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COROLLARY USE OF MULCHES AND PGR'S ON PHYSICO-CHEMICAL PROPERTIES OF STRAWBERRY (*FRAGARIA × ANANASSA)* CV. CAMAROSA IN POLYTUNNEL

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Abstract

The present aim was to study the response of different mulches and PGR's on growth, yield and quality of Strawberry cv. Camarosa in polytunnel. Strawberry has a very high nutritive value and is a good source of vitamin C, carbohydrates, fats, protein, potassium with several other dietary minerals. The experiment consists of 11 treatments and was laid out in RBD. GA_3 and NAA were used at concentrations of 50 and 100ppm in combination with three mulching materials *viz.*, black, white polyethylene and straw mulch. The results show that maximum plant height (22cm), no of leaves/plant (44.66), leaf area (19.50cm^2) was recorded in $GA_3$100 ppm with white transparent mulch, whereas number of flowers (15.33), number of fruits (14), fruit weight (11.80gm), yield (146.53g), TSS (9.3^{0}B), acidity (0.70%) and ascorbic acid (56.76mg) was recorded high with the application of GA_3 100ppm+Black polyethylene mulch. It was concluded that integration of PGR application with mulching significantly affects the plant growth, yield and quality.

Key words: Camarosa, strawberry, mulching, straw, polyethylene, GA_3, NAA,

Introduction

Strawberry (*Fragaria × ananassa*) also known as garden Strawberry, is a small soft and an important delicious fruit crop which is grown throughout the world (Sharma and Sharma, 2004). This is an octaploid fruit, which belongs to family Rosaceae. It is a cross of *Fragaria virginia* (♂) and *Fragaria chiloencis* (♀) (Darrow, 1966). Strawberry is a non climacteric fruit. It is commercially grown in temperate and subtropical regions. In temperate regions this crop behaves like perennial and in subtropical regions it behaves like an annual crop (Sharma and Badiyala, 1980). It is a good source of vitamin C (58.8mg/100gm), carbohydrates (7.68gm), fats (0.3gm), protein (0.67gm), potassium, and several other dietary minerals (Karkara and Dwivedi, 2002). It is good source of antioxidant, antibiotic and anti-carcinogenic and it is preferred by all age group consumers (Wang *et al.,* 1996).

Mulches protect the soil against soil heat accumulation during day and provide better thermal condition in early morning (Kesik and Maskalaniect, 2005). Plant growth regulators play an important role in increasing the growth and yield of strawberry. Gibberellic acid increases the fruit size in strawberry plant, whereas NAA improves the quality of strawberry (Thakur *et al.,* 1991). Use of growth regulator and time of transplanting improves fruit growth, quality and yield (Khokhar *et al.,* 2004). Mulches gives better quality produce and yield, it has strong influence on duration of harvesting which is due to improved nutrient availability, control on weed growth, protection from frost injury and reduces the incidence of diseased, dirty plants and have better soil and moisture conservation (Sharma, 2002).

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MATERIALS AND METHODS

Experimental Site and location

The study was performed in the polytunnel at Horticulture Farm, School of Agriculture, Lovely Professional University, Phagwara, Punjab to find out the most suitable mulching material and plant growth regulators for strawberry cv. Camarosa under polytunnel. Soil of this sub-region is deep, loamy sand to loam and developed on alluvium. Soil is alkaline in reaction with pH ranging from 7.5 to 8. Strawberry runner cv. Camarosa were procured from Rajgarh, Solan, H.P. and plants are transplanted at the Horticulture Farm at a

spacing of 30 × 45 cm. The experiment consists of eleven treatments (T_1-White transparent mulch+GA3 (50ppm), T_2-White transparent mulch+GA3 (100ppm), T_3-White transparent mulch+ NAA (50ppm), T_4-White transparent mulch+ NAA (100ppm), T_5-Black polythene mulch+ GA_3 (50ppm), T6-Black polythene mulch+GA_3(100ppm), T_7-Black polythene mulch + NAA (50ppm), T_8- Black polythene mulch+NAA(100ppm), T_9-Straw mulch + GA_3(100ppm), T_{10}-Straw mulch+NAA(100ppm), T_{11}-Control with three replications. The experiment was laid out in Randomized Block Design. Statistical analysis was carried out using ANNOVA with Opstat software.

