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EFFECT OF PLANT DENSITY AND SHOOT PRUNING ON PRODUCTIVITY OF OUTDOOR TOMATOES IN THE SUMMER SEASON:
B) TOTAL YIELD AND ITS QUALITY

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ABSTRACT

The study included the effect of planting system (single and double rows), plant spacing (20 and 30 cm) and shoot pruning (without pruning, pruned to three or six shoots, pruned to six shoots topped at 3rd leaf and all shoots topped at 3rd leaf) on total yield and its quality of tomato plants cv. Castlerock. Experiments were conducted during the summer season of 1993 and 1994.

Tomato plants grown in a single row at 30 cm spacing had higher total fruit yield per plant and average fruit weight than those grown in double rows at 20 cm spacing. In contrast, total yield per plot (marketable and nonmarketable) of plants grown in double rows at 20 cm spacing surpassed that of plants grown in a single row at 30 cm spacing. Likewise, fruit acidity percentage was increased by planting in double rows.

Shoot pruning level had no significant effect on fruit yield whether per plant or per plot in most cases. However, all pruning applications tended to produce higher marketable and total yields per plot, especially pruning treatment with three shoots. On the other hand, all pruning levels improved both average fruit weight and vitamin C content compared with the unpruned control, since the highest average fruit weight resulted from plants pruned to three shoots.

The highest total fruit yield per plot was obtained from plants grown in double rows at close spacing (20 cm) and pruned to three shoots per plant.

INTRODUCTION

Great efforts are needed to increase the productivity of tomatoes to meet the increase in local requirements and export demand. Besides, high fruit quality is of considerable importance. Pruning is a common practice in some countries to achieve these objectives whether in the open field or in protected cultivation. In Egypt, there is no pruning application at all in the open fields. Shoot pruning of tomato plants may reduce yield per plant and, consequently, yield per unit area, particularly if pruning was heavy. Therefore, it is necessary to increase the density of plants through the planting system and spacing within the row. This may compensate for the reduction in tomato yield per plant leading to increase in yield per unit area.

Several spacing studies on tomato plants indicated that increasing plant density resulted in high yield per unit area, but this increase in yield was mostly, at the expense of average fruit weight and size and yield per plant (Moldoveanu, 1976; El-Zawily, 1981; Stoffella *et al.,* 1988; Pyzik and

Dabrowska, 1989; Malash *et al.,* 1990; Smith *et al.,* 1992).

Concerning the side shoot pruning of tomato plants grown in the open field, many reports stated that this process reduced total fruit yield (Veselinov, 1977; Hartmann, 1978; Kusumo, 1978). In contrast, Davis and Estes (1993) concluded that yield of unpruned tomato plants was lower than that of pruned ones. Moreover, Malash *et al*. (1990) on tomatoes and Hamed (1997) on sweet pepper indicated that fruits of pruned plants had higher weight and vitamin C content.

For the combination of plant density and shoot pruning Sharfuddin and Ahmed (1986) reported that the highest yield was obtained from tomato plants pruned to 3 stems/plant and grown at the highest density of 27, 777 plants/ha.

The main objective of this research was to study the effect of planting system, plant spacing, shoot pruning and their combinations on fruit yield and quality of tomato plants cv. Castlerock.

MATERIALS AND METHODS

The experiments were carried out in a private farm in El-Mehalla El-Koubra District, Gharbia Governorate, during the two summer seasons of 1993 and 1994. The determinate tomato cv. Castlerock was used. Texture of the experimental soil was clay.

The experiments included 20 treatments which were the combinations of two planting systems, two spacings within the row, and five shoot pruning levels. Planting systems were single row on 1 m ridges, and double rows on 1.25 m ridges. Plant spacings within the row were 20 and 30 cm. Shoot pruning treatments were without pruning ($Pr._0$) as control, pruning to 3 shoots ($Pr._1$), pruning to 6 shoots ($Pr._2$), pruning to 6 shoots topped at 3rd leaf ($Pr._3$), and all shoots topped at 3rd leaf ($Pr._4$).

