Journal of Horticulture
ISSN: 2376-0354

Sidhu and Nandwani, J Hortic 2017, 4:2
DOI: 10.4172/2376-0354.1000201

Research Article OMICS International

Cultivar Evaluation and Yield Performance of Tomato in an Organic Management System

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Abstract

This paper presents evaluation of organic tomato cultivars on yield performance in local climatic conditions. Field research trials were conducted from April to October in 2015 and 2016 growing seasons at the Tennessee State University organic farm. Differences occurred in number of marketable fruit, fruit weight and total soluble solids. 'Arbason F1' (28.67 Mt·ha^{-1}), 'Gold Nugget' (26.08 Mt·ha^{-1}), 'Roma' (25.65 Mt·ha^{-1}) were the high yielding and 'Pink Bumblebee' (2.61 Mt·ha^{-1}), 'Hillbilly' (3.10 Mt·ha^{-1}), 'Cherokee Green' (5.99 Mt·ha^{-1}) had the lowest marketable yield. 'Mountain Prince' (57.68%), 'Pink Brandywine' (52.32%) and 'Black Prince' (44.74%) had the most culls and 'Pink Bumblebee' (1.80%), 'Rutgers VF' (4.98%), and 'Hillbilly' (5.02%) had the fewest cull fruit. 'Bing Cheery' and 'Cheery Sweetie' ranked highest in taste among cherry types. All twenty six cultivars did set fruits during the growing seasons in local climatic conditions. Results suggest that 'German Johnson' and 'Pink Brandywine' (beefsteak type), 'Gold Nugget', (cherry type), and 'Roma', (plum type) were top performers in higher yields and brix.

Keywords: Cultivars; Marketable fruits; Production; Total soluble solids

Introduction

Tomato is grown worldwide for its edible fruits, with antioxidants benefits. It has been reported that consumption of raw tomato and tomato based products is associated with reduced risk of cancer and cardiovascular disease [1]. Tomato contains phenolic compounds, lycopene, phytochemicals which have high antioxidant ability and free radical scavenging ability to inhibit the enzymes responsible for oxidative stress imposed by Reactive Oxygen Species (ROS) production [2]. The organic production system aims at supporting and sustaining healthy eating habits, ecosystems, soil, farmers, community, and the economy. There are rising numbers of customers who are in search of healthier, tastier and environmentally friendly food, increasing the demand for organic produce. Organic food sales and farmland are growing worldwide at a rate of 20% per year (UNCTAD, 2003). The constant requests for organic foods are similar in different parts of the world, where consumers are willing to pay more for these products [3,4]. According to the MORI poll (2001), 43% of consumers of organic food give "better taste" as a major reason for purchasing organic fruits and vegetables [5]. A large proportion of commercially grown tomato (*Solanum lycopersicum* L.) have been developed for, and adapted to, conventional agriculture systems which employs synthetic chemicals in its culture [6-8]. Performance of cultivars developed for conventional cropping systems differ in organic production system [9,10]. Organic cropping system is an alternative to develop organic tomato cultivars which can be adapted to local conditions and produce higher yields under organic management [7,11,12]. Organic farming is growing worldwide and consumer demand for organically produced food is increasing [3,4]. Organic fresh vegetables are the top selling category of organically grown food [13]. Consumers in America are 3-4 times likely to buy organic tomato than any other food products [14]. The objective of this study was to evaluate the yield performance and other agronomic characteristics of tomato cultivars grown in organic management systems.

Materials and Methods

Tomato research trials were conducted during April to October of 2015 and 2016 at the Tennessee State University certified organic farm in Nashville, TN (Latitude 36°10' N, 86°49' W). The soil was a well-drained sandy loam with 2% organic matter with pH 8. Seeds (organic or untreated) of twenty-six tomato cultivars were obtained from Johnny's Selected Seed Company (Winslow, MA), High Mowing Organic Seed (Wolcott, VT) and Territorial Seed Company (Cottage Grove, OR). The cultivars were: 'Bing Cherry', 'Black Cherry', 'Black Prince', 'Cherry Sweetie', 'German Johnson', 'Mortgage Lifter', 'Moskovich', 'Hillbilly', 'Mountain Prince', 'Northern Delight', 'Oregon Spring', 'Principe Borghese', 'Rutgers VF', 'Sweet Tomato', 'Tang Tomato', 'Storage', 'Arbason F1', 'Glacier', 'Gold Nugget', 'Siletz', 'Roma', 'Cherokee Green' (bicolor beefsteak), 'Pink Brandywine', 'Brandywine', 'Pink Bumblebee' and 'Indigo Rose'.

