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Standardization of Optimum Planting Time and Mulching Materials on Yield and Berry Quality of Strawberry var. Chandler under Sub-Tropical Mid Hill Conditions

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ABSTRACT
Based on the hypothesis on the significance of different planting time and mulching material used affects the yield and quality of strawberry and considering the fact that such agro-techniques have not yet been standardized under sub-tropical mid hill conditions of Arunachal Pradesh state in particular which is located in the north eastern region, India. A field experiment was carried out to standardize the optimum time of planting and mulching materials in strawberry var. Chandler with the objective to enhance the yield of better quality. The experiment was laid out in a randomized block design with twelve treatments replicated thrice. Findings revealed that fruits harvested from mid-october planting along with black polyethylene mulching (T_5) recorded the maximum fruit size of length (3.62 cm) and breadth (2.80 cm). The same treatment also exhibited maximum in fruit yield attributes with maximum average berry weight, number of berries per plant and fruit yield per plant of (13.99 g), (23.44) and (259.11 g) respectively. As far as nutritional qualities are concerned, highest TSS (9.05ºBrix) and anthocyanin content (90.21 mg per 100 g) with lower titratable acidity (0.58 %) were exhibited in fruits of treatment (T_5). The highest ascorbic acid content (77.82 mg per 100 g) was found in fruits harvested from plants of mid-october planting with paddy straw mulching (T_6) which was found at par with treatment (T_5) with 77.68 mg per 100 g. Both reducing and total sugars were found highest in fruits harvested from treatment (T_9) i.e. mid-november planting coupled with black polyethylene mulching exhibiting (4.60 %) and (7.96 %) respectively which was found at par with treatment (T_5) with a value of 4.41 % and 7.91 %.
Keywords: *Strawberry, Chandler, Planting time, Mulching, Mid-hill*

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INTRODUCTION

Strawberry (*Fragaria* x *ananassa* Duch.) is one of the important berry fruit of temperate region which is also cultivated in subtropical and tropical regions. The cultivated octaploid strawberry, a surface feeder herbaceous perennial crop belongs to the family Rosaceae, is one of the most delicious and nutritious soft fruits considered valuable food in the diet of millions of people across the globe [1]. Among the fruits, strawberry gives quick return in the shortest possible time. Apart from its fresh consumption, it has a demand in fruit processing industries for value addition *viz*. jam, ice-creams, syrups, dehydrated candy etc.

Strawberry yield and quality is affected by factors such as planting date, mulching, temperature, irrigation regime etc. [2, 3]. For a successful cultivation of strawberry, planting time is considered as one of the most important factor in affecting of the quality of the strawberry as both premature and late planting affect the development of the fruits because at early planting strawberries are at a sensitive stage of bud differentiation and at late planting the soil temperature decreases [4]. Several reports indicated that strawberry can be planted at several times of the year, depending on variety, location and climate [5]. As reported by authors [4], few investigators found that the planting time of strawberry was different in different regions, different varieties and under different cultivation methods and the differences in the yield, single fruit weight and the average yield can be caused by different planting time. Generally strawberry is planted on the onset of winter in the tropical and sub-tropical regions of India restricting

the fruit availability for a short period reducing the profit. However, in contrary to Indian condition, increased productivity and extension of fruit availability for a longer period are reported in many advanced countries through staggered planting [6, 7]. As per the author [8] mid-September planting recorded a higher yield with better quality fruits.

Strawberry being a low surface creeping crop hence, using plastic mulch is a common practice in cultivation of strawberry [9]. Mulching plays an important role by conserving soil moisture, weed control, regulation of soil temperature, improving the physical properties of soil, providing clean fruit and preventing diseases and pests [10, 11] further improving the plant growth, yield and quality in strawberry [12, 13]. For mulching, different materials such as black polyethylene, clear and coloured plastics, wheat and paddy straws, pine needles, etc. are used in different parts of the world, black polyethylene mulch being the most favoured [14]. Black mulch's thermal and radiation properties increased the soil temperature so it enhanced plant growth [15]. The black low density polyethylene mulch (LDPE) and red mulch had significant effects on the yield of the fruit [16].

