Assiut Journal of Agricultural Sciences 56 (3) 2025 (306-319)
ISSN: 1110-0486 / EISSN: 2356-9840
Website: http://ajas.journals.ekb.eg/
E-mail: ajas@aun.edu.eg

(Original Article)

Production of Tomato Axillary Shoots- Derived Transplants and Assessment of Their Fruit Yield in Protected Cultivation

Maha G. Kotb*; Ashraf G. Haridy; Mohamed F. Mohamed and Mohamed I. Farag

Department of Vegetable Crops, Faculty of Agriculture, Assiut University 71526, Assiut, Egypt.

*Corresponding author e-mail: mahagamal@agr.aun.edu.eg
DOI: 10.21608/AJAS.2025.384233.1484

Abstract

This research study was undertaken to evaluate the tomato fruit yield and some main quality traits of vegetative- versus seed derived-transplants. These traits included total fruit yield, average fruit number, average fruit fresh and dry weight, fruit polar diameters, fruit equatorial diameter, number of locules /fruit, fruit flush thickness and total soluble solids (TSS). A sample of 5 plants or 5 fruits was randomly taken per treatment/replicate/to assess these characteristics. Besides, the effect of node position was assessed (the developed axillary shoots on the 6th to the 14th stem nodes). Tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse was utilized. The transplants were produced using the discarded axillary lateral shoots. Rooting was achieved in peat-moss medium under high humidity conditions.

The data analysis revealed that most of the vegetative propagated transplants surpassed those originated from seeds in yield characteristics. Axillary shoot position affected transplant performance, but it was inconsistent sometimes. It is concluded that vegetative propagation seems to be feasible in tomato. The method complies with current sustainability issues.

Keywords: *Axillary Shoot, Protected Cultivation, Tomato, Rooting.*

Introduction

Tomato (Solanum *lycopersicum* L.) belongs to the family *Solanaceae*. It is one of the most popular vegetables in the world. It is widely grown in Egypt for both local consumption and exportation. Egypt is the fifth largest producer of tomato in the world (Siam and Abdelhakim, 2018). It is an important export crop, and the main destination of these exports is the Gulf countries, especially Saudi Arabia (Siam and Abdel hakim, 2018). In Egypt, tomato is produced year-round in the open field except when temperature is out of range, where it is cultivated as protected crop under plastic greenhouse conditions. Tomato is a good source of minerals and vitamins (Akinfasoye *et al.,* 2011). Its fruit is consumed as salads and in cooking, in addition, it is used as can, paste, ketchup, sauce, puree and fruit juice (Maitidevi and Kathmandu, 2008).

Fresh market tomato is demanded year-round; therefore, it is grown in five to six different dates (seasons) within year. Due to the harsh environmental conditions, especially high temperatures and photoinhibition, the fruit yield greatly varies among planting dates (Heuvelink, 1995). This is reflected in a shortage of yield around April

Received: 30 March 2025/ Accepted: 3 June 2025/ Published online: 25 July 2025

and October; in the spring before field tomato is harvested, and in the fall when field tomato is diminished (Pavani *et al*., 2020). Fruit set fails under such conditions owing to poor pollination as the pollen viability reduces much. Tomato yield is better when grown under conditions of moderate night temperature and difference between day and night temperatures, as this reduces the respiration rate.

Currently, protected cultivation technology has been widely employed to manage tomato production under unfavorable temperature in certain planting date conditions. Plastic greenhouses are used to warm up the inside naturally during the daytime by the sun and keep warm during night. Under high temperature conditions shading nets are used. Despite their importance in tomato production management, greenhouses are costly. The indeterminate F_1cultivars have to be utilized to economize the production by increasing fruit production per area unit.

However, one of the most expensive sources is still the hybrid seeds. Researchers have thought about vegetative propagation to produce true-to-type transplants derived from rooted cuttings of lateral shoots that are usually discarded during pruning. Nonetheless, this matter needs to be further verified, especially in terms of fruit yield compared to the traditional seed derived transplanting. The objectives of the current assessment, therefore, were 1) to assess fruit yield and some main quality measurements of cutting derived-transplants compared to seed derived-ones, and 2) to check the node position as affecting the performance of transplants growth and yield.

Materials and Methods

1. Experimental site and the preparation of initial plant material

The experiment of the current assessment was conducted in the protected Vegetable production facilities unit located at the Agriculture Experimental Station, Faculty of Agriculture, Assiut University, Egypt. This experiment was carried out during the period from October in two consecutive growing seasons (2022/2023 and 2023/2024) in a greenhouse sized 360 square meters. The plants were spaced within row planting distance of 50 cm on one-meter-wide ridges.