The different treatments were randomized in a split-split-plot arrangement in a randomized complete block design with four replications. Planting system treatments were assigned at random to the main plots. Each main plot was split into two spacing treatments as sub-plots, and the five pruning levels were randomly assigned to the sub sub-plots. Each experimental plot contained two ridges, each 6 meters long. Fruit yield was estimated from 12 m^2 of each sub sub-plot.

Tomato seedlings were transplanted on March 2nd in both years. The pruning process started one month after transplanting and was carried out weekly to keep the required number of shoots in the different treatments. The regular cultural practices were applied whenever it was needed and as usually done by growers.

Yield of the different treatments was evaluated quantitatively and qualitatively. Fruits were weighed and classified to marketable and nonmarketable (kg/12 m^2). Marketable yield was sorted into two sizes according to fruit weight: size I for fruits exceeding 80 g in weight, and size II for smaller fruits. The nonmarketable yield included the diseased and

malformed fruits. Fruit yield per plant was determined in samples consisting of five plants per experimental unit. Average fruit weight was likewise, estimated. The incidence of sun scald and blossom-end rot was recorded as percentage of the number of injured fruits to the total number of fruits. The percentage of total soluble solids (T.S.S.%) was determined by a hand refractometer. Titratable acidity (citric acid %) and vitamin C (ascorbic acid) were determined as recommended by Cox and Pearson (1962). Fruit acidity, T.S.S. and vitamin C were determined in samples consisting of ten marketable fruits of the second picking.

Data were tested by analysis of variance (Little and Hills, 1972). Duncan's multiple range test was used for the comparisons among treatment means (Duncan, 1955).

RESULTS AND DISCUSSION

I. Total yield:

A. Effect of planting system:

Data in Table (1) show that total fruit yield per plant was higher in tomato plants grown in a single row than in those grown in double rows. Increasing fruit yield per plant with single row planting system was reported by El-Zawily (1981) and Smith *et al*. (1992) on tomatoes. The single row system probably allowed better shoot and root development. This may however, positively reflect on flowering and fruiting with single row system leading to increased yield per plant.

Table (1): Effect of planting system on yield/plant and total yield/plot of tomato plants (1993 and 1994 seasons).

Planting system	Yield/ plant (kg)	Yield/plot (kg/12 m²)				
		Marketable			Non-marketable	Total
		Size I (> 80 g)	Size II (< 80 g)	Total		
	1993 season					
Single row	1.90	73.8	21.3	95.1	4.74	99.8
Double rows	1.13	69.4	50.7	120.1	5.95	126.0
F test	**	N.S	**	**	*	**
	1994 season					
Single row	1.36	48.4	18.5	66.9	4.54	71.4
Double rows	0.94	50.0	42.6	92.6	4.04	96.6
F test	*	N.S	**	*	N.S	*

****, * and N.S indicate significant differences at P < 0.01, P < 0.05 and not significant , respectively according to F test.**

Contrary to this response to planting system, marketable and total yield/plot of tomato plants grown in double rows surpassed that of plants grown in single rows which was mainly due to the increase in the weight of small fruits (size II). This may be attributed to the lesser plant vigour expected under dense planting which leads to a reduction in fruit size. Similar conclusion was drawn by Moldoveanu (1976), El-Zawily (1981) and Smith *et al*. (1992).

Data in Table (1) clarify also that nonmarketable yield was larger in

tomato plants grown in double rows than in pgrown in single rows in both seasons, although the differences were not significant in the second season.

B. Effect of spacing:

Data reported in Table (2) reveal that tomato plants grown at wide spacing (30 cm) outyielded (yield/plant) those plants grown at close spacing (20 cm) in the two seasons. In contrast, marketable yield (yield/plot) of both large and small fruits (size I and size II) and their total as well as total yield (marketable + nonmarketable) of tomato plants grown at close spacing (20 cm) exceeded those of plants grown at wide spacing (30 cm). The differences were highly significant in both seasons, except for size I in the second season as the differences were insignificant. Nonmarketable yield as influenced by spacing showed a similar trend as that of marketable and total yield in the second season, since plants grown under narrow spacing (20 cm) produced higher value than those plants grown under wide spacing (30 cm). However, in the first season, the differences in nonmarketable yield due to in-row spacing were not significant.

