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## Economics of Tomato F1 hybrid seed production (Arka Rakshak), as influenced by various pruning operations

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### Abstract

The study "Effect of shoot pruning and truss retention in hybrid seed production of Tomato (*Solanum lycopersicon* L.)" was conducted in a randomized block design with three replications to evaluate the performance of different treatments on plant growth, fruit quality, seed quality and yield in parental lines of variety Arka Rakshak. The experiment included ten treatments of shoot pruning (keeping 2, 3, 4 shoots /plant) and truss retention (keeping 4, 6, 8 trusses/ plant) and a control.

The B:C ratio is a key parameter for finding out the cost-effectiveness of any treatment. Treatment T<sub>1</sub> (two shoot retention and four truss retention) had the highest gross return (Rs 790300/ha), and highest cost of cultivation (Rs 260169 /ha) was found in T<sub>3</sub> (two shoot and eight truss retention). Maximum benefit: cost ratio was obtained with T<sub>1</sub> (3.12:1) followed by T<sub>2</sub> (2.64:1) and T<sub>4</sub> (2.51:1) whereas minimum was found with T<sub>10</sub> (1.02:1).

**Keywords:** Arka Rakshak, shoot pruning, truss retention, tomato, hybrid

### 1. Introduction

The growth patterns of *Solanum lycopersicon* L. plants are both determinate and indeterminate. The crop having cleistogamous flower results in a high proportion of self pollination. However, up to 5 % of natural cross pollination has also been reported and insects play an important role in cross pollination. In spite of the fact that tomato is a self-pollinating plant, plant breeders have used heterosis to create a number of effective hybrids. Tomato's adaptability to a range of ecological conditions and environments as well as its floral biology, method of reproduction and extended reproductive period allow for the development of commercial hybrid seeds.

Most of the native varieties planted by Chhattisgarh cultivators have not been properly employed in any genetic improvement programmes as far, despite the fact that some of them are very well responding to the high summer temperatures.

In 2020, the world produced 186.82 million tonne (MT) of tomatoes on 5,051,983 hectares, with an average productivity of 37.1 tonne / ha (T/ha). China is the world's largest tomato producer, accounting for 64.76 million tonne (MT), or 34.67% of the world's total production (FAOSTAT 2020) <sup>[8]</sup>.

In India, it is grown in an area of 852 (000' ha) with production of 21,003 (000'MT), higher than last year production of 20.55 million tonne (2.20% higher). This is attributed to increase in the acreage in states such as Tamil Nadu, Madhya Pradesh and Maharashtra (Anon. 2020-21) <sup>[1]</sup>.

In Chhattisgarh, Tomato is cultivated in an area of 61.33 (000' ha) with production of 1,151.48 (000'tonne) and having productivity of 18.77 T/ha. (Anon. 2021) <sup>[2]</sup>. Major Tomato producing districts in chhattisgarh are Durg, Jashpur, Kondagaon, Raipur, Raigarh, Sarguja and Bemetara.

There have been many open pollinated varieties which have been developed by various institute and private companies but F1 hybrids in tomato offer various advantages such as earliness, higher productivity, improved quality, resistance to biotic and abiotic stresses, and provide a quick and practical manner of combining desirable characters, and are one of the means to meet ever increasing demand for tomato.

The present investigation entitled "Effect of shoot pruning and truss retention in hybrid seed production of Tomato (*Solanum lycopersicon* L.)" was carried out at farm of Krishi Vigyan Kendra during Rabi 2021-22, Raipur under Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.).

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## 2. Materials and Methods

The experimental material for this study consisted of ten treatments viz., T<sub>1</sub>; two shoot with four truss retained, T<sub>2</sub>; two shoot with six truss retained, T<sub>3</sub>; two shoot with eight truss retained, T<sub>4</sub>; three shoot with four truss retained, T<sub>5</sub>; three shoot with six truss retained, T<sub>6</sub>; three shoot with eight truss retained, T<sub>7</sub>; four shoot with four truss retained, T<sub>8</sub>; four shoot with six truss retained, T<sub>9</sub>; four shoot with eight truss retained, T<sub>10</sub>; control, that were laid out in randomized block design and replicated three times. Observations were made on five randomly selected plants from each treatment for plant growth attributes, fruit quality and seed yield traits viz. plant height (cm), days to 50 % flowering, fruit set %, polar diameter of fruit (cm), equatorial diameter of fruit (cm), weight of fruit (g), no. of seeds /fruit, 1000 seed weight (g), seed yield /plant (g), seed yield /ha (kg), seed germination %, seedling length (cm), seed vigour index and B:C ratio. The recommended spacing (90 cm × 45 cm), plot size (2 m x 2 m) and package of practices were followed.