The tomato seed was used ‘Bistona’ F1 hybrid cultivar. Tomato seeds were sown in trays on October 1st in both seasons. The 10 to 15 cm long platelets were transplanted a month later into the experimental site. All basal axillary shoots up to the fifth stem node were removed to encourage the growth of lateral shoots along the main indeterminate stem. The flowers were also not allowed to set fruits, that is, to direct photosynthates toward vegetative canopy growth (Mejía *et al*.,2023).

2. Rooting of the stem cuttings and the establishment of transplants derived from axillary shoots

The developed axillary shoots on the 6th to the 14th stem nodes were harvested and incubated upright in medium composed of peatmoss for rooting. The medium was in 104-hole cork trays. The culture was covered with polyethylene sheets to maintain high humidity conditions. Afterward, the sheets were removed. The rooting time continued for 35 days. In preparing the cuttings, a diagonal cut to the stem and reduced leaf number (2 to 3) were practiced to assure favorable conditions for good rooting.

3. The treatments and the experiment layout

The experiment was laid out in a randomized complete-block design (RCBD) with 3 replicates. It comprised 10 treatments (stem nodes 6 to 14 plus the reference treatment). The reference treatment presented the plants propagated using the true seeds. Each treatment was presented by 9 plants/replicate.

4. Measurements

All studied traits were expressed per node. They included total fruit yield (kg/fed), average fruit number, average fruit fresh and dry weight (g), fruit polar diameters (cm), fruit equatorial diameter, (cm) number of locules /fruit, fruit flush thickness (cm), and total soluble solids (TSS %). A sample of 5 plants or 5 fruits was randomly taken per treatment/replicate/to assess these characteristics. Tomatoes were collected 4 times throughout the season, both for control and nodes. Fruit polar and equatorial diameters and fruit flush thickness were measured using calipers. The loculus number was determined per fruit using transversely cut fruits. The total soluble solids content of homogenized fruit juice was determined using a hand refractometer (Reichert, Scientific Instruments, China). The dry weight of the fruit was determined after taking its fresh weight and keeping it in an oven at 70 degrees Celsius until a constant dry weight was reached.

5. Statistical Analysis

Data were statistically analyzed using an analysis of variance (ANOVA) procedure for each year separately and homogeneity of error variances was assured. Subsequently, a combined analysis of variance (ANOVA) was tested over the two years (Gomez and Gomez, 1984). Treatment means differences compared to the control were tested using the Dunnett test (Dunnett, 1955). To study the effect of node position, the nine treatments were grouped into three groups each comprising three nodes. Class comparisons were employed to test variance significance among and within treatment groups (Montgomery, 2017). While differences of the means among and within groups were separated utilizing the least significant difference test LSD 0.05. All the mean significance was tested test at a 0.05 level of probability.

Results and Discussion

The partition of total variance for the assessed traits in the 2-season combined data showed significant effects due to all involved sources of variation (Tables 1 to 3). However, the variance due to the treatment and season interaction is lower than that devoted to the treatments. The significant effect of the treatment and season interaction suggests the presentation of the results for each year separately (Gomez and Gomez 1984).

Table 1. Combined analyses of variance for fruit number/ plant node, average fruit total yield (kg) /plant node and fruit fresh weight (g) / plant node in tomato F_1 hybrid

cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

SV	DF	Mean Squares		
		Fuit number/plant node	Average fruit total yield/ Plant node	Fruit fresh weight/ Plant node
Season	1	11.017**	2.705**	136.326**
Replicate (Season)	4	0.236	0.033	2.505
Treatment	9	13.952**	0.691**	198.994**
Treatment × Season	9	5.984**	1.216**	251.313**
Error	36	0.104	0.013	1.545
cv		3.532	4.029	1.447

** Significant difference at 1% probability level.

Table 2. Combined analyses of variance for fruit equatorial diameter (cm) /plant node, fruit polar diameter (cm)/plant node and loculus number per fruit /plant node in tomato F_1 hybrid cultivar 'Boston' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants.

SV	DF	Mean Squares		
		Fruit equatorial diameter/plant node	Fruit polar diameter/ plant node	Loculus number per fruit/plant node
Season	1	0.130 ns	0.0003 ns	4.371**
Replicate (Season)	4	0.042	0.011	0.024
Treatment	9	0.072*	0.092**	0.106**
Treatment × Season	9	0.273**	0.224**	0.169**
Error	36	0.033	0.021	0.011
Cv		3.365	3.295	3.318

* Significant difference at 0.05 probability level, ** significant at 1%, ns: no significant.

Table 3. Combined analyses of variance for average fruit pericarp thickness (cm)/plant node, total soluble solids (TSS %)/plant node and fruit dry weight (g)/plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants.