Seeds were sown in nursery trays (72 cell) using organic earthworm casting potting mix (Appalachian Mountain Crawler, Blairsville, GA) in a greenhouse. Fish Emulsion (5-1-1) (Ferti-lome, Bonham, Texas) was applied as foliar spray to young seedlings weekly at a concentration of 10 mL·L-1. Seedlings were irrigated twice a week with garden sprayer. Field was prepared using a tractor drawn Rotavator and drip irrigation system installed. Field experiment was designed in a Randomized Complete Block Design (RCBD) with 3 replications of each cultivar. Six plants in each block, total of 18 plants in each cultivar planted. Each block consisted of 26 rows (1 row of each cultivar) spaced 90 cm in-row and 60 cm plant to plant within rows. Three-week-old seedlings were transplanted by hand in the field and irrigated. Nutri-rich (4-3-2, Planet Natural, Bozeman, MT), 100% Natural Organic Fertilizer, (4-3-2) Ca 7% (Grow Organic, Grass Valley, CA) and Nature Safe (8-5-5,

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Received June 09, 2017; **Accepted** June 20, 2017; **Published** June 28, 2017

Citation: Sidhu V, Nandwani D (2017) Cultivar Evaluation and Yield Performance of Tomato in an Organic Management System. J Hortic 4: 201. doi: 10.4172/2376-0354.1000201

Irving, TX) fertilizers were spread by hand to plants after transplanting and continued every 2 weeks throughout the growing season. Tomato plants were staked using T-posts and twine for support. Lower leaves of plants were pruned to avoid contact in soil. Weeds were controlled manually or mechanically by tractor cultivator, rototiller or spade. Field scouting conducted for insect pest and diseases throughout the growing seasons.

Tomato fruit were harvested as they turned red and ripened during mid-July to the first week of October. Twelve and eleven harvests recorded in 2015 and 2016, respectively. Fruits were weighed and graded into marketable, unmarketable and culls. Data on plant height, fruit weight, number of total and marketable fruits, marketable yield, brix and acidity collected from eleven and twelve harvests during the growing season of 2015 and 2016 respectively. Data were analyzed using SAS (ver. 9.4, SAS, Inc., Cary, NC).

Results and Discussion

'Northern Delight' was the first cultivar harvested (55 Days). Data on total yield, marketable yield (US#1), fruit weight (Table 1), number of total fruit and marketable and culls are presented for 2015 (Table 2) and for 2016 (Table 3). In 2015, 'Arbason F1', 'Gold Nugget', and 'Roma' produced the highest marketable yield. 'Hillbilly', 'Cherokee Green' and 'Pink Bumblebee 'produced the lowest marketable yield. In 2016, 'Arbason F1', 'Glacier', and 'Roma' produced the most marketable yield. 'Pink Bumblebee', 'Hillbilly', and 'Cherokee Green' produced the lowest marketable yield. In 2015, 'Sweet Tomato' and 'Gold Nugget', cherry type tomato, 'Roma', a plum type tomato, and 'Glacier', a beefsteak type tomato, produced the most marketable fruit per plant. 'Hillbilly' and 'Cherokee Green', and 'Pink Brandywine', beefsteak type tomatoes, produced the fewest marketable fruit per plant. In 2016, 'Black Cherry' and 'Bing Cherry', cherry type tomatoes, 'Roma', plum type tomato, and 'Glacier', beefsteak type tomato, produced the most marketable fruit per plant and 'Cherokee Green' and 'Rutgers VF', beefsteak type tomatoes were low marketable fruit per plant producers. In 2015, 'Hillbilly', 'Pink Bumblebee' and 'Indigo Rose' had fewest cull fruit and 'Mountain Prince', 'Pink Brandywine', and 'Black Prince' had the most cull fruit. In 2016, 'Pink Bumblebee', 'Rutgers VF', and 'Hillbilly' had the least cull fruit, and 'Glacier', 'Roma' and 'Mortgage lifter' had the highest amount of cull fruit. Radial fruit cracking, infected or diseased and insect damaged fruit affected marketable yield. Frequent rainfall in 2016 affected yield and disease incidence such as *Septoria* leaf spot, early blight, bacterial spot and tomato cutworm infestation during the peak production period (Figure 1). Inconsistent water supply and temperature fluctuations increase the incidence of fruit cracking [14,15]. Use of cultivars resistant to fruit cracking and cultivars exhibiting hairiness inhibits sucking pests could minimize the loss of tomato yield [16]. Yields over harvests differed in 2015 and 2016 (Figure 2).

