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Pruned side shoots as planting material: Opening new dimensions for sustainable greenhouse cucumber production system

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ABSTRACT

The study was conceptualized to use pruned side shoots as planting material in greenhouse cucumber production system with 2 sets of experiments, 1st was to study the response of different cultivars to establish plants from side shoot cuttings and 2nd was to carry out the comparative performance of cultivars propagated through seeds and side shoot cuttings. Greenhouse cucumber cultivars showed variable response to propagation with the potential of using pruned side shoots as planting material, however, cv. V_2 was earliest to respond for getting side shot cuttings (14.44 days), took minimum days to establishment of transplant (12.22) with maximum survival of pruned shoots (73.11%) and produced maximum number of cuttings for propagation (15.98), while V_{11} showed maximum survival (93.21%) after transplanting in the field. The comparative study on the performance of different greenhouse cultivars propagated though seeds and pruned shoots showed first pistillate flower at earliest node (5.22) in cultivars raised though pruned side shoots, while maximum vine length (3.87 m), fruit length (15.93 cm), diameter (3.20 cm), and av. fruit weight (136.46 g) was observed in plants cultivated *via* seeds. Moreover, reproductive parameters like days to first flowering and picking, and yield parameters, namely, number of fruits per plant and yield per plant expressed non-significant differences between plants raised through seeds and side shoots. The interaction of different cultivars with propagation methods revealed significant differences with maximum plant height (4.68 m) in cv. V_5, number of fruits (32.94) in V9, average fruit weight (154.74 g) in V8, yield per plant (4.29 kg) in V_7 when raised through seeds. However, interaction between cultivar and method of propagation exhibited non-significant differences for days to first flowering & picking, node of first pistillate flower, fruit length & diameter, sensory scoring and yield thereby recommending propagation of greenhouse cucumber cultivars *via* pruned side shoots for getting not only the comparative yield but also minimizing capital investment on costlier seeds of such cultivars along with higher returns by the sale of extra plants generated through this technique to other greenhouse growers.

Key words: *Cucumis sativus*, economics, pruning, side shoots propagation, training.

INTRODUCTION

Cucumber (*Cucumis sativus* L.) is an important and valuable greenhouse vegetable crop and the development of parthenocarpic cucumbers has really revolutionized greenhouse cucumber production system (Hakkim and Chand, 5). The phenomenon of parthenocarpy was conceived by Noll for the first time in cucumber (Noll, 10), which is highly useful to develop fruits under environmental conditions like greenhouse unfavourable for successful pollination and fertilization. The development of gynoecious varieties with strong parthenocarpic expression is not only the major challenge for parthenocarpic hybrid development (Jat *et al*., 8, 9), but making available seeds of such hybrids to greenhouse growers at reasonable rates in developing nations like India. The major challenge being confronted by breeders for parthenocarpic cultivars/ hybrids is large scale multiplication after post identification to meet ever increasing demand. Production of parthenocarpic hybrids necessitates the use of chemicals/ plant growth regulators for maintenance and multiplication of parthenocarpic lines, which demands engagement of highly technical persons and simultaneously erection of protected structures to avoid any kind of contamination and deterioration (Pradeepkumar *et al*., 12; Singh and Singh, 14; Tomar *et al*., 15). On the other hand, parthenocarpic hybrids marketed by private seed players seem to be very costlier for growers of developing countries like India.

The concept of growing cucumber under greenhouse production system always advocates training of plants to maximize vertical space utilization, which can successfully be achieved by pruning side shoots so as to train plants into single stem system (Sanjeev Kumar *et al*., 13). The PPV & FR Act, 2001 safeguards the interest of Indian farmers through exemptions which entitle them to produce, save, use, sow, re-sow, exchange, share or sell his farm produce including seed/planting material of a variety protected

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under the Act (Anon., 2). Hence, these pruned side shoots can be utilized as planting material which otherwise go waste as part of training cucumber plants vertically. Therefore, the present investigation was planned to utilize the potential of pruned side shoots of greenhouse cucumber for mass production of true to type plants at very low cost and at the same time, this technique would help in maintaining the parthenocarpic lines.

