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Comparative Analysis of Profitability Among Different Cultivars of Chrysanthemum Flowers Using HDPE and Tarpulin as Covering Materials

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Abstract: Chrysanthemums are popular worldwide due to their beautiful range of colors, shapes, and flower sizes. Since they are in high demand during the off seasons, the present investigation was carried out on the effect of covering materials on off-season flower production of chrysanthemums during 2022-23. The covering materials used in the experiment included tarpaulin and three cultivars, each of standard and spray type. In the present investigation, the profitability of six chrysanthemum flower cultivars i.e. White Star, Yellow Star, Purnima, Surf, Apricot Parasol, and Wellspring White were assessed under two types of covering materials i.e. HDPE (High-Density Polyethylene) and Tarpaulin. The results show that Yellow Star (2.08) with HDPE as a covering material performs best in *w.r.t.* return on investment followed by Surf (2.01). In contrast, the cultivar Wellspring White has the lowest BCR of 1.38. The cultivar White Star (1.92) and Apricot Parasol (1.65) have moderate BCRs. The results further showed that the cultivar Yellow Star has the highest BCR value among others when HDPE is used as a covering material. The study also presents the yield and profitability of these cultivars under Tarpaulin covering. Yellow Star (1.64) has the maximum BCR, followed by white Star (1.25) which was almost twice that of Purnima (0.88). Surf and Apricot Parasol also have typical BCRs (0.94 and 0.81, respectively), while Wellspring White has a minimum BCR of 0.73. Finally, the study revealed that Yellow Star is the most beneficial variety in terms of yield and return under both HDPE and Tarpaulin, followed by White Star and Purnima. These results provide valuable insights for both cut flower farms and investors, highlighting the significance of cultivar choice and covering material type when making investment or resource allocation decisions.

Keywords: benefit-cost analysis; chrysanthemum; covering material; flower forcing

1. Introduction

The floriculture sector has boosted up in recent decades, reaching USD 42.4 Billion in 2019 in terms of export revenue globally and is expected to grow roughly 6.3 % over the next five years,

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reaching USD 57.4 Billion in 2024 [1]. The flora sector gives rise to employment opportunities, develops the livelihood and well-being of farmers, and increases export potentiality and profitability [2,3,4]. To sustain this growth, farmers are increasingly exploring innovative cultivation techniques to boost both productivity and profitability, such as off-season flower production by using crop regulation, which ensure optimal resource allocation, and provides a continuous supply of flowers to the market throughout the year. Chrysanthemum is one of the most beautiful and possibly the oldest ornamental plants grown worldwide. It is native to Europe and Asia, and is also known as 'Guldaudi' in Hindi and 'Queen of the East' in English [5,6]. Chrysanthemum is derived from the Greek words 'chrysos', which means golden and 'anthos', which means flower. Chrysanthemum is a herbaceous plant of Asteraceae family, it is the second most used cut flower in the world after rose and is one of the most important commercial ornamental plants in the international flowers market [7]. The origin of the chrysanthemum is still uncertain; however, the chrysanthemum plants are results of intercrossing between natural species found in China and Japan, including *C. japonicus, C. indicum, C. makinoi, C. erubescens, C. ornatum,* and *C. si*nense [8]. The genus Chrysanthemum includes 100-200 species [9] with different morphological characteristics and has a prevalent evolutionary history, morphological variation is significant; and the ploidy level is 2n = 2x = 18, 2n = 36, 54, 72, and up to 90 [10]. Chrysanthemum has been cultivated for millennia and is typically a hexaploid with chromosomal aneuploidy, the most common and stable chromosome number being 2n = 6x = 54 [11]. It is characterized by attractive blooms as well as by a broad variety of flower shapes and sizes. Chrysanthemum has comparatively high ornamental values in terms of flower shape and color ranges while flower architectural types are highly diverse, which could be attributed to its allohexaploid nature and the fact that it is one of the most complex genomes in the plant kingdom [12]. Chrysanthemum has been bred and cultivated in different parts of the world, and thousands of cultivars have been commercialized throughout the world with great variation in flower color and forms, which makes it the most popular ornamental plant in the world even today (13).Chrysanthemum is one of the most important flowers in India and plays a significant role in producing loose and cut flowers in the country. It is commercially cultivated in several states including Karnataka, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, West Bengal, Assam, Haryana, and Himachal Pradesh. Besides, the extent of chrysanthemum cultivation in India is nearly 23.93 thousand hectares with an average production of 454.20 thousand tonnes of loose flowers and 15.96 thousand tonnes of cut flowers [14]. Himachal Pradesh is one of the largest producers of chrysanthemums in the country with the land under its cultivation estimated to be around 0.11 thousand hectares. The state also contributes significantly to the production; the state produces 0.52 thousand tones of loose flowers and cut flowers with a production of 3.90 thousand tonnes [14].

