Evaluation on Agronomical Characteristics of F1 Hybrid Tomato Lines in Spring-Summer Season 2015 in Thua Thien Hue

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Abstract: The four F1 hybrid tomato lines (CT2011, CW2011, TS2011 and CLN2011) and two commercial F1 hybrid tomato cultivars used as control (TN52 and TN561) were evaluated for yield and yield components. The efforts were made to minimize reliance on the import of hybrid seed. The experiment was laid out in randomized complete block design (RCBD) with three replications in spring-summer season 2015. Data were recorded on five plants for each replication. The results indicated that all of F1 tomato hybrid lines grew well under Thua Thien Hue condition. CT2011 had the highest plant height, followed by TS2011 and CLN2011. CT2011 is a cherry type and obtained the highest percentage of fruit setting (82.87%) and the highest of Brix (4.97). This line also had high yield (70.91 tons/ha). TN52 had the highest yield (80.69 tons/ha) among the processing tomato lines, and TN561 had the biggest fruit (90.1 g). All of F1 hybrid tomato lines had high resistant level to late blight and bacterial wilt diseases.

Key words: Hybrid, bacterial wilt, late blight, *Solanum lycopersicum*, Thua Thien Hue.

1. Introduction

Tomato is one of important *Solanum* crops occupying 14% of world vegetable production in 2010 [1]. It is popular fruit vegetable and gives high fresh consumption in many countries, including Vietnam, because of its high nutrition and good adaptability under different agro-climatic conditions. Rick [2] indicated that in the US, tomatoes rank the first among fruits and vegetables by abundant sources of vitamins and minerals. In addition, tomatoes are rich of lycopene, a phytochemical that protects cells from oxidants [3]. Tomato is one of the most expected vegetables, not only rich nutrients but also high economic efficiency allows to be cultivated and invested commonly in the central provinces of

Vietnam, including Thua Thien Hue.

Due to high demand of tomatoes during entire year, enhancing tomato production and productivity is needed. Moreover, consumers are concerning about food safety due to pesticide residues on products. Thus, to restrict abuse of pesticides, the disease resistance cultivars are needed. Thus, many breeding programs aim to select F1 lines having good characteristics as well as resistant ability, high yield and good quality. Choudhary et al. [4] emphasized extensive utilization of heterosis to increase tomato production. In addition, Yordanov [5] indicated that the heterosis manifestation in tomato is in the form of the faster growth and development and the increased productivity. However, farmers are used to use old cultivars or import new hybrid tomatoes for sowing in next season, which caused qualitative decreasing,

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degeneration and high cost. In this study, the authors evaluated four F1 hybrid tomato lines, which were made at National Institute of Horticultural and Herbal Science (NIHHS), Korea, for their agronomical characteristics under Thua Thien Hue condition.

2. Materials and Methods

2.1 Materials

The four F1 hybrid tomato lines, namely CT2011, CW2011, TS2011 and CLN2011, which were made at NIHHS, Korea in 2011, and two commercial F1 tomato cultivars as control, namely TN52 and TN561, which are commonly used in Thua Thien Hue, were used in this study (Table 1).

2.2 Methods

The experiment was conducted during spring-summer season from January to May in 2015 at Agronomy Faculty of Hue University of Agriculture and Forestry. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Each plot was 1.2 m² containing six plants for each replication. Tomato population was obtained of 50,000 plants/ha. The distance between row to row was 50 cm and the distance between plant to plant was 40 cm. Seeds were sown in a plastic tray. When the seedlings grew to reach 5-6 true leaves, they were ready to transplant into experimental field. Taking care methods were applied regularly and uniformly to keep plant health. According to the guidelines of the national technical regulations QCVN01-63:2011/BNNPTNT of the Ministry of Agriculture and Rural Development, the relevant field techniques for this study were applied.

Table 1 List of tomato lines used.

No.	Name of hybrid	Place of collection
01	CT2011	NIHHS
02	CW2011	NIHHS
03	TS2011	NIHHS
04	CLN2011	NIHHS
05	TN52	Thua Thien Hue
06	TN561	Thua Thien Hue

The data parameters were saved on quantitative and qualitative characteristics in open field. Data included day to finish growth stages (day); vegetative characteristic, such as growth type, plant height, number of nodes and height from foot to the first flower, length and width of leaf (cm); morphological traits on leaf and fruit, as shape, color or firmness, flower number per bunch, percentage of flowering, fruit size (length, diameter, wall thickness...); yield components and pest situation. The data of five plants per experimental plot were recorded regularly. The Statistic 10.0 trial version was used to analyze analysis of variance (one-way ANOVA) and compare differences between means values by Duncan's test at $P < 0.05$ [6].