In 2015, high marketable fruit weight recorded in 'German Johnson', a beefsteak type tomato, 'Gold Nugget', a cherry type

Cultivar	Brix°		Fruit Weight (g/plant)	
	2015	2016	2015	2016
Arbason F1	5.0	5.5	126.25	96.43
Bing Cherry	5.5	6.0	11.40	9.85
Black cherry	7.0	6.5	13.25	16.07
Black Prince	4.0	4.5	101.41	97.5
Brandywine	5.0	4.5	166.97	196.33
Cherokee green	6.2	6.2	119	99.63
Cherry Sweetie	7.0	6.5	9.005	8.4
German Johnson	4.0	5.0	266.7	210.54
Glacier	4.2	4.5	48.1	34.68
Gold Nugget	5.1	5.5	14.64	16.9
Hillbilly	4.5	5.2	77.67	76.8
Indigo Rose	5.0	4.8	41	38.733
Mortgage Lifter	4.5	4.5	133.10	139.033
Moskovich	4.0	4.5	124.661	156.42
Mountain Prince	5.0	5.1	70.49	74.4
Northern Delight	5.5	5.5	52.77	52.314
Oregon Spring	5.0	4.5	118.01	92.64
Pink Brandywine	3.1	3.5	244.3	224.5
Pink Bumblebee	5.7	5.7	16.125	20.6
Principe Borghese	4.2	3.5	15.78	25.9
Roma	4.0	4.5	49.2	48.06
Rutgers VF	6.0	4.2	98.5	99.06
Siletz	5.4	5.2	120.05	90.96
Storage	4.2	4.5	69.34	95.06
Sweet Tomato	4.0	4.0	17.28	13.91
Tang Tomato	5.0	4.5	110.7	137.41

Table 1: Total soluble solids (Brix°) of 26 organic tomato cultivars grown at TSU organic farm, Nashville in 2015 and 2016.

Cultivar	Total yield (Mt·ha^{-1})	Marketable yield (Mt·ha^{-1})	Average number of fruits/plant)	Average number of marketable fruits/plant	Cull (%) (g)
Arbason F1	31.41^{a}	27.21^{a}	16.67	14.06	37.81^{d}
Gold Nugget	28.18^{a}	26.08^{ab}	123.11	111.28	28.99^{e}
Roma	27.19^{a}	25.65^{ab}	31.67	29.11	13.8315^{g}
Sweet Tomato	22.17^{ab}	21.03^{abc}	125.83	116.72	42.227^{cd}
Black Cherry	22.27^{ab}	19.64^{bcd}	104.28	91.22	40.0666^{cd}
Oregon Spring	23.25^{ab}	18.00^{bcd}	17.50	13.61	47.205^{b}
Principe Borghese	19.36^{bcd}	17.35^{bcd}	90.76	78.76	52.327^{ab}
Storage	19.88^{bc}	16.88^{cd}	12.28	10.33	10.273^{gh}
Moskovich	19.79^{bc}	16.87^{cd}	10.94	9.00	23.073^{f}
German Johnson	20.06^{bc}	16.59^{cd}	5.53	4.24	31.161^{de}
Black Prince	21.18^{abc}	16.21^{cd}	16.22	12.33	28.61^{e}
Mountain Prince	21.84^{abc}	15.43^{de}	15.72	10.56	57.6768^{a}
Rutgers VF	19.80^{bc}	15.23^{de}	10.61	8.11	41.1539^{cd}
Siletz	19.46^{bc}	14.77^{de}	12.17	8.83	27.06^{ef}
Bing cherry	18.10^{bcd}	13.65^{ef}	111.94	84.22	23.63^{f}
Glacier	16.86^{cd}	13.64^{ef}	26.83	21.94	18.9679^{fg}
Pink Brandywine	19.34^{bcd}	13.52^{ef}	5.06	3.44	18.1498^{fg}
Brandywine	13.83^{ef}	10.65^{fg}	5.83	4.56	44.74^{bc}
Northern Delight	13.20^{ef}	10.65^{fg}	21.67	17.22	22.9332^{f}
Tang Tomato	15.25^{de}	10.53^{fg}	8.61	6.33	42.477^{cd}
Indigo Rose	11.47^{fg}	10.25^{fg}	31.00	29.44	10.98^{gh}
Mortgage Lifter	12.80^{f}	10.23^{fg}	5.83	4.67	26.27^{ef}
cherry Sweetie	12.06^{f}	9.67^{g}	89.67	73.94	21.53^{f}
Pink Bumblebee	8.72^{gh}	7.74^{h}	25.50	22.78	8.81^{h}
Cherokee green	8.53^{gh}	6.00^{i}	3.28	2.17	22.74^{f}
Hillbilly	3.88^{j}	3.10^{j}	2.00	1.61	7.02^{hi}

[a]Values in columns followed by the same letter are not significantly different*, P<0.05, Tukey's test

Table 2: ANOVA results of year (2015) and cultivar for total yield, marketable yield, average number of fruits and culls.