Chrysanthemum flower has various sources of income for the farmers and the government like the generation of employment, upliftment of the rural areas, and the export income for the country. The crop can be a source of income for the farmers and the government, with export earnings being a potential boost to the economy. Flowers like chrysanthemums are also exported from India in a relatively increasing amount due to their ornamental look and usage in many floral products. Furthermore, the cultivation of chrysanthemum plays a significant part in agriculture as it offers multiple economic benefits for the country as well as contributes to sustainable agriculture.

Chrysanthemum forcing is a technique where the flowering process in chrysanthemum cultivars is regulated with the aim of getting good quality flowers all throughout the year. Growers use tarpaulin or HDPE as cover to control photoperiod as chrysanthemum is a short-day plant therefore they require short days (below 10 hours of photo-period) for flowering and long days for vegetative growth. This research establishes that the forcing techniques for flower production, farmers can improve their yields and their returns within the cut flower and loose flower market. Such a strategy enables farmers to benefit from year-round market consumption regardless of the changing weather conditions.

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2. Materials and Methods

2.1. Study Area

The present study was carried out at the experimental farm of RHR&TS, Dhaulakuan, Sirmour, affiliated to Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni Solan Himachal Pradesh during the year 2022-23. The experimental farm is situated at an altitude of 438 m above the mean sea level, at 30◦30′20″ North latitude and 77◦20′30″ East longitude. It comes under the low hill zone of Himachal Pradesh. The area's climate in general is sub-tropical characterized by a hot summer with heavy rains and a relatively cool winter.

2.2. Cultivars

Under the present study, six chrysanthemum Cultivars were used namely 'White Star', 'Yellow Star', 'Purnima' under the standard group, 'Surf', 'Well Spring White', and 'Apricot Parasol' under the spray group.

2.3. Planting Material

The shoot tip cuttings of 8–10 cm length were collected from the healthy disease-free mother plants in the morning hour, and these cuttings were dipped in a solution of Dithane M-45 (0. 2 %) and Bavistin (0. 1 %) for 30 minutes. The lower leaves of cuttings were trimmed off while a clean cut was made at the base of the node. The cut ends were dipped in NAA @ 500-ppm solution with the quick dip method. The treated cuttings were kept for rooting in media containing damp sand and coco peat (1:2) in the propagation chamber. The cuttings were successfully rooted within 25 to 30 days. For hardening, the rooted cuttings were kept in the shade net house and transplanting was done in the experimental farm after 8-10 days.

2.4. Planting

For normal season planting under low hills conditions is done during Aug-Sept as standard practice among farmers, but under the present investigation for off-season flower production, the rooted cuttings of the selected cultivars were planted in the 1st week of February of both years, 2022, and 2023. The healthy cuttings were carefully taken out from the propagation chamber and planted on raised beds with a spacing of 30 cm × 20 cm.