Table (2): Effect of spacing on yield/plant and total yield/plot of tomato plants (1993 and 1994 seasons).

Spacing	Yield/ plant (kg)	Yield/plot (kg/12 m^3)				
		Marketable			Non-marketable	Total
		Size I (> 80 g)	Size II (< 80 g)	Total		
	1993 season					
30 cm	1.67	66.4	28.8	95.2	5.42	100.6
20 cm	1.37	76.8	43.1	119.9	5.27	125.2
F test	**	**	**	**	N.S	**
	1994 season					
30 cm	1.30	48.9	24.3	73.2	3.84	77.0
20 cm	1.00	49.5	36.8	86.3	4.74	91.0
F test	**	N.S	**	**	*	**

****, * and N.S indicate significant differences at P < 0.01, P < 0.05 and not significant , respectively according to F test.**

The lower and higher yields/plot resulting from growing tomato plants at 30 and 20 cm, respectively seem to be a result of the decreased number of plants in the former than the latter. As a matter of fact, increasing number of plants per plot decreased their productivity (yield/plant), but the increase in number of plants compensated such reduction in yield/plant, thereby raising the yield per plot. This result was previously achieved by several workers (Moldoveanu, 1976; Stoffella *et al.,* 1988; Pyzik and Dabrowska, 1989; Malash *et al.,* 1990; Smith *et al.,* 1992).

C. Effect of pruning:

Data presented in Table (3) clear that the different pruning levels had no significant effect on fruit yield per plant and marketable yield per plot in the two seasons. Meanwhile, pruning plants to three shoots ($Pr._1$) produced the highest marketable yield from large fruits of size I and the lowest yield from small fruits of size II as the differences were significant for size I fruits in the first season and for size II fruits in the second season only.

Regarding nonmarketable yield, the highest record was obtained

from tomato plants pruned to either three or six shoots ($Pr._1$ or $Pr._2$) in both seasons. However, the differences were significant in the second season only.

For total yield (marketable + nonmarketable), all pruning levels, exceeded the control in this concern as the highest record was obtained from plants pruned to three shoots only ($Pr._1$) although, the differences were not significant in the second season.

In spite of the insignificant differences in most cases, pruning treatments, especially ($Pr._1$), outyielded both unpruned plants ($Pr._0$) and the remaining pruning treatments. Moderate pruning probably resulted in better distribution of leaf area over the ground area, thus, reducing shading (Heuvelink, 1995). Moreover, pruning reduced vegetative parts, therefore, increased efficiency of insects and diseases control. The positive effect of pruning applications on total yield of tomatoes was reported by Olson (1989) and Davis and Estes (1993). On the other hand, Veselinov (1977) and Campos *et al*. (1987) on tomatoes and Hamed (1997) on sweet pepper found negative effect of pruning on total productivity.

Table (3): Effect of pruning on yield/plant and total yield/plot of tomato plants (1993 and 1994 seasons).

@ Pruning	Yield/ plant (kg)	Yield/plot (kg/12 m^3)				
		Marketable			Non-marketable	Total
		Size I (> 80 g)	Size II (< 80 g)	Total		
	1993 season					
$Pr._0$	1.50	64.8 b	36.8	101.6	4.65	106.3 b
$Pr._1$	1.60	83.7 a	32.8	116.5	6.24	122.7 a
$Pr._2$	1.54	72.0 b	37.0	109.0	6.09	115.1 ab
$Pr._3$	1.48	69.5 b	35.4	104.9	4.98	109.9 b
$Pr._4$	1.45	67.9 b	37.9	105.8	4.76	110.5 b
F test	N.S	**	N.S	N.S	N.S	*
	1994 season					
$Pr._0$	1.13	43.8	31.3 ab	75.1	3.83 b	78.9
$Pr._1$	1.16	55.5	26.3 b	81.8	5.47 a	87.3
$Pr._2$	1.16	48.6	30.3 ab	78.9	4.60 ab	81.9
$Pr._3$	1.20	51.4	31.3 ab	82.7	3.33 b	86.0
$Pr._4$	1.11	46.6	33.6 a	80.2	4.22 ab	84.4
F test	N.S	N.S	*	N.S	*	N.S

