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# Prospects of Strawberry Cultivation under hilly conditions in India

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***Abstract:*** *The cultivated strawberry (*Fragaria X ananassa*) has commanded a premier position in the world fruit market due to its attractive fruit and distinctive flavour.It has adapted well to highly varied climatic conditions. It is today commercially cultivated under extreme temperate conditions, sub-tropical and high altitudes of tropical regions and even in the desert-like area of Israel. Being a shallow rooted crop, both crop damage and plant mortality can occur during extremely dry seasons. It is one of the most delicious and refreshing fruit cherished in gardens and commercial plantations for its beautiful and attractive red fruits. Strawberry cultivation has only recently received a great impetus in India with large business houses setting up a number of agro based establishments primarily aimed at large scale production of strawberry fruits. It has occupied a premier position in urban areas. Being a herbaceous annual fruit crop, it can also be grown easily in kitchen garden, roof garden, pots etc. It is regarded as a valuable food in the diet of millions of people around the globe and is in special demand by the fruit processing industries for preparing the jams, ice cream, candy, toffee and other products. A number of large fruited, high yielding varieties viz., Chandler, Pajaro, Etna, Sweet Charlie, Selva, Douglas, Confictura, Dana, Belrubi, Gorella and Addie have been introduced into the country from Europe and North America. Some of the day-neutral cultivars are Selva, Majestic, Phenomenal, Brighton, Etna, Fern, Sweet Charlie are very promising. Farmers in the vicinity of Delhi, Haryana, Punjab and Uttar Pradesh a sub-tropical area have been profitably cultivating strawberries during the winter months obtaining their planting materials from the hills of Himachal Pradesh / Uttarakhand. Besides, the income from strawberry fruits, growers in the hills thus can also earn by producing planting material for winter plantings in the plains. Besides the above mentioned state, strawberry is now growing in differentagro-climatic conditions in India viz. Jharkhand, Meghalaya., Leh, Lucknow,Chattisgarh, etc.The use of polyethylene mulch in commercial cultivation of strawberry can play a pivotal role in minimizing winter injury, plant mortality and increasing productivity. Covering the strawberry beds with plastic mulch prevented bed erosion and increased total yields by 20 per cent. The black polyethylene mulched beds did not require any weeding.*

***Keywords****: Strawberry, Cultivation, Yield, Runners, climate, climatic zone,*

## INTRODUCTION

The cultivated strawberry (*Fragaria X ananassa* Duch.) has commanded a premier position in the world fruit market due to its attractive fruit and pleasant distinctive flavor. It has adapted well to highly varying climatic conditions. It is today commercially cultivated in regions that are characteristically temperate to sub-tropical plains to high altitudes in tropical regions and even in the desert-like areas of Israel. Being a shallow rooted crop, both crop damage and plant mortality can occur during dry seasons. Strawberry cultivation recently received some impetus in India with large business houses setting up a number of agro based establishments primarily aimed at large scale production of strawberry fruits. Being an herbaceous annual fruit crop, it can also be grown easily in kitchen gardens, roof-top gardens, pots etc. It is regarded as a valuable food in the diet of millions of people around the globe and is in special demand by the fruit processing industries for preparing the jams, ice cream, candy, toffee and other products. A number of large fruited, high yielding varieties (e.g. 'Chandler', 'Pajaro',