SV	DF	Mean Squares		
		Average fruit pericarp thickness / plant node	Total soluble solids (TSS %) / plant node	Fruit dry weight / plant node
Season	1	0.154**	3.117**	0.009 ns
Replicate (Season)	4	0.002	0.045	0.027
Treatment	9	0.003 ns	0.098**	0.167**
Treatment × Season	9	0.005 ns	0.150**	0.408**
Error	36	0.003	0.009	0.039
Cv		12.040	1.818	6.005

** Significant difference at 1% probability level, ns: no significant.

1. Performance of reference versus vegetative propagated transplant treatments

Variance of the reference treatment (seed-originated transplants) versus all the studied transplant treatments (derived from discarded axillary shoots) is exhibited in Tables 4 to 12. Fruit quality traits, except fruit polar diameter, exhibited either an elevation or did not significantly deviate when comparing reference versus tested transplant treatments in the first season. However, all six measured fruit characteristics of vegetative propagated transplants showed no deviation from those of seed-derived ones (control). Interestingly, the number of fruits produced per plant node did vary in the first season as contrasted to the control. It clearly surpassed the fruit number obtained from the seed-derived transplants in the second season. Average fruit weight (kg) /plant node and average fruit fresh weight (g)/ plant node showed inconsistent alteration regarding the growing season.

Table 4. Average fruit number/plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

		First Season	Second Season
		Fruit number/plant node	
Treatments	Node	Means	
Group -1	6	9.007± 0.544 a	9.148±0.236 a
	7	9.724±0.108 a	8.601±0.081 a
	8	7.701±0.556 b	8.824± 0.417 b
Group Mean		8.810±0.402 B	8.857± 0.244 B
Group -2	9	5.561± 0.234 c	8.425±0.309 b
	10	8.042± 0.515 b	8.333±0.096 a
	11	9.212±0.128 a	10.400± 0.423 a
Group Mean		7.605± 0.292 C	9.052±0.276 A
Group -3	12	10.079±0.464 a	12.000±0.293 a
	13	9.111± 0.337 b	12.487± 0.351 a
	14	9.885± 0.231a	12.037±0.236 b
Group Mean		9.691±0.344 A	12.174± 0.293 A
Control		8.694±0.315	5.333±0.344
Mean overall groups		**8.70**	**10.03**
Contrasts	**Degree of freedom**	**Mean Squares**	
Control vs all Groups	1	0.0002 ns	59.522**
Among Groups	2	9.873**	31.174**8
Within Group-1	2	3.153**	0.226 ns
Within Group-2	2	10.431**	4.088**
Within Group-3	2	0.787**	0.220 ns

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability (level. ** Significant difference at 1% probability level, ns: no significant.

Table 5. Average total fruit yield (kg) /Plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants.

		First Season	Second Season
		Average total fruit yield (kg) /Plant node	
Treatment [1]	Node	Means	
Group -1[2]	6	3.154± 0.058 a	3.031±0.14 a
	7	2.682±0.080 b	2.746± 0.080 b
	8	2.785±0.100 b	2.767±0.044 b
Group Mean		2.874± 0.080 A	2.848± 0.077 B
Group -2	9	2.544±0.256 b	2.745± 0.090 b
	10	2.492±0.243 b	2.874±0.055 a
	11	2.779±0.042 a	2.668± 0.186 b
Group Mean		2.606±0.181 B	2.763±0.111 B
Group -3	12	2.253± 0.081b	4.293± 0.157 a
	13	2.693±0.158 a	4.203± 0.036 a
	14	2.717±0.146 a	3.964± 0.050 b
Group Mean		2.555±0.129 B	4.154± 0.081 A
Control		2.953± 0.087	2.008± 0.112
Mean overall groups		**2.678**	**3.255**
Contrasts	Degree of freedom	Mean Squares	
Control vs all Groups	1	0.204**	4.192**
Among Groups	2	0.264**	5.469**
Within Group-1	2	0.185**	0.075**
Within Group-2	2	0.070*	0.032 ns
Within Group-3	2	0.204**	0.086**

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Table 6. Average Fruit Fresh Weight (g) / plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants.

		First Season	Second Season
		Average Fruit Fresh Weight(g) /Plant node	
Treatment [1]	Node	Means	
Group -1[2]	6	106.47±2.226 a	89.687±1.159 a
	7	79.350±0.500 c	84.621±0.151 c
	8	96.305± 0.362 b	87.421± 0.678 b
Group Mean		94.042± 1.030 A	87.244±0.663 A
Group -2	9	88.283± 0.895 b	92.080±0.889 a
	10	83.347±2.467 c	82.198± 1.956 b
	11	95.826±1.182 a	68.229± 1.847 c
Group Mean		89.153± 1.515 B	80.836±1.565 C
Group -3	12	70.432±1.279 c	89.732± 0.248 a
	13	89.346±1.229 a	83.644± 0.649 b
	14	83.224± 2.217 b	80.383± 0.411c
Group Mean		80.998± 1.575 C	84.587±0.437 B
Control		81.412±0.722	85.834±0.321
Mean overall groups		**88.064**	**84.222**
Contrasts	Degree of freedom	Mean Squares	
Control vs all Groups	1	119.445**	7.098**
Among Groups	2	390.821**	93.275**
Within Group-1	2	563.104**	19.316**
Within Group-2	2	118.483**	430.844**
Within Group-3	2	279.712**	67.555**

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level) ** Significant difference at 1% probability level, ns: no significant.

