

RESPONSE OF GROWTH AND YIELD CHARACTERS OF TOMATO (*Solanum lycopersicum* L.) VARIETIES TO SEASONS IN GREENHOUSE CONDITION IN LAM DONG PROVINCE

Mai Hai Chau¹, Ngo Xuan Chinh²

¹Vietnam National University of Forestry

²Institute of Agricultural Science for Southern Vietnam

SUMMARY

Field experiments were conducted at Lien Nghia Town, Duc Trong district, Lam Dong province to investigate the performance of tomato (*Solanum lycopersicum* L.) varieties during rainy and dry seasons in greenhouse condition. The experiment was set up as one - way factorial design (Randomized Complete Block Design), including 4 different varieties (Lahay 344, Labell, Clay and Anna) with 3 replications spreading over two seasons: rainy season from March to October 2018 and dry season from October 2018 to April 2019. The results showed that the variety and season significantly ($P < 0.01$) effects on yield characteristics (individual fruit yield, fruit yield and marketable fruit yield) during the year of the experiments. Two varieties of Lahay 344 and Labell gave the highest quality and productivity in all varieties participating experiments, accounting for 205.51 tons per ha and 222.33 tons per ha, respectively. The Anna variety produced lowest yield in both seasons. However, the Lahay 344 gave the best choice for tomato's production in greenhouse condition based on their properties such as large fruit weight and stable quality during the crop, hard peduncle, less disease, flattened fruit shape, nice color and adapting to climate and cultivated conditions in Duc Trong district, Lam Dong province.

Keywords: fruit quality, fruit yield, greenhouse condition, tomato varieties.

1. INTRODUCTION

The tomato (*Solanum lycopersicum* L.) is one of the most popular, nutritious, and palatable vegetables in the world (Martin, 2013; Padayachee et al., 2017; Sturm and An, 2014; Chau and Chinh, 2021). It helps in supplying a varying commixture of nutrients that are necessary for human health and nutrition (Ilahy et al., 2016). In addition, tomatoes are rich in lycopene, which could improve the endothelial function of cardiovascular disease patients and reduce the risks of prostate cancer and possibly several other cancers (Zhang et al., 2015). In recent years, the tomato has been one of the main vegetable crops grown in greenhouses in Vietnam, because it offers a lot of health benefits for consumers and has a high potential profitability. The fruit yield of tomatoes depends heavily on biological factors and environmental conditions (D'Esposito et al., 2017; Raza et al., 2017). Amongst biological factors and environmental conditions, varieties and season

are two major factors affecting the vegetative growth and the reproductive phase of tomatoes. Therefore, optimum variety and season strategies can significantly enhance fruit yields.

Lam Dong is the province with the largest tomato growing area, accounting for 1/3 of the country's area (7,000 - 8,000 ha). On the other hand, Lam Dong has the advantage of climate, which is very suitable for tomato plants to grow and develop all year round. However, farming in Lam Dong has not been able to promote its strengths for tomato plants to develop into a key commodity because farmers mainly cultivate tomatoes by traditional methods, planting outdoors, using low-yield varieties, so the yield and quality are not high.

The objectives of the present study were to evaluate the effects of different varieties on greenhouse-grown tomatoes in terms of (1) the growth, (2) the fruit yield and (3) fruit quality at Lam Dong province, Vietnam.

2. RESEARCH METHODOLOGY

Site Description

The field experiment were conducted in greenhouse condition at Duc Trong district, Lam Dong province, Vietnam ($11^{\circ}41'50''$ N , $108^{\circ}18'58''$ E , altitude of 1400 m above the sea level) from March 2018 to April 2019. Te atmospheric pressure, temperature, light and photosynthetically active radiation (PAR), relative humidity and solar radiation inside the greenhouse were recorded using an automatic weather station (HOBO event logger, USA), which was located in the centre of the greenhouse. The greenhouse was oriented east-west, with an area of 500 m² (4 treatments, 3 replications, 24 m² per spot). The soil in the solar greenhouse had a heavy loam texture, according to the USDA texture classification system, and was derived from loess with a deep and even soil profile. Two rows of tomato plants were transplanted on the bed top. Furrow-film mulch was cultivated using the local traditional planting patterns and calendars using tomato ridging in a tube with a two-line layout.