The present study was taken up with a hypothesis that strawberry yield and quality is affected by factors such as different planting time and mulching material used. So based on this hypothesis on the significance of different planting time and mulching material used, and considering the fact that such agro-techniques have not yet been standardized under mid hill conditions of Arunachal Pradesh in particular, a systematic field experiment was carried out in order to identify and standardize the optimum time of planting and mulching materials in strawberry var. Chandler with the objective to enhance the yield of better quality fruits which in turn, from the results of this experiment can guide the cultivation of strawberry under sub-tropical mid hill condition of Arunachal Pradesh, India.

MATERIAL AND METHODS

Experimental Site

The present investigation was carried out at ICAR Research Farm, Gori, Basar, Arunachal Pradesh, India situated in the mid hill zone at the latitude of 27°59.537' N and longitude of 94°41.269' E with an altitude of 650 m above mean sea level during September to February 2015-16 and 2016-17. The location is under sub-tropical hill zone characterized by high rainfall with humid subtropical wet summer [17]. Rainfall occurs mainly due to south-west monsoon from April to October and the mean annual precipitation ranges from 2000 to 5000 mm [18]. The average annual minimum temperature of the study area is 15.6ºC with average annual maximum temperature of 24.2ºC (Agromet Observatory, ICAR (Research Complex) for NEH Region, Arunachal Pradesh Centre, Basar). The soil textural class of the experimental site is sandy loam with acidic soil pH of 4.9.

Experimental Design and Treatments

The field experiment was laid out in RBD (Randomized Block Design) with three replications having twelve treatments (Table 1). For further growth and development, well decomposed farmyard manure with 40 kg/ha each of P_2O_5 and K_2O were applied at the time of bed preparation, whereas 80 kg N was applied in two split doses, the first half dose after establishment of transplanted runners and the second dose before blooming. Uniform and disease free runners of cv. Chandler were transplanted on mid-september, mid-october and mid-november on raised bed maintaining a spacing of 25 cm x 50 cm followed by mulching with black polyethylene of fifty micron thickness, paddy straw, pine needle and without mulch as control. Plots with plants were regularly observed to find out any damage or dead seedlings for its replacement and all necessary cultural practices and plant protection measures were followed uniformly for all the plots and treatments during the entire experimental period. Further, data were collected from randomly selected five plants from each plot for data collection on growth, yield and nutritional compositions during the growth of plants and at harvesting time of the crop.

Physico-Chemical Quality of Fruits

Observations on berry size *viz*. length and breadth, number of berries per plant, average berry weight and berry yield per plant were recorded from five randomly selected plants from each treatment and were replicated thrice. Fruit size (length and breadth) was recorded with the help of digital Vernier calipers (Mitutoyo, Japan) and average fruit weight with electronic pan balance. Total soluble solid (TSS) was determined with digital Erma hand refractometer (0-32°Brix) where a drop of the juice was used on calibrated refractometer. Titratable acidity (as citric acid) was estimated by titrating against 0.1N sodium hydroxide using phenolphthalein as indicator and expressed in percentage [19] and ascorbic acid content by titrating sample filtrate with 4 % oxalic acid using 2, 6-dichlorophenol indophenol dye to pink end point and expressed as mg/100 g [20]. Total sugar was determined in pulp extracts according to the Anthrone method [21] and expressed in percentage. Here anthrone reagent was used in colour development resulting in blue green solution. The intensity of blue green colour was measured in UV-VIS

spectrophotometer at 630 nm against a reagent blank. Reducing sugar was estimated according to Nelson-Somogyi method [22]. In this, sugar was extracted by macerating 100 mg of the sample with 5 ml of hot 80% ethanol. After centrifuging the sample at 3000 rpm for 5 minutes, the supernatant was allowed to evaporate on water bath followed by dissolving the sugars with water. An aliquot of 0.2 ml was taken and diluted to 2 ml with distilled water. Further, 1 ml of alkaline copper tartarate reagent was added followed by heating in boiling water for 10 minutes. After cooling down, again 1 ml of arsenomolybolic acid reagent was added and final volume was made up to 10 ml with distilled water. The sample was read against the blank solution in a UV visible spectrophotometer at 620 nm after 10 minutes. The sugar content was estimated from a standard curve prepared with known concentration of glucose. Ranganna method [23] was followed for anthocyanin content and expressed as mg/100 g, wherein 10 g blended sample was mixed with 10 ml of ethanol–hydrochloric acid mixture (95% C_2H_5OH and 1.5 N HCl in the ratio 85:15) which was transferred into a 100 ml volumetric flask and kept overnight at 4°C, filtered through Whatman No. 1 and measured in spectrophotometer at 535 nm.