Cultivar	Total yield (Mt·ha^{-1})[a]	Marketable yield (Mt·ha^{-1})[a]	Average number of fruits/plant	Average number of marketable fruits/plant	Culls (%)[a]
Arbason F1	30.28^{a}	28.67^{a}	15.111	14.167	14.506^{efg}
Glacier	24.23^{bc}	21.89^{bcd}	26.667	23.500	8.899^{gh}
Roma	24.55^{bc}	21.83^{bcd}	25.111	22.833	24.464^{bcd}
Black Cherry	21.97^{cd}	21.30^{bcd}	78.722	76.389	16.7255^{def}
Siletz	21.55^{cd}	19.26^{cde}	16.938	14.375	5.549^{hi}
Sweet Tomato	18.81^{de}	17.42^{e}	79.944	73.833	20.571^{cd}
Principe Borghese	18.26^{de}	16.86^{ef}	37.111	34.389	20.605^{cd}
Gold Nugget	14.92^{ef}	13.93^{f}	54.611	51.389	21.096^{cd}
Moskovich	15.01^{ef}	13.16^{f}	9.222	8.333	42.01^{a}
Mortgage Lifter	17.08^{ef}	12.41^{gf}	4.941	3.706	16.658^{def}
Brandywine	12.94^{gf}	12.08^{gf}	2.389	2.222	18.577^{de}
Black Prince	13.79^{f}	11.73^{gf}	13.056	11.111	7.762^{h}
Pink Brandywine	13.24^{f}	10.95^{g}	3.375	2.813	12.602^{fg}
German Johnson	12.18^{gf}	10.73^{g}	5.267	4.267	13.115^{fg}
Mountain Prince	12.34^{gf}	10.56^{g}	9.278	8.222	16.075^{def}
Tang Tomato	9.63^{g}	8.54^{gh}	3.944	3.167	9.821^{gh}
Cherry Sweetie	9.78^{g}	8.41^{gh}	59.353	50.706	12.3696^{fg}
Indigo Rose	9.03^{gh}	8.31^{gh}	19.556	17.778	6.498^{h}
Bing cherry	9.79^{g}	7.93^{h}	65.667	53.867	6.055^{hi}
Oregon Spring	9.52^{g}	7.85^{h}	7.467	6.400	14.964^{efg}
Northern Delight	8.33^{gh}	7.51^{h}	15.813	14.000	7.391^{h}
Cherokee green	6.71^{hi}	5.99^{i}	2.063	1.813	6.472^{h}
Storage	6.22^{hi}	5.60^{i}	3.000	2.733	12.487^{fg}
Rutgers VF	5.05^{i}	4.50^{ik}	2.733	2.467	4.982^{hi}
Hillbilly	4.70^{ik}	4.14^{ik}	5.188	4.563	5.028^{hi}
Pink Bumblebee	2.81^{k}	2.61^{k}	8.357	7.714	1.804^{i}

[a]Values in columns followed by the same letter are not significantly different, P<0.05 level, Tukey's test

Table 3: ANOVA results of year (2016) and cultivar for total yield, marketable yield, average number of fruits and culls.

tomato, and 'Roma', a plum type tomato. 'Glacier' (beefsteak type) and 'Cherry Sweetie' (cherry type), produced the lower marketable fruits. In 2016, 'Pink Brandywine' (beefsteak type), 'Gold Nugget' (cherry type), and 'Roma', (plum type) produced the heaviest marketable fruit. 'Northern Delight' (beefsteak) and 'Cherry Sweetie' (cherry) produced the lightest marketable fruit (Table 3). Fruit diameter was least for 'Bing Cherry', a cherry type tomato and was greatest for 'Brandywine', a beefsteak type tomato. The shortest fruit was for 'Bing Cherry', a cherry type tomato and the longest fruit were for 'Arbason F1', a beefsteak type tomato. In 2015 and 2016, total soluble solids (brix) were high recorded in 'Bing Cherry' and 'Cherry Sweetie' (cherry type) (Table 3). In both years, 'Principe Borghese' had the lowest brix Cvs. 'Arbason F1', 'Roma' and 'Gold Nugget' attained considerable yield in organic management system in Tennessee. Further studies needed to improve determination of disease resistant cultivars would help local growers introduce new cultivars and attain better yields [17-19].

