.

Fig. 4. External fruit quality traits as affected by pruning systems: (a) fruit fresh weight plant⁻¹, (b) fruit length, (c) fruit width and (d) fruit flesh thickness during 2009/2010 and 2010/2011 growing seasons.

using 15 mL of fruit flesh (Antoniali et al., 2007). Total soluble solids (TSS, %) was measured using a portable digital refractometer (PR-101, ATAGO, Japan). Total sugars content (TS, % f.w.) were also determined (AOAC, 1995).

Statistical analysis

Data were subjected to analysis of variance through SAS version 8.1 computer program (SAS Institute, 2008). Treatment means were compared using a revised Least Significant Difference (L.S.D.) test at the 0.05 level of significance (Steel and Torrie, 1980).

Conclusions

'Pasodoble' F₁ yellow cultivar produced the highest early and total fruit yield which were, primarily, due to the rapid fruit set and high fruit number plant⁻¹. However, 'Lirica' F₁ yellow and 'Sondela' F₁ red had acceptable fruit size and fruit quality, particularly with a single branch pruning system. Pepper plants pruned to a single branch resulted in a significant increase in early fruit yield, fruit size and fruit quality traits due to reduced total number of branches plant⁻¹. Finding a proper balance between fruit number and fruit size by canopy management is a main target of pruning systems with a suitable cultivar. In conclusion, this study recommends that one branch pruning system of yellow cultivar 'Lirica' F₁ and red cultivar 'Sondela' F₁ have proven suitable for fruit quality traits under greenhouse conditions of Saudi Arabia for either local or export production markets.

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