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Effect of date of transplanting, spacing and training systems on plant height and interaction effect in tomato production under protected conditions

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Abstract
The effect of date of transplanting, spacing and training systems on plant height and interaction effect in tomato production under protected condition was studied at the Research Farm of Department of Agricultural Engineering, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during summer season of 2013 and 2014 in two separate experiments inside the naturally ventilated playhouses. In this experiment, treatments comprised of three dates of transplanting (15th March, 30th March and 15th April), two spacing (60 cm x 30 cm and 75 cm x 30 cm) and two training systems (two shoots and three shoots) was laid out in a randomized block design with three replications. With regards to the plant height, number of shoots per plant, the treatment two shoots per plant recorded significantly higher than plants trained to three shoots.

Keywords: Protected cultivation, training systems, ventilated polyhouse, transplanting

Introduction

Although, India has a wide range of diverse agro-climatic conditions, but vegetable cultivation practices have generally been restricted to regional and seasonal needs. In general, protected structures are used to overcome low temperature in temperate regions or high temperature in the countries having tropical climate. There is a lot of potential for increasing the area manifold under low cost greenhouses in peri-urban areas for production of high value low volume vegetables during off-season to take benefit of the high price of the produce (Phookan and Saikia 2003) [1] and to setup the vegetable production and improve its quality.

Tomato is a warm season tropical crop and lacks adaptability to varied environmental conditions. Despite its economic importance, growers are not in a position to produce good quality capsicum with high productivity due to various biotic (pest and diseases), abiotic (rainfall, temperature, relative humidity and light intensity) and crop factors (flower and fruit drop). Due to the behavior of weather, the crops grown in open fields are often exposed to fluctuating levels of temperature, humidity, wind flow *etc*. which ultimately affect the crop productivity adversely (Sanwal *et al.* 2008) [2]. Besides this, limited availability of land for cultivation hampers the vegetable production. Hence to obtain a good quality produce and production during off season, there is a need to cultivate tomato under protected condition such as green houses or polyhouses.

Time of transplanting is one of the important factors as optimum date of transplanting brings about proper growth and development of plants resulting in maximum yield of the crop and economic use of land (Islam *et al.* 2010) [3]. Furthermore, spacing and training also helps in improving the performance as well as yield of the crop.

Materials and Methods

This study "Effect of date of transplanting, spacing and training systems on plant height and interaction effect in tomato production under protected conditions" was conducted at the Research Farm of Department of Agricultural Engineering, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during summer season of 2013 and 2014 in two separate experiments inside the naturally ventilated playhouses. In this experiment, treatments comprised of three dates of transplanting (15th March, 30th March and 15th April), two spacing (60 cm x 30 cm and 75 cm x 30 cm) and two training systems (two shoots and three shoots) was laid out in a randomized block design with three replications.

In this experiment the most promising and high yielding hybrid (Naveen 2000 plus) was grown inside naturally ventilated polyhouse of size 15 m x 7 m (L x B) during the summer

Season of 2013 and 2014. Monthly variation in temperature and relative humidity inside the polyhouse was recorded during the entire period of investigation. Before sowing the crop, a composite soil sample (0-15 cm depth) was taken from the experimental site and important physical and chemical characteristics of the soil were determined by standard methods. Sand, silt and clay at the initiation of the experiment was 29.2, 36.1 and 34.5% respectively. The soil texture was silty clay loam. Soil pH and organic matter during 2013 was 5.6 and 0.7 per cent and in 2014 was 5.8 and 0.8, respectively. During 2013, available N, P and K were 263.2, 16.4 and 219.3 kg ha^{-1}. In the next year (2014) the nutrient status of available N, P and K were 275.2, 19.2 and 228.2 kg ha^{-1}.

The seeds of Naveen 2000 plus was sown in plastic plug trays by using soilless media having cocopeat, perlite and vermiculite in the ratio of 3:1:1, respectively inside the naturally ventilated polyhouse to get healthy and disease free seedlings of tomato. 25-35 days old seedlings were transplanted inside the naturally ventilated polyhouse equipped with drip irrigation system on different dates.

