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Studies on Environmental Influence and Different Months of Transplanting on Growth, Yield and Quality of Tomato Hybrid COTH 2

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An experiment was conducted at Agricultural College and Research Institute, Madurai, during 2011-12 to study the production potentials of tomato hybrid COTH 2 under naturally ventilated polyhouse and open condition. Observations on biometric and quality traits were made at every month of planting so as to study the environmental influence on growth, yield and quality of tomato. Plants grown under naturally ventilated polyhouse exhibited superior performance in terms of robust growth, early flowering, extended duration, the highest yield and good quality fruits. The tallest plants (187.3 cm) were obtained in October planting in polyhouse as compared to open field condition. Plants grown in polyhouse also exhibited early flowering in 26 days of transplanting. All the other vegetative and reproductive traits *viz.,* number of branches (4.80), number of flowers per plant (39.65), number of fruits per plant (52.4), fruit length (6.20cm), fruit girth (13.83 cm), fruit weight (71.3 g), dry matter production (121.49 g) and fruit yield per plant (3.70 kg/plant) was found to be the highest during the month of October closely followed by September planting in naturally ventilated polyhouse. Whereas in open condition, planting during the months of June, July enhanced biometric characters. The yield was almost tripled under polyhouse condition, as compared to open field planting. The biochemical constituents *viz.,* Ascorbic acid and TSS were found to be influenced by the growing environment.

Key words: Tomato, COTH 2, Naturally ventilated polyhouse, Open, Growth, Yield, Quality

Tomato (*Solanum lycopersicum L.*) is one of the most important vegetable crop in the world. It originated in western South America, and domestication is thought to have occurred in Central America (Sims, 1980). In India, tomato occupies a larger area of 1.204 million ha with an annual production of 19.40 million tonnes (NHB, 2014). Being an important vegetable crop, research on every aspect of its cultivation to improve its productivity becomes essential. The early and higher yield of different vegetable crops inside the polyhouse could be attributed to better microclimate such as higher temperature (4-9°C than the nearby open field) observed during winter months by Cheema *et al*. (2004). Production of vegetables under protected conditions involves protection of production stages of vegetables mainly from adverse environmental conditions such as temperature, high rainfall, hail storms, scorching sun *etc*. Therefore, the polyhouse environment may provide a new scope for commercial production of high value vegetable crops like tomato.

Materials and Methods

An experiment was conducted to study the effect of different months of transplanting on growth, yield and quality of tomato under naturally ventilated polyhouse and open conditions during 2011-12 at College Orchard, Agricultural College and Research Institute, Madurai. The seeds of tomato hybrid COTH2 were collected from the Department of Vegetable Crops, HC&RI, Coimbatore. The experiment was laid out in Factorial Randomized Block Design (FRBD) with three replications. Transplanting of tomato seedlings was taken up during every month. The naturally ventilated polyhouse was provided with drip irrigation facilities. Similar cultural practices were followed for both polyhouse and open field conditions. Observations on vegetative and yield parameters were recorded periodically. The quality traits like TSS (by digital hand refractometer), and ascorbic acid were estimated as per standard procedures (AOAC,1984). The data collected were subjected to statistical analysis as per the standard procedures described by Panse and Sukhatme (1967).

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Results and Discussion

Effect on morphological development

The morphological characters *viz.,* plant height and number of branches were found to be highly influenced by cultivation under naturally ventilated polyhouse condition. The highest plant height (187.3 cm) and increased number of branches (4.80) was observed in polyhouse during October planting, while in open condition, planting during the month of June resulted in tallest plants with increased number of branches. In general, the plants grown under polyhouse were taller than in open field which may

be due to long internodal length and thinner stems of the plants caused due to etiolation effect on the plants. Nagoata *et al.* (1979), obtained greater plant height under 20 and 40 per cent shade as compared to those grown under normal light conditions. Parvej *et al*. (2010) obtained the tallest plants with maximum number of branches per plant, higher leaf area expansion rate and LAI under polyhouse as compared to natural condition (*i.e*. open field). Similar results were observed by Sharma and Tiwari (1993) in tomato and Pankaj *et al.* (2002) in cauliflower.