Results and discussion

Plant height (cm)

Strawberry plants of cv. Camarosa showed statistically significant variation in terms of its plant height. The data in table 1, fig. 1 shows that the maximum plant height (22 cm) was found in T_2, which was closely followed by T_6 (21.66 cm) and T_7 (19.33 cm), which were at par with each other. While as in comparison to the above treatments, the plant height was found minimum in T_8 (14 cm) followed by T_3 (14.33 cm) and T_4 (14.66 cm) which differs significantly from all other treatments under study. In control (T_{11}) it was 12.30 cm only. The increase in plant height during the present investigation is due to $GA_3$100ppm which increases cell elongation. Indication of highest plant height under polythene mulch is due to fact that thick, matted surface covering capacity enhances better water retention and nutrient availability to the plant (Rajbir *et al.,* 2006). The above results are in confirmation with the work of Singh and Phogat (1983) and Dwivedi (1987).

No. of leaves/ plant

The perusal of data in table 1, fig. 1, shows that the maximum number of leaves were found in T_2 (44.66), which is closely followed by T_6 (44) and T_1 (44), whereas minimum number of leaves per plant was recorded in T_8 (34) and T_{10} (34) and were statistically at par. In control (T_{11}) it was found to be 30.00. It was observed from the present study that number of leaves per plant was influenced significantly by white transparent mulch which may be due to better conservation of moisture. Soil heat includes better biological function of soil and light penetration. The results coincide with results of Kour and Singh (2009) under polythene mulch. Many researchers pointed that mulching had clear effect on microclimate around the plants by modifying the radiation budget of the surface and significantly increased vegetative growth (Aguyoh and Taber, 1999; Osiru and Hahn, 1994).

Leaf area $(cm)^2$

Data pertaining to leaf area of strawberry showed significant variation. The perusal of data in table 1, fig.1, indicates that the leaf area (19.50cm^2) was maximum in T_2 which was significantly higher than other treatments followed by T_6 (17.33cm^2) and T_1 (17.00cm^2) both of which were at par with each other. In comparison to above, the minimum leaf area was recorded in T_{10} (11.00cm^2) followed by T_8 (12.16cm^2) which significantly differ from all treatments under study. In control (T_{11}) it was found to be 9.50. The higher leaf area in these treatments might be attributed due to more available metabolites and their allocation to the above ground parts of the plants through roots. The application of gibberellic acid has the potential to control growth and flowering by reduced leaf area and induces earliness in strawberry (Paroussi *et al*., 2002). These findings are in line with the work of Sharma and Singh (2009) and Kumar and Manimegalai (2008).

Plant spread (cm)

The maximum plant spread in North-South direction was found in T_6 (31.66 cm) which was significantly different from all other treatments under study as shown in table 1, fig.1. This was followed by T_2 and T_5 having maximum plant spread of 30.0 cm and 27.33cm and were found to be statistically at par with each other. However, the treatments T_8 and T_{10} exhibited minimum plant spread of 19.33cm and 20.00cm, respectively. In control (T_{11}) it was 18.66. However, the maximum plant spread in East-West direction was also found in T_6 (31.33cm). This was followed by T_2 and T_5 having maximum plant spread of 29.33cm and 27.00cm and were found to be statistically at par with each other as presented in table 1. However the treatments T_8, T_{10} exhibit minimum plant spread of 19.00cm and 19.66cm. In control (T_{11}) it was 18.33. The possible reasons for plant spread in N-S and E-W direction could be due the application of mulching and PGR treatments which led to congenial environment in root zone due to lower weed population, optimum soil moisture, increased availability of nutrients and favourable soil temperature which regulated growth of strawberry plant by causing cell elongation and corresponding increase in length of petiole by application of GA_3. These results are in consonance to that of Aulakh and Sur (1999) in pomegranate, Momnty *et al.,* (2002) in-mandarin, Slirgure *et al.,* (2003) in mandarin, Sharma and Sharma (2003), Khokhar *et al.,* (2004) and Sharma *et al.,* (2004) in strawberry.

Number of flowers/ plant

The number of flowers per plant varied significantly as per the variation in treatments. The data was shown in table 2, fig. 2 that the highest number of flowers per plant was reported in T_6 (15.33) which was closely followed by T_5 and T_2 (15.00 and 13.33, respectively) and were found to be statistically at par with each other

Table 1: Response of different mulches and plant growth regulators on vegetative growth parameters of strawberry cv. Camarosa.