3. Results and Discussion

3.1 Morphological and Vegetative Characteristic of Plant

Depending on the ability of growth and branching, growth types of tomatoes expressed different as indeterminate, determinate or semi-determinate. Growth habit of the F1 hybrids tomato lines was indeterminate or semi-determinate. CT2011, TS2011 and CLN2011 had indeterminate growth, and the others had semi-determinate (Table 2). Leaf shape included two types; potato leaf was found in CT2011, TN52 and TN561 hybrids, and regular leaf was found in the remains. Leaf color of tomato lines changed from green to dark green. Leaves of CT2011 and CW2011 had dark green color, TS2011 and CLN2011 had grey green color, and TN52 and TN561 had green color.

Significant difference in plant height was observed among F1 tomato hybrid lines. The highest plant height was obtained in CT2011 (277.13 cm), whereas the shortest plant height was observed in CW2011 (134.7 cm). The plant height of the remains ranged from 149.80 cm to 263.73 cm. Singh et al. [7] had evaluated of tomato hybrid (*Lycopersicon esculentum* Mill.) in Allahabad agro-climatic conditions during

Table 2 Vegetative traits of F1 hybrid tomato lines.

No.	Hybrids	Growth type	Leaf shape	Leaf color	Plant height (cm)	No of nodes from foot to 1 st flower (node)	Height from foot to 1 st flower (cm)	Leaf length (cm)	Leaf width (cm)
01	CT2011	I	PL	DG	277.13 ^a	11.80 ^a	52.47 ^b	41.80 ^{ab}	27.96 ^a
02	CW2011	S-D	RL	DG	134.70 ^c	11.13 ^{ab}	64.67 ^a	44.84 ^a	31.60 ^a
03	TS2011	I	RL	GG	263.73 ^a	10.00 ^{bc}	57.40 ^b	43.28 ^{ab}	28.41 ^a
04	CLN2011	I	RL	GG	216.37 ^{ab}	10.65 ^{ab}	58.70 ^{ab}	43.80 ^a	29.51 ^a
05	TN52	S-D	PL	Gr	149.80 ^{bc}	9.60 ^{bc}	45.73 ^c	40.28 ^{ab}	33.27 ^a
06	TN561	S-D	PL	Gr	171.00 ^{bc}	8.47 ^c	39.80 ^c	37.27 ^b	30.65 ^a
LSD _{0.05}					80.36	1.70	6.25	6.42	6.33

I = indeterminate, S-D = semi-determinate, PL = potato leaf, RL = regular leaf, DG = dark green, GG = grey green, Gr = green.

^{a, b, c} Different letters in each columns indicate significantly different means (Duncan's test, $P < 0.05$).

Table 3 Flower and fruit characteristics of F1 tomato hybrid lines.

No.	Hybrid	Inflorescence type	No. of flowers per bunch (flower)	Percentage of fruiting (%)	No. of seeds
01	CT2011	Compound dichasium	8.61 ^a	82.87 ^a	78.87 ^{abc}
02	CW2011	Compound dichasium	7.67 ^{ab}	41.57 ^b	82.63 ^{ab}
03	TS2011	Compound dichasium	7.40 ^{bc}	38.27 ^b	30.37 ^d
04	CLN2011	Compound dichasium	7.12 ^{bc}	45.98 ^b	51.13 ^{cd}
05	TN52	Compound dichasium	7.31 ^{bc}	41.07 ^b	89.17 ^a
06	TN561	Compound dichasium	6.45 ^c	46.80 ^b	55.27 ^{bcd}
LSD _{0.05}			1.09	13.88	30.23

^{a, b, c} Different letters in each columns indicate significantly different means (Duncan's test, $P < 0.05$).

the winter (rabi) season of 2011 and found that the best on the basic of plant height was 83.67 cm.

Number of nodes to first flower was significantly different between CT2011 and TN561 and expressed narrow variation. CT2011 had the highest number of nodes (11.80 nodes), whereas TN561 had the lowest number of node (8.47 nodes). There was significant difference in height from foot to first flower among F1 hybrid tomato lines. CW2011 had the longest (64.67 cm), and the shortest was observed in TN561 (39.80 cm). Leaves of CW2011 were the longest (44.84 cm), and the shortest one was control TN561 (37.27 cm). There was no significant difference about leaf width among F1 tomato hybrids lines. It ranged from 27.96 cm to 33.27 cm (Table 2).