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'Etna', 'Sweet Charlie', 'Selva', 'Douglas', 'Confictura', 'Dana', 'Belrubi', 'Gorella' and 'Addie') have been introduced into India from Europe and North America. Some of the day-neutral (DN) cultivars (e.g. 'Selva', 'Majestic', 'Phenomenal, 'Brighton', 'Etna, 'Fern') may be adapted for Indian climate. Farmers in the vicinity of Delhi and in the states of Haryana, Punjab, Maharashtra, Karnataka and Uttar Pradesh a sub-tropical / tropical area have been profitably cultivating strawberries during the winter months obtaining their planting materials from the hills of Himachal Pradesh and Uttarakhand . Besides, the income from strawberry fruits, growers in the hills thus can also earn by producing planting material for winter plantings in the plains. Besides the above mentioned states, strawberry is now growing in different agro-climatic conditions in India viz. Maharastra, Jharkhand, Meghalaya, Leh (Jammu & Kashmir), Lucknow, Chattisgarh, Rajasthan etc. The use of polyethylene mulch in commercial cultivation of strawberry can play a pivotal role in minimizing winter injury, plant mortality and increasing productivity. Covering the strawberry beds with low clear plastic tunnels induced one month early cropping, prevented bed erosion and increased total yields by 20 per cent. The black polyethylene mulched beds did not require any weeding. During summers (In hills) the polyethylene sheets of the tunnels were replaced by plastic anti-hail nets or anti- bird nets which resulted in advanced harvest, increased yield and improved fruit quality. This possibility of this had also been reported under different agro-climatic conditions earlier by Albergets and Chandler, 1993. Mulching is an important component of strawberry production system. Many synthetic and organic types of mulch are being used for strawberry cultivation in different parts of the country based on the climatic conditions and availability of raw materials. Hemelrick (1982) showed that plants grown on black polythene produce more runners and fruits than with bare soil. Different workers have reported beneficial effects of organic mulches on strawberry production (Rebandel and Przysiccka, 1981, Badiyala and Aggarwal, 1981, Hassan et al., 2000, Lille et al., 2003). Keeping this in view, the study was conducted to test the performance of the promising genotypes under hilly conditions in India.

## MATERIAL AND METHODS:

Strawberry cultivars representing diverse fruit and plant characteristics constituted the material for the present study (Table 1). The investigation was carried out at the Indian Agricultural Research Institute (IARI) Regional Station, Shimla (in hills), where all 33 cultivars were studied during 2013-2015. The observations were recorded from randomly selected five plants from each cultivar in each replication. Observations were recorded for plant height, number of leaves, plant spread, fruit weight (gm/fruit), percent of total yield before peak fruiting and total yield (Kg/ five plants).

The strawberry plants were planted 30 cm apart in rows that were 45 cm apart. Ten plants were planted in a bed of 150 × 60 cm. All runners were removed as soon as they appeared for better fruit production. There were three replications with five beds of each cultivar in each replicate. Other recommended agronomic, drip-irrigation, and plant protection measures were followed for successful strawberry cultivation. Effect of soil mulching with black polythene, transparent polythene sheet and grass mulches covering was studied on weed growth, earliness, yield and fruit quality in Shimla hills.

## RESULTS AND DISCUSSION

Performance of strawberry genotypes in the sub-tropical plains is presented in Tables 2 and 3 for plant and yield characteristics, respectively under black polythene, transparent polythene and locally available grass mulches. Maximum plant height,

**Table 1**
**List of strawberry Cultivars in trials**

| | | |
|---|---|---|
| (1.) Sweet Charlie | (2.) Phenomenal | (3.) North West |
| (4.) Sasta | (5.) Pusa Pride | (6.) Etna |
| (7.) Red Coat | 8. Florida–90 | (9.) Pusa Sweet |
| (10.) Belrubi | (11.) Dana | (12.) Dilpasand |
| (13.) Howard-17 | (14.) Katrain Sweet | (15.) Douglas |
| (16.) Shimla Delicious | (17.) Jutogh Special | (18.) Larson |
| (19.) Blakemore | (20.) Himalayan Scarlet | (21.) Missionary |
| (22.) Torrey | (23.) Sea Scape | (24.) Amartara Red |
| (25.) Addie | (26.) Majestic | (27.) Catskill |
| (28.) V.L. | (29.) Chandler | (30.) Fairfax |
| (31.) Selva | (32.) Fern | (33.) Pajaro |

