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The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(3): 2238-2242

www.thepharmajournal.com
Received: 01-12-2022
Accepted: 06-02-2023

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The efficacy of different mulching with spacing on quality of strawberry (*Fragaria ananassa* Duch.) cv chandler

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Abstract
An experiment was conducted at the Horticultural Research Farm of Babasaheb Bhimrao Ambedkar University, Lucknow. The experiment was performed to find out the most suitable mulching material and an ideal spacing for straw berry cultivation under Lucknow conditions. The experiment was laid out in a Factorial Randomized Block Design with three replications. The treatments comprised of three mulching materials *viz*. paddy straw, black polyethylene, and transparent polyethylene) with three spacings (30 x 15 cm and 30 x 30 cm and 30 x 30). On the basis of the statistical data, it is concluded that spacing of 30 x 30 cm with black polyethylene mulch was found to be the best in terms of quality *viz*. Juice, Total soluble solid, Acidity, Ascorbic acid, Total sugars, Reducing sugar, and non-reducing sugar. However, there was slight difference in quality parameters among different treatments.

Keywords: Straw berry, spacings, mulching, quality etc.

Introduction
Cultivated strawberry (*Fragaria x ananassa* Duch.) belongs to the rosaceae. It is a monociousoctaploid (2n=56) hybrid of two octaploid species, namely, *Fragariachilonensis* Duch and *Fragariavirginiana* Duch. Species with a basic chromosome number (x) of 7. Botanically, it is an aggregate fruit among the fruits, strawberry gives the quickest returns in the shortest possible time. It is a lucrative fruit with high market demand in India. Its commercial cultivation has recently begun in the country in India; Maharashtra is the leading state in the production of strawberry. Recently its area has considerably increased in Haryana and Punjab. It is desirable to enhance the yield of strawberry not only quantitatively but also qualitatively with ever limiting resource of cultivated lands. In India cultivated from September to April. In this point of view, strawberry may help to increase the availability of fruits in this lean period of the country. it is a major fruit of temperate region but it can be grown even in both tropical and subtropical region and the area under this crop in the sub-continent is increasing rapidly`. It grows well in the winter especially October; November is the best time for its planting so that it can complete its life cycle before March. Being a winter season crop, it has to face a lot of natural advertise like poor soil moisture, temperature fluctuation and so on specially during flowering and fruiting. The time of planting is a limiting factor for strawberry because of the short winter in India and furthermore the production of strawberry depends greatly on the day temperature, humidity and day length. The cultivars are significantly influenced by weather conditions and planting time, with the latter having a direct effect on day and night temperatures, day light intensity and photoperiod, which affect the floral induction, fruit size, quality and production. Thus, the planting time of strawberry is important for partitioning the assimilates, which directly influence the growth and yield of strawberry. But planting time is a limiting factor for growing strawberry in this country, because of prevailing short winter season. There are several reports available in the literature indicating that strawberry can be planted on different times of the year depending on the variety, location and climates.

Strawberry is one of the crops among the other crops that response drastically to the increase of soil temperature/light reflectance produced with the use of mulches. Observed that the use of plastic mulches in agriculture helped to increase the production per unit area for all types of crops as polyethyleneed polyethylene mulch films increase soil temperature 5-7 ^{0}C facilitating

faster germination and better root proliferation, in addition to checking weed growth, preserving the soil structure, retaining soil moisture and increasing CO2 contents around the plants. Considering these facts, the systematic studies were conducted to standardize the appropriate mulch material and spacing for quality and higher yield of strawberry fruits. It is know fact that mulching is the most important cultural practice in strawberry as it influences plant growth, yield and quality of fruits.

Materials and Methods

Geographically, Babasaheb Bhimrao Ambedkar University, (A Central University), Vidya Vihar, Rae Bareli Road, Lucknow (U. P.), India at 800 55' East longitude and 260 46' North latitude and 111 meter above MSL (mean sea level). The climate of Lucknow is characterized by Sub-tropical with hot, dry summer and cool winters. This region received an averages annual rainfall of 650-750 mm, which is distributed over a period of more than 100 days with peak period during July-August. It also received scattered showers during winter months. In general, the temperature ranges from 5.5^0c to 25^oc. The coldest month is January, while the maximum temperature is observed during May- June. The average relative humidity is 60% in different seasons of the year.