2.5. Controlled Photoperiod

Plants were subjected to artificial short day's photoperiodic treatments when plants attained sufficient vegetative growth and the side branches had grown to one-feet height after pinching. To mimic short days, artificial covers i.e. Tarpaulin and HPDE (one side black and the other silvery part) were used to create artificially short days. The semi-circular metallic tunnel frames (3 × 1. 5 × 1. 5 m) were fully covered with black polythene and were placed over the plants for 16 hours daily from 5:00 pm to 9:00 am. The short days persisted until 60-75 % of flower buds developed colour.

2.6. Method of Data Collection

Data for the present study was collected from a research trial carried out in the floriculture farm at RHR&TS Dhaulakuan, Himachal Pradesh, India. Field data was collected with the help of trained enumerators for the years 2022-23.

2.7. Analytical Techniques

Both fixed cost and variable cost were taken into account in calculating the cost of chrysanthemum cultivation. Land use cost was calculated based on the per year existing lease value of the land. The profitability of chrysanthemum cultivation was examined based on gross margin,

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net return, and benefit-cost analysis. The collected data was summarized, tabulated, and analyzed to fulfill the objectives of the study. The tabular method using descriptive statistics was mostly used in the study. The cobb-Douglas production function model was used to estimate the contribution of factors to marigold cultivation. The functional form of the Cobb-Douglas production function model [15] is given below:

$$Y = AX_1^{b1}X_2^{b2} \text{ ---------- } X_n^{bn}e^{ui}$$

The production function was converted to logarithmic form so that it could be solved by least square method

i.e. $\ln Y = \ln a + b_1 \ln X_1 + b^2 \ln X_2 + \ldots\ldots\ldots\ldots\ldots\ldots b_n \ln X_n + U_i$

3. Results

3.1. Data Presented in Table 1 Shows the Cost of Cultivation Including Fixed and Variable Cost and Total Expenditure of Different Chrysanthemum Cultivars by Using HDPE as Covering Material

3.1.1. Fixed Costs

Fixed cost consists of Rs 11,199 which is the initial cost of growing and harvesting chrysanthemum cultivars in a polyhouse located in the hills of Himachal Pradesh and these are incurred once and do not vary with the quantity of production. The major element of the fixed cost is the rental of the poly-house @ Rs 5,000 for six months, FYM @ Rs 1125, Fertilizers – Urea, Single super phosphate, Muriate of potash @ Rs 530.10, plant protection material – Spike and Bavistin @ Rs 390, Bamboo sticks @ Rs 500, and HDPE cladding @ Rs 3652.

Table 1. Cost of cultivation of different chrysanthemum cultivars for off-season flower production under low Hills of HP on an area of 200 m^2 Covered with HDPE.

Sr.No	Particulars/Items	Quantity required	Cost/unit (Rs)	Total cost (Rs)
D.	**Cost of box**	**No of boxes**	**Rate/box (Rs)**	**Total cost**
	White Star	17	80/box	**1360.0**
	Yellow Star	18	80/box	**1440.0**
	Purnima	12	80/box	**960.0**
	Surf	6 gunny bags	30/bag	**180.0**
	Apricot Parasol	5 gunny bags	30/bag	**150.0**
	Wellspring White	3 gunny bags	30/bag	**90.0**
	Total cost of boxes/bags and transportation			
	White Star	5100.0	1360.0	**6460.0**
	Yellow Star	54,00.0	1440.0	**6840.0**
	Purnima	3600.0	960.0	**4560.0**
	Surf	1800.0	180.0	**1980.0**
	Apricot Parasol	1500.0	150.0	**1650.0**
	Wellspring White	900.0	90.0	**990.0**
E	**Total cost of expenditure**			
		Fixed cost and Variable cost	**Transportation cost and cost of boxes/bags**	**Total cost (Rs)**
	White Star	21539	6460.0	**27999.0**