Experimental Design

The experiment was set up as one - way factorial design (Randomized Complete Block Design), including 4 different varieties (Lahay 344, Labell, Clay and Anna) with 3 replications spreading over two seasons: rainy season from March to October 2018 and dry season from October 2018 to April 2019. Each treatment plot received the same rates of cow dung (40 tons ha⁻¹) and lime powder (1 ton ha⁻¹) being applied before plantation. The 782 kg of urea (N 46.4%), 909 kg of superphosphate (P₂O₅ 44%), and 688 kg of potassium sulphate (K₂O 50%) were used for the fertilization. The whole fertilizer was divided into 5 applications, which the first application was at 15 days after transplanting (DAT) (10%), the second 25 DAT (10%), the 3th 35 DAT (10%), the 4th 45 DAT (15%), and the last (55%) throughout the harvest period (7 days per time). The drip line

consisted of an inserted cylinder head, a drip irrigation pipe with an inner diameter of 8 mm, a drop head span of 45 cm, a head ow of 1.38 L h⁻¹, and a drip irrigation operating pressure of 0.3 Mpa.

Tomato varieties are planted in two rows/plot, 100 plants/plot (24 m²/plot), spacing of 60 x 40 cm, double row planting, corresponding to density 25,000 trees/ha. Varieties were grafted with Vimina 1 tomato root to prevent bacterial wilt disease 12 days before planting.

Growth, yield and yield components

Parameters measured for physiological characteristics of tomato was germination rate (%), seedling height (cm), plant height (cm), flowering days and harvesting days. The following yield components analysis were determined: (i) fruit set (%); (ii) average fruit weight (g); (iii) number of fruit per plant; (iv) individual fruit yield (kg per plant); (v) fruit yield (tons per ha); and (vi) marketable fruit yield (ton per ha). The parameters of growth and yield of tomato was recorded by an average of over five random plants per experimental plot of three replicates.

Measurement of fruit quality

The fruit quality was measured during the third fruit enlargement period. For each measurement, five fruits of similar size and maturity and with no external defects were chosen from each plot. The brix content was measured using a digital refractometer (Link Co. Ltd., Taiwan).

Statistical analysis

An analysis of variance was conducted on the parameters of growth and yield components such as plant height, average fruit weight, number of fruit per plant, individual fruit yield, fruit yield, marketabel fruit yield and Brix content using a one-way analysis of variance (GLM procedure in SAS version 9.2, SAS Institute Ltd., North Carolina, USA). Tukey's HSD multiple range test results were considered signifcant at $p < 0.05$ and $p < 0.01$.

3. RESULT AND DISCUSSION

Response of growth characteristics to tomato varieties and seasons in the nursery stage

The effects of tomato varieties on germination rate (GR) and seedling height (SH) in the two consecutive growing seasons of the experiment are summarized in Table 1. The results of Table 1 showed that the germination rate (GR) between varieties was different. Lahay 344 and Labell varieties had the highest GR (99 - 100%) in both seasons, followed by Clay with the GR (92.5 - 94.4%), Anna had the lowest GR (85.8 – 87.2%). All of varieties have good GR (over 80%) after 3 days of sowing. There was no difference in the

growth ability of four tomato varieties in the rainy season and the dry season in the nursery period from 3 to 22 days after sowing (DAS). At the 22 DAS, the varieties had average seedling height (SH) from 17 to 18 cm.

The results showed that the mean plant height of tomato varieties growing in two seasons increased with time, but this increasing was not significant differences ($P < 0.05$) between the treatment groups from 60 – 180 days after transplanting (DAT). The Lahay 334 variety gave the highest average height (442.8; 479.1 cm), followed by the Labell and Clay varieties, the last was Anna variety (414.1; 404.1 cm) in both seasons, respectively (Table 2).