Statistical Analysis

Mean of two year's data of different parameters were pooled and analysed following randomized block design (RBD). Mean comparison were performed using the Tukey's Honest Significant Difference (HSD) test with SAS 9.3 (TS1MO) software package developed by SAS Institute (2000). The treatment means were separated using the least significant difference at 5% levels significance.

RESULTS AND DISCUSSION

Fruit Growth and Yield Attributes

Fruit growth and yield attributes, such as berry length and breadth, average berry weight, number of berries per plant and berry yield per plant were significantly influenced by planting time and mulching (Table I). Maximum berry size with length 3.62 cm and breadth 2.80 cm was found in fruits harvested from plants of mid-october planting along with black polyethylene mulching (T_5) followed by treatment mid-november planting coupled with black polyethylene mulch (T_9) with fruit length and breadth of 3.51 cm and 2.76 cm. Similarly in fruit yield parameters *viz.* maximum average berry weight (13.99 g), number of berries per plant (23.44) and fruit yield per plant (259.11 g) were significantly higher in treatment T_5 followed by treatment T_9 with a value of 13.44 g, 20.17 and 253.51 g respectively. Whereas treatment T_4 i.e. mid-september planting without mulching exhibited the minimum yield attributes with average single berry weight of 10.56 g and yield of 153.75 g per plant. Better fruit growth and yield attributes in mid-october planting with black polyethylene mulch probably may be due to favourable microclimate for the growth and development of plants [8] and also attributed to better soil hydrothermal regimes, moisture conservation and suppression of weeds in plants mulched with black polyethylene [10]. Minimum yield attributes in mid-september planting without mulching may be due to higher temperature in the area which was not conducive for proper establishment of seedlings which led to drying leading to multiple times of seedling replacement.

Fruit Quality Parameters

Planting time and mulching influenced the fruit qualities of strawberry var. Chandler significantly. Highest TSS (9.05ºBrix) and anthocyanin content (90.21 mg per 100 g) with lower titratable acidity (0.58 %) were exhibited in fruits harvested from plants of mid-october planting along with black polyethylene mulching (T_5). The highest ascorbic acid content (77.82 mg per 100 g) was found in fruits harvested from plants of mid-october planting with paddy straw mulching (T_6) closely followed by the treatment mid-october planting with black polyethylene mulch (T_5) with 77.68 mg per 100 g which was found at par with treatment (T_6). Similarly, the fruits harvested from plants of mid-november planting along with black polyethylene mulching (T_9) exhibited the highest reducing sugar (4.60 %) and total sugar content (7.96 %) which was found at par with fruits harvested from plants of mid-october planting with black polyethylene mulch (T_5) with a value of 4.41 % and 7.91 % respectively.

The better quality of fruits from mid-october planting along with black polyethylene mulch may be associated to the cumulative and synergistic effective of earlier planting and black polyethylene mulching, due to which plants have better growth, early flowering and fruiting, and fruits received extra time for growth and development, accumulation of quality traits in the fruit [8] and a better microclimate and weed-free environment by black polyethylene mulch in the fields, which led to higher TSS, ascorbic acid, sugars, anthocyanin and lower titratable acidity in fruits [13].

Table 1. Treatment details

Treatment notations	Treatments
T_1	P_1M_1
T_2	P_1M_2
T_3	P_1M_3
T_4	P_1M_4
T_5	P_2M_1
T_6	P_2M_2
T_7	P_2M_3
T_8	P_2M_4
T_9	P_3M_1
T_{10}	P_3M_2
T_{11}	P_3M_3
T_{12}	P_3M_4

Where, P_1: Mid-September planting, P_2: Mid-October planting, P_3: Mid-November planting, M_1: Black polyethylene mulch (50 micron), M_2: Paddy straw mulch, M_3: Pine needle mulch, M_4: No mulch

Table 2: Effect of different planting time and mulching materials on fruit growth and yield attributes of strawberry var. Chandler