@Pruning treatments:
$Pr._0$ = Unpruned (Control) $Pr._1$ = Pruned to three shoots $Pr._2$= Pruned to six shoots
$Pr._3$ = Pruned to six shoots topped at 3rd leaf $Pr._4$=All shoots topped at 3rd leaf.
****,* and N.S indicate significant differences at P<0.01, P<0.05 and not significant, respectively, according to F test.**
Means followed by a letter in common are not significantly different at the 5% level, according to Duncan's test.

D. Effect of the interactions between planting system, spacing and pruning:

There were insignificant differences in both marketable and total yields among the combinations of planting system & plants spacing, planting system & pruning and plant spacings & pruning. Thus, there was no need to present this in Tables. It is shown from Table (4) that planting in double rows at close spacing (20 cm) with pruning to 3 shoots only ($Pr._1$) produced the highest marketable and total yields. On the other hand, planting in a single

row at wide spacing (30 cm) either without pruning (control) or with pruning and all shoots topped at 3rd leaf ($Pr._4$) achieved the lowest yield. These findings agree with that mentioned by Sharfuddin and Ahmed (1986).

Although statistical analysis did not show significant differences between treatments, it can be noticed that a combination of close planting and Pr.1 (pruned to 3 shoots) would improve the productivity of tomatoes.

II. Fruit quality:

A. Effect of planting system:

It is evident from Table (5) that average fruit weight was larger in tomato plants grown in single rows than those grown in double rows. This may be due to that tomato plants grown under low density (single row) were more vigorous in their vegetative growth than those grown under high density (double rows) since, single row system caused less competition between plants. Similar results were obtained by Cockshull and Ho (1995).

Concerning the incidence of sun scald and blossom-end rot there were no significant differences in the two characters between the two planting systems in both seasons. Generally, the percentage of fruits affected by either disorder was low under the experimental conditions.

Fruit acidity was higher in tomato plants grown in double rows than those grown in single rows in the first season, whereas no significant difference was noticed in the second one. In this concern, El-Zawily (1981) indicated that acidity of tomato fruits was not significantly influenced by planting system.

Regarding the total soluble solids and vitamin C contents, data reveal that the planting system had no significant effect in both seasons. Similar results were obtained by El-Zawily (1981) and Mohamed and Ali (1988) on tomatoes.

Table (5): Effect of planting system on fruit quality of tomato plants (1993 and 1994 seasons).

Planting system	Average fruit weight (g)	#Sunscald (%)	#Blossom -end rot (%)	Acidity (%)	Total soluble solids (%)	Vitamin C (mg/100 ml juice)
	1993 season					
Single row	104.6	2.54	2.23	0.56	4.76	12.39
Double rows	92.1	2.64	2.53	0.70	4.96	12.96
F test	**	N.S	N.S	**	N.S	N.S
	1994 season					
Single row	86.6	2.44	3.52	0.49	5.03	10.89
Double rows	58.8	1.95	2.69	0.50	4.84	11.74
F test	**	N.S	N.S	N.S	N.S	N.S

 # Sunscald or blosssom-end rot in fruits was determined as percentage of number of injured fruits to the total number of fruits

**** and N.S indicate significant differences at P < 0.01 and not significant, respectively, according to F test.**

B. Effect of spacing:

Data presented in Table (6) show that, in both seasons, plants grown at wide spacing (30 cm) produced larger fruthan those grown at close spacing (20 cm). Average fruit weight was highly correlated with plant size since plants grown under wide spacing had more vigorous growth and consequently bigger fruits than those plants grown under close spacing. Similar results were obtained by Malash *et al*. (1990) and Davis and Estes (1993) on tomatoes.

Percentages of sun scald and blossom-end rot were higher under wide spacing (30 cm) than under narrow spacing (20 cm) in the first season as the differences were highly significant. In the second season, the differences between the two plant spacings for sun scald and blossom-end rot were not significant. In this connection, Mohamed and Ali (1988) reported that close spacing provided adequate foliage shading for tomato fruits from the sun and hence reduced sun-scalding.