Table 1. Effect of varieties and seasons on growth of tomato in the nursery stage

Varieties	GR (%)		SH (cm)	
	Dry	Rainy	Dry	Rainy
Lahay 344	99	100	18	18
Labell	100	100	18	18
Clay	92.5	94.4	18	18
Anna	85.8	87.2	17	18

Response of growth characteristics to tomato varieties and seasons in greenhouse condition

The experiments showed that the leaf set, internode length and fruit cluster of tomato varieties were different and had a great influence on the cultivation process in the greenhouse. The Anna, Clay has thin leaves and weak stems (Chinh NX and Vinh QV, 2008), so when growing in greenhouse, it is

necessary to hang the wire and clamp the stem earlier than Lahay 344 or Labell from 3-4 days. In particular, the Labell variety has a wide and thick leaf blade, but the fruit stalk was very weak, so it was often broken down (Mai Hai Chau and Ngo Xuan Chinh, 2021), affecting the growth of the fruit or having to use a belt to hang the fruit. One of varieties, Lahay 344 showed superiority when grown in greenhouses compared to the other varieties.

Table 2. Effect of varieties and seasons on plant height of tomato in greenhouse

DAT	Varieties				CV (%)	P
	Lahay 344	Labell	Clay	Anna		
Rainy season						
30	83.5 a	81.8 ab	78.1 bc	75.3 c	2.9	**
60	128.6	132.1	120.6	119.3	7.6	ns
90	192.2	192.5	181.5	172.1	5.7	ns
120	257.8	258.5	248.3	231.6	5.8	ns
150	347.5	353.8	314.5	289.1	13.2	ns
180	442.8	410.4	429.1	414.1	7.9	ns

DAT	Varieties					CV (%)	P
	Lahay 344	Labell	Clay	Anna			
Dry season							
30	125.6 a	118.2 a	123.4 b	121.9 c	2.4	**	
60	169.2 a	160.5 a	170.4 ab	165.4 b	6.3	*	
90	225.7	219.1	235.3	222.1	5.5	ns	
120	287.8	288.5	278.3	258.3	5.4	ns	
150	347.5	353.8	338.6	315.1	4.7	ns	
180	479.1	437.7	429.1	404.1	8.8	ns	

*In the same average group, the values with the same accompanying characters do not have statistical significance $P < 0.05$; ns: none significant; *significant difference ($p < 0.05$); **significant difference ($p < 0.01$).*

Table 3. Flowering, harvesting days and fruit shape of four varieties of tomato

Varieties	Flowering days		Harvesting days		Fruit shape
	Dry	Rainy	Dry	Rainy	
Lahay 344	27	27	130	130	Flat
Labell	27	27	130	130	Flat
Clay	26	26	112	112	Oval
Anna	25	25	105	105	Oval

The results summarized in Table 3 indicated that treatments were classified to two groups. First group consists of Lahay 344 and Labell varieties which had the same flowering days (27 days) and harvesting days (130 days), the shape of fruit was flat. In contrast, Clay and Anna varieties had a shorter flowering days (25 - 26 days) and harvesting days (105-112 days), the shape of fruit was oval. The data from Table 3 also indicated that season did not affect of parameter of flowering and harvesting days.

Response of yield and yield components to tomato varieties and seasons in greenhouse condition

The results (Table 4) showed that there was not significant difference ($P < 0.05$) in the fruit set rate of tomatoes at different varieties in two seasons. The fruit set ranged from 54.41 to 62.28% in the dry season, from 56.07 to 61.56% in the rainy season. Anna variety has a higher fruit set than other varieties from 3 to 5% and Lahay 344 has the lowest fruit set (54.4%, 56 %) in two seasons, respectively. Comparing with other research results, it was found that when growing in greenhouse, the varieties gave a lower fruit set than outside. In the field, Anna variety gave fruit set of over 70% (Ngo Xuan Chinh, 2008). According to Ngo Quang Vinh (2009), in the US and the Netherlands, growing tomatoes in greenhouses,

farmer often use some methods to increase the fruit set rate for tomatoes by shaking the plants daily in the morning or releasing bees to increase fruit set.

The rate of fruit set is an important criterion to evaluate the yield potential of the variety, which is also a factor that directly affects the individual yield of tomato plants. The results of Table 4 showed that the number of fruit per plant of the four tomato varieties were significantly different ($P < 0.01$) in both the rainy season and the dry season. The Lahay 344 and Labell varieties had the highest number of fruits per plant (over 80 fruits per plant) compared to Clay or Anna variety (over 17 fruits per plant) in both seasons. The number of fruits per plant of Anna variety growing in greenhouses was also higher than outdoors from 10 - 15 fruits per plant (Ngo Xuan Chinh, 2008). In addition, the date research also showed that although the fruit set of Clay and Anna varieties was higher than Lahay 344 and Labell varieties, but the number of fruit per plant was lower than ones in both season. This is because Lahay 344 and Labell varieties have a higher percentage of effective panicles than Clay and Anna varieties. In addition, the harvest time of these varieties was longer than 25 days, which leads to more fruits per plant.