Treatments	**Berry length (cm)**	**Berry breadth (cm)**	**Average berry weight (g)**	**No. of berries per plant**	**Fruit yield per plant (g)**
T_1	$3.35^{cd} \pm 0.075$	$2.70^{abcd} \pm 0.041$	$12.45^{b} \pm 0.302$	$18.50^{bcde} \pm 0.764$	$238.85^{cd} \pm 3.981$
T_2	$3.39^{bc} \pm 0.024$	$2.73^{abc} \pm 0.059$	$12.42^{b} \pm 0.061$	$18.61^{bcd} \pm 0.656$	$247.05^{bc} \pm 1.867$
T_3	$3.24^{def} \pm 0.076$	$2.62^{d} \pm 0.023$	$12.10^{b} \pm 0.274$	$16.72^{ef} \pm 0.546$	$219.48^{f} \pm 0.999$
T_4	$3.11^{fg} \pm 0.031$	$2.24^{f} \pm 0.035$	$10.56^{d} \pm 1.160$	$13.28^{g} \pm 0.682$	$153.75^{g} \pm 3.811$
T_5	$3.62^{a} \pm 0.033$	$2.80^{a} \pm 0.026$	$13.99^{a} \pm 0.453$	$23.44^{a} \pm 0.580$	$259.11^{a} \pm 2.610$
T_6	$3.43^{bc} \pm 0.081$	$2.76^{ab} \pm 0.024$	$13.38^{ab} \pm 0.232$	$18.98^{bc} \pm 0.290$	$248.09^{b} \pm 3.018$
T_7	$3.30^{cde} \pm 0.027$	$2.68^{bcd} \pm 0.043$	$12.40^{b} \pm 0.243$	$17.11^{def} \pm 0.675$	$230.48^{e} \pm 3.194$
T_8	$3.15^{fg} \pm 0.040$	$2.34^{f} \pm 0.021$	$10.72^{cd} \pm 0.936$	$13.34^{g} \pm 0.333$	$160.51^{g} \pm 4.264$
T_9	$3.51^{ab} \pm 0.038$	$2.76^{ab} \pm 0.023$	$13.44^{ab} \pm 0.249$	$20.17^{b} \pm 0.833$	$253.51^{ab} \pm 2.628$
T_{10}	$3.31^{cde} \pm 0.049$	$2.65^{cd} \pm 0.049$	$12.31^{b} \pm 0.235$	$17.83^{cdef} \pm 0.441$	$233.55^{de} \pm 5.221$
T_{11}	$3.19^{efg} \pm 0.044$	$2.49^{e} \pm 0.035$	$12.08^{bc} \pm 0.311$	$16.33^{f} \pm 0.928$	$215.17^{f} \pm 2.946$
T_{12}	$3.05^{g} \pm 0.047$	$2.29^{f} \pm 0.021$	$10.70^{d} \pm 0.479$	$13.22^{g} \pm 0.294$	$154.37^{g} \pm 0.943$
LSD (0.05)	0.150	0.109	1.382	1.802	8.281
CV (%)	2.672	2.460	6.641	6.113	2.231

*Values within the columns with similar superscripts are statistically identical and values with dissimilar superscripts differ significantly at $p<0.05$ level of significance

