J. Hortl. Sci.
Vol. 8(1):99-102, 2013

Short communication

Effect of age of transplants on fruit and seed yield of tomato (*Solanum lycopersicum* L.)

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ABSTRACT

Tomato is a major cash crop of the mid-hill regions of Himachal Pradesh. Among various factors that affect its growth and yield, age of the transplant - an important factor - is generally ignored by farmers. Therefore, the present investigation was undertaken at Vegetable Research Farm, Department of Vegetable Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, during the summer of 2008 and 2009 to ascertain optimum age of transplants for maximizing fruit and seed yield in tomato var. Solan Vajr. The experiment was laid out in RBD, with 3 replications. Age of the transplant starting with 15 days, and with subsequent gaps of 3 days each (upto 42 days, i.e., 10 stages) comprised different treatments. Among the various treatments imposed, 33-day old (middle-aged) transplants performed best with respect to fruit and seed yield than younger or older transplants. This treatment also gave the best results for number of fruits per plant, fruit yield per plot (kg), seed recovery (%), seed yield per plot (g), and germination percentage.

Key words: Age of transplant, fruit and seed yield, 'Solan Vajr', seed recovery, germination percentage

In Himachal Pradesh, tomato is grown in an area of 9.388 thousand ha, with production of 3.177 lakh metric tones, and productivity of 33.84 metric tonnes ha^{-1} (Anonymous, 2006). Mid-hills of Himachal Pradesh are leading suppliers of tomato to the plains. The crop is grown during summer and rainy seasons in the hills, and the entire produce is sent to markets of adjoining states. The farmers, thus, earn good money on account of premium price, as, this crop cannot be grown in the plains during summer months owing high temperatures.

Performance of any crop depends upon quality of the seed, various environmental factors, type of cultivar and cultural practices. Among these factors, optimum age of transplants is one that affects both growth and yield but, generally, this factor is ignored by farmers. Optimum seedling age depends on soil, environmental factors (temperature, moisture), location and cultural practices. Several investigations have been made to test the effect of transplant age on crop performance. Yield of tomato either increased linearly with age of transplants (3 to 6 weeks old) or was not influenced by transplant age (Leskover *et al*, 1991). Conflicting results in literature on transplant age may be due to different environmental and cultural conditions that plants were exposed to, both in greenhouse and in the field. Generally, 4-6 week old transplants are recommended for transplanting in mid-hill regions of Himachal Pradesh, but, this is a very wide range. Exact age of transplant would, therefore, be helpful in understanding relationship between physiological state of the transplant, its survival in field and growth response under various cultural systems and environments. Hence to reduce the wide gap (4-6 weeks after 50% germination of seed) existing in recommendation of the age of seedlings, the present study was conducted to ascertain optimum age of transplants for maximizing fruit and seed yield in tomato at Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan.

The research farm is located at an elevation of 1260 metres above MSL. Geographical location of the site is latitude 30.52° N and longitude 77.11° E which falls under the mid-hill agro-climatic zone of Himachal Pradesh. Seeds were sown in pro-trays on 20th February 2008. Temperature during this period varied from 15-18°C during daytime. All precautions were taken for raising a healthy nursery and seedlings of the required age were transplanted. Ten different ages of transplants (Table 1), starting with 15 day old, with a gap of three days comprised the treatments. Days to 50% seed germination was taken as zero day (18th day) and successive days were counted for determining seedling age. The field experiment was laid out in RBD, with three replications whereas, germination and seedling vigour studies were conducted in the laboratory using CRD, with four replications following ISTA (Anonymous, 1985). The variety used was "Solan Vajr" and was transplanted at a spacing of 90cm x 30cm in plots of 2.7m x 2.1m size. Observations were recorded on number of fruits per plant, fruit yield per plot (kg), total soluble solids (°B), pericarp thickness (mm), seed recovery (%), seed yield per plot (g), thousand seed weight (g), germination (%), Seedling vigour index-I and Seedling vigour index-II.

Table 1. Details of treatments imposed

Treatment	Age of seedling at transplanting (days after 50% germination of seeds)
T_1	15
T_2	18
T_3	21
T_4	24
T_5	27
T_6	30
T_7	33
T_8	36
T_9	39
T_{10}	42

Analysis of variance showed significant differences for characters like number of fruits per plant, fruit yield per plot (kg), seed recovery (%), seed yield per plot (g) and germination percentage. However, Total Soluble Solids (°B), pericarp thickness (mm), thousand seed weight (g), Seedling vigour index-I and Seedling vigour index-II were found to be non-significant among different treatments (Tables 2a & 2b).