Table 1: Effect of different months of transplanting on morphological and flowering behavior of tomato hybrid COTH 2 under naturally ventilated polyhouse and open field condition

	Plant height (cm)		No. of branches per plant		Earliness (days)		No. of flower cluster per plant		No. of flowers per cluster		No. of flowers per plant	
	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open
August	169.3	110.3	4.32	2.70	27.50	31.00	10.86	6.97	3.80	2.37	36.45	22.12
September	172.6	98.0	4.70	2.55	29.00	32.00	11.15	7.07	4.07	2.20	39.45	21.56
October	187.3	92.0	4.80	2.75	29.00	33.50	11.17	7.10	4.11	2.48	39.65	23.22
November	185.3	91.3	4.60	2.84	30.00	33.50	11.02	7.17	3.96	2.52	38.21	22.58
December	180.4	115.4	4.53	3.28	30.00	33.50	11.01	8.35	3.86	2.71	37.76	23.83
January	165.4	130.2	4.29	3.33	29.00	32.00	10.76	9.43	3.71	2.81	36.15	24.46
February	152.0	106.4	3.73	3.16	29.00	31.00	10.57	9.28	3.57	2.69	35.27	23.42
March	120.0	88.9	3.67	2.67	29.00	27.50	10.47	8.77	3.52	2.35	35.03	22.06
April	105.0	86.3	3.60	2.51	26.00	27.50	10.41	8.62	3.52	2.16	34.84	20.69
May	130.0	95.2	3.88	3.05	26.00	27.50	10.65	9.21	3.66	2.54	35.71	22.86
June	160.9	127.0	4.52	3.44	27.50	29.00	11.05	9.45	4.00	2.86	38.74	24.52
July	162.0	124.5	4.45	3.30	27.50	29.00	10.98	9.37	3.94	2.81	36.91	24.40

	Plant height (cm)		No. of branches per plant		Earliness (days)		No. of flower clusters per plant		No. of flower per cluster		No. of flowers per plant	
	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)
Factor 1	0.27	0.56	0.00838	0.01686	0.44753	0.90085	0.01961	0.03947	0.01722	0.03467	0.05489	0.11049
Factor 2	0.68	1.37	0.02052	0.04130	0.18270	0.36777	0.04803	0.09668	0.04219	0.08493	0.13446	0.27065
Interaction	0.96	1.94	0.02902	0.05841	0.63290	1.27399	0.06793	0.13673	0.05967	0.12011	0.19015	0.38276

Effect on phenological development

Tomato plants grown inside the polyhouse hastened flowering in 27.50 days as compared to the plants grown in the natural condition. Temperature plays a major role in phenological development and productivity of crop plants. Awal *et al*. (2003) reported that high temperature influences crops to mature earlier. The findings of Ganesan (2002) indicated that the tomatoes grown under polyhouse was observed to be earlier in flowering and fruit setting by about 3 and 8 days, respectively when compared to the crop raised under open condition. Therefore, the polyhouse environment may provide a new scope for commercial production of high value vegetable crops like tomato. Kang and Sidhu (2005) indicated that polyhouse climate influenced the crops to open flower and mature of fruits earlier than open field due to the advancement of required heat unit or thermal time of the crops grown inside the polyhouse. The dry matter production was found to be progressively influenced by the environment. Generally the favourable micro climate inside the polyhouse is conducive for the vigorous growth of the plants in terms of enhanced vegetative and reproductive characters, resulting in high dry matter production. Planting in the month of October, produced plants with increased dry matter (121.49 g/plant) while in open condition, the highest dry matter production (60.62 g) was recorded in June planted population. Similar findings were reported by Thangam and Thamburaj (2008), in tomato with significant increase in dry matter production under shade than in open condition.

Polyhoused plants possessed increased number of flower clusters per plant (11.17), flowers per cluster (4.11), and flowers per plant (39.65) when planting was taken up during the month of October. While in open condition, June month of planting registered increased flower production (Table 1). Parvej *et al*. (2010) reported significantly higher number of flower clusters per plant, flowers per cluster and flowers per plant under polyhouse conditions than those grown

under natural environments in tomato variety BARI Tomato-3.