**Table 2**
**Plant characteristics of strawberry cultivars grown in hilly conditions**

| S. No. | Cultivar | Plant Height (cm) | | | | No. leaves/plant | | | | Plant spread (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Black Poly. | White Poly. | Grass | Cultivar Means | Black Poly. | White Poly. | Grass | Cultivar Means | Black Poly. | White Poly. | Grass | Cultivar Means |
| 1. | SweetCharlie | 12.5 | 11.5 | 10.5 | 11.50 | 35.8 | 28.3 | 22.5 | 28.87 | 23.5 | 22.9 | 15.4 | 20.60 |
| 2. | Phenomenal | 15.9 | 13.5 | 11.5 | 13.63 | 48.9 | 38.7 | 29.5 | 39.03 | 29.6 | 25 | 22.5 | 25.70 |
| 3. | North West | 13.3 | 10.9 | 9.8 | 11.33 | 39.9 | 32.7 | 26.6 | 33.07 | 27.8 | 26.9 | 19.9 | 24.87 |
| 4. | Sasta | 14.4 | 12.1 | 10.9 | 12.47 | 35.6 | 30.3 | 27.6 | 31.17 | 28.8 | 23.3 | 24.5 | 25.53 |
| 5. | Pusa Pride | 12.5 | 10.9 | 10.6 | 11.33 | 23.8 | 20.7 | 19.9 | 21.47 | 23.7 | 21.7 | 21.6 | 22.33 |
| 6. | Etna | 13.9 | 12.9 | 10.9 | 12.57 | 34.4 | 30.6 | 30.8 | 31.93 | 31.1 | 24.4 | 24.5 | 26.67 |
| 7. | Redcoat | 10 | 9.7 | 8.8 | 9.50 | 24.5 | 22.6 | 20.5 | 22.53 | 20.8 | 18.4 | 15.5 | 18.23 |
| 8. | Florida-90 | 13.3 | 11.5 | 10.8 | 11.87 | 41.1 | 31.6 | 25.8 | 32.83 | 26.8 | 24.5 | 22.3 | 24.53 |
| 9. | Pusa Sweet | 10.5 | 9.7 | 8.5 | 9.57 | 20.6 | 18.4 | 15.1 | 18.03 | 18.9 | 16.4 | 15.8 | 17.03 |
| 10. | Belrubi | 15.5 | 12.8 | 11.5 | 13.27 | 54.5 | 41.5 | 30.5 | 42.17 | 31.2 | 25.6 | 20.2 | 25.67 |
| 11. | Dana | 14.4 | 12.5 | 10.9 | 12.60 | 36.6 | 25.5 | 20.4 | 27.50 | 31.5 | 25.9 | 21 | 26.13 |
| 12. | Dilpasand | 13.5 | 12.3 | 11.8 | 12.53 | 27.7 | 20.05 | 15.6 | 21.27 | 26.6 | 24.3 | 21.7 | 24.20 |
| 13. | Howard-17 | 16.6 | 14.5 | 12.4 | 14.50 | 44.9 | 31.7 | 29.9 | 35.50 | 35.5 | 30.4 | 19.7 | 28.53 |
| 14. | KatrainSweet | 12.7 | 10.8 | 10.6 | 11.37 | 31.3 | 28.8 | 25.5 | 28.53 | 26.6 | 25.6 | 19.1 | 23.77 |
| 15. | Douglas | 10.5 | 9.9 | 9.6 | 10.00 | 44.1 | 39.4 | 29.9 | 37.80 | 21.3 | 20.7 | 19.5 | 20.50 |
| 16. | Shimla Del. | 13.5 | 12.5 | 11.5 | 12.50 | 41.4 | 38.9 | 33.3 | 37.87 | 26.7 | 24.8 | 23.4 | 24.97 |
| 17. | JutoghSpecial | 12.9 | 11.5 | 10.7 | 11.70 | 36.6 | 32.6 | 28.3 | 32.50 | 27.7 | 26.6 | 23.2 | 25.83 |
| 18. | Larsan | 11.5 | 10.7 | 9.9 | 10.70 | 28.8 | 24.4 | 20.6 | 24.60 | 27.1 | 24.4 | 19.9 | 23.80 |
| 19. | Blakemore | 14.4 | 12.5 | 10.9 | 12.60 | 35.5 | 24.4 | 20.5 | 26.80 | 26.6 | 20.1 | 15.9 | 20.87 |
| 20. | Himalayan Scarlet | 12.2 | 10.7 | 9.5 | 10.80 | 41.1 | 30.5 | 25.6 | 32.40 | 25.5 | 20.8 | 19.9 | 22.07 |
| 21. | Missionary | 13.3 | 12.1 | 11.5 | 12.30 | 43.3 | 34.4 | 32.2 | 36.63 | 29.9 | 27.3 | 26.6 | 27.93 |
| 22. | Torrey | 13.3 | 12.2 | 10.9 | 12.13 | 29.4 | 24.9 | 18.8 | 24.37 | 27.1 | 25.7 | 13.3 | 22.03 |
| 23. | Seascape | 16.6 | 14.7 | 13.4 | 14.90 | 36.6 | 26.7 | 23.3 | 28.87 | 31.8 | 29.9 | 28.7 | 30.13 |
| 24. | Amartara Red | 11.8 | 10.5 | 9.2 | 10.50 | 20.7 | 18.7 | 15.5 | 18.30 | 25.7 | 23.1 | 20.7 | 23.17 |
| 25. | Addie | 13.6 | 12.5 | 11.4 | 12.50 | 28 | 26.4 | 22.6 | 25.67 | 28.3 | 26.6 | 26.1 | 27.00 |
| 26. | Majestic | 11.5 | 10.8 | 10.7 | 11.00 | 28.8 | 23.3 | 22.2 | 24.77 | 27.7 | 20.8 | 16.6 | 21.70 |
| 27. | Catskill | 12.5 | 11.7 | 10.2 | 11.47 | 22.7 | 21.8 | 20.1 | 21.53 | 22.5 | 21.6 | 21.1 | 21.73 |
| 28. | V.L. | 13.3 | 12.5 | 12.7 | 12.83 | 31.8 | 28.2 | 25.5 | 28.50 | 29.8 | 28.5 | 27.8 | 28.70 |
| 29. | Chandler | 15.5 | 13.2 | 12.8 | 13.83 | 45.5 | 32.2 | 25.6 | 34.43 | 30.4 | 25.8 | 22.7 | 26.30 |
| 30. | Fairfax | 12.2 | 11.9 | 11.5 | 11.87 | 26.2 | 24.3 | 17.7 | 22.73 | 28.8 | 27.9 | 25.5 | 27.40 |
| 31. | Selva | 12.9 | 11.6 | 10.8 | 11.77 | 33.3 | 30.5 | 21.6 | 28.47 | 24.4 | 20.5 | 18.7 | 21.20 |
| 32. | Fern | 14.2 | 13.5 | 12.8 | 13.50 | 35.5 | 24.6 | 17.7 | 25.93 | 26.8 | 23.6 | 20.4 | 23.60 |
| 33. | Pajaro | 13.3 | 12.9 | 11.5 | 12.57 | 30.7 | 26.6 | 25.5 | 27.60 | 29.7 | 25.9 | 23.8 | 26.47 |
| Means due to mulches | | 13.27 | 11.92 | 10.94 | | 34.53 | 28.32 | 23.84 | | 27.28 | 24.24 | 21.14 | 13.27 |
| CD at 5% Mulch | | 0.248 | | | | 1.093 | | | | 0.501 | | | |
| Cultivar | | 1.945 | | | | 6.401 | | | | 3.321 | | | |
| Mulch x Cultivar | | 1.123 | | | | 3.651 | | | | 1.913 | | | |