Concerning acidity and total soluble solids percentages, the differences in these characters were insignificant in both seasons. Similar conclusions were drawn by El-Zawily (1981) and Mohamed and Ali (1988) on tomatoes.

As for vitamin C in fruits, it was not significantly affected by plant spacing in the first season, but in the second season, tomato plants grown under wide spacing produced fruits with higher vitamin C content than those grown under close space. The former effect of spacing might had occurred through the variation in the indirect light intensity reaching the fruits as a result of varying canopy size between the two seasons.

Table (6): Effect of spacing on fruit quality of tomato plants (1993 and 1994 seasons).

Spacing	Average fruit weight (g)	#Sunscald (%)	#Blossom -end rot (%)	Acidity (%)	Total soluble solids (%)	Vitamin C (mg/100 ml juice)
	1993 season					
30 cm	100.4	3.00	2.59	0.65	4.84	12.61
20 cm	96.3	2.19	2.17	0.62	4.87	12.74
F test	**	**	**	N.S	N.S	N.S
	1994 season					
30 cm	76.0	2.19	2.92	0.50	4.85	11.65
20 cm	69.4	2.20	3.29	0.49	5.02	10.98
F test	**	N.S	N.S	N.S	N.S	*

 # Sunscald or blosssom-end rot in fruits was determined as percentage of number of injured fruits to the total number of fruits

**** and N.S indicate significant differences at P < 0.01 and not significant, respectively, according to F test.**

C. Effect of shoot pruning:

The effect of pruning on fruit quality is presented in Table (7). All pruning applications improved average fruit weight compared with the unpruned control in both seasons. Meanwhile, the highest average fruit weight was produced by tomato plants pruned to three shoots (Pr. $_1$). The other pruning treatments (Pr.$_2$, Pr.$_3$ & Pr.$_4$) occupied an intermediate position between (Pr.$_1$) and unpruned control (Pr.$_0$). Average fruit weight improvement induced by pruning may be due to improved air movement through plant canopy, thus, improving plant health. Similar trend was observed by Malash *et al*. (1990) on tomatoes and Hamed (1997) on sweet pepper.

Fruits affected by sun scald and blossom-end rot were higher in pruned compared with the unpruned plants in most cases. However, the differences were insignificant in both seasons, except for blossom-end rot percentage in the second season as the differences were highly significant.

Blossom-end rot percentages in the second season were higher in pruned plants than in the unpruned control as the highest record was obtained from ($Pr._4$). This may be due to the fact that pruned plants produce larger fruits which need more nutrients and water as compared to medium or small fruits. These findings agree with those obtained by Bruin and Ziel (1989).

Acidity percentages in fruits were not significantly affected by different pruning levels in both seasons.

Total soluble solids in fruits were higher in control plants ($Pr._0$) compared to pruned ones in the first season as the differences were highly significant whereas in the second season, insignificant differences were obtained. In this concern, Cockshull and Ho (1995) obtained a negative correlation between average fruit weight and T.S.S.% as the results obtained from the first season in the present study. However, Malash *et al*. (1990) and Hamed (1997) found that pruning had no significant effect on T.S.S% of fruits juice.

All pruning treatments improved vitamin C content in fruits compared with the unpruned treatment (Table 7). Therefore, unpruned plants ($Pr._0$) produced the lowest value of vitamin C in both seasons. This result was xpected since pruning allows good penetration of solar radiation which is the major factor affecting vitamin C content. These results are in harmony with those obtained by Malash *et al*. (1990) on tomatoes and Hamed (1997) on sweet pepper.

Table (7): Effect of pruning on fruit quality of tomato plants (1993 and 1994 seasons).