Maximum number of fruits per plant (19.5) was obtained in T_7 (33 days) and minimum number of fruits (12.99) was recorded in T_1 (15 days). In the present findings, middle-aged transplants produced higher number of fruits

Table 2a. Effect of age of transplants on horticultural and seed traits in tomato

Treatment	Age of the transplant (days)	Number of fruits / plant	Fruit yield / plot (kg)	Fruit yield / hectare (q)	Total Soluble Solids (^{0}B)	Pericarp thickness (mm)	Seed recovery (%)
T_1	15	12.99	14.76	260.32	3.97	5.64	0.486 (0.697)*
T_2	18	13.75	15.47	272.84	4.07	5.67	0.516 (0.719)
T_3	21	15.01	17.01	300.00	4.03	5.65	0.515 (0.718)
T_4	24	16.05	18.29	322.57	4.25	5.66	0.522 (0.723)
T_5	27	16.84	19.30	340.39	4.33	5.72	0.544 (0.737)
T_6	30	17.50	19.74	348.15	4.26	5.93	0.697 (0.835)
T_7	33	19.50	21.08	371.78	4.27	5.96	0.726 (0.852)
T_8	36	17.40	19.60	345.68	4.29	6.23	0.692 (0.832)
T_9	39	17.06	19.20	338.62	4.25	5.60	0.658 (0.811)
T_{10}	42	16.75	18.84	332.28	4.25	5.56	0.515 (0.718)
CD (*P=0.05*)	-	0.64	0.61	60.13	NS	NS	0.079
CV (%)	-	2.29	1.94	10.84	-	-	7.84
SEd	-	0.22	0.21	20.24	-	-	0.03

Table 2b. Effect of age of transplants on horticultural and seed traits in tomato

Treatment	Age of the transplant (days)	Seed yield / plot (g)	Thousand seed weight (g)	Seed germination (%)	Seedling vigour index- I	Seedling vigour index- II
T_1	15	47.49	2.84	58.67 (49.98)**	0.108	619.83
T_2	18	52.83	3.02	76.67 (61.25)	0.111	724.87
T_3	21	57.84	2.97	69.33 (56.39)	0.091	755.29
T_4	24	65.84	3.08	64.00 (53.53)	0.089	767.72
T_5	27	71.42	3.12	62.00 (51.94)	0.109	669.04
T_6	30	76.98	3.06	71.33 (57.63)	0.114	613.37
T_7	33	82.22	3.17	84.67 (67.61)	0.159	913.13
T_8	36	74.48	3.07	66.67 (54.74)	0.133	627.00
T_9	39	73.93	3.03	79.00 (62.75)	0.126	742.13
T_{10}	42	72.52	3.13	70.67 (57.21)	0.119	670.05
CD (*P=0.05*)	-	2.95	NS	7.57	NS	NS
CV (%)	-	56.40	-	6.28	-	-
SEd	-	0.99	-	2.55	-	-

*Figures in parentheses represent square root transformed values
** Figures in parentheses represent arc sine transformed values
NS: Non- significant; CV:Coefficient of variation; $SE_{(diff)}$:Standard error of difference; CD (*0.05*):Critical difference at 5% level of difference

than younger or older transplants. The reason seems to be that in the case of younger seedlings, there is comparatively lower rate of establishment because of limited storage of foods that are needed for vegetative extension; whereas, older shoots are mature enough and have more stored food material and therefore, divert it to production of fruits. However, middle-aged seedlings, on account of extended lateral branches, produced maximum number of fruits per plant than younger or older ones. Maximum number of fruits by middle-aged transplants is reported by Salik *et al* (2000). Contrary to this, Guo *et al* (1991) reported maximum number of fruits from younger transplants, while Renuka and Perera (2002) recorded higher number of fruits from older transplants.

Maximum fruit yield per plant, per plot and per hectare was recorded in T_7 (33 days old) which showed significant difference over the other treatments. Second best treatment was T_6 (30 days old) but showed non-significant differences with T_8 (36 days old), T_5 (27 days old) and T_9 (39 days old). Minimum fruit yield was observed in T_1 (15 days old). Middle-aged seedlings produced maximum yield, followed by older ones. Minimum yield was recorded with younger seedlings. A possible reason for maximum yield in middle-aged transplants (rather than in younger or older transplants) seems to be that a greater number of marketable fruits was produced per plant here. Similar differences were observed by Cooper and Morelock (1983), Zhao Rui *et al* (2000) and Salik *et al* (2000) who obtained maximum yield in middle-aged transplants.