### Cultural practices

#### ▪ Field preparation

The experimental plot was ploughed twice, harrowed with a disc to achieve a fine tilth, and leveled. Weeds and other stubbles were removed from the field, and the field was divided into sub plots according to the experiment's layout. After field preparation the field was divided into 30 equal plots and mulched with grey plastic mulch. Drip pipe also provided per mulching bed for efficient irrigation.

#### ▪ Seed

Seeds of parental-line of 'Arka Rakshak'- male and female line (IIHR-2834, IIHR-2833) was obtained from Indian Institute of Horticultural Research (IIHR), Bangalore.

Before sowing of the crop, seeds were treated with fungicide carbendazim @ 2g/kg of seed.

#### ▪ Details of practices followed

- 1. Transplanting:** Transplanting was done as per the recommended ratio of female and male line for hybrid seed production *i.e.* 3:1.
- 2. Pruning:** Pruning began 30 days after transplanting and continued for the duration of the plant's growth, leaving the prescribed number of shoots and trusses. Pruning was done by scissors to maintain the trusses and branches as per the treatments.
- 3. Fertilizer dose:** The recommended fertilizer dose of 150 kg N, 100 kg P<sub>2</sub>O<sub>5</sub> and 60 kg K<sub>2</sub>O per ha. The first top dressing of nitrogen and potash was applied 20 days after transplanting. The second top dressing was applied 40 days after planting at the same doses as the first.
- 4. Pollen collection:** Started on a day before pollination, in evening hrs 4 to 6 pm. It was accomplished by collecting flowers from the male parental line and retaining only the anthers from the flower. Anthers were then sundried or bulb dried in order to extract pollen.
- 5. Date of pollination:** Started on 19<sup>th</sup> February and continued upto 25 days. Pollination is usually done by stigma touch and dusting with the help of fine brush.

**6. Hybridization technique:** Hand emasculation and pollination technique is mostly used in hybridization for tomato breeding. For emasculation, straight forceps were used to remove the anther cone and corolla. One or two calyx were also removed for identification of crossed fruit. The flower of seed parents was emasculated 12-15 hrs before anthesis or at perfect bud stage and anthers were removed by forceps and fingernail. Emasculation was done in the afternoon and pollination in the next day morning hours 8 to 11 Am.

After emasculation the powdered form of pollen were dusted over stigma with the help of 0' size painting brush and covered with cotton wool to restrict contamination.

**7. Plant protection measures:** Recommended plant protection measures were applied during the crop period of Tomato.

**8. Harvesting period:** Mature fruits were harvested manually at different intervals when they were fully ripe, dark red in color.

**9. Seed extraction –** Harvested fruits from each treatment were mashed for seed extraction, and the seed and pulp were fermented overnight (Singh *et al.* 1985). The next day, the seeds were washed with water to separate them from the pulp. The seeds were cleaned and dried in the sun for two days. These seeds were then used to evaluate seed quality parameters.

#### ▪ Field observations

##### 1. Plant height (cm)

The average of 10 randomly selected plants from each treatment were measured from the ground level to the tip of the main plant stem just before harvest.

##### 2. Days to 50% flowering

The number of days from the date of sowing to the date when at least 50% of the plants show open flower is recorded.

##### 3. Days taken to fruit set

Days taken to fruit set was recorded as number of days from the date of transplanting to the date of first fruit set.

##### 4. Polar diameter of the fruit (cm)

Polar diameter of the fruits was measured with vernier callipers by selecting five fruits at random from each treatment combination and estimating the average.

##### 5. Equatorial diameter of the fruit (cm)

The equatorial diameter of the fruits was measured treatment by treatment using vernier calipers, with five fruits chosen from each treatment combination and an average was calculated.

##### 6. Weight of the fruit (g)

The weight of the fruits was recorded for each treatment combination, and the mean fruit weight for each treatment was calculated.

##### 7. Fruit set percentage

The number of fruit set out of those pollinated was recorded for each treatment combination, and the percentage of fruit set in each treatment combination was calculated.