MATERIALS AND METHODS

The study was undertaken at Regional Horticultural Research Station, Navsari Agricultural University, Navsari (Gujarat), India during 2015-16, 2016-17 and 2017-18 under naturally ventilated polyhouse. The experimental site is located at latitude 20˚ 57′N and longitude 72˚ 54′E with an altitude of 12 m AMSL and has characteristically humid climate with high annual rainfall of more than 1,600 mm majorly during rainy season. The experiment was undertaken in 2 parts; 1st part was meant to study the response of greenhouse cucumber cultivars to vegetative propagation through side shoot cuttings, basically for establishment of plants from side shoot cuttings, and 2nd part of the experiment compared the performance of greenhouse cucumber cultivars raised through seed and side shoot cuttings, which were was laid out in randomized block design. Name of parthenocarpic cultivars have been decoded, however potential of this technology can be fully harnessed by the farmers, who have been provided with special privilege under PPV & FRA.

Seeds of 11 parthenocarpic cultivars (V_1 to V_{11}) were sown in naturally ventilated polyhouse to raise few plants of each cultivar and trained to single stem system. In this system, it is mandatory to remove side shoots emerging from the axials of leaves to train plants vertically so as to maximize vertical space utilization inside protected structure. So, side shoots which otherwise go wastes (Fig. 1) were used as the means of propagation.

Procedurally, the side shoots of 9-10 cm were cut from each plant for raising true to true type plants with utmost care of not taking cuttings from virus affected plants (if any). The whole process was performed in the afternoon at 4.00 pm onwards for better survival. These side shoots were immediately transferred to plug trays having coco-peat as growing media. These plug trays were then put in water bath covered with polyethylene film to initiate healing process, which helped to maintain relative humidly of more than 85% for better survival of cuttings. Once side shoot cuttings started to show rooting, water supply was reduced till completion of rooting process. After the completion of rooting process, water supply was withheld for hardening of transplants and the rooted cuttings were ready for translating in 15-20 days (Fig. 2a, b, c).

The data on days taken to first cutting, survival of cuttings (%), days taken to planting, No. of cuttings per plant and survival of transplants (%) were recorded during all the years of experimentation to review the potential of side shoots in greenhouse cultivars to produce transplants for commercial planting.

The second part of experiment included 11 popular parthenocarpic hybrids among greenhouse growers, which were raised through seeds and side shoot cuttings constituting 2 factors experiment [Factor 1: parthenocarpic hybrids/cultivars (V_1 to V_{11}) and Factor 2: Propagation method: Seed (S_1), Side shoot cuttings (S_2)]. The experiment was established inside polyhouse using transplants of equivalent height and number of leaves prepared from seeds and side shoot cuttings for comparison of various horticultural traits *viz*., days to first flowering, days to first Picking,

Fig. 1: Pruning of side shoots as a part of training greenhouse cucumber into Single Stem system (Side shoots go as waste under normal practice of pruning and training).

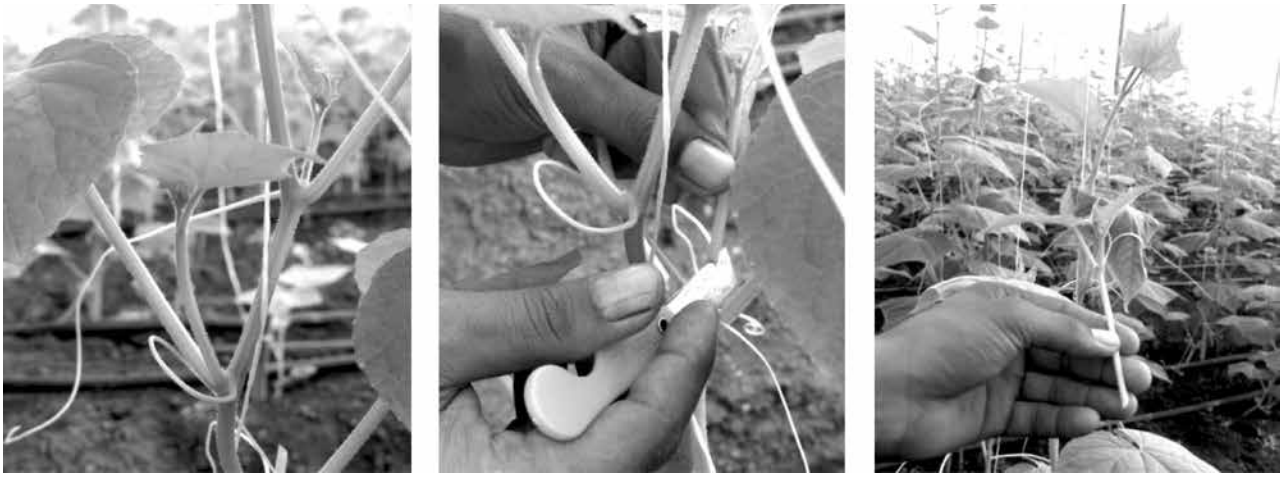

Fig. 2a: Methodology for using side shoots as planting material in greenhouse cucumber.