Cultivars

Strawberry cultivar (chandler) collected from the Dr. Y. S. Parmar University of Horticulture & Forestry, Nauni, Himachal Pradesh and maintained in Horticulture Research Farm-I of the Department of Horticulture, Baba sahib Bhimrao Ambedkar University, Vidya-Vihar, Rae Bareli Road, Lucknow, (U.P.), India.

Details of Experiment

The experimental materials for the study comprised of three spacing of strawberry along with three treatment of mulching including control laid out under Factorial Randomize Block Design and replicated thrice. Thus there were 9 treatments in each replication.

Treatment detail

A. Plant spacing (S)

There were three levels of plant spacing as follows:

1.	Plant spacing (30 x15)	S_1
2.	Plant spacing (30 x 20)	S_2
3.	Plant spacing (30 x 30)	S_3

B. Mulch (M)

1.	Transparent mulches	M_1
2.	Black polythene mulch	M_2
3.	Paddy straw	M_3

Treatments Combination

Sl. No	Symbol	Treatments combination
T_1	S_1M_1	30×15 cm + Transparent mulching
T_2	S_1M_2	30×15 cm + Black polythene
T_3	S_1M_3	30×15 cm + Paddy straw
T_4	S_2M_1	30×20 cm + Transparent mulching
T_5	S_2M_2	30×20 cm + Black polythene
T_6	S_2M_3	30×20 cm + Paddy straw
T_7	S_3M_1	30×30 cm + Transparent mulching
T_8	S_3M_2	30×30 cm + Black polythene
T_9	S_3M_3	30×30 cm + Paddy straw

Details of layout

Name of crop	Strawberry (*Fragaria x ananassa* Duch.)
Number of treatments	09
Number of replication	03
Number of plants per plot	32, 24, 16
Total number of plants	648
Design	Factorial Randomized Block design
Gross experimental area	80.85 m2
Net plot size	1.20 m x 1.20 m = 2.44 m2
Plant spacing	30 x15cm, 30 x 20cm, 30 x 30cm, (Row to Row x Plant to Plant)
Date of transplanting (Cultivar: Chandler)	26th October, 2019

Result and Discussion

Total soluble solid TSS (^{0} Brix)

The observations recorded on total soluble solid of strawberry as influenced by both the factors *viz*., planting distance and mulching and their interactions for the years 2019-20 analysis has been exhisted in Table 1.

The data recorded was significant difference in total soluble solid. Spacing 30x30 cm treatment S_3 gave the maximum total soluble solids (7.44) which was statistically similar (6.76) to at 30x20 cm spacing, while 30x15 cm spacing gave the minimum total soluble solid (6.82).

Different mulching showed significant differences on thetotal soluble solids. The maximum total soluble solids was recorded in (7.58) from black polythene mulch (M_2) which was closely followed treatment (M_3) and maximumtotal soluble solid was recorded in (6.22) M_1 (Transparent polythene mulch).

The total soluble solids significantly differed by the interaction effect of spacing and mulch. The maximum total soluble solidwas recorded (8.01) in the combined effect of S_3M_2 (Spacing 30×20 cm and black polythene mulch), while the treatment combination S_1M_1 (Spacing 30×15 cm and transparent polythene mulch) gave the minimum total soluble solid (6.05) was recorded from S_1M_1.

Acidity (%)

The observations recorded on acidity percentage strawberry as influenced by both the factors *viz*., planting distance and mulching and their interactions for the years 2019-20 analysis has been given in Table 1.

The data recorded was significant difference in acidity percentage. Spacing 30x30 cm treatment S_3 gave the minimum acidity percentage (0.65), which was statistically similar (0.0.72) to at 30x20 cm spacing, while 30x15 cm spacing gave the maximum acidity percentage (0.80).

Different mulching showed significant differences on the acidity percentage. The minimum acidity percentage was recorded in (0.71) from black polythene mulch (M_2) which was closely followed treatment (M_3) and maximum specific acidity percentage was recorded in (0.76) M_1 (Transparent polythene mulch).