Table 4. Effect of varieties and seasons on fruit set and number of fruit per plant of tomato in greenhouse

Varieties	Fruit set (%)		No. fruit per plant	
	Dry	Rainy	Dry	Rainy
Lahay 344	54.41	56.07	80.22 a	85.70 b
Labell	57.48	59.30	83.78 a	99.93 a
Clay	60.87	60.78	65.56 b	65.52 c
Anna	62.28	61.56	63.22 b	63.89 c
CV (%)	8.81	8.76	4.02	6.39
P	ns	ns	**	**

In the same average group, the values with the same accompanying characters do not have statistical significance $P < 0.05$; ns: none significant; *significant difference ($p < 0.05$); **significant difference ($p < 0.01$).

Table 5. Effect of varieties on average fruit weight and individual fruit yield of tomato in greenhouse

Varieties	Average fruit weight (g)		Individual fruit yield (kg per plant)	
	Rainy	Dry	Rainy	Dry
Lahay 344	107.40 b	114.34 b	8.61 b	9.14 b
Labell	116.41 a	123.74 a	9.75 a	10.40 a
Clay	104.25 bc	104.85 c	6.84 c	6.59 c
Anna	97.71 c	92.32 d	6.18 d	5.82 c
CV (%)	3.50	4.25	3.27	8.67
P	**	**	**	**

In the same average group, the values with the same accompanying characters do not have statistical significance $P < 0.05$; ns: none significant; *significant difference ($p < 0.05$); **significant difference ($p < 0.01$).



Fig 1. Experimental design



Fig 2. Parameters evaluation site



Fig 3. Labell variety



Fig 4. Clay variety



Fig 5. Lahay 344 variety



Fig 6. Anna variety

Similar to the number of fruits per plant, the average fruit weights of the four tomato varieties were significantly different ($P < 0.01$) in the rainy and dry seasons. The Lahay 344, Labell and Clay varieties had an average fruit weight of over 100g per fruit, which was of great commercial significance because the

price and consumption was also better. Labell variety had the highest average fruit weight (116.41; 123.74g) and the lowest was Anna variety (92.32; 97.71g) in both seasons, respectively. However, uniformity in fruit size and color throughout the harvest period was recorded in Lahay 334 variety.

Table 6. Effect of varieties on fruit yield, marketable fruit yield and brix content of tomato in greenhouse

Varieties	Marketable fruit yield (tons per ha)		Fruit yield (tons per ha)		Brix content (%)	
	Rainy	Dry	Rainy	Dry	Rainy	Dry
Lahay 344	205.51 a	198.05 a	215.25	228.50	5.11	5.26
Labell	222.33 a	212.89 a	243.75	260.00	5.16	5.37
Clay	166.77 b	162.97 b	171.00	164.75	5.36	5.24
Anna	142.33 b	147.40 b	154.50	145.50	5.54	5.26
CV (%)	9.91	5.79			3.50	2.53
P	**	**			ns	ns

*In the same average group, the values with the same accompanying characters do not have statistical significance $P < 0.05$; ns: none significant; *significant difference ($p < 0.05$); **significant difference ($p < 0.01$).*

The variety and season effects on yield characteristics (individual fruit yield, fruit yield and marketable fruit yield) during the year of the experiments are summarized in Table 5, 6. The individual treatments of varieties significantly ($P < 0.01$) affected the yield characteristics. Averaging across seasons, the Lahay 334 and Labell increased individual fruit yield by 28.22% and 36.61%, compared to Anna; averaging across varieties, individual fruit yield of Layhay 334 and Labell varieties

in rainy season were higher than dry season, respectively (Table 5).

