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## Comparative economic analysis of grafted vis-a-vis non-grafted tomato cultivation under protected conditions in mid hills of Himachal Pradesh

**Vibhuti Sharma, Pardeep Kumar, Parveen Sharma and Ashok Kumar**

### Abstract

The objective of present study was to compare the costs and returns of grafted and non grafted tomatoes in 250 m<sup>2</sup> polyhouse. The experimental trials were conducted for two consecutive years (2016-17 and 2017-18) in the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur. Total sixteen different rootstocks and one non-grafted Scion 'GS-600' were used. The experiment was laid-out in randomized block design (RBD) along with three replications. The study revealed that grafted plants grown under protected conditions resulted in higher benefit: cost ratio than non-grafted ones. The net returns of grafted tomato production was increased by Rs. 210.47 /m<sup>2</sup> during 2016-17 (with benefit-cost ratio of 5.32) and Rs. 211.36 /m<sup>2</sup> (with benefit-cost ratio of 5.42) in 2017-18 as compared to non-grafted tomato which were Rs. 103.76 /m<sup>2</sup> (with benefit-cost ratio of 4.52) during 2016-17 and Rs 104.65 /m<sup>2</sup> (with benefit-cost ratio of 4.67) during 2017-18.

**Keywords:** Tomato, gross returns, net returns, benefit, cost

### Introduction

The benefit- cost ratio is an important indicator for the profitability and preferential adoption of the crop. It gives an idea about the investments on inputs, agricultural operations and output realized. Grafting has been used successfully in countering biotic and abiotic stresses along with yield improvement (Lee and Oda, 2003 and Lee *et al.*, 2010) <sup>[2, 3]</sup>. This technology is gaining momentum in areas where land is intensively used and continuous cropping is practiced (Khah *et al.*, 2006) <sup>[1]</sup>. Commercial vegetable grafting is a new technique and the area under vegetable grafting is progressively increasing. The use of resistant rootstocks reduces dependency on agrochemicals, the technique is therefore, considered eco-friendly for sustainable vegetable production (Rivard and Louws, 2008) <sup>[4]</sup>. Grafting is used to improve production, productivity and quality parameters besides, improving resource use efficiency in crops under protected conditions. The present study was undertaken for two consecutive years to work out the costs and benefits realized by using grafted transplants over non-grafted ones under mid hills of Himachal Pradesh. Grafting reduced dependency on agrochemicals besides, improving yield and quality.

### Materials and Methods

Total forty nine treatments comprising of sixteen rootstocks and Control non-grafted were used. The grafted seedlings were transplanted in a Randomized Block Design (RBD) having three replications in a modified naturally ventilated Quonset polyhouse of the size 25 m × 10 m with spacing of 70 x 30 cm. Experiments were carried out during two consecutive years i.e. 2016-17 and 2017-18 in the Department of Vegetable Science and Floriculture, CSKHPKV, Palampur. The nurseries of rootstocks and scion were raised in plastic plug trays having uniform size and cells of equal size using soil-less media (cocopeat: perlite: vermiculite) in the ratio of 3:1:1, respectively in the growth chamber of Department of Vegetable Science and Floriculture CSKHPKV, Palampur. One seed was sown per cell by making small depression (0.5 cm) with finger so as to ensure that seed is kept in the centre of cell. Seeds of tomato, brinjal, chilli rootstocks were sown in plug trays having 98 small cells. While, seeds of pumpkin were sown in plug trays having 50 cells. Water was sprayed initially through rose can and trays were covered with net so that seeds do not come outside.

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Trays were regularly monitored and checked and on emergence of germination the net was removed. All the necessary precautions were taken for raising healthy seedlings.

Rootstocks were sown one week earlier than scion so that the diameter of both the stems matches with each other for ensuring successful grafting. For the first season trial sowing of rootstocks was done on 19<sup>th</sup> July 2017 and sowing of scion on 26<sup>th</sup> July 2017. For the second season trial rootstocks were sown on 7<sup>th</sup> February 2018 and sowing of scion was done on 14<sup>th</sup> February 2018. The scion variety GS-600 was grafted on various rootstocks using cleft grafting on attaining graftable height of 15-20 cm with stem thickness of 5-10 mm to ensure higher grafting success rate and compatibility. Scion seedlings were grafted on various rootstocks on 24<sup>th</sup>, 26<sup>th</sup> and 27<sup>th</sup> August 2017, while transplanting was done on 12<sup>th</sup> September 2017. Whereas, during 2018 seedlings were grafted on 12<sup>th</sup>, 14<sup>th</sup> and 15<sup>th</sup> April 2018 and transplanting was done on 24<sup>th</sup> May, 2018.