Table 7. Average fruit equatorial diameter (cm)/ plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

		First Season	Second Season
Average Fruit equatorial diameter (cm) / Plant			
Treatment [1]	**Node**	**Means**	
Group -1[2]	6	5.653±0.110 a	5.336±0.044 a
	7	5.212± 0.016 b	5.265±0.060 a
	8	5.505± 0.074 a	5.338±0.037 a
Group Mean		5.457± 0.067 A	5.313± 0.047 A
Group -2	9	5.570± 0.080 a	5.341±0.048 a
	10	5.211± 0.075 b	6.044±0.706 b
	11	5.759± 0.026 a	4.974±0.028 c
Group Mean		5.514 ±0.061 A	5.454± 0.261 A
Group -3	12	5.188± 0.063 b	5.484±0.072 a
	13	5.564± 0.043 a	5.306±0.059 a
	14	5.474± 0.319 a	5.209±0.042 a
Group Mean		5.409±0.142 B	5.333±0.058 A
Control		5.350±0.141	5.257±0.036
Mean overall groups		**5.46**	**5.366**
Contrasts	**Degree of freedom**	**Mean Squares**	
Control vs all Groups	1	0.032 ns	0.032 ns
Among Groups	2	0.024 ns	0.051 ns
Within Group-1	2	0.150 **	0.005 ns
Within Group-2	2	0.232**	0.556**
Within Group-3	2	0.115**	0.058 ns

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Table 8. Average fruit polar diameter (cm) /plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

		First Season	Second Season
fruit polar diameter (cm) /Plant node			
Treatment [1]	**Node**	**Means**	
Group -1[2]	6	4.596±0.076 a	4.317±0.030 a
	7	4.229±0.012 b	4.392±0.028 a
	8	4.546±0.038 a	4.430±0.035 a
Group Mean		4.457±0.043 A	4.380± 0.031B
Group -2	9	4.490±0.015 a	4.583±0.018 a
	10	4.283±0.111 b	5.170±0.567 a
	11	4.583±0.054 a	4.087±0.067 b
Group Mean		4.453± 0.060 A	4.614± 0.218 A
Group -3	12	4.204±0.067 b	4.501±0.025 a
	13	4.475±0.031 a	4.349±0.021 b
	14	4.402±0.189 a	4.288±0.067 b
Group Mean		4.361± 0.096 B	4.380± 0.038 B
Control		4.586±0.041	4.322±0.077
Mean overall groups		**4.424**	**4.458**
Contrasts	**Degree of freedom**	**Mean Squares**	
Control vs all Groups	1	0.071**	0.049 ns
Among Groups	2	0.026*	0.163*
Within Group-1	2	0.118**	0.009 ns
Within Group-2	2	0.070**	0.881**
Within Group-3	2	0.059**	0.036 ns

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Table 9. Average loculus number per fruit /plant node in tomato F_1 hybridcultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

		First Season	Second Season
		loculus number per fruit /plant node	
Treatment (1)	Node	Means	
Group -1(2)	6	3.419±0.146 b	3.385±0.148 a
	7	3.672±0.131 a	3.118±0.012 b
	8	3.722±0.141a	3.187±0.019 b
Group Mean		3.605 ±0.140 A	3.231±0.060 A
Group -2	9	3.670±0.191 a	3.161±0.083 b
	10	3.491±0.106 b	3.352±0.295 a
	11	3.817±0.093 a	2.630±0.068 c
Group Mean		3.660±0.131 A	3.048±0.149 B
Group -3	12	3.464±0.009 b	2.986±0.036 a
	13	3.673±0.032 a	2.728±0.050 b
	14	3.387±0.039 a	2.817±0.031 b
Group Mean		3.509±0.027 B	2.841±0.040 C
Control		3.359±0.112	2.291±0.083
Mean overall groups		**3.618**	**3.04**
Contrasts	Degree of freedom	Mean Squares	
Control vs all Groups	1	0.144**	0.037 ns
Among Groups	2	0.052*	0.342**
Within Group-1	2	0.078**	0.057*
Within Group-2	2	0.079**	0.420**
Within Group-3	2	0.065**	0.052*

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Table 10. Average fruit pericarp thickness (cm) / plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