Table 1: Date of nursery sowing and transplanting of seedlings in the year 2013 and 2014

Number of transplanting	Date of sowing of nursery		Date of transplanting		Seedling age (days)	
	2013	2014	2013	2014	2013	2014
D_1	10th February	8th February	15th March	15th March	33	35
D_2	1st March	2nd March	30th March	30th March	30	28
D_3	18th March	17th March	15th April	15th April	25	26

Before transplanting, beds were prepared. These beds were thoroughly sterilized with 4 per cent formalin (1 litre of 40 per cent commercial formalin in 7 litre of water). Beds were covered with black polyethylene sheet for 7 days after formalin application. Then polyethylene sheet was removed and soil raked well for a week in order to remove the fumes of formalin.

The basal dose of N, P and K @ 100 kg ha^{-1} from straight fertilizers was applied in the form of urea (21.5 g m^{-2}), single super phosphate (62.5 g m^{-2}) and muriate of potash (16.5 g m^{-2}). Remaining dose of 150:150:150 kg ha^{-1} NPK was applied with water soluble fertilizer (polyfeed 19:19:19) starting from 3rd week after transplanting and up to 15 days prior to final harvest. Fertigation was done twice a week. The plants were irrigated daily with drip irrigation system, one dripper was provided for each plant. Plants were watered regularly before 12 noon or late evening. Other cultural practices and standard plant protection measures were also adopted from time to time to ensure healthy crop stand.

After one month of transplanting, the lateral shoots were pinched out (pruned) at their emergence and two healthy lateral shoots preferably at first node of the plants to obtain double shoot plants. Two healthy lateral shoots preferably at first and second node of the plants were retained to obtain triple shoot plants.

Plant height

Five plants were selected randomly from each plot and tagged. Height of these tagged plants was recorded from the ground level up to top most leaf tip at 30, 60, 90 and 120 days after transplanting and at final harvest. The average of these was taken as mean plant height.

Results and Discussions

Plant height (cm)

The plant height under three dates of transplanting was significantly different from each other. In general, the increase in plant height was rapid up to 120 days after transplanting, thereafter the elongation rate of the plant declined suddenly thus giving a sigmoid nature of the curve.

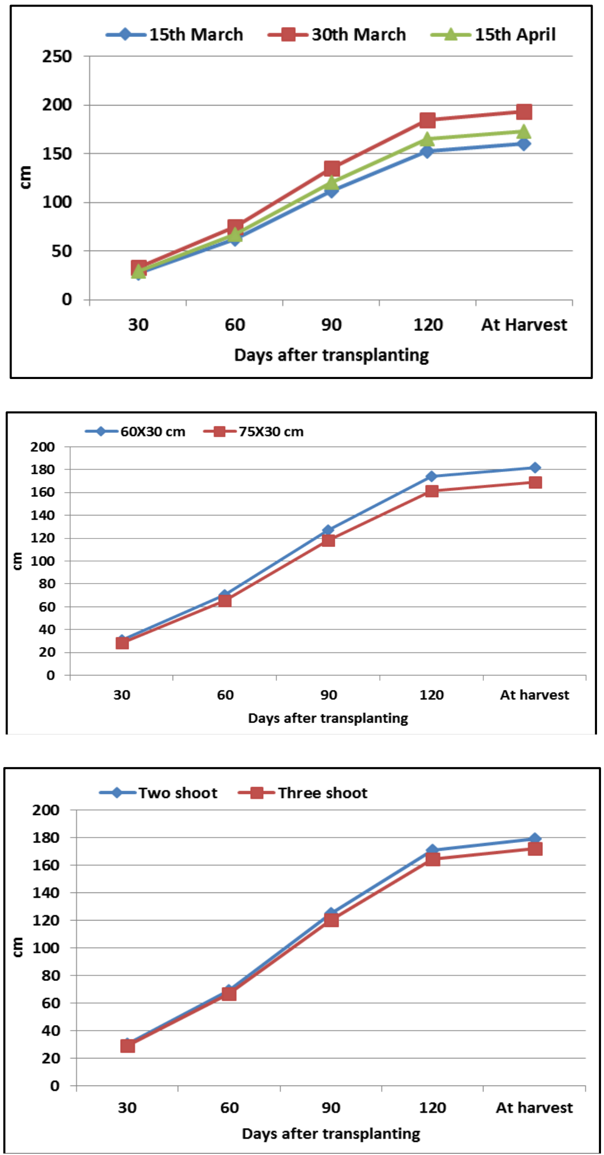

Fig 1: Plant height (cm) as influenced by different treatments at different growth stages (2013)