Effect on reproductive development

The number of fruits per plant (52.4), fruit length (6.20 cm) and diameter (13.83 cm) and individual fruit weight (71.3 g) of tomato crop grown under polyhouse, were significantly higher when planted during the month of October. Likewise the plants grown in open field registered the highest values for fruit characters when planted during the month of June (Table 2). Individual tomato fruits obtained from polyhouse were about 10% bigger than the fruits obtained from the plants grown in open field. Early maturity and extended duration are the characteristic features of crops grown under protected conditions. Pandey *et al*. (2004) acclaimed that total number of fruit harvests was more in polyhouse than in open field. Planting during the month of October produced the highest yield (3.70 kg/ plant). Whereas, in open condition, heaviest plant mortality leading to reduced yield was reported during the months of September, October due to the exposure to maximum number of rainy days (8,7 respectively) and increased amount of rainfall (169.0 and 123.2 mm, respectively) as compared to other months of transplanting. The plants under protective cover were saved from the problem of soil saturation, therefore, in spite of prevailing higher temperature, showed better survival. The tomato plants grown with polyhouse climate produced 26% higher fruit yield than the tomato plants grown in open field conditions. Significantly higher fruit yield in the plants grown under polyhouse condition over the plants grown in open space was associated with the production of higher number of fruits with greater length and diameter than those in the open field. Likewise, the prevalence of high temperatures (38.3^{o}C) during the month April resulted in poor fruit yield (0.47 kg/plant) in polyhouse condition (Table 4). The results are in agreement with Mishra *et al*. (2003) and Kang and Sidhu (2005) although lower amount of available PAR under polyhouse could not affect the growth and yield of tomato as reported by Aberkain *et al*. (2006).

Table 2: Effect of different months of transplanting on fruit characters and yield of tomato hybrid COTH 2 under naturally ventilated polyhouse and open conditions

	No. of fruits per plant		Fruit length (cm)		Fruit girth (cm)		Fruit weight (g)		Dry matter production (g)		Yield per plant (kg)	
	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open
August	47.2	17.6	5.82	3.46	12.73	10.55	70.4	57.4	110.76	51.36	3.34	0.97
September	52.1	16.1	6.18	3.43	13.62	10.34	71.0	44.8	115.76	47.71	3.61	0.85
October	52.4	23.6	6.20	3.56	13.83	10.79	71.3	46.8	121.49	42.80	3.70	1.05
November	50.5	29.6	6.04	3.64	13.25	10.95	68.0	45.2	112.76	41.64	3.42	1.26
December	52.1	37.4	5.92	4.02	12.93	11.44	66.8	61.3	118.90	52.55	3.43	2.12
January	47.5	39.5	5.69	4.15	12.35	11.51	63.5	58.1	106.57	57.49	2.86	2.21
February	26.5	34.5	5.25	3.96	12.43	11.28	46.5	44.6	100.12	50.64	1.10	1.42
March	15.4	17.8	5.08	3.51	12.33	10.46	37.0	35.6	99.67	39.67	0.85	0.57
April	12.4	15.3	4.99	3.35	12.16	10.25	38.0	32.4	97.69	38.28	0.47	0.44
May	43.7	31.5	5.53	3.77	12.59	11.19	40.4	36.4	99.41	42.21	1.90	1.30
June	48.2	37.5	6.00	4.57	13.31	11.95	65.0	63.2	101.64	60.62	3.17	2.26
July	49.0	35.4	6.00	4.47	13.26	11.84	64.9	62.5	105.34	58.59	3.21	2.25

	No. of fruits per plant		Fruit length (cm)		Fruit girth (cm)		Fruit weight (g)		Duration (days)		Dry matter production (g)		Yield per plant (kg)	
	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)	SEd	CD (0.05%)
Factor 1	0.19	0.41	0.03372	0.06787	0.02445	0.04922	0.16	0.32	0.29115	0.58606	0.24719	0.49758	0.03	0.06
Factor 2	0.40	0.88	0.08259	0.16624	0.05990	0.12057	0.39	0.79	0.71316	1.43555	0.60549	1.21882	0.07	0.15
Interaction	0.64	1.28	0.11680	0.23510	0.08470	0.17050	0.55	1.12	1.00856	2.03017	0.85630	1.72367	0.10	0.22