Conclusion

The cultivar evaluation trials demonstrated that tomato can be successfully grown under organic management system in Tennessee. Analysis of Variance (ANOVA) indicated the significant differences in yield performance between cultivars. Overall, marketable yield ranged from 3.10 tons/ha to 27.25 ton/ha with 'Arbason F1' yielding the highest and 'Hillbilly' yielding the lowest. 'Arbason F1', 'Roma' and 'Gold Nugget' performed well. 'Bing Cherry' and 'Cherry Sweetie' cultivars ranked highest in terms of taste in cherry type tomatoes. The unmarketable fruits ranged from 1.80 to 57% with 'Pink Bumblebee' having the lowest culled fruit and 'Mountain Prince' having the highest culled fruit.

Acknowledgments

Author sincerely thank to the organic research program team for field assistance. Funding for the study received from Evans Allen project (DN).

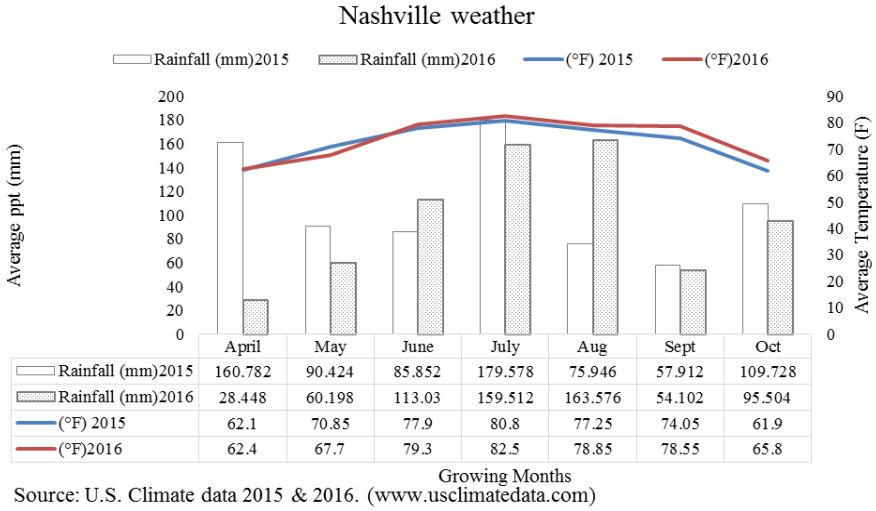

Figure 1: Environmental factors during the 2015 and 2016 growing seasons, Nashville, TN (Latitude 127.30 m, 36°10' N, 86°49' W).

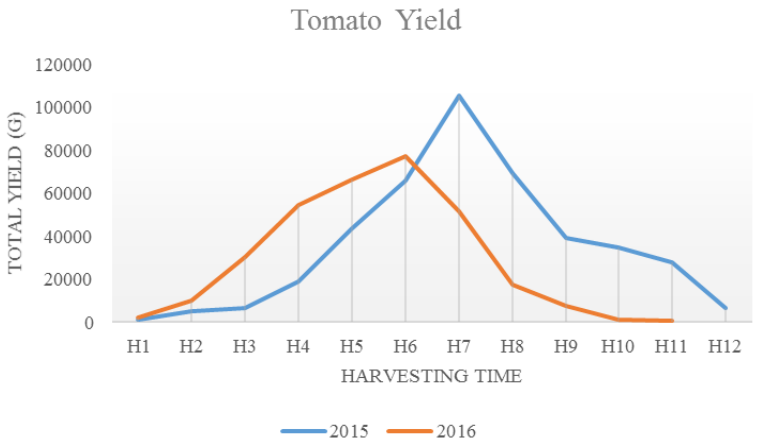

Figure 2: Yield of organic tomato cultivars in 2015 and 2016 grown at TSU organic farm, Nashville, TN (Latitude 127.30 m, 36°10' N, 86°49' W).

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Citation: Sidhu V, Nandwani D (2017) Cultivar Evaluation and Yield Performance of Tomato in an Organic Management System. J Hortic 4: 201. doi: 10.4172/2376-0354.1000201