@Pruning	Average fruit weight (g)	#Sunscald (%)	#Blossom -end rot (%)	Acidity (%)	Total soluble solids (%)	Vitamin C (mg/100 ml juice)
	1993 season					
$Pr._0$	93.5 c	2.29	2.21	0.62	5.05 a	11.83 b
$Pr._1$	104.2 a	3.02	2.55	0.64	4.80 ab	13.17 a
$Pr._2$	99.3 b	2.83	2.77	0.65	4.85 ab	13.19 a
$Pr._3$	99.0 b	2.44	2.37	0.62	4.82 ab	12.41 ab
$Pr._4$	95.8 bc	2.38	2.00	0.63	4.75 b	12.77 a
F test	**	N.S	N.S	N.S	**	*
	1994 season					
$Pr._0$	67.5 c	1.98	2.69 b	0.49	4.95	10.25 b
$Pr._1$	79.5 a	3.22	3.16 ab	0.48	5.03	11.45 ab
$Pr._2$	71.8 bc	2.53	3.24 ab	0.47	4.79	11.45 ab
$Pr._3$	77.1 ab	1.55	2.69 b	0.51	5.09	11.10 ab
$Pr._4$	67.7 c	1.68	3.75 a	0.50	4.83	12.33 a
F test	**	N.S	**	N.S	N.S	**

@Pruning treatments:
$Pr._0$ = Unpruned (Control) $Pr._1$ = Pruned to three shoots $Pr._2$= Pruned to six shoots
$Pr._3$ = Pruned to six shoots topped at 3rd leaf $Pr._4$=All shoots topped at 3rd leaf.
 # Sunscald or blosssom-end rot in fruits was determined as percentage of number of injured fruits to the total number of fruits
****, * and N.S indicate significant differences at P < 0.01, P < 0.05 and not significant , respectively according to F test.**
Means followed by a letter in common are not significantly different at the 5% level, according to Duncan's test.

D. Effect of the interactions between planting system, spacing and pruning:

Fruit quality parameters under study; i.e., average fruit weight, sun scald, blossom-end rot, and acidity and vitamin C contents were not appreciably affected by the combinations of planting system x plant spacing, planting system x pruning and plant spacing x pruning. Thus, there was no

need to present this in Tables. It is shown from Table (8) that the combinations of planting system, spacing and pruning did not considerably

affect all the fruit quality parameters under study in most cases during both seasons. However, the highest average fruit weight was obtained from planting in a single row at wide spacing (30 cm) using pruning to three shoots).

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تأثير الكثافة النباتية والتقليم على إنتاجية الطماطم فى الحقل المكشوف فى العروة الصيفية

ب- المحصول الكلى وجودته

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اشتملت الدراسة على تأثير نظام الزراعة (ريشة واحدة ، وريشتين) والمسافة بين النباتات (20 ، 30 سم) ومستويات التقليم (بدون تقليم كمقارنة ، وترك 3 فروع جانبية ، و6 فروع جانبية ، و6 فروع جانبية مطوشة عند الورقة الثالثة ، وجميع الفروع الجانبية مطوشة عند الورقة الثالثة) وتوليفاتهم على المحصول الكلى وجودته من الطماطم صنف كاسل روك. نفذت التجارب بالعروة الصيفية لموسمى 1993 ، 1994م.

نتج أعلى محصول/نبات وأعلى متوسط لوزن الثمرة من نباتات الطماطم المنزرعة على ريشة واحدة بمسافة زراعة 30 سم مقارنة بالنباتات النامية على الريشتين بمسافة 20 سم. فى المقابل ، أنتجت النباتات المنزرعة على الريشتين بمسافة زراعة 20 سم أعلى محصول كلى/قطعة تجريبية (المحصول الصالح وغير الصالح للتسويق) مقارنة بالنباتات النامية على ريشة واحدة بمسافة 30 سم وازدادت نسبة الحموضة بالثمار بالزراعة على الريشتين.

لم تؤثر معاملات التقليم المختلفة تأثيرا معنويا على محصول الثمار سواء قدرت للنبات او للقطعة التجريبية فى معظم الحالات ، ومع هذا فقد كان هناك اتجاه لزيادة المحصول الصالح للتسويق والمحصول الكلى/قطعة تجريبية باستخدام مستويات التقليم المختلفة خاصة التقليم على 3 فروع/نبات. وعلى الجانب الأخر ، أدت جميع مستويات التقليم إلى زيادة فى متوسط وزن الثمرة وفيتامين ج بالثمار مقارنة بالنباتات غير المقلمة حيث نتج أعلى وزن للثمرة من النباتات المقلمة على 3 فروع فقط.