The acidity percentage significantly differed by the interaction effect of spacing and mulch. The minimum acidity percentage was recorded (0.62) in the combined effect of S_3M_2 (Spacing 30×20 cm and black polythene mulch), while the treatment combination S_1M_1 (Spacing 30×15 cm and transparent polythene mulch) gave the maximum acidity percentage (0.84) was recorded from S_1M_1.

Ascorbic acid (mg/100g)

The observations recorded on ascorbic acid strawberry as influenced by both the factors *viz*., planting distance and mulching and their interactions for the years 2019-20 analysis has been showen in Table 1.

The data recorded was significant difference in ascorbic acid. Spacing 30x30 cm treatment S_3 gave the maximum ascorbic acid (57.84), which was statistically similar (56.32) to at 30x20 cm spacing, while 30x15 cm spacing gave the minimum ascorbic acid (53.98).

Different mulching showed significant differences on the ascorbic acid. The maximum ascorbic acid was recorded in (57.36) from black polythene mulch (M_2) which was closely followed treatment (M_3) and maximum specific ascorbic acid was recorded in (54.65) M_1 (Transparent polythene mulch).

The ascorbic acid significantly differed by the interaction effect of spacing and mulch. The maximum ascorbic acid was recorded (59.22) in the combined effect of S_3M_2 (Spacing 30×20 cm and black polythene mulch), while the treatment combination S_1M_1 (Spacing 30×15 cm and transparent polythene mulch) gave the minimum ascorbic acid (53.36) was recorded from S_1M_1.The ascorbic acid (59.22) was associated in the treatment T8 (30x30 + black polythene).

Total sugars (%)

The observations recorded on total sugar of strawberry as influenced by both the factors *viz*., planting distance and mulching and their interactions for the years 2019-20 analysis has been exhibited in Table2.

The data recorded was significant difference in total sugar. Spacing 30x30 cm treatment S_3 gave the maximum total sugar (6.18), which was statistically similar (5.54) to at 30x20 cm spacing, while 30x15 cm spacing gave the minimum total sugar (5.02).

Different mulching showed significant differences on the total sugar. The maximum total sugar was recorded in (6.10) from black polythene mulch (M_2) which was closely followed treatment (M_3) and maximum total sugar percentage was recorded in (4.89) M_1 (Transparent polythene mulch).

The total sugar significantly differed by the interaction effect of spacing and mulch. The maximum total sugar was recorded (6.91) in the combined effect of S_3M_2 (Spacing 30×20 cm and black polythene mulch), while the treatment combination S_1M_1 (Spacing 30×15 cm and transparent polythene mulch) gave the minimum total sugar (4.70) was recorded from S_1M_1.

Reducing Sugar (%)

The observations recorded on reducing sugar strawberry as influenced by both the factors *viz*., planting distance and mulching and their interactions for the years 2019-20 analysis has been existing in Table 2.

The data recorded was significant difference in reducing sugar. Spacing 30x30 cm treatment S_3 gave the maximum reducing sugar (4.48), which was statistically similar (4.11) to at 30x20 cm spacing, while 30x15 cm spacing gave the minimum reducing sugar (3.80).

Different mulching showed significant differences on the reducing sugar. The maximum reducing sugar was recorded in (4.53) from black polythene mulch (M_2) which was closely followed treatment (M_3) and maximum specific reducing sugar was recorded in (3.68) M_1 (Transparent polythene mulch).

The reducing sugar significantly differed by the interaction effect of spacing and mulch. The maximum reducing sugar was recorded (4.97) in the combined effect of S_3M_2 (Spacing 30×20 cm and black polythene mulch), while the treatment combination S_1M_1 (Spacing 30×15 cm and transparent polythene mulch) gave the minimum reducing sugar (3.62) was recorded from S_1M_1.

Non-reducing sugar (%)

The observations recorded on non-reducing sugar strawberry as influenced by both the factors *viz*., planting distance and mulching and their interactions for the years 2019-20 analysis has been existing in Table 2.

The data recorded was significant difference in non-reducing sugar. Spacing 30x30 cm treatment S_3 gave the maximum non reducing sugar (1.61), which was statistically similar (1.32) to at 30x20 cm spacing, while 30x15 cm spacing gave the minimum non-reducing sugar (1.12).