For marketable fruit yield, there were a significant difference ($P < 0.01$) in four varieties. The Labell variety gave the highest marketable fruit yield (222.33; 212.89 tons per ha), followed by Lahay 334 (205.01; 198.05 tons per ha) and the last Anna (142.33; 147.50 tons per ha) in two seasons, respectively (Table 6). This result was also very consistent with the criteria such as fruit set, number of fruits

per plant and average fruit weight of tomato planted in the rainy season which were higher than in the dry season. The individual yield of Lahay 344 and Labell was different from the other two varieties from 3.0 - 3.5 kg per plant, which was very significant when producing on a large area. According to the research results of Ngo Quang Vinh and Ngo Xuan Chinh (2008), marketable fruit yield of Anna variety growing in the greenhouse was higher than in the field from 2.0-2.5 kg per plant.

The Anna variety produced with 50-60 tons per ha in the field depending on each household (Dao Huy Duc, 2008), but in greenhouse condition, the yield has increased by 3-4 times compared to the outdoor. This showed that tomatoes growing in greenhouses contributes to increasing the yield of tomato varieties significantly, especially for Anna variety. From the results of the selection of tomato varieties grown in greenhouses at Duc Trong district, Lam Dong province, Lahay 344 was the most suitable variety for tomato production in greenhouses, with high yield and adaptability.

The effects of varieties on the brix content in the growing seasons of the experiment are summarized in Table 6. There was no significant difference ($P < 0.05$) between varieties and seasons in relation to brix content (5.11 – 5.54%). According to the literature, when the tomato varieties have medium brix, the tomato fruit was firmer and suitable for the rough transportation conditions like Vietnam.

4. CONCLUSION

The two varieties of Lahay 344 and Labell gave the highest quality and productivity in all varieties, accounting for 205.51 tons/ha and 222.33 tons/ha respectively. However, the Lahay 344 gave the best choice for tomato's production in glasshouse condition based on their properties such as large fruit weight and stable quality during the crop, hard peduncle, less disease, flattened fruit shape, nice color

and adapting to climate and cultivated conditions in Duc Trong district, Lam Dong province.

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ẢNH HƯỞNG CỦA GIỐNG VÀ THỜI VỤ TỚI SINH TRƯỞNG, NĂNG SUẤT VÀ CHẤT LƯỢNG CÀ CHUA TRỒNG TRONG ĐIỀU KIỆN NHÀ MÀNG TẠI LÂM ĐỒNG

Mai Hải Châu¹, Ngô Xuân Chinh²

¹*Trường Đại học Lâm nghiệp*

²*Viện Khoa học kỹ thuật Nông nghiệp miền Nam*

TÓM TẮT

Thí nghiệm được thực hiện tại thị trấn Liên Nghĩa, huyện Đức Trọng, tỉnh Lâm Đồng nhằm đánh giá khả năng sinh trưởng, năng suất và chất lượng của các giống cà chua năng suất cao trồng trong nhà màng, trong điều kiện mùa mưa và mùa khô. Thí nghiệm được bố trí theo kiểu khối đầy đủ ngẫu nhiên, một yếu tố, 3 lần lặp lại với 4 giống (Lahay 344, Labell, Clay và Anna) trong vụ mưa từ tháng 3 đến tháng 10 năm 2018 và mùa khô từ tháng 10 đến tháng 4 năm 2019. Kết quả nghiên cứu cho thấy giống và mùa vụ có ảnh hưởng đến chiều cao và các yếu tố cấu thành năng suất (năng suất cá thể, năng suất thực thu và năng suất kinh tế) của các giống cà chua tham gia thí nghiệm ở cả hai mùa vụ. Giống cà chua Lahay 344 và Labell cho năng suất và chất lượng trong số các giống tham gia thí nghiệm, đạt 205,51 tấn/ha và 222,33 tấn/ha, tương ứng với thí nghiệm trong mùa mưa và mùa khô. Tuy nhiên, giống Lahay 344 là lựa chọn tốt nhất cho sản xuất cà chua trồng trong nhà màng bởi chúng có trọng lượng quả, chất lượng ổn định, cuống cứng, ít bệnh, hình dạng quả đẹp, màu sắc đẹp và thích nghi với điều kiện canh tác tại huyện Đức Trọng, tỉnh Lâm Đồng.

Từ khóa: chất lượng quả, giống cà chua, năng suất quả, trồng trong nhà màng.

Received : 21/10/2021

Revised : 23/11/2021

Accepted : 09/12/2021