Treatments	Plant height (cm)	No. of leaves/ plant	Leaf area $(cm)^2$	Plant spread (N-S)	Plant spread (E-W)
T_1	15.33	42.00	17.00	26.00	26.33
T_2	22.00	44.66	19.50	30.00	29.33
T_3	14.66	36.66	12.41	25.00	24.33
T_4	14.33	34.66	14.41	21.66	21.33
T_5	15.00	36.66	15.75	27.33	27.00
T_6	21.66	44.00	17.33	31.66	31.33
T_7	19.33	35.00	15.41	24.00	23.66
T_8	14.00	34.00	12.16	19.33	19.00
T_9	14.66	39.00	13.16	20.66	20.33
T_{10}	17.33	34.00	11.00	20.00	19.66
T_{11}(Control)	12.30	30.00	9.50	18.66	18.33
C.D.	**2.15**	**2.29**	**1.37**	**1.72**	**2.23**
SE(m)	**0.72**	**0.77**	**0.46**	**0.58**	**0.75**
C.V.	**7.65**	**3.58**	**5.56**	**4.17**	**5.49**

and the minimum number of flowers per plant was recorded in T_8 (10) followed by T_7 (10.66) which significantly differ from all others treatments. In control (T_{11}) it was found to be 9.33. The more number of flowers per plant and earliness in flowering were probably because of hormone application which accelerated the development of differentiated inflorescence and stimulated flowering. Mulching provided optimum soil moisture and temperature due to application of GA_3 and black polyethylene mulch as reported by Thakur *et al.,* (1991), Gupta and Acharya (1993), Khokhar *et al.,* (2004), Singh and Singh, (2009) and Ali and Gaur (2007) in Strawberry.

No. of fruits/plant

The number of fruits borne by a plant has a direct bearing on total yield. Cultivar Camarosa showed significant differences for this character. The data shown in table 2, fig. 2, that the maximum number of fruits per plant were found in T_6 (14) followed by T_5 (13.33) and T_9 (11.33) which were statistically at par with each other and the minimum number of fruits per plant was recorded in T_8 and T_7 (8.66 and 9.33). In control (T_{11}) it was found to be 8.00. The number of fruit per plant was recorded maximum with $GA_3$100ppm + Black polyethylene mulching (T_6). The higher number of fruits may be due to increased flowering and more fruit set and higher fruit weight. The results agree with the observation of Kumar *et al., (*2012), Khokhar *et al., (2004)* and Singh and Singh (2005) in Strawberry.

Fruit length (cm)

Statistical analysis with respect to fruit length showed significant differences among different applications of plant growth regulators and mulches cv. Camarosa. The data in table 2 fig 2 shows that based on fruit length, T_6 had the longest fruit size of 3.66 cm followed by T_5 (3.55cm) and T_1 (3.16cm) which were at par with each other and the least fruit length size of (2.66cm) was recorded in T_8 and T_4 (2.66cm). In control (T_{11}) it was found to be 2.00cm. The increase in fruit size and during the present investigation might be due to the increased photosynthetic ability of plants treated with GA_3 100 ppm and black polythene mulch, which in turn might have favoured and increased the accumulation of dry matter (Tripathi and Shukla, 2010; Khokhar *et al.,* 2004; Sharma and Singh, 2002 and Sharma and Singh 2009).

Fruit breadth (cm)

Statistical analysis with respect to fruit breadth show significant differences among different applications of plant growth regulators and mulches cv. Camarosa. The data shows in table 2 fig 2 that the Fruit breadth (3.16cm) was found to be maximum in T_6 which was significantly higher in comparison to other treatments followed by T_5 and T_9 (3.00cm and 3.00cm respectively). The least fruit breadth size of 2.16cm was recorded in T_8 followed by T_7 (2.33cm) which were statistically at par with each other. In control (T_{11}) it was 1.50cm. Baba *et al.,* (2010) studied the effect of inorganic and biofertilizers on soil physicochemical properties and micronutrient availability in Strawberry, Ali and Gaur (2007); Kumar *et al.* (2012); Sonkar *et al., (2012);* Karimi *et al.,*(2013); Kumar *et al.,* (2014).

Table 2: Response of different mulches and plant growth regulators on quality parameters of strawberry cv. Camarosa.

Treatments	No. of flowers/ plant	No. of fruits/ plant	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (gm)	Fruit Yield (gm)
T_1	12.66	11.00	3.16	2.66	9.13	141.1
T_2	13.33	10.33	2.83	2.66	10.4	142.26
T_3	12.66	11.00	3.00	2.5	8.76	140.00
T_4	12.00	10.33	2.66	2.16	9.76	139.26
T_5	15.00	13.33	3.55	3.00	11.13	144.6
T_6	15.33	14.00	3.66	3.16	11.8	146.53
T_7	10.66	9.33	3.16	2.5	10.16	136.66
T_8	10.00	8.66	2.66	2.16	9.46	136.2
T_9	11.66	11.33	3.40	3.00	10.43	142.60
T_{10}	11.66	10.00	3.33	2.83	8.36	137.86
T_{11}**(Control)**	9.33	8.00	2.00	1.50	8.26	134.2
C.D.	**1.65**	**1.76**	**0.06**	**0.66**	**1.59**	**0.08**
SD(m)	**0.55**	**0.59**	**0.65**	**0.22**	**0.53**	**0.24***
C.V.	**7.88**	**9.68**	**11.24**	**14.97**	**9.45**	**33.4**

Table 3: Response of different mulches and plant growth regulators on quality parameters of strawberry cv. Camarosa.