	First Season		Second Season
		Average fruit pericarp thickness(cm) / plant node	
Treatment (1)	Node	Means	
Group -1(2)	6	0.549±0.008 a	0.419±0.005 b
	7	0.637±0.248 a	0.422±0.015 b
	8	0.541±0.009 a	0.447±0.005 a
Group Mean		0.576± 0.089 A	0.430±0.009 B
Group -2	9	0.537±0.002 a	0.448±0.009 a
	10	0.501±0.033 b	0.459±0.035 b
	11	0.508±0.001 b	0.367±0.019 b
Group Mean		0.516±0.013 B	0.425±0.021 B
Group -3	12	0.495±0.007 b	0.488±0.010 a
	13	0.528±0.008 a	0.453±0.006 b
	14	0.520±0.016 a	0.437±0.017 b
Group Mean		0.515±0.011 B	0.460±0.011 A
Control		0.565±0.013	0.428±0.010
Mean overall groups		**0.536**	**0.438**
Contrasts	Degree of freedom	Mean Squares	
Control vs all Groups	1	0.002 ns	0.0003 ns
Among Groups	2	0.010 ns	0.003 **
Within Group-1	2	0.008 ns	0.0007 ns
Within Group-2	2	0.001 ns	0.007 **
Within Group-3	2	0.009 ns	0.002 **

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Table 11. Average total soluble solids (TSS %) / plant node in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants

	First Season		Second Season
	Total soluble solids (TSS %) / plant node		
Treatment (1)	**Node**	**Means**	
Group -1(2)	6	5.517±0.026 b	5.138±0.062 b
	7	6.027±0.094 a	5.159±0.062 b
	8	5.534±0.222 b	5.215±0.069 a
Group Mean		5.693±0.115 A	5.171±0.065 B
Group -2	9	5.881±0.021 a	4.964±0.066 b
	10	5.651±0.147 b	5.396±0.017 b
	11	5.763±0.099 a	5.553±0.110 a
Group Mean		5.766±0.089 A	5.305±0.065A
Group -3	12	5.582±0.173 b	5.135±0.004 b
	13	6.033±0.051 a	5.193±0.049 b
	14	5.643±0.286 b	5.674±0.127 a
Group Mean		5.753±0.171 A	5.335±0.060 A
Control		5.607±0.115	5.252±0.053
Mean overall groups		**5.737**	**5.270**
Contrasts	**Degree of freedom**	**Mean Squares**	
Control vs all Groups	1	0.045 ns	0.0008ns
Among Groups	2	0.513 ns	0.063**
Within Group-1	2	0.251**	0.004 ns
Within Group-2	2	0.039 ns	0.279**
Within Group-3	2	0.179**	0.262**

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSD test at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Table 12. Average fruit dry weight (g) / plant in tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants.

	First Season		Second Season
	Fruit dry weight (g) / plant node		
Treatment (1)	**Node**	**Means**	
Group -1(2)	6	3.757±0.137 a	3.154±0.102 a
	7	3.070±0.068 b	3.248±0.115 a
	8	3.658±0.378 a	3.311±0.052 a
Group Mean		3.495±0.195 A	3.238±0.090 B
Group -2	9	3.453±0.015 a	3.252±0.049 a
	10	3.043±0.277 b	3.491±0.370 a
	11	3.592±0.078 a	2.770±0.114 b
Group Mean		3.363±0.124 A	3.171±0.178 B
Group -3	12	3.042±0.110 b	3.853±0.114 a
	13	3.582±0.336 a	3.356±0.185 b
	14	3.200±0.285 a	3.143±0.065 b
Group Mean		3.275±0.244 A	3.451±0.122 A
Control		2.722±0.269	3.284±0.035
Mean overall groups		**3.357**	**3.287**
Contrasts	**Degree of freedom**	**Mean Squares**	
Control vs all Groups	1	1.158**	0.0001 ns
Among Groups	2	0.110 ns	0.192**
Within Group-1	2	0.413**	0.0118 ns
Within Group-2	2	0.244*	0.404**
Within Group-3	2	0.231*	0.398**

Group means followed by the same capital letter and within group means followed by the same small letter are not significantly different using the least significant difference (LSDtest at 0.05 probability level). ** Significant difference at 1% probability level, ns: no significant.

Differences between transplants of reference treatments (control) and the transplants derived from individual tested stem node treatment for the assessed yield and its main component traits in the two seasons are presented in Tables 13 to 18. Obviously, the positive values are larger in number than those having negative signs. This indicates greater value for a given trait of vegetative transplants than the seed derived from true seeds. Stars denote their statistical significance. Notably, in this study, tomato stem cuttings formed extensive adventitious hairy roots. Those hairy roots are efficient in the absorption of nutrients and moisture. Consequently, it is reasonable that transplants derived from axillary shoots would be superiority (Geiss *et al*., 2009; Guan *et al*.,2019 and Husen, 2022). Markedly, the most reliable means over the two seasons for the number of fruits was found for transplants derived from lateral shoots of nodes 7, 8, 9, 10, 11, 12 and 14. For total fruit yield, such nodes were 9, 10, 11, 12 and 14. For average fresh fruit weight was 6 and 9.