### 8. Number of seeds per fruit

To determine the number of seeds per fruit, the total number of seeds per treatment combination was recorded and divided by the number of fruit sets per treatment.

### 9. Seed yield per plant (g)

The weight of the seeds obtained from each treatment combination was recorded in order to calculate the seed yield per plant.

### 10. Seed yield per hectare (kg)

The yield of seed per hectare was calculated for each treatment combination based on the yield of seed obtained per treatment combination.

### 11. Seedling length (cm)

On the day of germination count ten seedlings per treatment at random, and total length of the seedlings were recorded in cm. on 14<sup>th</sup> day after sowing. From this, average value for each treatment calculated.

### Calculation of Benefit-cost ratio (B:C ratio)

To estimate the benefits obtained under different treatments for each rupee of expenditure incurred, B:C ratio of each treatments was calculated as below.

$$B:C \text{ ratio} = \frac{\text{Gross income}}{\text{Total cost}}$$

Where gross return is selling price of seeds and net return is actual profit after deducting cost of cultivation.

### 3. Results and Discussion

Table shows data on economics of tomato fl hybrid seed production. Total expenditure of each treatment was divided into two parts viz., common expenditure and treatments wise extra cost. Common expenditure includes cost of field preparation, seed cost, sowing expenses, spraying of plant protection chemicals, irrigation and miscellaneous expenses. The cost of cultivation of Rs 70763/- was common for all the treatments but the cost of different treatments of shoot pruning, pollination, harvesting and seed extraction varied from treatment to treatment.

The highest gross return (Rs 790300/ha) was found in T<sub>1</sub> treatment (two shoot retention + four truss retention) and highest total cost of cultivation (Rs 260169 /ha) was found in T<sub>3</sub> (two shoot and eight truss retention).

- **Gross return:** Data embodied in Table 4.5 revealed that the maximum gross return of Rs 790300/ha was obtained with the treatment two shoot and 4 truss retention (T<sub>1</sub>).
- **Net return:** Maximum net return of Rs 598917/ha was found with T<sub>1</sub>.
- **Benefit: Cost ratio:** Maximum benefit: cost ratio obtained with T<sub>1</sub> (3.12:1) followed by T<sub>2</sub> (2.64:1) and T<sub>4</sub> (2.51:1). Whereas, minimum with T<sub>10</sub> (1.02).