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	Yellow Star	21539	6840.0	**28379.0**
	Purnima	21539	4560.0	**26099.0**
	Surf	21539	1980.0	**23519.0**
	Apricot Parasol	21539	1650.0	**23189.0**
	Wellspring White	21539	990.0	**22529.0**
F	**Gross returns**			
	Cultivars	**Cut flower yield (Number of cut stems)**	**Cost/cut stem (Rs)**	**Gross returns (Rs)**
	White Star	6824	Rs12/cut stem	**81888.0**
	Yellow Star	7290	Rs12/cut stem	**87480.0**
	Purnima	4941	Rs12/cut stem	**59292.0**
	Surf	284kg	Rs250/kg	**71000.0**
	Apricot Parasol	246kg	Rs250/kg	**61500.0**
	Wellspring White	215kg	Rs250/kg	**53750.0**
G.	**Net return**			
	White Star	81888.0	27999.0	**53889**
	Yellow Star	87480.0	28379.0	**59101**
	Purnima	59292.0	26099.0	**33193**
	Surf	71000.0	23519.0	**47481**
	Apricot Parasol	61500.0	23189.0	**38311**
	Wellspring White	**53750.0**	**22529.0**	**31221**

3.1.2. Transportation Costs

Transportation costs include the cost of transporting flowers to the market; this depends on the number of flowers harvested and the distance for transportation. This cost is presented separately for each cultivar, with the following amounts: White Star Rs 5,100, Yellow Star Rs 5,400, Purnima Rs 3,600, Surf Rs 1,800, Apricot Parasol Rs 1,500, and Wellspring White Rs 900. Additionally, the total cost of boxes, bags, and transportation for each cultivar is as follows: White Star at Rs 6,460, Yellow Star at Rs 6,840, Purnima at Rs 4,560, Surf at Rs 1,980, Apricot Parasol at Rs 1,650 and Wellspring White at Rs 990.

3.1.3. Variable Costs

The total variable cost of cultivating chrysanthemum cultivars in the polyhouse located in the hills of Himachal Pradesh is Rs 10,340, which includes costs occurring during the cultivation of the crop and varies in proportion to the quantity of production. The major heads of variable cost consist of planting material (cuttings) which costs Rs 5,100 and labor cost for land preparation, layout, irrigation, pinching, weeding, hoeing, disbudding, and de-shooting which costs Rs 5,240.

3.1.4. Total Cost of Expenditure

Total expenses of chrysanthemum varieties include fixed cost, variable costs, and transport charges. Expenditure break-up per cultivar for White Star (Rs 27,999), Yellow Star (Rs 28,379), Purnima (Rs 26,099), Surf (Rs 23,519), Apricot Parasol (Rs 23,189), and Wellspring White (Rs 22,529). The highest expected gross return per hectare was recorded from White Star and Yellow Star (Rs 81,888 to Rs 87,480). On average, the additional yield of Surf is produced at about the same cost as year-round cultivars, and they do not fit easily into any particular seasonality pattern such as Apricot Parasol and Wellspring White presents the lowest return accordingly.

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3.2. Cost of Cultivation of Different Chrysanthemum Cultivars for Off-Season Flower Production Under Low Hills of Himachal Pradesh on an Area of 200 m² Covered with HDPE

3.2.1. Benefit-Cost Ratio for HDPE

Data from Table 2 compares the benefit-cost ratio (BCR) of three varieties, with the highest BCR for Yellow Star (2.08), showing that for every rupee invested, there is a return of approximately 2.08 rupees, whereas the lowest being Purnima having a return of 1.27 rupees. The rest of the cultivars are intermediate, with White Star (1.92) and Apricot Parasol (1.65). The benefit-cost ratio of Wellspring White (1.38) is lower compared to other cultivars, which suggests that it might not be as profitable, while Surf has a higher BCR (2.01) value among others, making it a practical option. Both White Star and Surf hold a higher BCR, indicating that they are good investment opportunities for farmers.

Table 2. Benefit cost ratio (Cost of Cultivation Gross returns/Total cost) for HDPE.