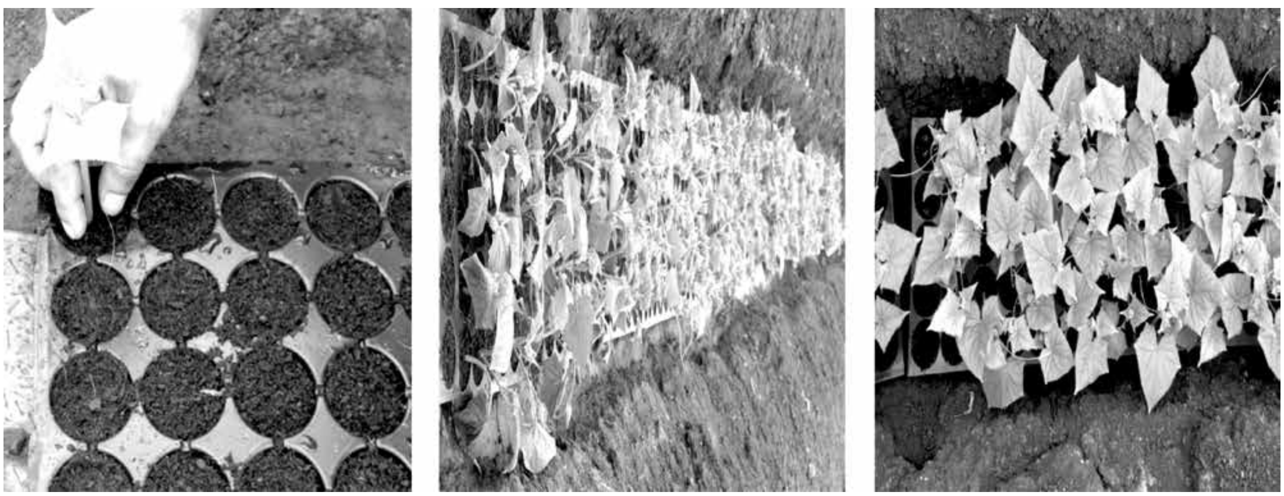

Fig. 2b: Planting of side shoots cuttings in plug trays and placement of plug trays in water bath for better survival.

Fig. 2c: Root initiation and development in cucumber transplants raised from side shoots and hardening of transplants for final planting.

node of first pistillate flower, vine length (m), sensory parameters, fruit length (cm), fruit diameter (cm), number of fruits per plant, average fruit weight (g), yield per plant (kg), yield per 1000 m^2 (ton) and the mean values were subjected to statistical analysis (Panse and Sukhatme, 11). The recommendation on fertilizers and training system made by Navsari Agricultural University, Navsari (Sanjeev Kumar *et al*., 13) was used and the experiment was laid in randomized block design with factorial concept.

The economic analysis of the experiment was carried out through accounting method (Gittinger, 4). The actual values on fixed investment were subjected to amortized accounting by adopting certain assumptions, wherein useful life of polyhouse structure, red soil and plant support system was assumed to be 10, 10 and 5 years, respectively with a condition that sufficient organic matter will be incorporated into it over the period of time. The labour wages were established as per the notification of Assistant Labour Commission and Minimum Wages Act, Gandhinagar, Government of Gujarat State for respective years of experimentation (Anon., 1). The variable components of cost were calculated based on the prevailing market value of inputs.

RESULTS AND DISCUSSION

The results presented in Table 1 shows that cultivar V_2 was the earliest to respond in respect of days taken to first cutting side shoots for vegetative propagation compared to other cultivars. All the cultivars under study showed more than 50% survival of side shoot cuttings, however side shoots obtained from cv. V_2 recorded highest survival percentage which was at par with cv. V_{11} (Table 1). All the cultivars responded differentially to the time taken by the side shoots to planting in main field with minimum number of days of establishment in V_2 (12.22) which were at with V_1, V_3 and V_{11}. Number of side shoots cuttings obtained from V_2 was significantly higher over all other cultivars under the study. The study revealed maximum survival percentage of transplants in V_{11} after planting in main field which was at with V_2 (Table 1).