نتج أعلى محصول كلى/قطعة تجريبية من النباتات النامية على الريشتين بمسافة زراعة ضيقة

(20 سم) والمقلمة بترك 3فروع/نبات.

Table (4): Effect of planting system, spacing and pruning on yield/plant and total yield/plot of tomato plants (1993 and 1994 seasons).

Planting spacing @Pruning system			1993 season						1994 season					
			Yield/ plant (kg)	Yield/plot (kg/12 m^3)					Yield/ plant (kg)	Yield/plot (kg/12 m^3)				
				Marketable			Non-marketable	Total		Marketable			Non-marketable	Total
				Size I (> 80 g)	Size II (< 80 g)	Total				Size I (> 80 g)	Size II (< 80 g)	Total		
Single row	30 cm	$Pr._0$	1.98	60.7	18.6	79.3	4.04	83.3	1.58	51.3	10.4	61.7	2.63	64.3
		$Pr._1$	2.28	77.1	14.1	91.2	6.17	97.4	1.49	54.4	10.4	64.8	5.88	70.7
		$Pr._2$	2.21	70.9	17.3	88.2	5.13	93.3	1.60	45.8	18.4	64.2	3.66	67.9
		$Pr._3$	2.06	68.2	16.2	84.4	4.43	88.8	1.64	51.8	13.6	65.4	2.89	68.3
		$Pr._4$	1.99	59.5	20.1	79.6	3.50	83.1	1.44	42.0	15.7	57.7	4.28	62.0
	20 cm	$Pr._0$	1.76	74.0	26.9	100.9	4.00	104.9	1.17	46.2	19.4	65.6	4.83	70.4
		$Pr._1$	1.81	104.0	23.4	127.4	5.80	133.2	1.16	53.5	16.1	69.6	6.93	76.5
		$Pr._2$	1.64	72.3	26.0	98.3	5.11	103.4	1.16	46.9	22.5	69.4	4.04	73.4
		$Pr._3$	1.67	77.7	22.7	100.4	4.47	104.9	1.17	48.0	27.0	75.0	4.52	79.5
		$Pr._4$	1.55	73.0	27.7	100.7	4.77	105.4	1.18	43.9	31.6	75.5	5.71	81.2
Double rows	30 cm	$Pr._0$	1.22	60.7	46.1	106.8	5.24	112.0	0.98	36.5	42.1	78.6	3.80	82.4
		$Pr._1$	1.21	68.9	34.7	103.6	6.96	110.6	1.11	57.0	31.6	88.6	3.86	92.5
		$Pr._2$	1.25	67.8	40.0	107.8	7.96	115.8	1.06	52.4	32.3	84.7	4.83	89.5
		$Pr._3$	1.18	62.4	40.3	102.7	5.43	108.1	1.04	51.8	31.7	83.5	3.27	86.8
		$Pr._4$	1.25	67.4	41.2	108.6	5.34	113.9	1.04	46.3	37.0	83.3	3.31	86.6
	20 cm	$Pr._0$	1.04	63.8	55.7	119.5	5.34	124.9	0.79	41.2	53.1	94.3	4.08	98.4
		$Pr._1$	1.10	84.7	58.9	143.6	6.04	149.6	0.87	57.1	47.2	104.3	5.23	109.5
		$Pr._2$	1.07	77.2	64.5	141.7	6.15	147.8	0.81	49.5	48.1	97.6	5.86	103.5
		$Pr._3$	1.00	69.8	62.5	132.3	5.58	137.9	0.96	54.1	52.9	107.0	2.63	109.6
		$Pr._4$	1.01	71.5	62.5	134.0	5.42	139.4	0.78	54.2	50.2	104.4	3.57	108.0
F test			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

@ Pruning treatments : $Pr._0$ = Unpruned (Control) $Pr._1$ = Pruned to three shoots $Pr._2$= Pruned to six shoots
$Pr._3$= Pruned to six shoots topped at 3rd leaf $Pr._4$=All shoots topped at 3rd leaf.
N.S = Not significant

Table (8):Effect of planting system, spacing and pruning on fruit quality of tomato plants (1993 and 1994 seasons).