Treatments	TSS (^{0}Brix)	Acidity %	Ascorbic acid (mg/100gm)
T_1	8.0	0.36	55.80
T_2	8.3	0.35	53.66
T_3	7.5	0.37	51.33
T_4	7.8	0.40	52.42
T_5	8.6	0.34	56.03
T_6	9.3	0.33	56.76
T_7	7.4	0.46	51.00
T_8	7.4	0.49	51.33
T_9	7.8	0.39	47.1
T_{10}	7.7	0.40	44.33
T_{11}(Control)	6.9	0.72	41.00
S.E(m)	**0.31**	**0.08**	**1.14**
C.D.(P=0.05)	**0.92***	**0.24***	**3.40***
C.V.	**6.76**	**33.4**	**3.89**

Fruit weight (gm)

Fruit yield is directly related to average berry weight. Significant differences among various treatments and the data was obtained by taking average berry weight of Strawberry. The data shows in table 2 fig 2 that the maximum fruit weight (11.80 g) was recorded in T_6 followed by T_5 and T_9 (11.13g and 10.43 g) which were at par with each other and the minimum fruit weight was found in T_{10} (8.36g) and T_3 (8.76g). In control (T_{11}) it was found to be 8.26. This might be due to fact that such treatment induced good vegetative growth and flower bunch hence initiated higher number of flowers and per cent berry set. This could also be attributed to the improvement in the water retention in the medium, better uptake of nutrients and water, which might increase photosynthetic rate causing maximum fruit weight. These observations are supported by the findings of Verma and Sharma (2010). Similar observations on larger fruits by mulching with black polythene have also been reported by Mathad and Jholgiker (2005) and Kumar *et al*., (2012).

Fruit yield/plant

The perusal of data reveal in table 2 shows significant differences in fruit yield per plant of Strawberry cv. Camarosa with different concentration of plant growth regulators and mulching material. The maximum fruit yield per plant was recorded in T_6 (146.530g) followed by T_5 (144.60g), T_9 (142.60g) and whereas the lowest fruit yield per plant was recorded in T_8 and T_7 (136.20gm and 136.46gm respectively. In control (T_{11}) it was found to be 134.2. The higher yield might also be due to formation of more metabolites by large leaves in these plants resulting in bumper flowering, fruit setting besides better vegetative growth. The above results agree with Sharma and Singh (1990), Anwar and Hafiz (1990) and Lal and Seth (1980) also indicated that the characters like days to runner formation, number of inflorescences, number of fruits, fruit length, fruit diameter and number of achenes showed positive correlations with the fruit yield.

Total Soluble Solid (^{0}Brix)

Significant differences were observed among the different concentration of plant growth regulators and mulches for TSS in strawberry cv. Camarosa. The data clearly reflects in table 3 fig.3 that TSS significantly varies from T_1 to T_9. Highest value of TSS (9.33%) was recorded from T_6 and was closely followed by T_5 (8.66%) and T_2 (8.33%) which were significantly at par with each other. However, the lowest TSS of 7.40% and 7.43% was recorded in T_8 and T_7 In control (T_{11}) it was found to be 6.9. Higher fruit quality is related to weed free environment, higher moisture conservation and maximum nutrient uptake under black polythene mulch treatment. These results are in conformity with the findings of Mathad and Jholgiker (2005) and Singh *et al.,* (2007). Thakur *et al.,* (1991) pointed out that exactly how growth regulators are involved in metabolic reactions which are related to the improvement of fruit quality while working on strawberry. These observations are supported by the findings of Athani and Revanappa (2009); Liu *et al.,* (2014)

Titratable Acidity (%)

Data presented in table 3 fig.3 shows the significant difference in titratable acidity. The treatment T_6 had the minimum acidity of 0.33% followed by 0.34% and 0.35%, respectively in T_5 and T_2 and maximum acidity was recorded in T_8 (0.49%) followed by T_7 (0.46%) which were at par with each other and showed very less variation in acidity. In control (T_{11}) it was found to be 0.72%. The increase in total acidity might be due to large sized plant and more number of leaves which in turn enhanced the photosynthetic activities and accumulation of more carbohydrates in presence of optimum soil moisture and their involvement at metabolic level in regulating vital