Effect on quality attributes

The quality parameters viz., ascorbic acid and TSS were found to be highly influenced by the environment and season of planting. The results of quality analysis indicated that field-produced fruits possessed greater ascorbic acid (20.81 mg/100 g) compared to fruits produced in a protected environment (18.97 mg/100g) (Table 3). Ascorbic acid biosynthesis can be strongly influenced by environmental conditions, with light intensity affecting the content of ascorbic acid in tomato fruits. The ascorbic acid content of the fruits

analyzed in this work are in agreement with Davies and Hobson (1981), who reported a variation between 10 and 30 mg of ascorbic acid per 100 g of fresh fruit in a protected environment and in the field conditions. Singh et al. (2014) reported that in polyhouse grown tomatoes, the ascorbic acid content ranged from 12.65 - 15.63 mg /100g. Despite not being essential for ascorbic acid synthesis, luminosity may affect its accumulation during the growth of the plant and fruit. Neeraj *et al.,* (2014) obtained significantly high ascorbic acid content in open field (14.50 mg/100g) than in the fruits grown in polyhouse (12.82 mg/100 g). Thus, a low ascorbic acid content of the fruits produced in a protected environment is probably caused by the lower luminosity in that environment, which may have reduced the production of sugar, a substrate that is used in the synthesis of ascorbic acid.

Table 3: Effect of different months of transplanting on quality of tomato hybrid COTH 2 under naturally ventilated polyhouse and open conditions

	Ascorbic acid (mg/100 g)		TSS (°Brix)	
	Polyhouse	Open	Polyhouse	Open
August	19.16	21.00	3.40	3.02
September	19.16	21.00	3.42	3.02
October	19.02	20.84	3.46	3.02
November	18.88	20.54	3.40	3.04
December	18.54	20.25	3.40	3.08
January	18.50	20.25	3.34	3.13
February	18.50	20.32	3.28	3.15
March	18.82	20.74	3.20	3.10
April	19.23	21.12	3.22	3.05
May	19.33	21.25	3.22	3.05
June	19.24	21.24	3.30	3.15
July	19.24	21.12	3.35	3.18

	Ascorbic acid (mg/100 g)		TSS (°Brix)	
	SEd	CD (0.05%)	SEd	CD (0.05%)
Factor 1	0.02062	0.04151	0.02116	0.04260
Factor 2	0.05051	0.10168	0.05184	0.10434
Interaction	0.07144	0.14380	0.07331	0.14756

The results of the present study affirmed that growing tomatoes in polyhouse house conditions, favoured higher TSS content (3.33° brix) than in natural environment (3.08° brix). Total soluble salts in tomato is mostly composed of reducing sugar (Ho and Hewitt, 1986). Purkayastha and Mahanta (2011) reported a TSS content of 3.60 to 5.40°brix under polyhouse conditions. Thus, any factor that alters sucrose synthesis (photosynthetic activity) will affect glucose and fructose accumulation in the fruits, thereby altering the TSS content.

Tomato, a prioritized vegetable in almost all types of preparations of Indian cuisine, is highly season bound in nature causing phenomenal market demand in the off-season and glut in the regular growing season. From the above study, it can be concluded that better growth, yield and quality of tomato can be achieved under polyhouse due to optimum climatic requirements during the months of September, October which positively influenced the morpho-phenological and physiological characters of tomato plants. The naturally ventilated polyhouses are cost effective and highly suitable for tropical regions like Madurai where, summer is the hottest and the monsoon devastating the field grown crops. The optimum temperature accompanied by low relative humidity inside polyhouse hasten early maturity and extended duration, benefitting the growers to produce off-season tomato which fetched premium prices in the market.

Table 4. Weather data for during the year 2012

Month	Rainfall	Rainy days	Temperature		RH	
			Max. (°C)	Min. (°C)	Max	Min
January	Nil	Nil	30.6	20.4	85	50
February	Nil	Nil	32.5	21.3	86	47
March	27.4	1	35.8	23.4	85	40
April	40.8	2	38.3	26.5	83	44
May	33.4	2	37.7	26.2	72	46
June	5.2	1	36.8	24.5	68	40
July	54.8	3	37.7	25.5	71	42
August	61.2	3	36.7	24.5	74	48
September	169.0	8	36.0	24.2	77	46
October	123.2	7	32.8	23.1	87	54
November	27.8	1	32.0	22.0	85	52
December	7.0	1	31.8	21.7	85	53

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