Total 6 terraces or beds were constructed having 51 plots. Well decomposed Farmyard Manure (FYM) @ 2 kg, urea @ 6 g, 12:32:16 @ 9g and MOP @ 4 g were applied per plot before transplanting during both the seasons i.e. (2016-17 & 2017-18) through proper mixing by hand. In each pit one plant was transplanted and slightly pressed or moved without damaging the earth ball. Per plot twelve plants were raised. The beds were 2 m 40 cm long and 80 cm wide. The gap of 60 cm was kept per plot and channels were made at a spacing of 80 x 60 cm.

For the computation of benefit-cost analysis the market prevailing prices of inputs and output were taken. The

variable cost (VC) was computed by multiplying the prices of the inputs with their respective quantities i.e.  $(VC = \sum p_i x_i)$  (where  $i = 1-----n$ ). The  $p_i$  is the price of  $i^{th}$  input. The gross returns (GR) were computed by multiplying the quantities of the produce with their sale price i.e.  $(GR = \sum p_i q_i)$  (where  $i = 1-----n$ ).  $p_i$  is the sale price of  $i^{th}$  output and  $q_i$  is the quantity of  $i^{th}$  output. The benefit-cost ratio (BCR) was computed by dividing the gross returns with total variable cost (i.e.  $BCR = \text{Total gross returns} / \text{total variable cost}$ ). Benefit-cost ratio indicated returns accrued to one rupee investment in tomato cultivation. The cost of production was also estimated by computing the cost per unit of output.

## Results

### Cost of cultivation of grafted and non-grafted tomato.

The cost of cultivation is the cost of the cultivating the tomato in per unit area. Costs of inputs required for raising grafted and non-grafted tomato are given in (Table 1 and Table 2). All phases of grafted and non-grafted transplanted tomato cultivation were considered. The cost of seeds used as rootstock was less as compared to seed of scion. The total cost for rootstock seed was ₹. 80.15 and for scion seed was Rs. 275.00. Thus, scion seed were costlier by 29.15% as compared to rootstocks. Input costs/m<sup>2</sup> for grafted and non-grafted plants during the year 2016-17 were ₹ 28.91/m<sup>2</sup> and ₹ 12.83 /m<sup>2</sup>. Whereas, it was ₹ 28.02 /m<sup>2</sup> and ₹ 11.94/m<sup>2</sup> respectively. Additional cost was also incurred in grafted seedlings. The additional cost of producing a grafted plant included the expenses on grafting labour, cello tape and grafting clips.

**Table 1:** Economics/cost of inputs of 250 m<sup>2</sup> polyhouse under protected conditions, 2016-17

S. No.	Inputs	Quantity & units	Rate/unit (₹)	Cost (₹)	Grafted tomato (₹)	Non-grafted tomato (₹)
1.	Seed (Rootstock)					
a)	Tomato	4.00 g	300/kg	1.20	1.20	-
b)	Brinjal	2.50 g	1500/kg	3.75	3.75	-
c)	Chilli	2.00 g	1600/kg	3.20	3.20	-
d)	Local Pumpkin	3.00 g (72 seeds)	1/seed	72.00	72.00	-
	Seed (Scion GS-600)	8.00 g (4 g each for grafted and non-grafted)	550/8 g	550.00	275.00	275.00
2.	Nylon ropes (for staking)	15.00 kg (7.5 kg each)	70.00/kg	1050.00	525.00	525.00
3.	Wiring	4 kg 500 g (2 kg 250 g each)	80.00/kg	360.00	180.00	180.00
4.	Growing media (for nursery)					
a)	Cocopeat	2 kg (1 kg each)	30.00/kg	60.00	30.00	30.00
b)	Perlite	2 kg (1 kg each)	30.00/kg	60.00	30.00	30.00
c)	Vermiculite	1 kg (0.5 kg each)	60.00/kg	60.00	30.00	30.00
5.	Protrays/plug trays	64 Nos (32 each)	25.00/tray	1600.00	800.00	800.00
6.	Grafting clips	1960 Nos.	2.00/No	3920.00	3920.00	-
7.	Cello tape	2 No.	10/No	20.00	20.00	-
8.	Yellow sticky traps	25 No	50/No	1250.00	625.00	625.00
9.	<b>Manures and Fertilisers</b>					
a)	Farmyard Manure (FYM)	1 q 8 kg (For Both)	200 /q	216.00	108.00	108.00
b)	Urea	3 kg 24 g	284/50 kg	17.18	8.59	8.59
c)	MOP	2 kg 16 g	48.00/kg	96.76	48.38	48.38
d)	IFFCO (12:32:16)	4 kg 86 g	1105/50 kg	90.30	45.15	45.15
e)	NPK (19:19:19)	1 kg 620 g	150.00/kg	243.00	121.50	121.50
f)	Calcium Chloride	120 g	910/500g	218.40	109.20	109.20
10.	<b>Insecticides and Fungicides</b>					
a)	Acetamiprid	45 g	180/100g	81.00	40.50	40.50
b)	Dicofol	50 ml	110/100ml	55.00	27.50	27.50
c)	Pyromite	50 ml	110/100ml	55.00	27.50	27.50
d)	Plethora	45 ml	478/100 ml	215.10	107.55	107.55
e)	Dithane M-45	120 g	191/500g	45.84	22.92	22.92
f)	Hexaconazol	45 ml	250/126 ml	89.28	44.64	44.64
	Total			10433.01	7226.58	3206.43
	Input cost/m <sup>2</sup>			41.73	28.91	12.83