The data presented in Tables 2 shows that days to first flowering and picking were significantly affected by the individual effect of cultivars only and it was cv. V_4 which exhibited earliest flowering as well as picking of fruits with at par performance with that of cvs. V_5 & V_6. These reproductive traits remained uninfluenced by individual as well as interaction effect (Table 2). The node of first pistillate flower is an indicator of earliness in cucurbitaceous vegetable crops. Significant variations were not only observed amongst varieties but this trait was also influenced significantly by methods of propagation. In case of cultivars, V_1 showed pistillate flower at early node with at par position of female flower in V_5, V_6, V_7 and V_9, whereas in case of methods of propagation plants raised through side shoot cuttings showed pistillate flowers at early nodes (Table 2).

Vine length was significantly affected by individual as well as interaction effect of cultivars and methods of propagation. The results show that V_6 recorded significantly maximum vine length over all other cultivars. In case of methods of propagation, plants raised through seeds showed maximum vine length. The interaction between cultivars and methods of

Table 1. Response of greenhouse cucumber cultivars to vegetative propagation through side shoots cuttings (pooled mean of 3 years).

Treatment	Days taken to first cutting	Survival of cutting (%)	Days taken to planting	Cuttings per plant	Transplant survival (%)
V_1	19.33	60.97 (51.42)	14.22	11.71	87.23 (69.42)
V_2	14.44	73.11 (59.12)	12.22	15.98	91.77 (74.34)
V_3	22.22	60.24 (51.04)	14.33	10.60	84.91 (67.64)
V_4	24.89	58.89 (50.16)	16.55	9.42	83.05 (66.30)
V_5	25.66	58.37 (49.96)	17.00	8.98	84.43 (67.50)
V_6	26.89	57.63 (49.47)	17.00	10.53	84.09 (66.81)
V_7	20.11	62.22 (52.43)	15.22	12.27	84.98 (68.35)
V_8	27.78	54.44 (47.68)	18.00	9.96	82.92 (66.12)
V_9	21.22	57.03 (49.24)	15.77	10.91	86.35 (69.56)
V_{10}	25.66	60.00 (50.86)	16.66	10.40	79.90 (63.67)
V_{11}	20.22	64.81 (53.84)	14.11	11.07	93.21 (76.97)
$LSD_{0.05}$	2.73	5.52	2.36	1.59	6.10

Values in parenthesis are Arc Sin transformed

Table 2. Comparative performance of greenhouse cucumber cultivars raised through seed and side shoot cuttings for days to first flowering, days to first Picking, node of first pistillate flower, vine length and fruit length (pooled mean of 3 years)**.**

Treatment	Trait														
	Days to first flowering			Days to first picking			Node of first pistillate flower			Vine length (m)			Fruit Length (cm)		
	S_1	S_2	Mean	S_1	S_1	S_1	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
V_1	28.78	20.78	24.78	38.67	30.22	34.44	5.96	4.11	5.03	3.63	2.88	3.26	14.89	13.61	14.25
V_2	31.00	24.33	27.67	41.11	34.56	37.83	7.69	5.78	6.73	3.68	3.08	3.38	15.50	13.92	14.71
V_3	31.67	24.89	28.28	41.67	34.22	37.94	7.98	5.00	6.49	4.03	3.06	3.55	15.86	14.38	15.12
V_4	25.11	19.33	22.22	34.56	29.67	32.11	7.60	5.89	6.74	3.56	2.89	3.22	17.42	16.43	16.93
V_5	26.78	18.44	22.61	36.11	29.11	32.61	6.42	4.22	5.32	3.65	2.77	3.21	15.46	13.93	14.69
V_6	26.44	18.22	22.33	36.78	27.89	32.33	6.22	4.67	5.44	4.68	3.22	3.95	16.71	15.06	15.88
V_7	28.33	21.33	24.83	38.56	31.67	35.11	6.34	4.44	5.39	3.79	2.88	3.33	15.78	14.26	15.02
V_8	31.78	24.44	28.11	41.56	33.89	37.72	6.96	6.11	6.53	3.96	3.18	3.57	16.53	14.60	15.56
V_9	31.78	23.78	27.78	41.22	34.11	37.67	6.87	5.33	6.10	4.03	3.06	3.55	14.92	13.44	14.18
V_{10}	31.33	25.00	28.17	40.78	34.67	37.72	7.61	5.33	6.47	4.19	3.03	3.61	15.64	14.15	14.90
V_{11}	28.67	24.78	26.72	38.78	35.44	37.11	6.00	6.56	6.28	3.39	2.61	3.00	16.47	15.00	15.73
Mean	29.24	22.30		39.07	32.31		6.88	5.22		3.87	2.97		15.93	14.43	
								$LSD_{0.05}$							
V		1.73			1.87			1.15			0.22			1.16	
S		NS			NS			0.27			0.46			0.43	
V × S		NS			NS			NS			0.30			NS	