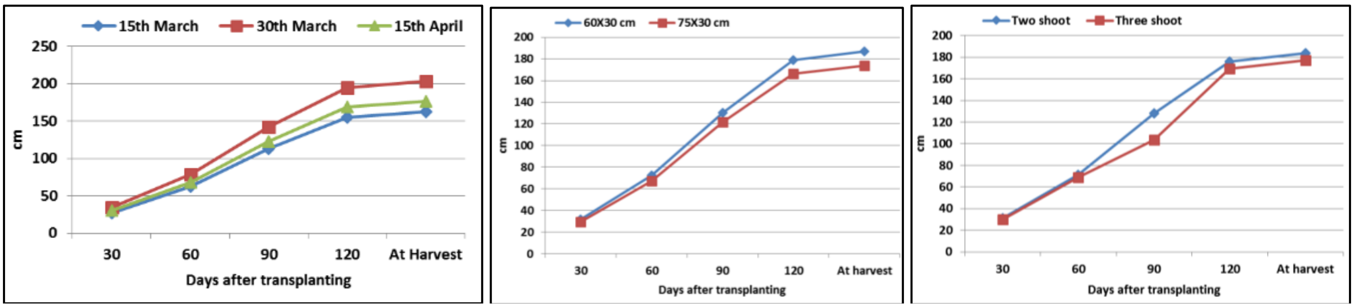

Fig 2: Plant height (cm) as influenced by different treatments at different growth stages (2014)

Table 2: Plant height (cm) as influenced by different treatments at different growth stages

Treatment	Plant height (cm)									
	2013					2014				
	30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
Date of transplanting										
15th March	27.2	62.0	111.6	152.9	160.0	27.5	62.8	113.0	154.8	162.2
30th March	32.9	75.0	134.9	184.9	193.4	34.6	78.8	141.9	194.4	203.4
15th April	29.5	67.2	120.9	165.7	173.3	30.0	68.3	123.0	168.5	176.3
SEm±	0.1	0.3	0.6	0.8	0.9	0.1	0.3	0.6	0.8	0.9
CD (P=0.05)	0.4	1.0	1.8	2.4	2.5	0.4	1.0	1.8	2.4	2.5
Spacing										
60 cm X 30 cm	31.0	70.6	127.1	174.1	182.1	31.8	72.5	130.5	178.8	187.1
75 cm X 30 cm	28.7	65.5	117.9	161.6	169.1	29.6	67.5	121.4	166.4	174.1
SEm±	0.1	0.3	0.5	0.7	0.7	0.1	0.3	0.5	0.7	0.7
CD (P=0.05)	0.4	0.8	1.4	2.0	2.1	0.4	0.8	1.4	2.0	2.1
Training systems										
Two shoot	30.4	69.4	124.8	171.0	178.9	31.3	71.3	128.3	175.8	183.9
Three shoot	29.3	66.8	120.2	164.6	172.2	30.1	68.7	103.6	169.4	177.2
SEm±	0.1	0.3	0.5	0.7	0.7	0.1	0.3	0.5	0.7	0.7
CD (P=0.05)	0.4	0.8	1.4	2.0	2.1	0.4	0.8	1.4	2.0	2.1

Transplanting on 30th March recorded significantly taller plants than transplanting on 15th March and 15th April in both the crop seasons, which may be ascribed to the fact that plant growth occurred in suitable temperature range which might have attributed to the enhanced plant metabolic activities like photosynthesis due to favorable weather conditions. Ahammad *et al.* (2009) [4] have also suggested the optimum temperature range for tomato to be between 18-25^{0}C as the temperature range is lower; growth is more than the flower development. Plant height in early (15th March) and late (15th April) transplanted crop was affected by low (< 18^{0}C) and high temperature (>30^{0}C) prevalent in the early stages of the vegetative growth, respectively, which led to the reduction in plant height.

The plant height increased significantly with decrease in plant spacing. Plant spacing of 60 cm x 30 cm produced significantly taller plants (182.1 and 187.1 cm in 2013 and 2014, respectively) than plants spaced at 75 cm x 30 cm. This might be due to the greater competition for space and light, thereby forcing the plants to grow taller. The short and stout plants were produced at wider spacing because of availability of more growth space. Similar observations were also reported by Raghav (2000) [5] and Kumar (2001) [6].

