Assessment of the Effect of Pruning Systems on Plant Developmental Cycle – Yield and Quality of Selected Indeterminate Tomato Lines

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Keywords: indeterminate tomato lines, pruning, yield, quality

Abstract

Preliminary evaluations have shown that indeterminate new tomato breeding lines produce high yields of large fruits. Pruning systems have been reported to regulate tomato fruit size and overall yield performance. A study to evaluate the effect of pruning levels (non pruning, single stem, two stems and three stems) on plant developmental cycle, yield, and quality of five indeterminate tomato breeding lines and one commercial cultivar was conducted from November 2009 to March 2010 at the Horticulture Unit of Sokoine University of Agriculture, Morogoro, Tanzania. Results showed that two stem pruned plants gave the highest number of marketable fruits per plant. The highest number of non marketable tomato fruits per hectare was observed in unpruned plants. Tomato lines differed in their performance, with the longest period of harvesting, highest number of flowers flowers, highest percentage of fruit-set, the highest yield, high number of marketable fruits observed in lines P20-(03) and 186-2(06), which is probably a result of their genetic characteristic. It was concluded that, the large fruit size of the new tomato breeding lines can be reduced to meet consumer's needs without reducing yield by two and three stem pruning in lines P20-03 and S186-2(07).

INTRODUCTION

Tomato (*Solanum lycopersicon* L.) cultivars belong to the family *Solanaceae*. They are perennials but in some regions tomatoes are grown as annual crops (Kalloo, 1993). Among the cultivars, flowering habit ranges from highly indeterminate to strongly determinate, and flowers are self-pollinated. They have erect to prostrate stems, pubescent foliage with glandular trichomes (Rubatzky, 1996). They have a main stem which extends regularly while issuing a cluster of flowers, on average at an interval of every 3 leaves (Peralta, 2001). In Tanzania tomato production is divided into regions that are specialized in production of indeterminate ('Moneymaker' type) tomato cultivars, whilst others are specialized in determinate ('Roma' type) tomato cultivars. Indeterminate types are normally desuckered (pruned) to retain a single main stem while the determinate type is left with no pruning and consists of several main branches. The old cultivars such as 'Marglobe', 'Moneymaker' and 'Roma' are still the cultivars of choice of many East and Central Africa farmers (Kagiraneza, 2007). The main weaknesses of these old cultivars are low productivity due to the lack of resistance to pests and low fruit-set. It is important to search for improved tomato lines so as to increase tomato productivity and consumption. To solve these weaknesses, new improved tomato (determinate and indeterminate) lines have been introduced into Tanzania. The effect of pruning is related to increased quantity and quality as well as productivity of tomato (Frank, 2007). The efficacy of single stem, double, three or multiple stems on fruit size and general performance of the recently introduced tomato lines, is not well documented under field conditions in Tanzania. The objective of this study was therefore to establish an optimal pruning system for enhanced yield productivity and quality of selected lines and cultivars of field-grown tomatoes.

Proc. 2nd All Africa Horticulture Congress
Eds.: K. Hannweg and M. Penter
Acta Hort. 1007, ISHS 2013

MATERIALS AND METHODS

The study was conducted at the Horticultural Unit, Department of Crop Science at Sokoine University of Agriculture (SUA) in Morogoro, Tanzania. The area is located at 6°05' South latitude, and 35°37' East longitude, at an altitude of 525 m above sea level. The location has generally a warm tropical climate with moderate annual rainfall of 600-1000 m. The soils of the area are fertile with dark sandy loams with a pH of around 7. The experiment was conducted under field conditions from November 2009 to March 2010. Five tomato breeding lines (S178, S181-1(06), S186-2(07), S175, and P20-03) and one commercial cultivar ('Tengeru 97'), all indeterminate tomato cultivars, were used during the study. The field experiment was laid in a split plot design with 3 replications. The main factor was tomato breeding lines and sub factor was the branching level.

Application of fertilizer was done three times. Firstly, a basal application of Triple Super Phosphate (TSP) (P_2O_5 46%) at the rate of 150 kg /ha before transplanting; the second application was done at four weeks after transplanting at the rate of 60 kg of urea (46-0-0) per hectare and the last one was applied at six weeks after transplanting at the rate of 150 kg calcium ammonium nitrate (CAN) (27% N) per hectare. Pruning was done as new unwanted suckers appeared. For single stem (SS) system, all suckers and old leaves were removed and for two stem (2S) system; the main stem and the first sucker were retained while other suckers were removed. For the three stem (3S) system, the main stem, the first and second suckers were retained and subsequent suckers removed. There was no removal of suckers for the no pruning system.