**Table 2:** Economics/cost of inputs of 250 m<sup>2</sup> polyhouse under protected conditions, 2017-18

S. No.	Inputs	Quantity & units	Rate/unit ( ₹)	Cost (₹)	Grafted tomato (₹)	Non-grafted tomato (₹)
1.	Seed (Rootstock)					
	Tomato	4.00 g	300/kg	1.20	1.20	-
a)	Brinjal	2.50 g	1500/kg	3.75	3.75	-
b)	Chilli	2.00 g	1600/kg	3.20	3.20	-
c)	Local Pumpkin	3.00 g (72 seeds)	1/seed	72.00	72.00	-
d)	Seed (Scion GS-600)	8.00 g (4 g each for grafted and non-grafted)	550/8 g	550.00	275.00	275.00
2.	Nylon ropes (for staking)	15.00 kg (7.5 kg each)	70.00/kg	1050.00	525.00	525.00
3.	Wiring	4 kg 500 g (2 kg 250 g each)	80.00/kg	360.00	180.00	180.00
4.	Growing media (for nursery)					
a)	Cocopeat	2 kg (1 kg each)	30.00/kg	60.00	30.00	30.00
b)	Perlite	2 kg (1 kg each)	30.00/kg	60.00	30.00	30.00
c)	Vermiculite	1 kg (0.5 kg each)	60.00/kg	60.00	30.00	30.00
5.	Protrays/plug trays	64 Nos (32 each)	25.00/tray	1600.00	800.00	800.00
6.	Grafting clips	1960 Nos.	2.00/No	3920.00	3920.00	-
7.	Cello tape	2 No.	10/No	20.00	20.00	-
8.	Yellow sticky traps	25 No	50/No	1250.00	625.00	625.00
9.	Manures and Fertilisers					
a)	Farmyard Manure (FYM)	1 q 8 kg (For Both)	200 /q	216.00	108.00	108.00
b)	Urea	3 kg 24 g	284/50 kg	17.18	8.59	8.59
c)	MOP	2 kg 16 g	48.00/kg	96.76	48.38	48.38
d)	IFFCO (12:32:16)	4 kg 86 g	1105/50 kg	90.30	45.15	45.15
e)	NPK (19:19:19)	1 kg 620 g	150.00/kg	243.00	121.50	121.50
10.	Insecticides and Fungicides					
a)	Pyromite	50 ml	110/100ml	55.00	27.50	27.50
b)	Plethora	45 ml	478/100 ml	215.10	107.55	107.55
c)	Dithane M-45	120 g	191/500g	45.84	22.92	22.92
	Total			9989.23	7004.64	2984.59
	Input cost/m <sup>2</sup>			39.96	28.02	11.94

**Labour cost of Grafted and non-grafted tomato plants**

Average wage rate for labour was ₹ 267.53/man day. The existing wage rate was employed for all calculations for estimating total and per unit labour cost. The labour cost /m<sup>2</sup> was calculated for grafted and non-grafted transplants (Table

3). Grafted tomato plants required additional labour of ₹ 802.60 for grafting. The total labour cost was estimated to be ₹ 19.82/ m<sup>2</sup> for grafted and ₹ 16.61/ m<sup>2</sup> for non-grafted transplants during both the years.