**Table 3**
**Yield characteristics of strawberry cultivars grown in hilly conditions**

| S. No. | Cultivars | Plant Height (cm) | | | | No. leaves/plant | | | | Plant spread (cm) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Black Poly. | White Poly. | Grass | Cultivar Means | Black Poly. | White Poly. | Grass | Cultivar Means | Black Poly. | White Poly. | Grass | Cultivar Means |
| 1. | Sweet Charlie | 83.89 | 81.23 | 80.84 | 81.99 | 6.77 | 5.7 | 4.42 | 5.63 | 1.75 | 1.2 | 1.04 | 1.3 |
| 2. | Phenomenal | 79.32 | 66.82 | 65.45 | 70.53 | 5.24 | 3.68 | 4.24 | 4.39 | 0.79 | 0.98 | 0.89 | 0.9 |
| 3. | North West | 82.06 | 75.12 | 73.23 | 76.80 | 4.51 | 4.08 | 3.98 | 4.19 | 0.92 | 0.69 | 0.61 | 0.7 |
| 4. | Sasta | 84.92 | 76.82 | 78.67 | 80.14 | 4.89 | 3.41 | 4.19 | 4.16 | 0.6 | 0.59 | 0.58 | 0.6 |
| 5. | Pusa Pride | 75.87 | 71.38 | 68.56 | 71.94 | 4.78 | 4.27 | 4.08 | 4.38 | 1.49 | 0.98 | 0.75 | 1.1 |
| 6. | Etna | 54.72 | 49.07 | 46.76 | 50.18 | 8.63 | 7.99 | 6.04 | 7.55 | 2.39 | 2.16 | 2.28 | 2.3 |
| 7. | Redcoat | 79.12 | 69.36 | 59.74 | 69.41 | 5.29 | 5.22 | 4.55 | 5.02 | 1.09 | 0.98 | 0.68 | 0.9 |
| 8. | Florida-90 | 98.12 | 93.87 | 89.3 | 93.76 | 4.98 | 3.39 | 3.17 | 3.85 | 1.89 | 1.35 | 0.99 | 1.4 |
| 9. | Pusa Sweet | 97.53 | 99.67 | 98.74 | 98.65 | 3.89 | 3.48 | 3.27 | 3.55 | 0.96 | 0.83 | 0.71 | 0.8 |
| 10. | Belrubi | 65.32 | 57.39 | 55.18 | 59.30 | 5.98 | 4.58 | 4.97 | 5.18 | 2.57 | 2.26 | 1.79 | 2.2 |
| 11. | Dana | 74.62 | 73.02 | 70.2 | 72.61 | 5.39 | 4.38 | 4.51 | 4.76 | 2.89 | 1.87 | 1.97 | 2.2 |
| 12. | Dilpasand | 70.03 | 59.76 | 49.79 | 59.86 | 5.06 | 4.45 | 4.37 | 4.63 | 2.3 | 1.66 | 1.42 | 1.8 |
| 13. | Howard-17 | 67.09 | 61.45 | 54.6 | 61.05 | 5.88 | 4.19 | 5.28 | 5.12 | 0.99 | 0.75 | 0.81 | 0.9 |
| 14. | Katrain Sweet | 88.14 | 78.24 | 69.46 | 78.61 | 4.15 | 3.11 | 3.56 | 3.61 | 0.88 | 0.74 | 0.79 | 0.8 |
| 15. | Douglas | 91.79 | 82.91 | 85.48 | 86.73 | 8.37 | 7.59 | 7.41 | 7.79 | 2.01 | 1.97 | 1.99 | 2.0 |
| 16. | Shimla Del. | 79.95 | 77.28 | 74.95 | 77.39 | 4.49 | 3.87 | 4.23 | 4.20 | 1.19 | 0.98 | 1.17 | 1.1 |