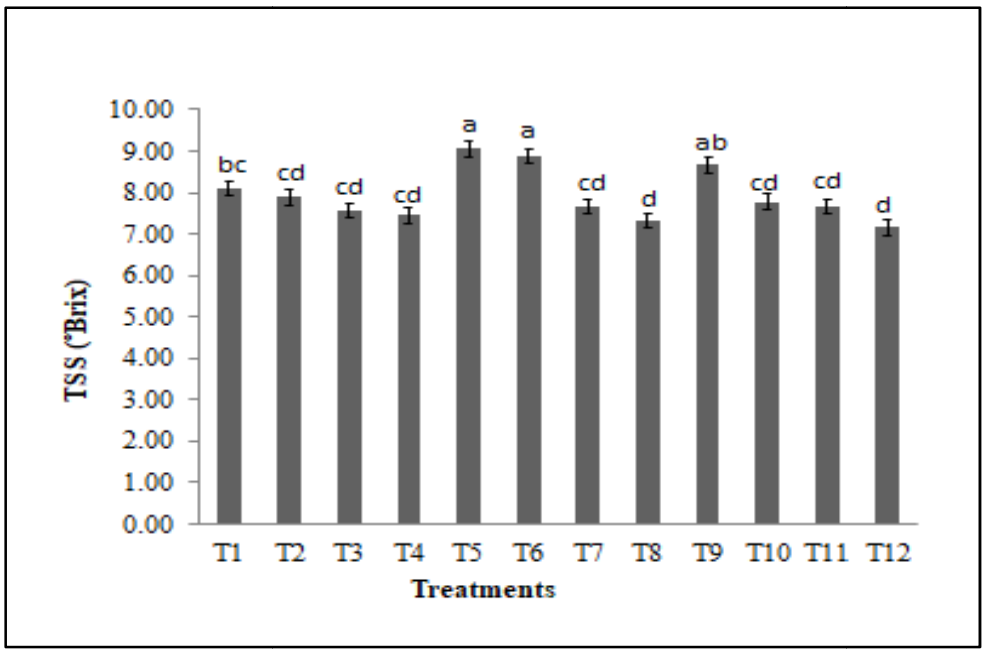

Fig 1. Effect of different planting time and mulching on TSS content of Chandler strawberry

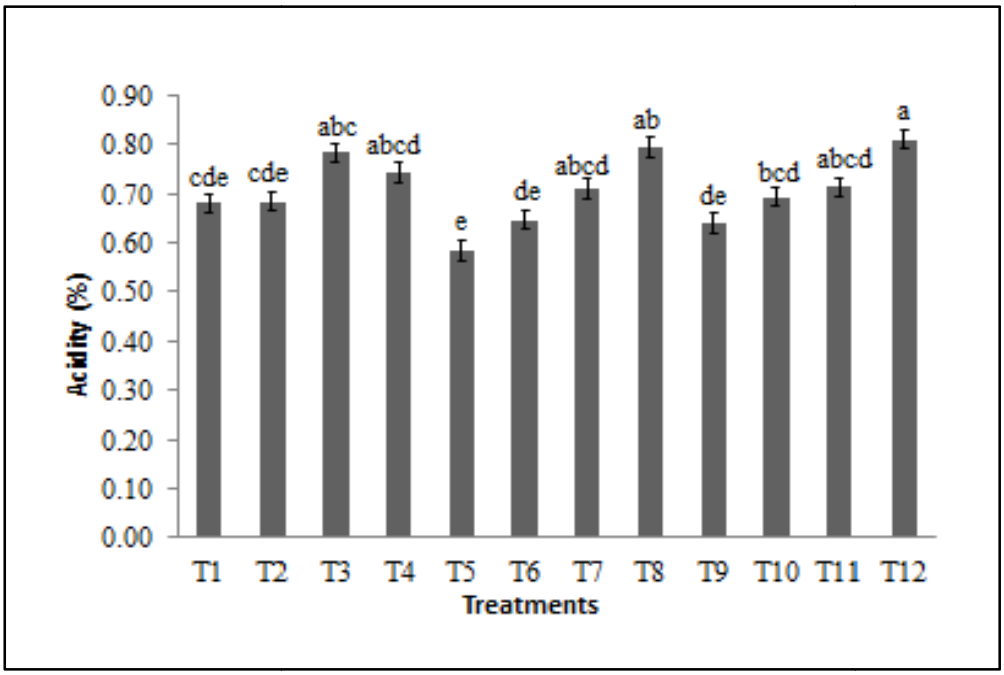

Fig 2. Effect of different planting time and mulching on acidity percentage of Chandler strawberry