Cultivars	Cost of Cultivation	Gross Return	Net Return	B:C Ratio
White Star	27999.0	Rs 81888.0	Rs 53889.0	**1.92**
Yellow Star	28379.0	Rs 87480.0	Rs 59101.0	**2.08**
Purnima	26099.0	Rs 59292.0	Rs 33193.0	**1.27**
Surf	23519.0	Rs 42600.0	Rs 47481.0	**2.01**
Apricot Parasol	23189.0	Rs 36900.0	Rs 38311.0	**1.65**
Well Spring White	**22529.0**	**Rs 32250.0**	**Rs 31221.0**	**1.38**

Table 3 shows the benefit-cost ratio (B: C) of production for chrysanthemum flowers in a polyhouse under the low hills of Himachal Pradesh, India. Data are provided for six cultivars namely White Star, Yellow Star, Purnima, Surf, Apricot Parasol, and Wellspring White**.**

Table 3. Cost of cultivation of different chrysanthemum cultivars for off-season flower production under low Hills of Himachal Pradesh on an area of 200 m² Covered with Tarpaulin.

Sr.no	Particulars/Items	Quantity required	Cost/unit (Rs)	Total cost (Rs)
A.		**Fixed cost**		
1.	Rental value of the poly house	200 m² for 6 months	Rs 5000/100 m²/year	5,000.0
2.	Farm Yard Manure	750 kg	1.5/kg	1125.0
3.	Urea	9.75 kg	Rs 380/50kg	74.1
4.	Single Super Phosphate	28.1 kg	Rs 556/50kg	312.0
5.	Muriate of Potash	7.5 kg	Rs 780/50kg	147.00
	Plant protection materials			
	Spike	50 g (Twice)	Rs 200/100g	200
	Bavistan/(SAAF)	250g	Rs 190/250g	190
6.	**Staking material**			
	Bamboo sticks	-	-	500.0
	Cladding materials (Tarpaulin)	974 m²	Rs 100/m²	4850.0
	Considering total life span of 10 years			

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	Total			**12398**
B.		**Variable cost**		
Sr. no.	**Particulars**	**Quantity required**	**Cost/unit (Rs)**	**Total cost(Rs)**
1.	**Planting material**			
	Cultivars	2040	Rs 2.5/cutting	5,100.00
2.	**Labour cost**			
	Land preparation (Ploughing through power tiller)	1 hour	200/hour	200.00
	Layout, preparation of beds, incorporation of FYM, Basal application of fertilizers, planting, irrigation and staking	2 man-days	420/man-day	840.0
	Labour cost for irrigation, pinching, weeding, hoeing, disbudding and de-shooting			
		10 man-days	420/man-day	4200.0
	Total			**10,340**
C.	**Transportation cost (400cut stems/box) 50 kg per gunny bag**	**Number of boxes**	**Cost/box(Rs)**	**Total cost**
	White Star	13 box	300/box	3900
	Yellow Star	15 box	300/box	4500
	Purnima	11 box	300/box	3300
	Surf	4 gunny bags	300/bag	1200
	Apricot Parasol	3 gunny bags	300/bag	900
	Wellspring White	3 gunny bags	300/bag	900
Sr. No	**Particulars/Items**	**Quantity required**	**Cost/unit (Rs)**	**Total cost (Rs)**
D.	**Cost of box**	**No of boxes**	**Rate/box(Rs)**	**Total cost (Rs)**
	White Star	13 box	80/box	1040
	Yellow Star	15 box	80/box	1200
	Purnima	11 box	80/box	880
	Surf	4 gunny bags	30/bag	120
	Apricot Parasol	3 gunny bags	30/bag	90
	Wellspring White	3 gunny bags	30/bag	90
E.	**Total cost of boxes/bags and transportation**			
	White Star	3900	1040	4940
	Yellow Star	4500	1200	5700
	Purnima	3300	880	4180