Data Collection

From each plot, eight central plants were marked and used for data collection on vegetative, reproductive growth parameters and fruits characteristics.

Data Analysis

The data collected was subjected to analysis of variance (ANOVA) using statistical software COSTAT6.4 (Cohort Software, Minneapolis, USA, 2006). All tests were carried out at 5% level of significance and mean separation was done using Student-Newman-Keuls to determine differences among treatment means.

RESULTS AND DISCUSSION

Table numbers and figure numbers need to included in the text and referred to when specific results are discussed. Arguments within the discussion are very tenuous and there is often insufficient evidence for the conclusions reached.

Horticultural and Plant Developmental Characteristics

1. Plant Height and Stem Diameter. Plant height to the first fruit cluster was not affected by pruning levels (Table 1). This probably implies that the effect of pruning on nutrient and water up-take occurs at after the first fruit cluster. Differences observed between lines for the height at the first fruit cluster and height at the last harvest period corresponds are influenced by the genetic characteristics of these tomato lines as also reported by Bitala (2001). Nganga (1984) reported that in general many stems increased plant height. The major limiting factor of plant height was the senescence characteristic of these lines. Although "stopping" was not practiced in the crop, the plants appeared to age naturally, and had little tendency to regenerate.

2. Flowering Time and Harvest Duration. Pruning affected flowering time and harvest duration though the effect varied with tomato lines. The difference of response to the pruning treatments between the lines is associated with the difference in genetic makeup of morphological habit in these lines combined with the pruning treatment. Pruned and staked tomato plants produce flowers two three weeks earlier than non pruned plants.

3. Fruiting and Fruit Maturity Stages. Plants with single stem system matured earlier after transplanting followed by two stem, three stem and non pruning systems (Table 1) but this differed between these breeding lines. Line S186-2(07) and P20-03 reached the first fruiting at 44th day from the date of transplanting and the last was 'Tengeru 97' with setting fruits at 51st days (Table 2). The difference observed among the lines tested on the response of pruning treatments in terms of the number of days to the first fruiting can be attributed to the genetic factors. Difference of the number of days to the first fruit maturity observed in different lines was caused by the genetic characteristic of the lines tested associated with the pruning treatments. The time of planting until first fruit harvest is dependent on cultivar and growing conditions (Rubatzky, 1996).

It is clear that as the number of stems increases, there is a delay in fruit maturity. These results show that pruning accelerates earlier fruiting and fruit maturity due to photosynthetic efficiency. Growth, flowering and fruiting responses are regulated by pruning when plants are pruned (Mnzava, 1984). The removal of apical and lateral vegetative growth hence reducing sink number, thereby making more assimilates available for fruit set in indeterminate types. Pruning in general enhances fruit size and earliness for growing vigorously plants (Mnzava, 1984).

4. Leaf Length and Width and Length of Harvest Period. Pruning level affected the size of leaf with single stem pruned plants having the longest leaf with 32.72 cm, and no pruned plants having the shortest leaf of 28.89 cm (Table 1). This shows that pruning encourages the growth due to the photosynthetic efficiency, as in pruned plants, many branches were removed, there was limited competition between leaves, leading to good assimilation and hence to bigger leaf length. In unpruned plants there was competition within canopy resulting in reduced leaf length (Nganga, 1984). This situation shows that the more plant branches, the smaller the leaf size becomes. The results show that the two and three stem pruning might probably increase the period of vegetative and productive stages in tomato plants by making available more assimilates for the fruit set period in indeterminate types because of reduced completion within the plant stems. These results are similar to those of Sandersfeld (2008) who reported that two stem pruned plants have a long harvest period than unpruned.

Yield and Yield Components

1. Number of Flowers per Cluster and per Plant. Non-pruned plants were the first to bear many flowers followed by three, two, and single pruned plants (Table 3). Mbinga (1983) also found that the more severe the pruning, the lower the number of flowers per plant but the fruits were bigger. The non pruning treatment resulted in a significantly higher number of flowers per plant of line P20-03, S181-1(06), S178 and S175 lines.