| 17. | Jutogh Special | 76.32 | 72.57 | 69.18 | 72.69 | 4.78 | 3.12 | 3.87 | 3.92 | 1.29 | 0.98 | 0.79 | 1.0 |
| 18. | Larsan | 79.49 | 67.4 | 65.46 | 70.78 | 4.29 | 5.98 | 3.47 | 4.58 | 1.49 | 1.18 | 1.09 | 1.3 |
| 19. | Blakemore | 91.15 | 85.27 | 79.11 | 85.18 | 4.67 | 4.12 | 3.98 | 4.26 | 0.98 | 0.69 | 1.03 | 0.9 |
| 20. | Himalayan Scarlet | 90.76 | 81.01 | 74.9 | 82.22 | 4.19 | 3.88 | 3.53 | 3.87 | 0.59 | 0.58 | 0.62 | 0.6 |
| 21. | Missionary | 70.52 | 67.34 | 63.13 | 67.00 | 4.37 | 4.86 | 4.98 | 4.74 | 0.79 | 0.66 | 0.49 | 0.6 |
| 22. | Torrey | 64.8 | 55.43 | 54.86 | 58.36 | 5.29 | 3.71 | 4.01 | 4.34 | 1.96 | 0.56 | 1.41 | 1.3 |
| 23. | Seascape | 61.42 | 59.95 | 55.42 | 58.93 | 6.78 | 5.01 | 4.67 | 5.49 | 0.79 | 0.89 | 0.58 | 0.8 |
| 24. | Amartara Red | 57.23 | 49.87 | 41.28 | 49.46 | 4.76 | 3.29 | 3.47 | 3.84 | 0.79 | 0.65 | 0.59 | 0.7 |
| 25. | Addie | 94.56 | 93.67 | 85.36 | 91.20 | 5.29 | 4.37 | 4.77 | 4.81 | 1.09 | 0.85 | 0.79 | 0.9 |
| 26. | Majestic | 83.14 | 78.34 | 63.81 | 75.10 | 4.7 | 3.85 | 3.41 | 3.99 | 1.19 | 0.98 | 0.78 | 1.0 |
| 27. | Catskill | 60.23 | 55.44 | 51.09 | 55.59 | 6.21 | 5.75 | 4.98 | 5.65 | 1.91 | 1.65 | 1.34 | 1.6 |
| 28. | V.L. | 94.31 | 91.63 | 88.92 | 91.62 | 4.07 | 4.47 | 4.06 | 4.20 | 1.02 | 1.08 | 0.91 | 1.0 |
| 29. | Chandler | 96.65 | 91.67 | 87.38 | 91.90 | 8.01 | 7.57 | 7.29 | 7.62 | 1.68 | 1.74 | 1.59 | 1.7 |
| 30. | Fairfax | 93.06 | 88.72 | 82.07 | 87.95 | 5.82 | 5.35 | 4.23 | 5.13 | 1.02 | 1.07 | 1.02 | 1.0 |
| 31. | Selva | 95.47 | 93.32 | 85.33 | 91.37 | 6.3 | 5.98 | 5.89 | 6.06 | 1.98 | 1.89 | 1.55 | 1.8 |
| 32. | Fern | 86.78 | 75.45 | 69.95 | 77.39 | 4.51 | 4.64 | 4.21 | 4.45 | 0.89 | 0.74 | 0.76 | 0.8 |
| 33. | Pajaro | 59.36 | 57.55 | 56.88 | 57.93 | 4.58 | 5.36 | 4.25 | 4.73 | 0.92 | 0.87 | 0.97 | 0.9 |
| Means due to Mulches | | 79.63 | 73.88 | 69.55 | | 5.36 | 4.69 | 4.46 | | 1.37 | 1.12 | 1.05 | |
| CD at 5% Mulch | | N.S. | | | | N S | | | | N.S. | | | |
| Cultivar | | 32.86 | | | | 1.16 | | | | 0.45 | | | |
| Mulch x Cultivar | | 19.4 | | | | 2.23 | | | | 0.37 | | | |