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	Surf	1200	120	1320
	Apricot Parasol	900	90	990
	Wellspring White	900	90	990
F.	**Total cost of expenditure**	**Fixed cost and Variable cost**	**Transportation cost and cost of boxes/bags**	**Total cost (Rs)**
	White Star	22738	4940	27678
	Yellow Star	22738	5700	28438
	Purnima	22738	4180	26918
	Surf	22738	1320	24058
	Apricot Parasol	22738	990	23728
	Wellspring White	22738	990	23728
G.	**Gross returns**			
	Cultivars	**Cut flower yield (Number of cut stems)**	**Cost/cut stem (Rs)**	Gross returns (Rs)
	White Star	5204	Rs12/cut stem	62448.0
	Yellow Star	6277	Rs12/cut stem	75324.0
	Purnima	4232	Rs12/cut stem	50784.0
	Surf	187 kg	Rs 250/kg	46750.0
	Apricot Parasol	172 kg	Rs 250/kg	43000.0
	Wellspring White	165 kg	Rs 250/kg	41250.0
H.	**Net return**			
	White Star	62448.0	27678	34770
	Yellow Star	75324.0	28438	46886
	Purnima	50784.0	26918	23866
	Surf	46750.0	24058	22692
	Apricot Parasol	43000.0	23728	19272

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Sr.No.	Particulars/Items	Quantity required	Cost/unit (Rs)	Total cost (Rs)
A.	**Fixed cost**			
	Rental value of the poly -house	200 m^2 for 6 months	Rs 5000/100 m^2/year	**5,000.0**
	Farm Yard Manure	750 kg	1.5/kg	**1125.0**
	Urea	9.75 kg	Rs 380/50 kg	**74.1**
	Single Super Phosphate	28.1 kg	Rs 556/50 kg	**312.0**
	Muriate of Potash	7.5 kg	Rs 780/50 kg	**147.00**
	Plant protection materials			
	Spike	50 g (Twice)	Rs 200/100 g	**200**
	Bavistan/(SAAF)	250g	Rs 190/250 g	**190**
6.	**Staking material**			
	Bamboo sticks	-	-	**500.0**
	Cladding materials (HDPE) Considering total life span of 10 years	974 m^2	Rs75/m^2	**3652.0**
	Total			**11,199**
B.	**Variable cost**			
Sr. No	**Particulars**	**Quantity required**	**Cost/unit (Rs)**	**Total cost (Rs)**
1.	**Planting material**			
	Cultivars	2040	Rs 2.5/cutting	**5,100.00**
2.	**Labour cost**			
	Land preparation (Ploughing through power tiller)	1 hour	200/hour	**200.00**
	Layout, preparation of beds, incorporation of FYM, Basal application of fertilizers, planting, irrigation and staking	2 man-days	420/man-day	**840.0**
	Labour cost for irrigation, pinching, weeding, hoeing, disbudding and de-shooting			
		10 man-days	420/man-day	**4200.0**
	Total			**10,340**
C.	**Transportation cost (400 cut stems/box)**	**Number of boxes**	**Cost/box (Rs)**	**Total cost**
	White Star	17 box	300/box	**5100.0**
	Yellow Star	18 box	300/box	**54,00.0**
	Purnima	12 box	300/box	**3600.0**
	Surf	6 gunny bags	300/bag	**1800.0**
	Apricot Parasol	5 gunny bags	300/bag	**1500.0**
	Wellspring White	**3 gunny bags**	**300/bag**	**900.0**

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3.2.2. Fixed Cost

The fixed costs include the rental value of the polyhouse, farm yard manure (FYM), urea, single super phosphate (SSP), and muriate of potash (MOP) which is Rs. 12,398. Variable cost is the sum of planting material, land preparation, planting, and post-harvest operations. The total variable cost was Rs. 10,340.

3.2.3. Transportation Cost

Transportation costs depend on the cultivar and the yield of flowers harvested. The cost includes boxes and bags used for packaging and transportation. The total transportation cost and the cost of boxes and bags range from Rs. 990 to Rs. 5,700.