In this study it was observed that severe pruning increased the number of flowers per cluster except in line P20-(03). Similar results were reported by Ara et al. (2007) and Myint (1999) that single pruned plants produced a high number of flowers per cluster than multiple stem pruning.

2. Number of Fruits per Plant. There were highly significant differences between pruning levels with respect to the total number of fruits per plant, with the highest number of fruits per plant observed in non-pruned plants, followed by three stems, two stems and single stem pruned plants (Table 3). These results are similar to those of Ara et al. (2007) who also observed that one stem pruning gave the lowest number of fruits per plant. However, unpruned plants bear many fruits due to the higher number of reproductive branches and subsequent flowers. This leads to smaller fruit and non-marketable fruits from non-pruned plants. In general, plant with more stems produced more, smaller fruit than pruned plants (Resh, 1997).

3. Fruit Set. The lines which had the highest percentage fruit-set were P20-(03) and 186-2(06) in all pruning treatments. Single stem pruned plants produced the highest fruit set followed by two stem, three stem and non pruned plants (Table 3). This is because, in pruned plants, there were few leaves and the spray of pesticides arrived on flowers consequently reduced the number of diseases on flowers and therefore fruit formation was improved and better leaf-fruit ratio therefore less competition in pruned plants. The same results were found by Ara et al. (2007) who observed that the highest proportion of flowers formed fruits under a single stem system. Mnzava (1984) reported in his study that pruning to a single stem had the effect of increasing fruit set. Nganga (1984) found in his experiment that pruning resulted in a higher flower-fruit ratio in general, and it is suggested that a higher fruit:leaf ratio achieved on fewer leaves through pruning may enhance fruit yield production in a plant. Pruning controls carbon partition and thus affects the ratio and hence fruitfulness (Resh, 1997).

4. Fruit Mass. Fruit mass was higher in fruits from single stem pruned plants of line S181-1(06) followed by three, two and non-pruned plants (Table 3). This difference was possibly attributed to genetic characteristic of line S181-1(06) associated with the response of this line to the environment created by the single pruning system leading to bigger fruits compared to those of other pruning systems. Similar results were reported when pruned and non-pruned indeterminate tomato lines were compared by Kagiraneza (2007), Ara et al. (2007), Bitala (2001) and Mulungu et al. (1995). Rubatzky (1996) reported that pruning allows for some regulation of fruit size and flowering. Fruit size can be improved by removing the axillary shoots and regulating the number of fruits per cluster. The light utilization in the canopy is not limited by much foliage which reduces shading, and thus the supply of assimilates to all the fruits is sufficient to sustain the growth of the majority of fruits. Pruning helps to control the amount of light reaching each plant and allows for better ventilation around each plant. It also keeps a better balance with the root system and usually produces larger fruit than if the plant is allowed to grow into a bush (Opena et al., 1995). Unpruned tomato plants produce many branches per plant which increases competition for assimilate and results in shading.

5. Fruit Yield. The tomato breeding lines showed a difference in the total fruit yield with lines 186-2(06) and P20-03 giving the highest yield per hectare and the control cultivar 'Tengeru 97' giving the lowest yield per ha for all pruning treatments. Differences in yield in any crop species could be attributed to the effects of many factors including weather, water availability, soil fertility status, seedbed condition and cultivars.

The results show that non pruning and three stem treatments increased the yield of line P20-03 and line186-(06) and single stem pruned treatments increased the yield of line S181-1(06) and 'Tengeru 97'. Non-pruning and three stem pruning treatment effects on yield were more pronounced in line P20-03. It is clear that these lines were responding differently to the pruning practice for yield.

6. Marketable Tomato Fruits Yield. The two stem pruned plants gave the highest number of marketable fruits per ha and the number of marketable fruits per plant, with single stem pruned plants giving the lowest number of marketable fruits per hectare and per plant (Table 3). These results are similar to those of Myint (1999), who indicated that the two stem pruning method gave the highest marketable yield compared to single stem and non pruned plants of indeterminate tomato cultivars. Pruning facilitates insecticide spraying and harvesting (AVRDC, 1999) thus increasing the number of marketable fruits in pruned plants.