1. Effect of node position

Tables 4 to 12 exhibit the means and variances for among and within groups of tomato F1 hybrid cultivar 'Bistona' grown in the greenhouse and vegetatively propagated by transplants established from discarded lateral shoots of seed-derived plants. Both among and within variability existed in the traits studied, which may occur owing to differential physiological status of the axillary lateral shoots (Maldiney *et al*.,1986; Gül *et al*., 1994 and Rao *et al*., 2005). Endogenous levels of abscisic acid, indole-3-acetic acid, zeatin and zeatin-riboside during adventitious root formation in cuttings of Craigella and Craigella lateral suppressor tomatoes.

Regarding the among-groups component of variance, the greatest average fruit number/plant node was produced by transplants derived from discarded lateral shoots of group 3 (nodes 12, 13 and 14) in both growing seasons. However, group 1 (nodes 6, 7 and 8) gave the greatest values in both seasons for fruit fresh weight (g) /plant. Fruit total yield (kg)/plant node behaved like fruit number in the second season and alike fruit fresh weight (g)/plant in the first season. Noticeably, all six assessed fruit characteristics were greater in group 1 (nodes 6, 7 and 8) than in the other two groups in the first season. This result applies only equatorial diameter and loculus number in the second season**.**

Mean comparisons within-group 1 revealed that transplants prepared from discarded axillary shoots of nodes 6 and 7 were the greatest over the majority of the traits in the first season. Transplants derived from nodes 6 and 8 showed the greatest performance in the second season. Such a result was found for node 11 in both seasons for comparisons of means within-group 2. Within-group 3, the finest results were obtained from transplants derived from axillary shoots 13 and 12, respectively, in the first and second seasons. Noticeably, the variance ratio among-groups and the corresponding within-groups was large in most traits. This suggests the existence of more homogeneity for the within-groups compared to the among-groups component of variation.

Table 13. Differences between transplants prepared from discarded lateral shoots and those transplants derived from seeds of the tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse.

Characters	(season 1) Treatments			
	Reference treatment.	Node 6	Node 7	Node 8
Fruit number/ plant node	8.693	0.314	1.03*	-0.99*
Average fruit Weight (kg) /plant node	2.95	0.203*	-0.263*	-0.163
Fruit fresh weight (g) / Plant node	81.413	25.057*	-2.063	14.894*
Fruit equatorial diameter (cm) / plant node	5.350	0.307*	-0.137	0.157
Fruit polar diameter (cm) / plant node	4.583	0.01	-0.356*	-0.036
Loculus number per fruit /plant node	3.36	0.06	0.313*	0.363*
Average fruit pericarp thickness (cm) / plant node	0.567	-0.02	0.066	-0.027
Total soluble solids (TSS %) / plant node	5.607	-0.09	0.42*	-0.077
Fruit dry weight (g) / plant node	2.727	1.03*	0.343*	0.93*

* Significant difference at 0.05 probability level using Dunnett's test.

Table 14. Differences between transplants prepared from discarded lateral shoots and those transplants derived from seeds of the tomato F_1 hybrid cultivar 'Bistona' grown in the greenhous

Characters	Dunnett's test Treatments (season 1)			
	Reference treatment.	Node 9	Node 10	Node 11
Fruit number/ plant node	8.693	-3.13*	-0.653*	0.52*
Average fruit Weight (kg) /plant node	2.95	-0.407*	-0.457*	-0.173
Fruit fresh weight (g) / Plant node	81.413	6.87*	1.934	14.414*
Fruit equatorial diameter (cm) / plant node	5.350	0.22*	-0.137	0.407*
Fruit polar diameter (cm) / plant node	4.583	-0.093	-0.3*	-0.003
Loculus number per fruit /plant node	3.36	0.31*	0.13	0.46*
Average fruit pericarp thickness (cm) / plant node	0.567	-0.03	-0.047	-0.06
Total soluble solids (TSS %) / plant node	5.607	0.273*	0.043	0.156
Fruit dry weight (g) / plant node	2.727	0.723*	0.316	0.863*

* Significant difference at 0.05 probability level using Dunnett's test.

Table 15. Differences between transplants prepared from discarded lateral shoots and those transplants derived from seeds of the tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse.