3.2 Flowering Ability

Inflorescence type of all tomato lines was compound dichasium (Table 3). Significant differences were detected in number of flowers per

bunch among F1 tomato hybrid lines. It ranged from 6.45 to 8.61 flowers per bunch. The highest number of flowers was found in CT2011 (8.61 flowers) and significantly different from the others, except CW2011 (7.67 flowers). The number of flowers of control TN561 was observed to be the lowest (6.45 flowers), followed by CLN2011, TN52 and TS2011 hybrids with 7.12, 7.31 and 7.40 flowers, respectively. The highest fruiting rate was observed in CT2011 (82.87%) and obviously different significance from the remains. Percentage of fruiting of TN561 was 46.80%, which was similar to CLN2011 (45.98%). The lowest percentage of fruiting was observed in TS2011 (38.27%). The analyzed data showed large variation on number of seeds. TN52 revealed the highest number of seeds per fruit (89.17 seeds), next were CW2011 (82.63 seeds) and CT2011 (78.87 seeds). Number of seeds per fruit of the remains ranged from 30.37 seeds to 55.27 seeds.

3.3 Fruit Morphological and Qualitative Characteristics

The morphological characteristics were described by one time observation and recorded in Table 4. Almost fruits of the F1 hybrid tomato lines had medium firmness, excepted for CT2011, which had soft fruits. Color of fruit shoulder changed from light green to dark green among F1 hybrids tomato lines. Fruits of CW2011, TS2011 and TN52 had light green shoulder before ripening. Dark green was observed in TN561. Fruits of CT2011 and CLN2011 had green shoulder. At maturity stage, all of F1 hybrid tomato lines revealed red fruit color. However, fruit flesh color was different between lines. Red color was observed in CT2011 and CLN2011, whereas orange-yellow was in CW2011, TS2011 and TN52. Fruit of TN561 had pink fruit flesh. The fruit shape is dependent on genetic and may distinguish between varieties. Recorded data described four type of fruit bottom shape, such as flat, point, pointless and depress. TN52 and TN561 had depressed fruit bottom, whereas CT2011 and CLN2011 had flat fruit bottom. Fruit bottom was pointed in CW2011 and pointed less in

TS2011. Wetness of flesh and firmness of fruit are related. Only CT2011 obtained soft fruit, because it had wet flesh. Therewith, fruits of TS2011 and TN52 had wet flesh. Mild dry was found in the remains. Tasty of fruits of CT2011 was mild sour, and sour in TS2011, CLN2011 and TN52. Tasteless was found in CW2011 and TN561.

Fruit quality was described by parameters, including diameter, length, pericarp thickness, number of locules and Brix, as presented in Table 5. There was significant difference in fruit diameter among F1 tomato hybrid lines. TS2011 had the widest fruit (5.53 cm), followed by CLN2011 (5.47 cm), TN52 (5.44 cm) and TN561 (5.19 cm). The smallest fruit width was observed in CT2011 (2.84 cm). While Singh et al. [7] had reported that the tomato hybrid (*Lycopersicon esculentum* Mill.) line that well adapted in Allahabad agro-climatic conditions during the winter (rabi) season of 2011 had fruit diameter 6.47-6.65 cm (polar and radial), Farooq et al. [8] had reported that fruit diameter of tomato hybrid line ranged from 5.49 cm to 7.89 cm. Thus, significant differences in fruit diameter were observed in this study and previous studies [8, 9].

Table 4 Fruit morphological traits.

No.	Hybrid	Firmness	Color of fruit shoulder	Fruit color at maturity	Fruit flesh color	Shape of bottom fruit	Wetness (flesh)	Tasty
01	CT2011	Soft	Green	Red	Red	Flat	Wet	Mild sour
02	CW2011	Medium	Light green	Red	Orange-yellow	Point	Mild dry	Tasteless
03	TS2011	Medium	Light green	Red	Orange-yellow	Point less	Wet	Sour
04	CLN2011	Medium	Green	Red	Red	Flat	Mild dry	Sour
05	TN52	Medium	Light green	Red	Orange-yellow	Depress	Wet	Sour
06	TN561	Medium	Dark green	Red	Pink	Depress	Mild dry	Tasteless

Table 5 Fruit qualitative characteristics.