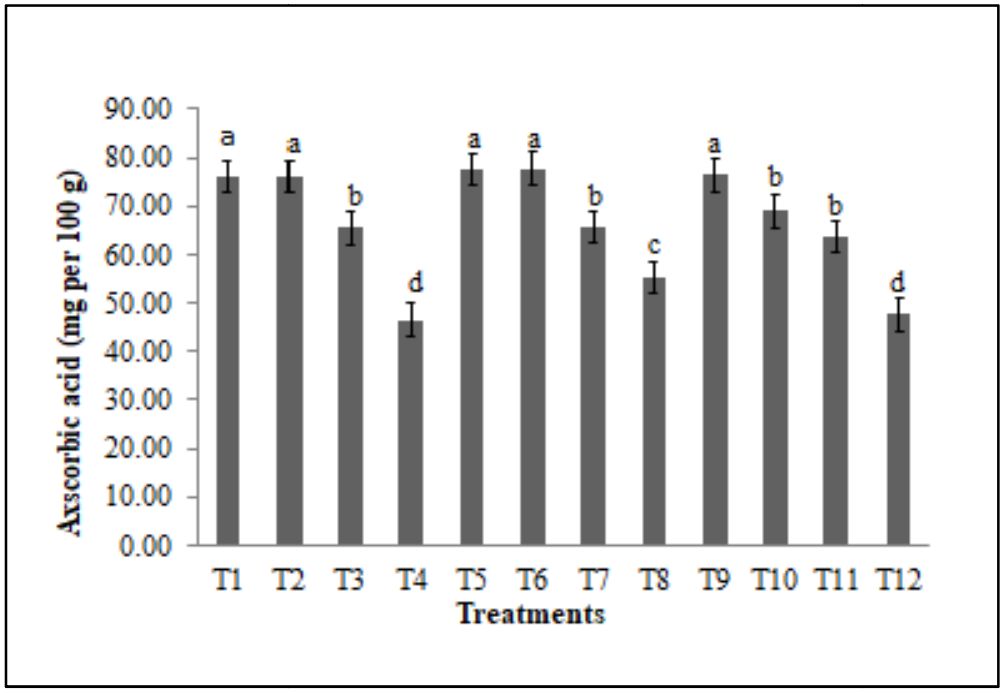

Fig 3. Effect of different planting time and mulching on Ascorbic acid content of Chandler strawberry

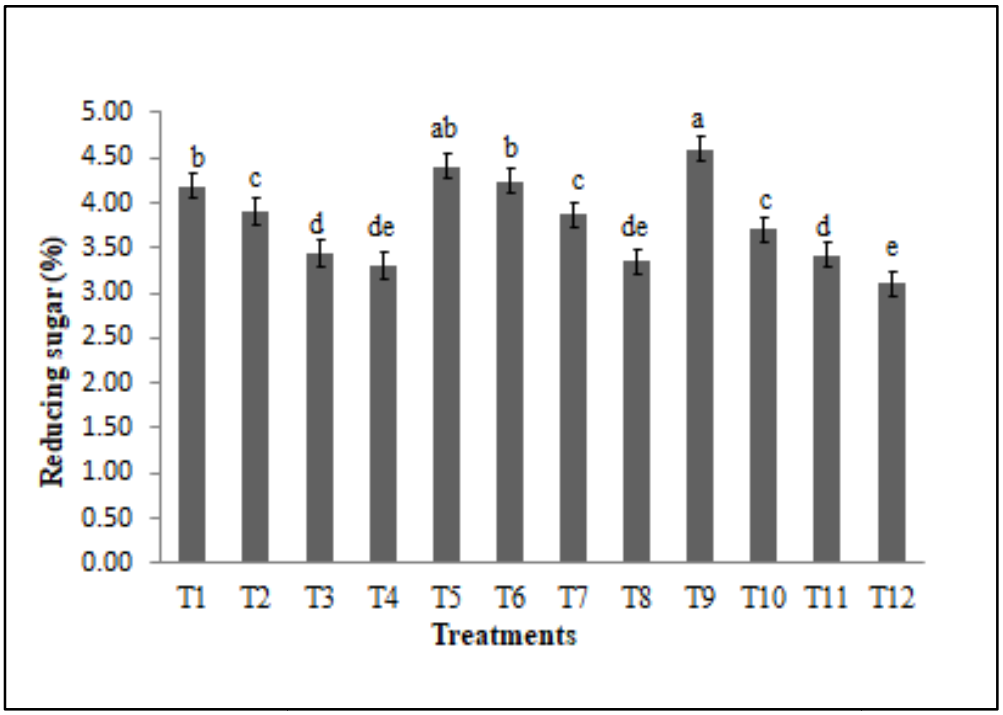

Fig 4. Effect of different planting time and mulching on reducing sugar of Chandler strawberry