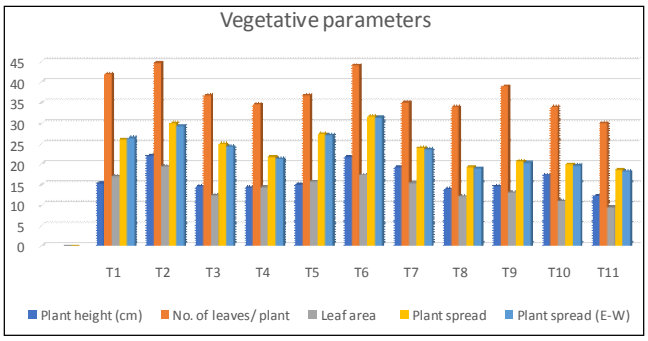

Fig.1: Response of different mulches and PGR's on vegetative parameters of strawberry.

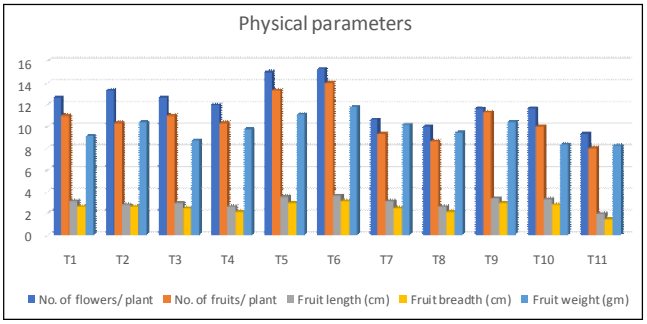

Fig. 2: Response of different mulches and PGR's on physical parameters of strawberry.

physiological and biochemical processes seem to increase total acidity in fruit. This is in conformity with the findings of Wang *et al.,* (1996). Hancock, (1999) and Hassan *et al*., (2000) reported the similar findings.

Ascorbic acid (mg/100gm)

Data in table 3 fig 3 shows the significant variation in the ascorbic acid content as they were influenced significantly by different applications of plant growth regulators and mulches. The maximum ascorbic acid (56.76mg/100g) content was recorded in $\mathbf{T_6}$ and was closely followed by $\mathbf{T_5}$ and $\mathbf{T_1}$ (56.03mg/100g, 55.80mg/100g, respectively) which were at par with each other. In comparison to above treatments the lowest ascorbic acid content was recorded in $\mathbf{T_{10}}$ (44.43 mg/100g), $\mathbf{T_9}$ (47.10 mg/100g). In control ($\mathbf{T_{11}}$) it was found to be 41mg/100g. Ascorbic acid content of fruits was influenced significantly by different application of plant growth regulators and mulches. This is due to positive influence on sink strength (reproductive growth) as evident by more TSS and juice mass (%). Higher fruit quality is related to weed free environment, higher moisture conservation and maximum nutrient uptake under black polythene mulch treatment. These results are in conformity with the findings of Mathad and Jholgiker (2005) and Singh *et al*., (2007).

Conclusion

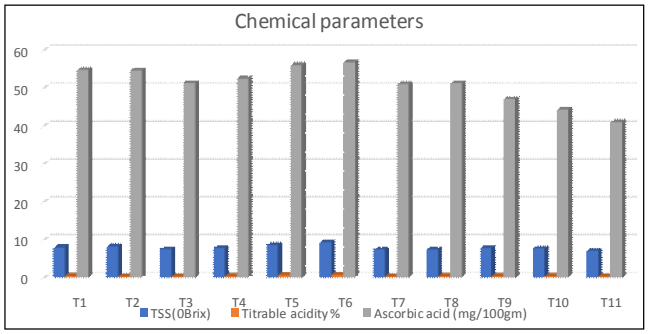

Fig. 3: Response of different mulches and PGR's on chemical parameters of strawberry.

From the results obtained during the present investigation with different treatments of mulch materials and plant growth regulators on vegetative growth, yield and quality of strawberry cv. Camarosa, it can be concluded that plants treated with $GA_3$100ppm with white transparent mulch significantly increased the height of plant, plant spread, number of leaves, whereas plants treated with $GA_3$100 ppm with black polythene mulch recorded maximum number of flower/ plant, fruit/ plant, fruit length, fruit width, fruit weight, fruit yield, higher TSS, acidity and ascorbic acid.

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