No.	Hybrid	Fruit diameter (cm)	Fruit length (cm)	Fruit firmness (mm)	No. of locules (locular)	Brix
01	CT2011	2.84 ^c	2.57 ^c	3.00 ^c	2.40 ^d	4.97 ^a
02	CW2011	5.09 ^b	4.89 ^b	4.73 ^b	4.43 ^a	2.95 ^d
03	TS2011	5.53 ^a	5.27 ^a	6.02 ^a	3.90 ^{abc}	3.35 ^{bc}
04	CLN2011	5.47 ^{ab}	5.11 ^{ab}	6.12 ^a	4.43 ^a	3.18 ^{cd}
05	TN52	5.44 ^{ab}	5.22 ^a	5.99 ^a	3.60 ^{bc}	3.45 ^{bc}
06	TN561	5.19 ^{ab}	5.06 ^{ab}	6.25 ^a	3.23 ^c	3.51 ^b
LSD _{0.05}		0.41	0.27	0.71	0.81	0.27

a, b, c Different letters in each columns indicate significantly different means (Duncan's test, $P < 0.05$).

Fruit length had wide variation among tomato lines ranged from 2.57 cm to 5.27 cm. TS2011 produced the longest fruit length (5.27 cm) and CT2011 had the shortest fruit length (2.57 cm). Fruit length of CLN2011, TN52 and TN561 lines were alike by 5.11, 5.22 and 5.06 cm, respectively.

Fruit firmness varies significantly among the hybrids. Fruit firmness of CT2011 was the lowest (3.00 mm), next was CW2011 (4.73 mm) and they are significantly different from the others. The fruit firmness of the remains ranged from 5.99 mm to 6.25 mm. The fruit firmness in this study was higher than those in study of Farooq et al. [8], similar to fruit firmness of Chaudhry et al. [10] and correlated with the studies of Kanno and Kanno [11] and Hall [12] who also observed significant differences in fruit firmness in different cultivars of tomato.

A significant difference was observed among tomato hybrids for number of locules. Number of locules showed wide variation from 2.40 locules to 4.43 locules. CW2011 and CLN2011 had the highest number of locules (4.43), whereas CT2011 had the lowest number of locules (2.40). The result in this study is similar with those in study of Farooq et al. [8] and correlated with the study of Kartoffel [13] who obtained varied number of locules in different tomato cultivars.

There was significant difference in Brix among F1 tomato hybrid lines. The results indicated the highest Brix was found in CT2011 (4.97) and significantly different from the others. The lowest Brix was observed in CW2011 (2.95).

3.4 Yield Components and Yield

Yield and yield components of pepper were influenced by conditions of growth and cultivation, and potential of cultivar. Fruit weight and number of fruits per plant are relevant components to use as selection criteria for improving pepper yield. Fruits of almost F1 hybrid tomato lines were obviously different (Table 6). Fruits of CT201 were the smallest (16.47 g), which is belonged to cherry tomato. The remains ranged from 74.41 g to 90.1 g, which are belonged to processing tomato. TN561 had the biggest fruits (90.10 g), next was TN52 (87.64 g) and TS2011 (82.96 g). Chaudhry et al. [14] evaluated 10 tomato hybrids under plastic tunnel. The maximum fruit weight of 167.11 g was observed in Carmello. Chaudhry et al. [15] evaluated six indeterminate tomato hybrids under plastic tunnel, and Carmello gave the highest fruit weight of 163.33 g. Farooq et al. [8] had evaluated 17 tomato hybrids under plastic tunnel and got the result that the maximum individual fruit weight of 170.63 g was recorded in NTT-05-08. Singh et al. [7] had reported that fruit weight of the tomato hybrid (*Lycopersicon esculentum* Mill.) line which was well adapted in Allahabad agro-climatic conditions during the winter (rabi) season of 2011 was 72.27 g. The fruit weight of tomato hybrid line in this study is similar with previous studies.

There was significant difference in number of fruit per plant between CT2011 and the others. Only cherry type tomato hybrid CT2011 produced the highest number of fruits per plant (82.87 fruits), whereas the

Table 6 Yield and yield components.

No.	Hybrid	Fruit weigh (g)	No. of fruit per plant	Yield (ton/ha)
01	CT2011	16.47 ^e	82.87 ^a	70.91 ^{ab}
02	CW2011	74.41 ^d	41.57 ^b	39.03 ^{bc}
03	TS2011	82.96 ^c	38.27 ^b	38.39 ^{bc}
04	CLN2011	75.09 ^d	45.97 ^b	22.67 ^c
05	TN52	87.64 ^b	41.07 ^b	80.69 ^a
06	TN561	90.10 ^a	46.80 ^b	40.95 ^{bc}
LSD _{0.05}		2.40	13.88	36.92

^{a-e} Different letters in each columns indicate significantly different means (Duncan's test, $P < 0.05$).