7. Non-Marketable Tomato Fruits Yield. The highest number of non-marketable tomato fruits per hectare and per plant was observed in non-pruned plants and single stem pruned plants gave the lowest number of non-marketable tomato fruits (Table 3). In his study, Kagiraneza (2007) reported that the highest number of non-marketable fruits was observed in unpruned plants and the lowest in the pruned treatment. High foliage: fruit ratio resulting from fruit pruning significantly increases the number of fruit affected by cracking (Ehert and Ho, 1886).

8. Fruit Quality Characteristics. Two stem pruned plants produced the greatest number of marketable fruits per ha for line P20-03, S186-2(07), with medium fruits size, without loss in yield per ha and fruit quality in terms of TSS, fruit acidity and fruit firmness in all lines. This fruit mass is comparable to the mass of fruits required by the consumers in Tanzania, which ranges from 80 to 120 g/fruit.

CONCLUSIONS AND RECOMMENDATIONS

Results of this study showed that pruning levels influence plant developmental characteristics, yield, and fruit quality of the new indeterminate tomato breeding lines.

These results indicate that single stem pruned plants were more vigorous among the lines tested to the 4th node and had the biggest leaf size. Single stem pruned plants gave the highest proportion of flowers which formed fruits, in contrast the yield per ha did not differ among the pruning systems. The two stem pruned plants produced the highest number of marketable fruits per ha whereas non-pruned plants gave the highest number of non-marketable fruits per hectare. The length of harvesting period was high for fruits from three stem pruned plants. For the same pruning treatment, lines 186-2(06) and P20-03 were precocious in terms of the first fruiting day. 'Tengeru 97' was the tallest to the first fruit cluster and line P20-03 was the tallest at the last harvest within the same pruning system. Lines P20-03 and S186-2(07) were associated with the longest period of harvest, many flowers and fruits per plant, higher percentage of fruit-set, the highest yield and number of marketable fruits. In view of this study it appears that the tomato breeding lines tested combined with pruning systems gave promising high yield. It is therefore recommended that these lines should be subject of multilocational trials before their release. Two stem and three stem pruning systems per plant should be recommended to tomato growers as the best husbandry practice for increasing marketable tomato fruit yield of medium sized fruits.

Literature Cited

Ara, N., Bashar, M.K., Begum, S. and Kakon, S.S. 2007. Effect of spacing and stem pruning on the growth and yield of tomato. Int. J. Sustain. Crop Production 2(3):35-39.

AVRDC. 1980. Proceedings of the first International Symposium on Tropical, AVRDC, Shanhua, Tainan, Taiwan. 132p.

AVRDC. 1999. Progress report Summaries 1996. AVRDC, Shanhua, Tainan, Taiwan. 148p.

AVRDC. 2002. Progress report Summaries 2001. AVRDC, Shanhua, Tainan, Taiwan. 182p.

Bitala, M.F. 2001. The effect of pruning on growth and yield of tomato. Special Project Report. SUA, Morogoro. Tanzania. 46p.

De Kreij, C., Janse, J., van Goor, J. and van Doesburg, J.D.J. 1992. The incidence of calcium oxalate crystals in fruit walls of tomato (*Lycopersicon esculentum* Mill.) as affected by humidity, phosphate and calcium supply. Journal of Horticultural Science 67:45-50.

Dorais, M. and Papadopoulos, A. 2001. Greenhouse tomato fruit quality. Journal of Horticultural Science 68:195-201.

Ehret, D.L. and Ho, L.C. 1986. Translocation in calcium in relation to tomato fruit growth. Annuals of Botany 58:679-688.

FAO. 2003. FAO Production Yearbook 2002. 56:142-144.

Fecadu, Y. and Teshome, T. 1998. Effect of drip and fullow irrigation and plant spacing on yield of tomato at Dire Dawa, Ethiopia. Alemaya University of Agriculture, Ethiopia. Elsevier, Agricultural Water Management 35:201-207.

Gomez, K.A. and Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. Second edition. John Wiley and Sons. Interscience Publication. New York. 680p.

Ho, L.C. 1996. Tomato-photoassimilate distribution in plant and crops: source-sink relationship. Annual Review of Plant Physiology 79:355-368.

Kagiraneza, B. 2007. Effect of spacing and pruning on growth, yield and quality of five high β-carotene tomato lines. Dissertations for award of Master of Science Degree at Sokoine University of Agriculture, Morogoro Tanzania, 126p.

Kalloo, G. 1993. Genetic Improvement of Vegetable Crops. Pergamon Press, Oxford, England, 660p.