**Table 3:** Labour cost of 250 m<sup>2</sup> polyhouse, 2016-17 and 2017-18

S. No.	Particulars	Mandays (No.)	Cost (₹)	Grafted tomato (₹)	Non-grafted tomato (₹)
1.	Land preparation	3	802.60	401.30	401.30
2.	Manures and Fertilisers	1	267.53	133.77	133.77
3.	Sowing	1.5	401.30	200.65	200.65
4.	Layout	2	535.06	267.53	267.53
5.	Grafting	3	802.60	802.60	-
6.	Transplanting	0.5	133.77	66.88	66.88
7.	Hoeing and weeding	3	802.60	401.30	401.30
8.	Fertigation	2	535.06	267.53	267.53
9.	Foliar application	0.5	133.77	66.88	66.88
10.	Staking	4	1070.12	535.06	535.06
11.	Pruning	3	802.60	401.30	401.30
12.	Plant protection sprays	1	267.53	133.77	133.77
13.	Irrigation	1	267.53	133.77	133.77
14.	Harvesting	2	535.06	267.53	267.53
15.	Machinery (Power tiller)	2.5 (Hour) @ ₹. 700/hour	1750.00	875.00	875.00
	Total		9107.13	4954.86	4152.27
	Labour cost/m <sup>2</sup>		36.43	19.82	16.61

\*Calculated @ INR (₹) 267.53/manday

**Comparative economics of grafted and non-grafted tomato (₹/Sq. m)**

The total cost/ m<sup>2</sup> for grafted tomato plants during 2016-17 and 2017-18 was estimated to be ₹ 48.73 and ₹ 47.84 respectively (Table 4). Whereas, for non-grafted transplants it was ₹ 29.44 /m<sup>2</sup> during 2016-17 and ₹ 28.55/ m<sup>2</sup> in 2017-18. Total yield for grafted transplants was 12.96 kg/m<sup>2</sup>. Whereas,

it was 6.66 kg/m<sup>2</sup> for non-grafted transplants. Total gross returns were worked out by multiplying the total yield with price of marketable fruits. The total gross returns came out to be ₹ 259.20/ m<sup>2</sup> for grafted plants. Whereas, it was ₹ 133.20 / m<sup>2</sup> for non-grafted plants. The net returns were worked out by subtracting gross returns from total variable cost of cultivation and were estimated to be ₹ 210.47 / m<sup>2</sup> during 2016-17 and ₹

211.36 /m<sup>2</sup> during 2017-18. Whereas, for non-grafted transplants it was ₹ 103.76 / m<sup>2</sup> during 2016-17 and ₹ 104.65 / m<sup>2</sup> for the year 2017-18. The benefit- cost ratio for grafted transplants during 2016-17 was 5.32 and 5.42 for 2017-18. Whereas, non- grafted transplants recorded 4.52 during 2016-17 and 4.67 for 2017-18. The benefit-cost ratio indicated that

one rupee investment in grafted tomato will result into returns of ₹ 5.42. However, in case of non-grafted tomato one rupee investment will result into returns of ₹ 4.67. Thereby, depicting higher profitability in grafted tomato as compared to non-grafted.

**Table 4:** Cost and returns of grafted and non-grafted transplants

Cost	Grafted tomato		Non-grafted tomato	
	2016-17	2017-18	2016-17	2017-18
<b>A.</b>				
Input cost/m <sup>2</sup>	28.91	28.02	12.83	11.94
Labour cost/m <sup>2</sup>	19.82	19.82	16.61	16.61
Total cost/m <sup>2</sup>	48.73	47.84	29.44	28.55
Returns				
i) Yield (kg/m <sup>2</sup> )	12.96	12.96	6.66	6.66
ii) Sale rate (₹ /kg)	20.00	20.00	20.00	20.00
iii) Gross returns (₹ /m <sup>2</sup> )	259.20	259.20	133.20	133.20
iv) Net returns (₹ /m <sup>2</sup> )	210.47	211.36	103.76	104.65
v) Benefit: cost ratio	5.32	5.42	4.52	4.67

### Conclusions

Grafted plants produced higher benefit- cost ratio during both the years in comparison to non-grafted ones. They also recorded higher returns both in terms of gross and net benefits. Use of grafted technique was a profitable venture for earning higher returns per square metre in relation to non-grafted ones. The main aim for present investigation was to estimate and compare the inputs invested, costs incurred and net returns obtained from grafted tomato plants in comparison to non-grafted ones. Further, the enhanced economic benefits of tomato will attract the farmers in adoption of this technique for better quality produce and lucrative returns. Growing grafted tomatoes demonstrated higher production costs due to the increased costs associated with grafting but at the same time the yield and returns were very high.

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