### Fig Detailed package of practices

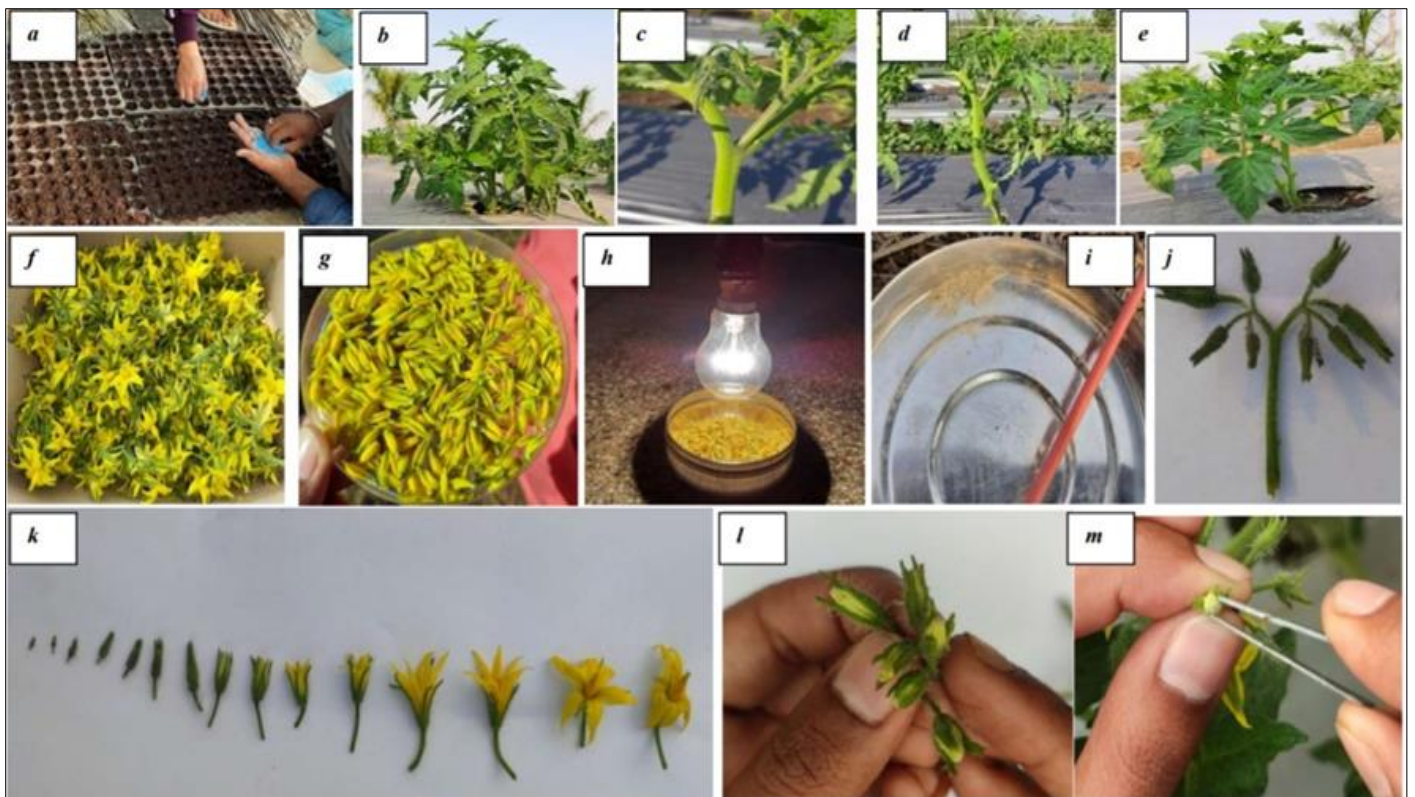
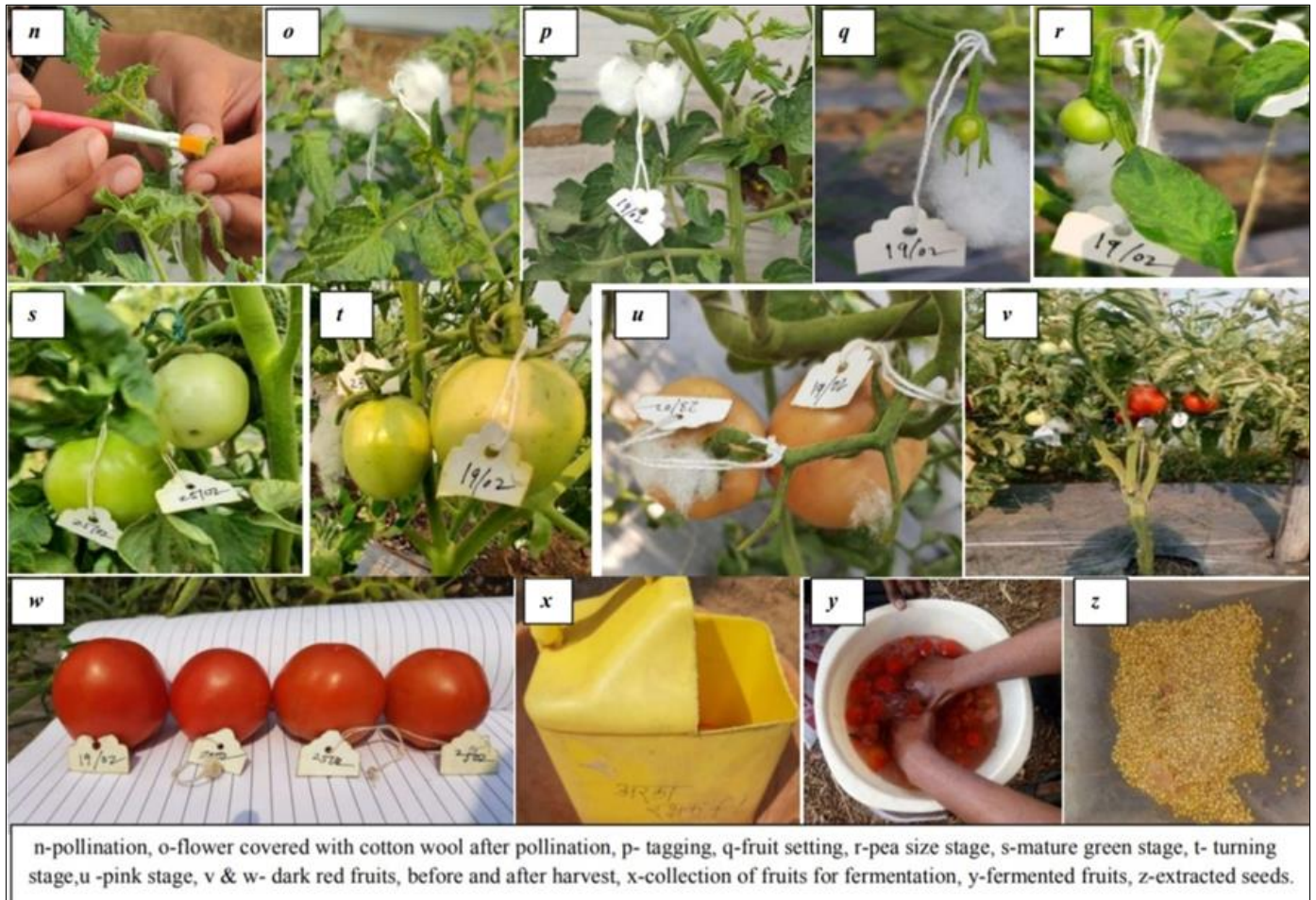