number of leaves per plant and plant spread was observed under black polythene mulch. The othertwo mulches did not differ significantly from each other for plant height and spread though for number of leaves per plant white plastic mulch was superior to grass mulch. 'Seascape' exhibited maximum plant height (14.9 cm) and spread (30.13 cm). 'Pusa Sweet' exhibited the least the plant height (9.56 cm) and spread (17.03 cm). Maximum number of leaves per plant was exhibited by 'Douglas' (37.8), while 'PusaSweet' put forth the least number of leaves (18.03). None of the yield characteristics studied was appreciably affected by any of the three mulch treatments. Percent of total yield before peak fruiting is an indicator of the pattern of yield distribution in a cultivar (Table 3). The cultivars with higher percent of total yield before peak fruiting stage (>80%) were generally prolonged bearers. Irrespective of mulches, 'Pusa Sweet' had the maximum per cent of total yield produced before peak fruiting stage. Significant difference in yield distribution pattern within a cultivar on different mulching was observed in 'Florida-90', 'Douglas', 'Chandler', 'Selva', 'Addie', 'Blackmore', V.L. and 'Fairfax'. Different mulches probably led to differences in canopy temperature, moisture content and the quantity and quality of light transmitted, reflected or absorbed (Wang et al.,1998).These differences, in turn, may have affected plant growth, development and fruit quality in the strawberry plants. The data on fruit weight and yield (per 5 plants) of strawberry cultivars grown on different mulches has been presented in Table 3. Irrespective of mulches, the maximum average fruit weight was observed in Douglas (7.79g) which was almost at par with that in case of Chandler, Etna and Selva. Among the mulches the fruit weight did not differ significantly. Significant effects of mulches were observed on the yield of different cultivars. On all the mulches, cultivar Etna recorded the maximum yield followed by Dana,Belrubi,Douglas and Selva. The average yield of strawberry cultivars was the maximum on black polythene mulch, where as, on white polythene and grass mulch, it did not differ significantly.Hence keeping in view the yield and fruit quality, the cultivars Etna ,Chandler, Douglas, Dana, Belrubi, Selva were found to be most suitable for cultivation on all the three types of mulches under the hilly region in Himachal Pradesh.According to Nitsch (1950),Janick& Eggert(1968) and Moore et al.(1970), those differences in fruit size were primarily due to plant vigour, competition among fruits in the inflorescence number and size of developed achenes, climatic conditions, irrigation and plant nutrient status.