propagation revealed that V6 recorded significantly higher vine length when raised though seeds (Table 2). Fruit length as well as diameter was significantly affected by individual effect of cultivars and methods of propagation. V_4 showed significantly maximum fruit length which was at par with V_6, whereas maximum fruit diameter was found in V_5 and V_6 with at par value in V_4. In case of methods of propagation, crop raised through seed showed significantly higher fruit length as well as diameter (Tables 2 & 3). Organoleptic evaluation of the cultivars showed higher overall acceptability in V_9, which was at par with V_6, whereas sensory parameters remained unaffected either by individual effect of methods of propagation or interaction effect (Table 3).

Number of fruits was significantly affected by individual effect of cultivars and interaction effect of cultivars. Higher number of fruits was obtained from V_9 which was at par with V_5 and V_7. The cultivars interacted positively with seeds and showed maximum number of fruits in V_9 when raised through seeds, which was at par with V_4, V_5 and V_7 raised though seeds and V_9 raised through side shoot cuttings (Table 4). Average fruit weight was affected individually as well as interaction effect of cultivars and methods of propagation. Cultivar V_8 recorded maximum fruit weight which was at par with V_6. The crop raised through seeds showed significantly higher fruit weight compared to one grown through side shoot cuttings. Fruit weight was observed to be maximum in V_8 when raised through seeds, which was at par with V_6 that too raised though seeds (Table 4).

Yield per plant was significantly affected by individual effect of cultivars and interaction effect of both the factors under study. Cultivar V_7 showed higher fruit yield per plant with at par performance in V_4, V_5, V_8 and V_9. V_7 also showed maximum yield per plant when raised through seeds or side shoot cuttings. It was only the varietal differences which differentiated the varieties for yield performance per square meter. The different cultivars under study showed significant differences for yield per 1000 m^2 however, this character remained unaffected by individual effects of methods of propagation as well as interaction effect of both the factors (Table 4).

The comparative economic analysis of parthenocarpic varieties raised through seeds and side shoot cuttings clearly depicted higher net returns as well as benefit cost ratio (Table 5) because of additional income generation by the sale of plants raised from side shoots and very minimum expenditure

Table 3. Comparative performance of greenhouse cucumber cultivars raised through seed and side-shoot cuttings for fruit diameter and sensory parameters (pooled mean of 3 years).

Treatment	Trait														
	Fruit dia. (cm)			Fruit colour			Fruit flavour			Fruit texture			Overall acceptability		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
V_1	3.08	2.62	2.85	6.96	6.25	6.60	6.78	6.79	6.78	7.13	7.17	7.15	6.96	6.73	6.84
V_2	3.18	2.70	2.94	6.54	6.29	6.42	6.53	6.46	6.50	6.43	6.47	6.45	6.50	6.41	6.45
V_3	3.13	2.60	2.87	6.49	6.32	6.40	6.33	6.34	6.33	6.50	6.63	6.56	6.44	6.43	6.43
V_4	3.29	2.72	3.01	5.80	6.59	6.19	6.10	6.09	6.09	6.75	7.41	7.08	6.22	6.70	6.46
V_5	3.40	2.88	3.14	6.29	6.35	6.32	6.41	6.43	6.42	7.19	7.17	7.18	6.63	6.65	6.64
V_6	3.39	2.88	3.14	7.04	6.90	6.97	7.17	7.14	7.16	7.58	7.59	7.58	7.26	7.21	7.24
V_7	3.22	2.71	2.96	7.44	7.28	7.36	6.55	6.52	6.54	6.88	7.04	6.96	6.96	6.95	6.95
V_8	3.04	2.53	2.79	7.06	6.33	6.69	6.95	6.92	6.93	7.24	7.26	7.25	7.08	6.83	6.96
V_9	3.13	2.64	2.88	7.54	7.36	7.45	7.22	7.28	7.25	7.40	7.48	7.44	7.38	7.37	7.38
V_{10}	3.16	2.71	2.94	6.86	6.72	6.79	6.74	6.47	6.61	6.53	6.55	6.54	6.71	6.58	6.65
V_{11}	3.16	2.70	2.93	6.54	6.33	6.44	6.36	6.29	6.32	6.54	6.54	6.54	6.48	6.39	6.43
Mean	3.20	2.70		6.78	6.61		6.65	6.61		6.92	7.03		6.78	6.75	
	$LSD_{0.05}$														
V	0.14			0.48			0.35			0.36			0.28		
S	0.06			NS			NS			NS			NS		
V × S	NS			NS			NS			NS			NS		