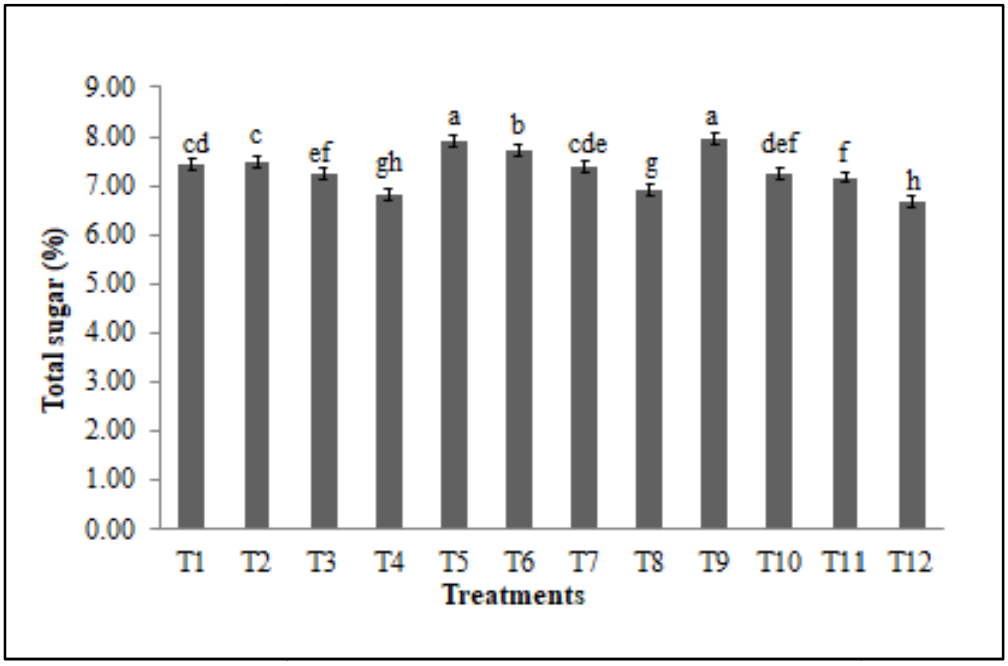

Fig 5. Effect of different planting time and mulching on total sugar of Chandler strawberry

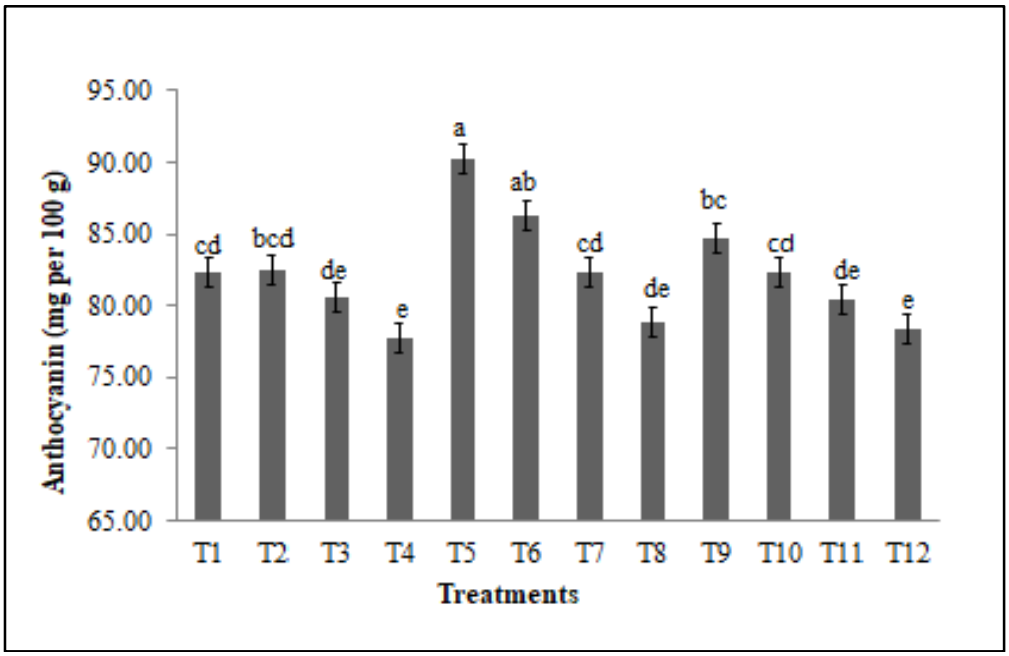

Fig 6. Effect of different planting time and mulching on anthocyanin content of Chandler strawberry

CONCLUSIONS

To summarize, the two year study concluded that mid-october planting coupled with black polyethylene mulching of fifty micron thickness was found and considered to be effective and promising in increasing the yield for successful cultivation of 'Chandler' strawberry. This information could be used as phonological base line for developing more efficient plant management strategies under sub-tropical mid hill conditions of Arunachal Pradesh, India.

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