Characters	Dunnett's test Treatments (season 1)			
	Reference treatment.	Node 12	Node 13	Node 14
Fruit number/ plant node	8.693	1.387*	0.417	1.194*
Average fruit Weight (kg) /plant node	2.95	-0.7*	-0.257*	-0.233*
Fruit fresh weight (g) / Plant node	81.413	-10.99*	7.934*	1.814
Fruit equatorial diameter (cm) / plant node	5.350	-0.16	0.213*	0.123
Fruit polar diameter (cm) / plant node	4.583	-0.376*	-0.11	-0.183*
Loculus number per fruit /plant node	3.36	0.107	0.313*	0.027
Average fruit pericarp thickness (cm) / plant node	0.567	-0.07	-0.04	-0.047
Total soluble solids (TSS %) / plant node	5.607	-0.024	0.423*	0.036
Fruit dry weight (g) / plant node	2.727	0.313	0.856*	0.475*

* Significant difference at 0.05 probability level using Dunnett's test.

Table 16. Differences between transplants prepared from discarded lateral shoots and those transplants derived from seeds of the tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse

Characters	Dunnett's test			
	Treatments (season 2)			
	Reference treatment.	Node 6	Node 7	Node 8
Fruit number/ plant node	5.337	3.813*	3.598*	3.49*
Average fruit Weight (kg) /plant node	2.01	1.023*	0.737*	0.757*
Fruit fresh weight (g) / plant node	85.843	3.847*	-1.223	1.58*
Fruit equatorial diameter (cm) / plant node	5.257	0.08	-0.006	0.076
Fruit polar diameter (cm) / plant node	4.323	-0.006	0.07	0.107
Loculus number per fruit /plant node	2.92	0.467*	0.197*	0.27*
Average fruit pericarp thickness (cm) / plant node	0.43	-0.013	-0.007	0.017
Total soluble solids (TSS %) / plant node	5.25	-0.113	-0.09	-0.037
Fruit dry weight (g) / plant node	3.283	-0.13	0.036	0.027

* Significant difference at 0.05 probability level using Dunnett's test.

Table 17. Differences between transplants prepared from discarded lateral shoots and those transplants derived from seeds of the tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse.

Characters	Dunnett's test			
	Treatments (season 2)			
	Reference treatment.	Node 9	Node 10	Node 11
Fruit number/ plant node	5.337	3.09*	3.33*	5.396*
Average fruit Weight (kg) /plant node	2.01	0.733*	0.863*	0.66*
Fruit fresh weight (g) / plant node	85.843	6.237*	-3.643*	-17.613*
Fruit equatorial diameter (cm) / plant node	5.257	0.083	0.786*	-0.287
Fruit polar diameter (cm) / plant node	4.323	0.26	0.847*	-0.236
Loculus number per fruit /plant node	2.92	0.24*	0.433*	-0.29*
Average fruit pericarp thickness (cm) / plant node	0.43	0.017	0.03	-0.063
Total soluble solids (TSS %) / plant node	5.25	-0.287*	0.143	0.307*
Fruit dry weight (g) / plant node	3.283	-0.03	0.21	-0.513

* Significant difference at 0.05 probability level using Dunnett's test.

Table 18. Differences between transplants prepared from discarded lateral shoots and those transplants derived from seeds of the tomato F_1 hybrid cultivar 'Bistona' grown in the greenhouse.

Characters	Dunnett's test			
	Treatments (season 2)			
	Reference treatment.	Node 12	Node 13	Node 14
Fruit number/ plant node	5.337	6.663*	6.7*	6.703*
Average fruit Weight (kg) /plant node	2.01	2.287*	1.997*	1.957*
Fruit fresh weight (g) / Plant node	85.843	3.89*	-0.57	-5.46*
Fruit equatorial diameter (cm) / plant node	5.257	0.226	0.163	-0.047
Fruit polar diameter (cm) / plant node	4.323	0.18	0.074	0.033
Loculus number per fruit /plant node	2.92	0.063	0.103	-0.113
Average fruit pericarp thickness (cm) / plant node	0.43	0.06	0.05	0.007
Total soluble solids (TSS %) / plant node	5.25	-0.113	0.23	0.423*
Fruit dry weight (g) / plant node	3.283	0.57*	0.34*	0.15

* Significant difference at 0.05 probability level using Dunnett's test.

Conclusion

In conclusion, this study reports on the vegetative propagation of the 'Bistona' tomato F_1 hybrid cultivar. Transplants were prepared from discarded lateral shoots and rooted readily in peatmoss under high humidity conditions. These transplants surpassed the seed-originated ones in yield in the majority of treatments.

References

Akinfasoye, J., Dotun, A., Ogunniyan, J., and Ajayi, E. O. (2011). Phenotypic relationship among agronomic characters of commercial tomato (*Lycopersicum esculentum*) hybrids. American-Eurasian Journal of Agronomy, 4(1): 17-22.

Dunnett, Charles W. (1955). A multiple comparison procedure for comparing several treatments with a control. Journal of the American Statistical Association 50(272): 1096-1121.