3.2.4. Gross Return

The gross returns are then multiplied by the number of cut stems produced per cultivar and the market price per cut stem. Gross returns range from Rs. 41,250 for Wellspring White to Rs. 75,324 for Yellow Star.

3.2.5. Net Return

The net return is calculated by subtracting the total cost of expenditure from the gross returns. The net returns range from Rs. 19,272 for Wellspring White to Rs. 46,886 for Yellow Star.

3.2.6. Benefit-Cost Ratio

The benefit-cost ratio (B:C) is calculated by dividing the gross returns by the total cost of cultivation. The B:C ratio indicates the return on investment for each cultivar. The higher the B:C ratio, the more profitable the cultivar is. Data pertaining in Table 4, shows that the chrysanthemum cultivar Yellow Star has the highest benefit-cost ratio of 1.64, indicating that it generates the highest return on investment. White Star and Surf also have relatively high B:C ratios of 1.25 and 0.94, respectively. On the other hand, Wellspring White has the lowest B: C ratio of 0.73, showing that it generates a lower return on investment compared to the other cultivars. Purnima and Apricot Parasol have moderate B: C ratios of 0.88 and 0.81, respectively. In general, the results suggest that Yellow Star is the most profitable cultivar, followed by White Star and Surf. Wellspring White has a lower profitability compared to the other cultivars.

Table 4. Benefit-cost ratio (Cost of Cultivation Gross return/Total cost) for Tarpaulin.

Cultivar	Cost of Cultivation	Gross Return	Net Return	B:C Ratio
White Star	27678	62448.0	34770	1.25
Yellow Star	28438	75324.0	46886	1.64
Purnima	26918	50784.0	23866	0.88
Surf	24058	28050.0	22692	0.94
Apricot Parasol	23728	25800.0	19272	0.81
Wellspring White	23728	24750.0	17522	0.73

4. Discussion

The cost analysis of different chrysanthemum cultivars grown in polytunnel, particularly in the unique climatic conditions of Himachal Pradesh, reveals significant light into fixed, variable, and total expenditures associated with different cultivars. The comprehensive breakdown of costs informs both economic viability and practical management decisions for growers. The fixed costs, Rs 11,199, primarily stem from the rental of polyhouses and essential inputs like FYM, fertilizers, and

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plant protection materials. The substantial rental expense reflects the capital-intensive nature of polyhouse cultivation, which is aligned with previous findings that demonstrate the high initial investment required for controlled environment agriculture [16]. The dominance of rental costs underscores the importance of optimizing space utilization and potentially sharing costs among multiple growers to enhance economic efficiencies [17].

Transportation costs, which vary significantly among the cultivars examined, influence the overall profitability and marketability of the flowers. For instance, 'White Star' and 'Yellow Star' incur the highest transportation costs (Rs 6,460 and Rs 6,840 respectively), likely due to their higher yield per hectare necessitating more robust logistics. Conversely, 'Wellspring White' shows the lowest transportation costs (Rs 990), indicating lesser quantities harvested. This is consistent with research indicating that proximity to markets can significantly affect the transportation cost component in horticultural economics [18]. Understanding these dynamics allows growers to better strategize their distribution channels and possibly select cultivars that balance profitability with logistical feasibility [19].

The total variable cost of Rs 10,340 incorporates both labor and planting materials. Notably, the labor cost (Rs 5,240) highlights the labor-intensive nature of chrysanthemum cultivation, reflecting the need for continuous management throughout the production cycle. Studies have shown that labor costs often constitute a significant portion of total costs in flower production, particularly where labor practices are less mechanized [20]. Growers need to optimize labor utilization through efficient practices such as mechanization and workforce training to reduce these variable costs without compromising quality [21].