Table 4. Comparative performance of greenhouse cucumber cultivars raised through seed and side shoot cuttings for number of fruits per plant, average fruit weight and yield (Pooled mean of 3 years).

Cultivar	No. of fruits per plant			Av. fruit wt. (g)			Yield per plant (kg)			Yield per 1000 m^2 (tonne)		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
V_1	29.02	26.07	27.54	122.89	118.02	120.45	3.56	3.07	3.31	10.12	8.78	9.45
V_2	25.88	23.07	24.47	127.92	119.66	123.79	3.27	2.80	3.03	9.48	8.06	8.77
V_3	26.48	24.78	25.63	129.29	118.66	123.97	3.39	2.92	3.16	9.90	8.39	9.15
V_4	29.49	27.80	28.64	141.60	141.55	141.58	4.17	3.85	4.01	12.11	11.01	11.56
V_5	31.30	28.87	30.08	136.65	132.15	134.40	4.26	3.81	4.03	12.40	10.93	11.66
V_6	27.13	25.24	26.19	148.89	142.08	145.48	4.02	3.58	3.80	11.70	10.27	10.98
V_7	31.53	29.44	30.49	137.38	139.23	138.30	4.29	4.08	4.19	12.64	11.67	12.16
V_8	24.98	29.51	27.24	154.74	142.39	148.57	3.78	4.17	3.98	11.31	11.79	11.55
V_9	32.94	30.51	31.73	125.37	132.23	128.80	4.24	3.99	4.12	12.53	11.45	11.99
V_{10}	24.59	23.93	24.26	138.83	120.35	129.59	3.36	2.84	3.10	9.68	8.26	8.97
V_{11}	23.98	23.04	23.51	137.55	119.23	128.39	3.26	2.75	3.00	9.35	7.83	8.59
Mean	27.94	26.57		136.46	129.60		3.78	3.44		11.02	9.86	
	$LSD_{0.05}$											
V	1.85			5.01			0.23			0.74		
S	NS			2.33			NS			NS		
V × S	2.62			7.11			0.32			NS		

on seeds. It is ascertained from the present study that though the significant differences occurred among 11 parthenocarpic cultivars in response to days taken to first cutting, survival of cutting (%), days taken to planting, no. of cuttings per plant and survival of transplants (%), but it also substantiate the possibility of vegetative propagation of greenhouse cucumber cultivars through side shoot cuttings. As auxins plays an important role in cell elongation, cell division, initiation of cambium and early differentiation of xylem and phloem tissues, which stimulate root formation in plants (Jasim and Abed, 7; El-Eslamboly, 3), similarly pruning of shoots in the present study starts to build up concentration of auxins leading to formation of roots.

The comparative performance of 11 parthenocarpic cultivars clearly showed non-significant differences among cultivars raised through seeds and side shoot cuttings for majority of important traits like days to first flowering & picking, node of first pistillate flower, fruit length & diameter, sensory parameters and yield per unit area thereby suggesting this technique as potential one for minimizing capital investment on costlier seeds of such cultivars. Importantly, higher returns could be obtained from crop raised from side shoot cuttings compared to seeds by investing less on seeds and simultaneously through the sale of excess plants generated through this technique to other greenhouse growers. Plant development through vegetative shoots as observed in the present study is modulated by genetic and environmental factors, which have effects on auxin biosynthesis, metabolism, transport and signaling pathway (Han *et al*., 6).