Mnzava, N.A. 1984. Influence of cluster and spacing on set, growth, yield and quality of early fruit of the West Virginia 63 tomato (*Lycopersicon esculentum* Mill.). Dissertation for Award of M.Sc. Degree at Sokoine University of Agriculture, Morogoro Tanzania, 54p.

Mulungu, L.S., Reuben, S.O.M.M., Manyama. A.A.A., Mbilinyi, L.B. and Godwin, J. 1995. Tomato Multilocation Trial Report. Sokoine University of Agriculture, Department of Crop Science and Production, Franco-Tanzania horticultural development project. 35p.
Myint, A. 1999. Effect of pruning and spacing on performance of fresh market tomato. AVRDC report. Kasestart University, Thailand. http:/www.arc-avrdc.org.pdf_files/ Myint Aung.pdf site visited on 20/06/2010.
Nganga, K.S. 1981. Some physiological and cultural investigations with fresh market tomatoes in Kenya. Thesis for award of Ph.D. Degree at Makerere University, Kampala, Uganda. 226p.
Opena, R.T. 1985. Development of tomato and Chinese cabbage adapted to the hot, humid tropics. Acta Hort. 178:624-635.
Palangyo, R. 2009. Horticultural performance of tomato accessions during the dry and rainy seasons. Special Project Report. SUA, Morogoro. Tanzania. 36p.
Peralta, I.E. and Spooner, D.M. 2001. Granule-bound starch synthase (Gbssi) gene phylogeny of wild tomatoes (*Solanum* L. section *Lycopersicon* Mill. Wettst. Subsection *Lycopersicon*). [http://en.wikipedia.org/wiki/Tomato#picking and ripening] site visited on 10/05/2009.
Rawshan, A.S.M. 1996. Effect of plant population density on tomato. In: ARC-AVRDC Training Report. Kasetrasrt University Bangkok, Thailand: ARC-AVRDC. 152-124p.
Resh, H.M. 1997 Hydroponic Tomatoes for the Home Gardener. Published by Woodbridge Press Publishing Company. Calofornia. www.goodreads.com/.../ 169768.Howard_M_Resh site visited on 17/05/2010.
Rubatzky, V.E. 1996. World Vegetables: Principles, Production and Nutritive Values. Second Edition. Chapman and Hall, ITP International Thomson Publishing 115 Avenue. New York, USA. NY1003. 843p.
Sandersfeld, T. 2006. How to Prune Tomato: Tomato Plant to Care Tips. http://www.howtodothings.com/home-and-garden/a2947.html site visited on 11/06/2010.
Villareal, R.L. 1980. Tomatoes in the Tropics. Westview Press, Bouder, Colado, USA, 294p.
Went, F.W. and Cosper, G.E. 1975. Plant growth under controlled conditions. Comparison between field and air conditioned greenhouse culture of tomatoes. American Journal of Botanic 32:643-654.
Zhang, Y. 1998. Spacing and pruning on tomato variety Yuexing. AVRDC-ARC Research report 1998; Taiwan, China. http:www.arc-avrdc.org/html_files/ ZhangYanrong.html site visited on 17/05/2010.

Tables

Table 1. Plant developmental characteristics as observed among pruning treatments for all tomato lines.

Pruning treatment	Number of days to 1^{st} flowering	Number of days to 1^{st} fruit maturity	Harvest duration (days)	Plant height at last harvest (m)	Stem diameter at 4^{th} node (cm)	Leaf length (cm)	Leaf width (cm)
Single stem	39.35a	76.47c	25.23a	1.14a	1.08a	32.72a	26.05a
Two stem	39.83a	77.71b	25.27a	1.1a	0.94b	29.63b	23.34b
Three stem	39.73a	77.91b	26.21a	1.08a	0.84 bc	29.06b	22.59b
Non pruning	38.91a	80.36a	21.83b	1.1a	0.89 bc	28.89b	20.52c
Mean	39.46	78.11	24.64	1.1	0.93	30.07	23.1
LSD 0.05	0.81	0.7	1.79	0.08	0.06	1.13	1.42
F-test	ns	***	***	ns	***	***	***
CV(%)	7.66	3.39	27.13	19.57	25.45	14.13	23

Means followed by the same letter(s) within the column are not significant at 5% level based on Student-Newman-Keuls. ns=not significant, *=significant (P<0.05), **=highly significant (P<0.01), ***=very highly significant (P<0.001).