Black polyethylene mulch in the strawberry beds (in hills) resulted in considerable reduction in weed growth (Table- 4). This is in accordance with the result of Wang et al. (1998). The weed growth under the black polyethylene mulch was limited (28.43 % to 14.75 % of the weed growth observed on un-mulched strawberry beds). The translucent / transparent polyethylene mulch was less effective in this respect. The black polyethylene mulched beds did not require any weeding while the un-mulched beds required weeding at 20 to 30 days interval during the period. Being a shallow rooted crop, strawberry was prone to extremes of weather. Use of plastics in strawberry cultivation played a pivotal role in minimizing plant mortality and increasing productivity. Black polyethylene mulching resulted in better soil moisture regime and considerably reduced weed growth. Savings in terms of labour costs was to the extent of 25 to 30 per cent. Covering the strawberry bed with mini-plastic tunnels induced early cropping and total yield by 20 per cent and considerably reduced winter injury.

During summers (in the hills) the plastic sheets of the tunnels were replaced by plastic anti-hail nets / anti bird nets which resulted in higher yields and better fruit quality (Hemelrick, 1982), Pramanicket al. (2003) and Locascioet al.(1968). The adoption of protected systems for strawberry production in Brazil must be carefully evaluated and implemented, since a number of reports mention the occurrence of higher temperatures under protected environments in relation to field conditions, specially with regard to maximum temperatures (Montero et al., 1985), this condition could be adverse for strawberry production (Iuchi, 1993), requiring an adaptation of cultural practices. Iuchialso observed smaller *strawberry* vegetative growth under protected cultivation, when compared to open field conditions.

**Table 4**
**Effect of plastic soil mulch on weed growth on strawberry plots in hills.**

| *Mulch* | *Weed biomass (% of Naked or unmulched soil)* | | | |
|---|---|---|---|---|
| | *30 Mar. 2014* | | *10 June 2014* | |
| | *Fresh Wt.* | *Dry Wt.* | *Fresh Wt.* | *Dry Wt.* |
| Black Polyethylene Sheet | 28.43 | 18.26 | 14.75 | 13.53 |
| Transparent Polyethylene Sheet | 62.41 | 52.34 | 19.61 | 17.82 |
| Naked (Un Mulched) Soil | 100.00 | 100.00 | 100.00 | 100.00 |

Means of 20 (2′ x 5′= 10 $ft^2$ or 0.600 m x 1.500 m= 0.90 $m^2$) plots

Gast and Pollard (1991) found that row covers could enhance yield of marketable fruits in Earliglow strawberry but not the number of flowers. Yield increase was primarily due to increase in development of tertiary berries in trusses. 'Darrow', 'Earliglow', and 'Sparkle' strawberries grown under spun-bounded polypropylene, polyester, polyamide or silted polyethylene films, flowered 13 days earlier and their fruits were ready for harvest 10 days earlier than uncovered plants (Pollard et al., 1989). Fruiting in plastic-covered 'Rahnyaya' and 'Redgauntlet' strawberries was hastened by 20 days (Kopylov, 1991). These variations in yielding potential may be ascribed to the fact that strawberry yields are markedly influenced by environmental parameters like photoperiod, temperature & light intensities (Avidov, 1986).

## CONCLUSION

Covering the strawberry beds with mini plastic tunnels induced one month early cropping and increased total yields by 20%. Winter injury and consequent mortality was also appreciably reduced. During summers (in the hills) the plastic sheets of the tunnels were replaced by plastic anti-hail nets or anti-bird nets which resulted in higher yields and better fruit quality. Black polyethylene mulching resulted in a better soil moisture regime and considerably reduced weed growth and irrigation. Otherwise, being a shallow rooted crop it requires irrigation almost daily during summer season.

Considering all these factors it may be concluded that the genetic stock of strawberry used in these investigation had a wide range of variability of fruit and yield characters. As such, there is enough scope for improvement of these characters by selection / breeding.

Farmers in the tropical and sub-tropical area have been profitably cultivating strawberries during the winter months obtaining their planting materials from the hills. Besides, the income from strawberry fruits, growers in the hills thus can also earn by producing planting material for winter plantings in the plains. The growers in the plains can not produce their own disease free planting material as these plants do not survive in the extreme summer, even if they do so, they are prone to various diseases, particularly those transmitted by aphids or other insect pests. It is highly commercialized fruit crop being sold at a premium price.

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