Plate 3.2: Different stages involved in hybrid seed development, a-seed sowing, b-plant before pruning, c-plant pruned to two shoot, d-plant pruned to three shoots, e-plant pruned to four shoots, f-collection of flowers from male line, g-separation of anthers, h-bulb drying of anthers, i- collection of pollen, j-immature flower truss, k-different stages of flowers, l-perfect stage of bud for pollination, m-emasculatation of flower from female parental line,





**Table 1:** Mean performance of effect of shoot pruning and truss retention in Tomato hybrid (Arka Rakshak) development

Treatment	Plant height (cm)	Days to 50% flowering	Fruit set %	Polar diameter of fruit (cm)	Equatorial diameter of fruit (cm)	Fruit weight (g)	Number of seeds/ fruit	1000 seed weight (g)	Seed yield / plant (g)	Seed yield / ha (kg)
T <sub>1</sub>	116.96	42.40	62.56	5.27	5.40	82.12	82.95	2.69	0.90	22.58
T <sub>2</sub>	113.38	44.27	54.30	5.15	5.23	80.13	78.10	2.65	0.86	21.47
T <sub>3</sub>	99.59	47.20	48.75	4.82	5.13	77.81	74.98	2.58	0.71	17.75
T <sub>4</sub>	94.69	45.13	52.15	4.84	5.25	73.27	77.55	2.56	0.75	18.67
T <sub>5</sub>	93.65	47.27	47.59	4.68	4.81	72.77	74.94	2.49	0.72	18.00
T <sub>6</sub>	91.38	49.07	46.94	4.66	4.78	66.40	67.61	2.44	0.65	16.08
T <sub>7</sub>	86.16	46.07	43.72	4.71	4.83	69.53	64.82	2.39	0.68	16.92
T <sub>8</sub>	76.02	49.73	33.87	4.48	4.63	65.37	61.66	2.37	0.59	14.65
T <sub>9</sub>	75.18	51.13	34.58	4.51	4.37	66.08	54.18	2.33	0.55	13.57
T <sub>10</sub>	73.67	50.47	31.04	4.15	4.00	57.22	49.05	2.32	0.52	13.08
Mean(x)	92.06	47.27	45.55	4.72	4.84	71.1	68.58	2.48	0.69	17.28
SEm±	3.31	2.06	5.21	0.19	0.15	2.66	5.32	0.13	0.05	1.36
CD(0.05)	9.84	6.11	15.47	0.56	0.46	7.90	15.80	0.39	0.16	4.03
CV	6.22	7.52	19.8	6.88	5.49	6.48	13.43	9.22	13.4	13.6