Table 5. Comparative economic analysis of greenhouse cucumber cultivars raised through seed and side shoot cuttings under polyhouse.

Treatment	Yield (t/ 1000 m^2)	Return (Rs.)	Additional returns (Rs.)	Overall gross returns (Rs.)	Amortized fixed cost for a single season (Rs.)	Cost A (Variable Cost + Actual Interest on working Capital)	Cost B (Cost A + Rental Value of land + Amortized Cost of Structure)	Cost C	Net returns	BC ratio
T_1 (V_1S_1)	10.12	151,800	20,705	1,72,505	28,243	50,756	90,499	90,499	82,006	1.91
T_2 (V_1S_2)	8.78	131,700	20,705	1,52,405	28,243	38,619	77,023	77,023	75,382	1.98
T_3 (V_2S_1)	9.48	142,200	33,881	1,76,081	28,243	49,128	89,110	89,110	86,971	1.98
T_4 (V_2S_2)	8.06	120,900	33,881	1,54,781	28,243	38,452	77,014	77,014	77,767	2.01
T_5 (V_3S_1)	9.9	148,500	18,518	1,67,018	28,243	50,704	90,081	90,081	76,937	1.85
T_6 (V_3S_2)	8.39	125,850	18,518	1,44368	28,243	38,529	76,396	76,396	67,972	1.89
T_7 (V_4S_1)	12.11	181,650	16,088	1,97,738	28,243	55,652	97,078	97,078	100,660	2.04
T_8 (V_4S_2)	11.01	165,150	16,088	1,81,238	28,243	39,139	79,465	79,465	101,773	2.28
T_9 (V_5S_1)	12.4	186,000	15,.201	2,01,201	28,243	57,198	98,855	98,855	102,346	2.04
T_{10} (V_5S_2)	10.93	163,950	15,201	1,79,151	28,243	39,121	79,307	79,307	99,844	2.26
T_{11} (V_6S_1)	11.7	175,500	17,598	1,93,098	28,243	55,557	96,673	96,673	96,425	2.00
T_{12} (V_6S_2)	10.27	154,050	17,598	1,71,648	28,243	38,967	78,653	78,653	92,995	2.18
T_{13} (V_7S_1)	12.64	189,600	22,140	2,11,740	28,243	57,254	99,613	99,613	112,127	2.13
T_{14} (V_7S_2)	11.67	175,050	22,140	1,97,190	28,243	39,293	80,682	80,682	116,508	2.44
T_{15} (V_8S_1)	11.31	169,650	15,724	1,85,374	28,243	51,033	91,634	91,634	93,740	2.02
T_{16} (V_8S_2)	11.79	176,850	15,724	1,92,574	28,243	39,321	80,402	80,402	112,172	2.40
T_{17} (V_9S_1)	12.53	187,950	18,044	2,05,994	28,243	61,662	1,03,638	103,638	102,356	1.99
T_{18} (V_9S_2)	11.45	171,750	18,044	1,89,794	28,243	39,242	80,138	80,138	109,656	2.37
T_{19} ($V_{10}S_1$)	9.68	145,200	18,096	1,63,296	28,243	50,653	89,782	89,782	73,514	1.82
T_{20} ($V_{10}S_2$)	8.26	123,900	18,096	1,41,996	28,243	38,498	76,207	76,207	65,789	1.86
T_{21} ($V_{11}S_1$)	9.35	140,250	20,806	1,61,056	28,243	55,010	93,990	93,990	67,066	1.71
T_{22} ($V_{11}S_2$)	7.83	117,450	20,806	1,38,256	28,243	38,398	75,858	75,858	62,398	1.82

It can be inferred from the present study that multiplication of greenhouse cucumber cultivars through side shoot cuttings opens up new dimensions in greenhouse cucumber production system. Greenhouse farmers can grow successive crops of cucumber by generating true to type plants through side shoot cuttings, which otherwise goes as waste in the process of training cucumber plants vertically. The cucumber crop raised either through seeds or side shoot cuttings perform equally well for various desired horticultural traits. The farmers may even sell excessive plants generated through side shoot cuttings for additional income. Handful amount of greenhouse cucumber cultivar available with farmers can be used to generate plenty of plants required for cultivation in a larger area of greenhouse. In this way, the burden of high cost of seeds can be minimized to a greater extent.

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