Table 7 Level of damage by diseases and insect.

No.	Hybrids	Percentage of wilted plant by bacteria wilt disease (%)	Index of late blight disease (%)	Percentage of harmed fruit by fruitworm (%)
01	CT2011	20.00 ^a	25.33 ^b	48.00 ^a
02	CW2011	6.67 ^{ab}	26.67 ^b	6.67 ^b
03	TS2011	0.00 ^b	18.67 ^b	9.33 ^b
04	CLN2011	6.67 ^{ab}	29.33 ^b	20.67 ^b
05	TN52	20.00 ^a	78.67 ^a	18.67 ^b
06	TN561	20.00 ^a	72.00 ^a	56.67 ^a
LSD _{0.05}		18.75	16.09	22.91

^{a, b} Different letters in each columns indicate significantly different means (Duncan's test, $P < 0.05$).

remains had number of fruit per plant ranged from 38.27 to 46.80. Chaudhry et al. [16] evaluated 12 indeterminate tomato hybrids and reported that cherry hybrid gave significantly higher number of fruits per plant. While Singh et al. [7] had reported that the tomato hybrid (*Lycopersicon esculentum* Mill.) line that well adapted in Allahabad agro-climatic conditions during the winter (rabi) season of 2011 had 22 of fruits per plant, Farooq et al. [8] reported that fruit number of tomato hybrid ranged from 11.75 to 30.26. Thus, fruit number in this study is in agreement with previous studies.

TN52 had the highest yield (80.69 tons/ha), followed by CT2011 (70.91 tons/ha). Yield of the remains ranged from 22.67 tons/ha to 40.95 tons/ha, and were statistically at par with each other. CLN2011 produced the lowest actual yield (22.67 tons/ha), followed by TS2011 (38.39 tons/ha). Thus, among processing tomato type, control hybrid variety TN52 have the highest yield (80.69 tons/ha), followed by control TN561 (40.95 tons/ha), but there is no significant difference with the rest of hybrid tomato lines. Farooq et al. [8] have evaluated 17 tomato hybrids which had yield ranging from 34.75 tons/ha to 71.85 tons/ha. It is thus concluded that CT2011 had high yield, good quality and should be grown under local condition for cherry tomato.

3.5 Pest Situation

All of four new F1 hybrid tomato lines had high resistant level to bacteria wilt and late blight disease. Bacterial wilt caused by *Ralstonia solanacearum* is

one of the most damaging soilborne diseases of many important crops worldwide. The results in Table 7 showed that almost F1 hybrid tomato lines were affected slightly by bacteria wilt disease, except for TS2011. CT2011, TN52 and TN561 had 20% of infected plants, whereas CW2011 and CLN2011 had 6.67% of infected plants. The winter-spring season is considered as appropriate environmental conditions (temperature, humidity, sun...) for late blight (*Phytophthora infestans*) development. Late blight disease was observed in all of F1 tomato hybrid lines. Index of late blight disease ranged from 18.67% to 78.67%. TN52 and TN561 had the highest susceptible level to late blight, up to 78.67% and 72.00%, respectively. The remains were infected at low level as 29.33% in CLN2011, 26.67% in CW2011 and 25.33% in CT2011. Fruitworm (*Helicoverpa zea*) damages tomato at fruiting development stages. Percentage of harmed fruit by fruitworm ranged from 6.67% to 56.67% among F1 tomato hybrid lines. Of these, TN561 had the highest damaged level (56.67%), followed by CT2011 (48%).

4. Conclusions

All F1 tomato hybrid lines grew well under Thua Thien Hue conditions. CT2011, TS2011 and TN561 lines were considered as displaying good growth and development ability. Fruits of TS2011, CLN2011 and TN52 lines were suit for transporting and process. CT2011 is a cherry tomato, which had small fruit and high Brix, and good for fresh food and decoration. TS2011 had higher predicted yield than TN52 and

TN561. CT2011 produced higher actual yield than TN561. Almost new F1 hybrid tomato lines had high resistant level to bacteria wilt and late blight diseases. The F1 tomato hybrid lines gave good characteristics and should be designed in next experiments in different seasons and ecological areas to assess their potentiality to complete crop structure.

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