**Table 2:** Economics of tomato F1 hybrid seed production (Arka Rakshak)/ B:C ratio

Treatments	Common cost (Rs)	Treatment cost (Rs)	Total cost of cultivation (common cost + treatment cost)	Seed yield kg /ha	Gross return (sales price) (Rs)	Net return (Rs)	B: C ratio
T <sub>1</sub>	70763	120620	191383	22.58	790300	598917	3.12
T <sub>2</sub>	70763	135502	226265	21.47	751450	545185	2.64
T <sub>3</sub>	70763	189406	260169	17.75	621250	361081	1.38
T <sub>4</sub>	70763	115404	186167	18.67	653450	467283	2.51
T <sub>5</sub>	70763	150286	221049	18.00	630000	408951	1.85
T <sub>6</sub>	70763	184190	254953	16.08	562800	307847	1.20
T <sub>7</sub>	70763	112796	183559	16.92	592200	408641	2.23
T <sub>8</sub>	70763	147678	218441	14.65	512750	294309	1.35
T <sub>9</sub>	70763	151582	222345	13.57	474950	252605	1.13
T <sub>10</sub>	70763	155452	226215	13.08	457800	231585	1.02

#### 4. Conclusion

This investigation was conducted for one season. Consequently, no definitive conclusion could be reached. However, based on the result obtained, it can be concluded that the effects of shoot pruning and truss retention on the growth and yield characteristics of both fruits and seeds were significant. The majority of growth and yield traits were found to be greatest with treatment T<sub>1</sub> (plant pruned to two shoots with four trusses retained) followed by T<sub>2</sub> (two shoot and six truss retention) than in T<sub>4</sub> (three shoot and four truss retention).

The results showed that the treatment T<sub>1</sub> - plant pruned to two shoots with four trusses retained recorded the maximum data on plant height (cm), fruit set %, polar diameter of fruit (cm), equatorial diameter of fruit (cm), weight of fruit (g), no. of seeds /fruit, 1000 seed weight (g), seed yield /plant (g), seed yield /ha (kg), seed germination %, seedling length (cm) and seed vigour index. Also, the B:C ratio was more cost-effective with T<sub>1</sub> compared to all other treatments.

#### 5. Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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**Appendix 1:** Calculation of common cost of cultivation of hybrid seed production of tomato

S. No.	Particulars	Fixed cost of cultivation (Rs./ha)		Total cost (Rs.)
		Input	Price (Rs.)	
01	Land preparation (a) ploughing (b) rotavator	Cultivator (2 times) 5 hr Rotavator (1 time) 3 hr	1000 hr <sup>-1</sup> 1200 hr <sup>-1</sup>	5000/- + 3600/-
02	Seed rate	25 g male parent seed 100 g female parent seed	10 g @ 2000/-	25000 /-
03	Sowing	Nursery preparation 2 labour/day + transplanting 15 labour/ day	326 /-day	650/- + 4890/-
04	Irrigation	Drip system of irrigation		4890/-
05	Fertilizer (a)N (urea) (b)P (DAP) (c) K (MOP)	As per the RDF 150:100:60 kg/ha of N, P <sub>2</sub> O <sub>5</sub> and K <sub>2</sub> O	240 kg Urea 217 kg DAP 100 kg MOP	9000/-
06	Plant protection (a) fungicide (b) insecticide (c) Herbicide	Carbendazim		11300/-
		Indoxacarb, Chlorpyrifos, Acetamiprid		
		Roundup (Glyphosate), Gramoxone (paraquate)		
A	Common cost			64330/-
B	Miscellaneous cost	(10 % of common cost)		6433/-
Total fixed cost (A+B)				70763/-

**Appendix 2:** Calculation of treatment cost

Treatments	Cost of pollination (Rs/ha)	Cost of Pruning operation (Rs/ha)	Cost of Harvesting and seed extraction (Rs/ha)	Total cost (Rs/ha)
T <sub>1</sub> - two shoot retention + four truss retention	97800	15648	7172	120620
T <sub>2</sub> - two shoot retention + six truss retention	110840	15648	9454	135502
T <sub>3</sub> - two shoot retention + eight truss retention	163000	15648	10758	189406
T <sub>4</sub> - three shoot retention + four truss retention	97800	10432	7172	115404
T <sub>5</sub> - three shoot retention + four truss retention	130400	10432	9454	150286
T <sub>6</sub> - three shoot retention + four truss retention	163000	10432	10758	184190
T <sub>7</sub> - four shoot retention + four truss retention	97800	7824	7172	112796
T <sub>8</sub> - four shoot retention + four truss retention	130400	7824	9454	147678
T <sub>9</sub> - four shoot retention + four truss retention	135000	6824	9758	151582
T <sub>10</sub> - Control.	144500	0	10952	155452