Training systems also had significant influence on plant height. Plants trained to two shoots produced significantly taller plants (178.9 in 2013 and 183.9 cm in 2014) than plants trained to three shoots. The increase in plant height due to training to two shoot over three shoot plants was to the tune of 3.89 per cent in 2013 and 3.78 per cent in 2014 at final harvest. This increase in plant height may be due to training of side branches causing flow of nutrients to the axillary branches might have reduced which in turn lead to flow to the apical tissues leading to elongation of shoot. Similar findings were also reported by Razzak *et al.* (2013) [7].

Plants spaced at 60 cm x 30 cm and transplanted on 30th March produced significantly taller plants than other treatment combinations in both the years. Crop transplanted on 15th March and spaced at 75 cm x 30 cm produced significantly shorter plants.

Tomato plants transplanted on 30th March and plants trained to two shoots produced significantly taller plants than other treatment combinations of date of transplanting and training systems. 15th April transplanting and three shoot trained plants without differing with the two shoot trained plants and transplanted on 15th April produced significantly smaller plants. Similar trend was observed in both the years.

Table 3: Interaction effect of date of transplanting and spacing on plant height at harvest

Date of transplanting	Year			
	2013		2014	
	60 cm x 30 cm	75 cm x 30 cm	60 cm x 30 cm	75 cm x 30 cm
15th March	164.5	155.5	166.5	157.5
30th March	203.7	183.2	213.7	193.2
15th April	178.3	168.5	181.2	171.5
Date of transplanting x spacing	SEm ± 1.2 CD (P=0.05) =3.6		SEm ± 1.2 CD (P=0.05) = 3.6	

Table 4: Interaction effect of date of transplanting and training system on plant height at harvest

Date of transplanting	Year			
	2013		2014	
	Two shoot	Three shoot	Two shoot	Three shoot
15th March	163.7	156.3	165.7	158.3
30th March	198.3	188.5	208.3	198.5
15th April	174.8	171.8	177.8	174.8
Date of transplanting x spacing	SEm + 1.2 CD (P=0.05) =3.6		SEm + 1.2 CD (P=0.05) = 3.6	

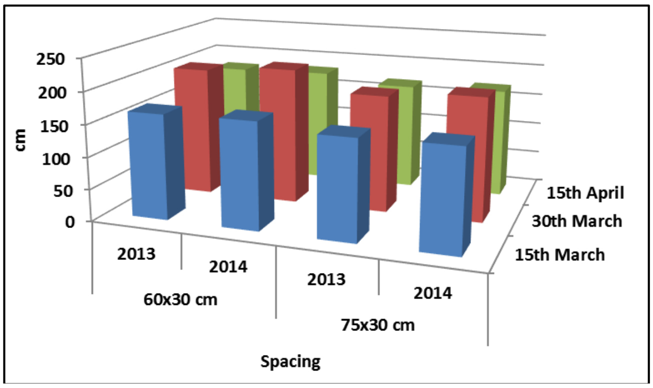

Fig 3: Interaction effect of date of transplanting and spacing of plant height at harvest

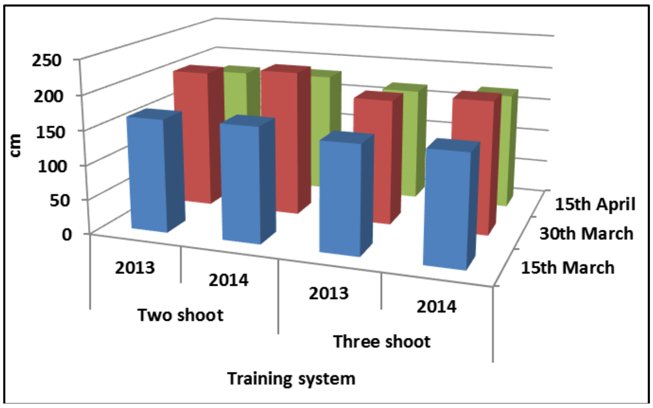

Fig 4: Interaction effect of date of transplanting and training system of plant height

Conclusions

- Transplanting on 30th March recorded significantly taller plants than transplanting on 15th March and 15th April in both the crop seasons. Plant spacing of 60 cm x 30 cm produced significantly taller plants than plants spaced at 75 cm x 30 cm. Plants trained to two shoots produced significantly taller plants than plants trained to three shoots.
- 30th March transplanted and plants spaced at 60 cm x 30 cm produced significantly taller plants than other treatment combinations in both the years whereas 30th March transplanted and two shoots trained plants recorded significantly taller plants in both the years than other treatment combination.

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