The overall expenditures range significantly across cultivars, with White Star representing the highest cost (Rs 27,999) and Wellspring White the lowest (Rs 22,529). These variations can be attributed to differences in labor needs, market prices, and cultivation methods inherent to each cultivar. Importantly, the high expected gross returns from White Star and Yellow Star create an attractive revenue potential that justifies the corresponding investments [22]. Conversely, Apricot Parasol and Wellspring White yield lower returns, emphasizing the importance of cultivar selection in maximizing profitability. The finding that Surf maintains a similar expenditure as year-round cultivars yet presents potential for additional yield warrants further exploration into seasonality impacts and market trends [23]. This underlines the necessity for growers to conduct thorough market analyses and consider seasonality as a crucial factor when planning their production strategies.

In this analysis, we examine the economic viability of various chrysanthemum cultivars cultivated in a polyhouse setup covered with HDPE (High-Density Polyethylene) in the low hills of Himachal Pradesh. The benefit-cost ratio (BCR), fixed and variable costs, transportation costs, gross returns, and net returns are crucial indicators that shape the economic landscape of chrysanthemum production. The benefit-cost ratio serves as a fundamental metric for assessing the profitability of different cultivars. The findings reveal that Yellow Star exhibits the highest BCR for every rupee invested, underscoring its potential as a high-value crop (Table 2). In contrast, Purnima presents the lowest BCR at, indicating it may not yield sufficient returns relative to the investment made. The intermediate BCRs of White Star and Surf suggest these cultivars, too, provide favorable investment opportunities. The BCR calculations highlight a critical aspect of agricultural economics: the presence of differential profitability across cultivars can guide growers in making informed decisions regarding which varieties to cultivate based on economic outcomes [24]. The findings support existing literature, which consistently emphasizes cultivar selection as a key determinant of financial sustainability in flower production [25].

The fixed costs, amounting to Rs 12,398, incorporate essential inputs such as rental, fertilizers, and farmyard manure (FYM). High fixed costs are characteristic of controlled environment agriculture and necessitate careful management to ensure long-term viability [26] Furthermore, the total variable cost of Rs 10,340 encompasses labor-intensive activities, including planting and post-harvest operations, reflecting the labor dynamics inherent in chrysanthemum cultivation. This aligns

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with previous studies indicating that variable costs significantly affect profitability, often requiring growers to optimize labor utilization [27].

The transportation costs of cultivars illustrate the importance of logistics in determining overall economic success. Ranging from Rs 990 to Rs 5,700, these costs can greatly impact net returns depending on market distance and harvested yield. Notably, transport costs increase with quantity and distance, highlighting the need for efficient market access strategies. This is consistent with findings by several authors, who emphasized that effective logistic management is fundamental to maximizing profitability in floriculture [28,29].

Gross returns vary significantly among cultivars, with Yellow Star yielding the highest, while Wellspring White generates the lowest gross return. The resultant net returns reinforce this trend: Yellow Star offers net returns of Rs 46,886, while Wellspring White shows a meager Rs 19,272. These findings underscore the necessity for a robust understanding of market trends and consumer preferences when evaluating potential cultivars for commercial production [30].

5. Conclusion

From the present study, it can be concluded that HDPE sheet as a covering material for the cultivar Yellow Star, gave the highest benefit-cost ratio (BCR) produced by chrysanthemums grown under environmentally controlled conditions. Furthermore, using tarpaulin as a covering material for Yellow Star also yields the highest BCR (2.08) followed by Surf (2.01). Thus, Yellow Star seems to be the most profitable cultivar even when using tarpaulin as a covering. The other cultivars, including White Star, Purnima, Apricot Parasol, and Wellspring White, showed lower BCR values, with Purnima being the lowest. This implies that these cultivars may not achieve the same profit level as Yellow Star. Based on the results, it can be concluded that Yellow Star is economically viable for chrysanthemum production under polyhouse conditions, as its BCR value and gross return were higher than other treatments. The study emphasizes the importance of selecting the appropriate covering material for polyhouse, as it can significantly impact the profit margin. Thus, the present study concludes that Yellow Star is the most profitable cultivar for chrysanthemum production under polyhouse, conditions with both HDPE and tarpaulin being effective covering materials to increase profitability.

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