Geiss, G., Gutierrez, L., and Bellini, C. (2009). Adventitious root formation: new insights and perspectives. Annual plant reviews volume 37: root development, 37: 127-156.

Gomez, K. A., and Gomez, A. A. (1984). Statistical procedures for agricultural research. 2nd ed. Wiley, New York.

Guan, L., Tayengwa, R., Cheng, Z., Peer, W. A., Murphy, A. S., and Zhao, M. (2019). Auxin regulates adventitious root formation in tomato cuttings. BMC plant biology, 19: 1-16.

Gül, A., Tüzel, Y., and Yoltas, T. (1994). Possibilities of using side shoots as propagation material in greenhouse tomato production. Acta Horticulturae, 271-271.

Heuvelink, E. (1995). Growth, development and yield of a tomato crop: periodic destructive measurements in a greenhouse. Scientia horticulturae, 61(1-2): 77-99.

Husen, A. (Ed.). (2022). Environmental, physiological and chemical controls of adventitious rooting in cuttings. Academic Press.

Maitidevi, M., and Kathmmandu, M. (2008). Product chain study tomato (p. 480). Ministry of Agriculture and Cooperatives. Project Management Unit, Biratnagar, Nepal.

Maldiney, R., Pelese, F., Pilate, G., Sotta, B., Sossountzov, L., and Miginiac, E. (1986). Endogenous levels of abscisic acid, indole-3-acetic acid, zeatin and zeatin-riboside during the course of adventitious root formation in cuttings of Craigella and Craigella lateral suppressor tomatoes. Physiologia plantarum, 68(3): 426-430.

Mejía-Betancourt, F. D. L. Á., Sánchez Del Castillo, F., Moreno-Pérez, E. D. C., and González-Molina, L. (2023). Rooted cuttings, an alternative for tomato production under greenhouse in short cycles. Revista mexicana de ciencias agrícolas, 14(3): 389-399.

Montgomery, D. C. (2017). Design and analysis of experiments. John wiley & sons.

Pavani, K., Jena, C., Divya Vani, V., and Mallikarjunarao, K. (2020). Cultivation technology of tomato in greenhouse. Protected Cultivation and Smart Agriculture edited by Sagar Maitra, Dinkar J Gaikwad and Tanmoy Shankar© New Delhi Publishers, New Delhi, 121-129.

Rao, K. V., Kiranmayee, K., Pavan, U., Sree, T. J., Rao, A. V., and Sadanandam, A. (2005). Induction of multiple shoots from leaf segments, in vitro-flowering and fruiting of a dwarf tomato (*Lycopersicon esculentum*). Journal of plant physiology, 162(8): 959-962.

Siam, G., and Abdelhakim, T. (2018). Analysis of the tomato value chain in Egypt and establishment of an action plan to increase its efficiency. (Doctoral Dissertation, CIHEAM-IAMM).

إنتاج شتلات الطماطم من الأفرع الجانبية وتقييم محصولها الثمري في الزراعات المحمية

مها جمال قطب، أشرف جلال هريدي، محمد فؤاد محمد، محمد ابراهيم فرج

قسم الخصر، كلية الزراعة، جامعة اسيوط، 71526 اسيوط، مصر.

الملخص

أجريت هذه الدراسة البحثية لتقييم إنتاجية ثمار الطماطم وبعض الصفات النوعية الرئيسية للشتلات المشتقة من البذور مقارنةً بالشتلات الخضرية وتضمنت هذه الصفات المحصول الكلي للثمار ومتوسط عدد الثمار ومتوسط الوزن الطازج والجاف للثمار وطول الثمار وقطر الثمار وعدد الحجرات/الثمرة وسمك جدار الثمار وإجمالي المواد الصلبة الذائبة الكلية (TSS%) تم أخذ عينة من 5 نباتات أو 5 ثمار بشكل عشوائي لكل معاملة/تكرار لتقييم هذه الخصائص. بالإضافة إلى ذلك، تم تقييم تأثير موقع العقدة (البراعم الإبطية المتطورة على العقد الجذعية من السادس إلى الرابع عشر). استُخدم صنف الطماطم "بيستونا" الهجين F_1 المزروع في الصوبة، أُنتجت الشتلات باستخدام البراعم الجانبية الإبطية المهملة. تم تحقيق التجذير في وسط peat-moss في ظل ظروف رطوبة عالية. كشف تحليل البيانات أن معظم الشتلات المتكاثرة خضريًا تفوقت على تلك التي نشأت من البذور في المحصول. أثر موقع البراعم الإبطية على أداء الشتلات، ولكنه غير متوافق في بعض الأحيان. يُستنتج أن التكاثر الخضري يبدو ممكنًا في الطماطم، تتوافق هذه الطريقة مع متطلبات التنمية المستدامة الحالية.

الكلمات المفتاحية: *تجذير، زراعة محمية، طماطم، فرع إبطي.*