Different mulching showed significant differences on the non-reducing sugar. The maximum non-reducing sugar was recorded in (1.47) from black polythene mulch (M_2) which was closely followed treatment (M_3) and maximum specific non-reducing sugar was recorded in (1.15) M_1 (Transparent polythene mulch).

The reducing sugar significantly differed by the interaction effect of spacing and mulch. The maximum non-reducing sugar was recorded (1.85) in the combined effect of S_3M_2 (Spacing 30×20 cm and black polythene mulch), while the treatment combination S_1M_1 (Spacing 30×15 cm and transparent polythene mulch) gave the minimum non-reducing sugar (1.03) was recorded from S_1M_1.The non-reducing sugar (1.85) was associated in the treatment T8 (30x30 + black polythene).

Table 1: Effect of various spacing and mulching on TSS (^{0}Brix), Acidity (%) and Ascorbic acid (mg/100g)

Treatment	TSS (^{0}Brix)	Acidity (%)	Ascorbic acid (mg/100g)
Spacing			
S_1	6.82	0.77	49.67
S_2	6.96	0.78	51.01
S_3	7.24	0.79	52.55
C.D	0.16	N/A	1.28
S.E.(d)	0.07	0.07	0.60
S.E.(m)	0.05	0.05	0.42
Mulching			
M_1	6.22	0.77	49.58
M_2	7.78	0.78	52.08
M_3	7.03	0.79	51.58
C.D	015	N/A	1.26
S.E.(d)	0.06	0.07	0.58

S.E.(m)	0.06	0.05	0.40
Interaction			
S_1M_1	6.05	0.74	48.33
S_1M_2	7.35	0.82	50.68
S_1M_3	6.90	0.76	50.68
S_2M_1	6.09	0.75	49.15
S_2M_2	7.80	0.84	52.12
S_2M_3	6.99	0.76	51.12
S_3M_1	6.52	0.76	51.78
S_3M_2	8.01	0.85	51.45
S_3M_3	7.20	0.78	52.95
C.D	N/A	N/A	N/A
S.E.(d)	0.13	0.13	1.03
S.E.(m)	0.09	0.09	0.73

Table 2: Effect of various spacing and mulching on total sugars (%), reducing sugar (%) and non-reducing sugar (%)

Treatment	Total sugar (%)	Reducing sugar (%)	Non- reducing sugar (%)
Spacing			
S_1	5.02	3.84	1.12
S_2	5.54	4.11	1.32
S_3	6.18	4.48	1.61
C.D	0.06	0.03	0.06
S.E.(d)	0.03	0.01	0.02
S.E.(m)	0.02	0.01	0.02
Mulching			
M_1	4.89	3.68	1.15
M_2	6.10	4.55	1.47
M_3	5.74	4.20	1.46
C.D	0.07	0.03	0.06
S.E.(d)	0.02	0.02	0.03
S.E.(m)	0.03	0.02	0.03
Interaction			
S_1M_1	4.70	3.62	1.03
S_1M_2	5.35	4.24	1.05
S_1M_3	5.02	3.66	1.29
S_2M_1	4.80	3.63	1.11
S_2M_2	6.05	4.45	1.52
S_2M_3	5.77	4.27	1.42
S_3M_1	5.18	3.80	1.31
S_3M_2	6.91	4.97	1.85
S_3M_3	6.45	4.68	1.68
C.D	0.11	0.05	0.10
S.E.(d)	0.05	0.01	0.04
S.E.(m)	0.03	0.05	0.03

Conclusion

The overall results obtained from this present investigation clearly revealed that the application of S_3M_2(30x30 + black polythene) significantly the plant height (cm), number of leaves, number of flower, fruit length (mm), fruit diameter (mm), specific gravity, juice (%), number of fruit per plant, fruit weight (g), fruit yield per plant(g), fruit yield per plot (kg), fruit yield per ha (t), total soluble solid, acidity, ascorbic acid, total sugars (%), reducing sugar (%) and non-reducing sugar(%) performed better response of growth, yield and quality traits in strawberry under Lucknow condition.

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