Table 2. Plant developmental characteristics observed among tomato lines.

Lines	Number of days to the 1^{st} flowering	Number of days to the 1^{st} fruit maturity	Harvest duration (days)	Plant height at last harvest (m)	Stem diameter at 4^{th} node (cm)	Leaf length (cm)	Leaf width (cm)
186-2(06)	39.35b	72.76	30.97ab	0.73c	0.98a	28.60c	22.82bc
P20-03	37.64b	79.25b	36.08a	1.52a	0.82a	27.56c	21.76bc
S181-1(06)	39.07b	78.69b	17.65c	1.25b	0.96a	32.54ab	25.94a
S175	39.15b	74.81bc	26.69b	0.61c	0.87a	27.17c	21.11c
S178	36.90b	75.5bc	18.44c	1.30b	0.94a	30.15bc	22.24bc
Tengeru 97	44.63a	87.67a	17.97c	1.22b	1.06a	34.43a	24.90ab
Mean	39.46	78.11	24.64	1.1	0.93	30.07	23.13
LSD 0.05	2.89	3.35	6.15	0.07	0.19	3.05	2.4
F-test	**	***	***	ns	ns	**	**
CV(%)	7.66	3.39	27.13	19.57	25.45	14.13	23.04

Means followed by the same letter(s) within the column are not significant different at 5% level based on Student-Newman-Keuls. ns=not significant,*= significant (P<0.05), **=highly significant(P<0.01), ***=very highly significant (P<0.001). P20-03, 186-2(06), S175, S178, 181-(01) are new tomato breeding lines, Teng 97=Tengeru 97 is a local cultivar (control).

Table 3. Total yield and yield components observed as a result of different pruning levels.

Pruning treatment	Number of fruits/plant	Number of flowers/cluster	Number of flowers/plant	Fruit set (%)	Mass of single fruit (g)	Total fruit yield (t/ha)	Number of marketable fruits per ha	Number of non-marketable fruits/ha
Non pruning	12.91a	3.93b	66.43a	18.84b	126.11b	14.09a	132,716a	77,160.49a
Single stem	9.95b	4.37a	31.19c	31.71a	159.89a	12.71a	91,269b	49,272.49b
Two stems	9.94b	4.29a	44.64b	22.82b	152.26a	14.83a	136,519a	71,318.34ab
Three stems	10.72b	3.94b	48.69b	22.47b	153.18a	14.81a	135,251a	67,791.01ab
Mean	10.75	4.13	47.73	23.96	147.86	14.11	123,939	66,385.58
LSD 0.05	1.78	0.24	4.62	3.65	13.54	2.64	26,797	19,320.62
F-test	***	***	***	***	**	ns	**	*
CV(%)	61.97	21.64	36.25	56.97	13.55	27.71	31.98	43.05

Means followed by the same letter(s) within the column are not significant at 5% level based on Student-Newman-Keuls. ns=not significant,*=significant (P<0.05), **=highly significant (P<0.01), ***=highly significant (P<0.001).

Table 4. Fruit quality characteristics observed as a result of different pruning treatments.

Pruning levels	Fruit pH	TSS	Fruit length (cm)	Fruit width (cm)	Fruit width (cm)	Fruit firmness (kg/cm^2)
Non pruning	3.96a	4.24a	5.26b	5.93b	5.93b	3.57a
Single stem	4.23a	4.66a	5.52 a	6.48a	6.48a	3.65a
Two stem	4.13a	4.61a	5.53a	6.42a	6.42a	3.70a
Three stem	4.13a	4.66a	5.50a	6.50a	6.50a	3.60a
Mean	4.12	4.54	5.45	6.33	6.33	3.63
LSD 0.05	0.23	0.38	0.12	0.17	0.17	0.15
F-test	ns	ns	***	***	***	ns
CV (%)	8.24	12.51	7.29	8.94	8.94	3.72

Means followed by the same letter(s) within the column are not significant at 5% level based on Student-Newman-Keuls. ns=not significant, *=significant (P<0.05), **=highly significant (P<0.01), ***=very highly significant (P<0.001). P20-03, S186-2(07), S175, S178, S181-1(06) are new tomato breeding lines, 'Tengeru 97' is a local cultivar (control).