Planting System	Spacing @	Pruning	1993 season						1994 season					
			Average Fruit weight(g)	Sunscald (%)	Blossom -end rot (%)	Acidity (%)	Total soluble solids (%)	Vitamin C (mg/100 ml juice)	Average fruit weight(g)	Sunscald (%)	Blossom -end rot (%)	Acidity (%)	Total soluble solids (%)	Vitamin C (mg/100 ml juice)
Single row	30 cm	$Pr._0$	99.7	2.87	2.23	0.56	4.80	11.16	87.5	2.22	2.29	0.49	5.30 b	11.47
		$Pr._1$	113.0	3.73	2.56	0.61	4.75	12.39	95.0	4.00	3.41	0.39	4.75 fg	11.50
		$Pr._2$	108.5	3.25	2.21	0.55	4.70	12.56	90.3	2.35	2.92	0.50	4.83 ef	10.80
		$Pr._3$	108.5	2.60	2.56	0.57	4.85	11.71	92.8	1.34	2.90	0.51	5.20 bc	11.55
		$Pr._4$	100.0	2.15	2.27	0.62	4.47	12.56	82.5	2.18	4.68	0.47	4.50 h	11.80
	20 cm	$Pr._0$	98.0	2.08	1.79	0.53	5.07	11.63	85.3	2.33	3.30	0.53	5.00 cde	10.35
		$Pr._1$	111.5	2.21	2.36	0.56	4.87	12.87	87.8	4.05	4.42	0.48	5.03 cde	10.30
		$Pr._2$	103.3	2.24	2.73	0.60	4.80	13.71	80.8	2.79	2.79	0.57	5.17 bcd	10.60
		$Pr._3$	103.8	2.27	1.98	0.52	4.65	12.79	85.0	1.41	3.79	0.43	4.83 ef	10.40
		$Pr._4$	99.5	1.99	1.65	0.52	4.60	12.55	79.3	1.71	4.70	0.48	5.67 a	10.10
Double rows	30 cm	$Pr._0$	92.0	2.20	2.61	0.70	5.00	12.32	52.3	1.75	2.63	0.48	4.50 h	9.67
		$Pr._1$	98.3	4.11	2.79	0.73	4.80	13.95	74.0	2.07	2.04	0.57	5.17 bcd	12.60
		$Pr._2$	96.0	3.56	3.84	0.74	4.96	13.49	61.3	2.81	2.95	0.41	4.65 fgh	11.40
		$Pr._3$	93.7	2.62	2.71	0.71	5.04	12.56	69.0	1.87	2.21	0.60	4.98 de	11.55
		$Pr._4$	94.8	2.88	2.17	0.69	5.05	13.43	55.8	1.32	3.14	0.55	4.61 gh	14.20
	20 cm	$Pr._0$	84.3	2.02	2.23	0.70	5.33	12.21	45.0	1.63	2.54	0.48	5.00 cde	9.50
		$Pr._1$	94.0	2.03	2.48	0.66	4.80	13.49	61.3	2.75	2.77	0.48	5.17 bcd	11.40
		$Pr._2$	89.5	2.27	2.29	0.73	4.96	13.02	54.8	2.18	4.31	0.42	4.50 h	13.00
		$Pr._3$	90.0	2.26	2.25	0.68	4.76	12.56	61.8	1.59	1.86	0.50	5.33 b	10.90
		$Pr._4$	88.8	2.50	1.91	0.70	4.87	12.56	53.3	1.53	2.46	0.52	4.53 h	13.23
F test			N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S

@ Pruning treatments : $Pr._0$ = Unpruned (Control) $Pr._1$ = Pruned to three shoots $Pr._2$= Pruned to six shoots
$Pr._3$= Pruned to six shoots topped at 3rd leaf $Pr._4$ =All shoots topped at 3rd leaf.

*** and N.S indicate significant differences at P < 0.05 and not significant, respectively according to F test.**
Means followed by a letter in common are not significantly different at the 5% level, according to Duncan's test.