Total soluble solids (TSS) content was found to be non-significant among different treatments. However, highest TSS (4.33°B) was recorded in T_5 (27 days old), closely followed by T_8, T_7 and T_6. Lowest TSS (3.97°B) was observed in T_1 (15 days old). Non-significant effect of age of transplants was noticed in TSS of fruits. Similar findings are reported by Salik *et al* (2000).

Pericarp thickness was found to be non-significant among different treatments. However, maximum pericarp thickness was obtained in T_8 (36 days old) (6.23mm), followed by treatments T_7, T_6 and T_5. Minimum pericarp thickness (5.56 mm) was recorded in T_{10} (42 days old). Generally, middle-aged transplants produced fruits with greater pericarp thickness. This might be due to the transplants having produced higher yields and well-developed fruits, having a thicker pericarp. This is in conformity with findings of Salik *et al* (2000).

Maximum seed recovery (0.726%) observed in T_7 (33 days old) was at par with T_6, T_8, and T_9 (having seed recovery of 0.697, 0.692 and 0.658 per cent, respectively) and minimum seed recovery 0.486% was recorded in T_1 [at par with five other treatments, i.e., T_{10}, T_3 (21 days old), T_2 (18 days old), T_4 (24 days old) and T_5 having seed recovery of 0.515, 0.515, 0.516, 0.522 and 0.544% respectively]. In the present findings, middle-aged transplants had better seed recovery in tomato than in younger transplants. It is seen that transplants that produced more number of fruits and higher yield, also had better % seed recovery than younger transplants. The youngest seedlings may had less food stored needed for vegetative extension. Likewise, older seedlings turned mature enough, thus limiting their vegetative extension. It seems that middle-aged seedlings, on account of extended lateral branches, produced maximum number of fruits per plant resulting in higher % seed recovery.

Maximum seed yield (82.22g/plot) observed in T_7 (33 days old) was significantly superior to that in all other treatments. This was followed by T_6 and T_8 with seed yield of 76.98g and 74.48g per plot; while, minimum value (47.49g/plot) was observed in T_1. However, maximum seed yield per plot was produced by middle-aged transplants, while, minimum by younger transplants. This may be because of the fact that middle-aged transplants produced more number of marketable, healthy and disease-free fruits (which, ultimately, resulted in better seed yield). Osman and George (1984) were also of the opinion that a greater number of ripe fruits produced by plants of middle-aged seedlings were responsible for higher seed yield.

Germination percentage was found to be significant among different treatments. Maximum seed germination (84.67%) was recorded in seeds of treatment T_7 (33 days old). Minimum seed germination (58.67%) was recorded in T_1. In general, maximum germination was recorded using middle-aged transplants than younger or older ones. It appears that plants developed from middle-aged seedlings could establish well early in the season, produced vigorous plants that yielded higher number of good-sized fruits with better seed yield, better test weight and, ultimately, good germination; while, younger transplants may have stored less food needed for vegetative extension, thereby producing non-vigorous plants having low yield and poor quality seeds. Almost similar results were reported by Salik *et al* (2000). In general, germination was low in all the treatments as seeds were raised in summer rather than in the rainy season.

Both Seedling vigour index-I and II were found to be non-significant among different treatments. However, maximum Seedling vigour index-I was obtained in T_7 (33 days old) (0.159), closely followed by T_8, T_9 and T_{10}. Minimum Seedling vigour index-I (0.089) was recorded in T_4 (24 days old). Maximum seedling vigour index-II (913.13) was recorded in T_7 (33 days old), closely followed by T_4, T_3 and T_9; whereas, minimum Seedling vigour index-II (613.37) was recorded in T_6.

The present results may hold good for summer or early crop, but not for the rainy season crop, as, in the rainy season, nursery is raised during June-July and temperature during this period is generally high compared to that in February (summer or early crop). Hence, rate and speed of germination is likely to be high. Consequently, seedling growth is also higher at high temperature. As a result, seedlings are ready for transplanting quite early, than at low temperature. It can, thus, be concluded that seed emergence and seedling growth is correlated with temperature and other environmental factors rather than the month or season of cropping.

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(MS Received 08 May 2012, Accepted 10 September 2012, Revised 08 October 2012)