ISSN: 2518-2021 (Print), 2415-4474 (Online) Fundam Appl Agric 2017, 2(1): 202-206

Fundamental and Applied Agriculture

Journal homepage: www.f2ffoundation.org/faa

Crop Science
ORIGINAL ARTICLE

Growth and yield performance of strawberry (*Fragaria* × *ananassa* Duch.) as influenced by variety and mulch materials

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ARTICLE INFO

Article history:

Received: 25 December 2016
Received in revised form: 12 January 2017
Accepted: 21 January 2017
Available online: 31 January 2017

Academic Editor: Md Parvez Anwar

Keywords:

Strawberry
Plant growth
Fruit yield
Organic mulch
Synthetic mulch

ABSTRACT

Application of mulch materials in strawberry cultivation may have significant impact on quality fruit production in Bangladesh. Therefore, this study was undertaken in order to explore the effects of different mulch materials on plant growth and fruit yield of strawberry (*Fragaria*× *ananassa* Duch.). The factorial experiment consisted of two strawberry varieties namely Rabi strawberry-1 and Rabi strawberry-3 and four mulch materials *viz.*no mulch (control), rice straw, water hyacinth and black polythene mulches. The experiment was laid out in a randomized complete block design with three replications. The influences of strawberry variety, mulch material and their combinations showed significant variations on plant growth, yield contributing characters and fruit yield. The two varieties differed significantly in respect of all the parameters studied. Number of leaves, leaf length, plant height and fruit yield were found higher in Rabi strawberry-1. It was also found that mulching treatments enhanced vegetative as well as reproductive growth of strawberry thus improved fruit yield as compared to control treatment. Among the mulch materials, black polythene gave the highest plant height (26.83 cm), leaf length (27.35 cm), number of leaves (8.00) at different growth stages, number of inflorescence (12.50), number of fruits plant^{-1} (33.00), fruit length (51.45 mm), fruit fresh weight (23.01 g fruit^{-1}) and fruit yield (613.37 g plant^{-1}).The combined effects of variety and mulch treatments showed significant variation on plant growth and yield of strawberry. However, the highest fruit yield (569.62 g plant^{-1}) was achieved from the combination of Rabi strawberry-1 with black polythene mulch.

INTRODUCTION

Strawberry (*Fragaria* × *ananassa* Duch.) is one of the most delicious and fragrantly sweet flavored fruit of the world. It is a low creeping, perennial, stoloniferous herb belongs to the family Roseaseace. The modern cultivated strawberry is a hybrid of two largely dioecious octaploid species *Fragaria chelonesis* and *Fragaria varginiana* (Sharma and Sharma 2004). Strawberry has a unique place among all the berry fruits because of its charming red color and high nutritive value (Sharma et al. 2013).In Bangladesh, strawberry is a newly introduced small fruit crop (Chowdhury et al. 2013) and farmers are showing their positive intension to grow this crop. Strawberry farming has become popular in the northern region of Bangladesh from last couple of years. Rajshahi, Jaypurhat, Bogra, Dinajpur, Mymensingh, Jessor etc. are the main growing regions of this fruit in our country along with the surrounding areas of Dhaka city like Manikgonj, Munshigonj and Gazipur etc.

Strawberry is a thermo and photo sensitive crop (Sharma 2002). But now-a-day, day neutral varieties are becoming favorite to the growers. In Bangladesh, strawberry is planted in the month of October-November and it starts flowering from December. January to March is harvesting time of fruits. Being a winter fruit crop, it has to face a lot of natural advertise like poor soil moisture, temperature fluctuation and so on specially during flowering and fruiting (Sharma 2013). On the other hand, when the strawberry fruits lay down on the soil they become infested by many soil borne fungi such as *Pythium, Rhizoctonia, Phytopthora* etc.

In Bangladesh, almost all cultural managements are practiced in commercial strawberry cultivation except mulching but it is one of the important ones. Farmers are growing this fruit without using any mulch therefore fruits become infected by soil borne organism which results in reduced marketable yield. It is

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noteworthy that small growers are being using such materials to keep the fruits free from diseases. Mulching is any kind of material that is applied on the top soil, it may be of straw, compost, manure, chipped bark, plastic sheet etc.(Prasad and Kumar 1999).Mulches are applied on the soil surface, around the trees, path or beds to prevent soil erosion, conserve soil moisture and optimize soil temperature. Mulch layer is normally two inches or more deep when applied (Dennis 2002). In case of strawberry, mulch also prevents the fruits from fruit rot (Perez de Camacaro et al. 2002).Organic mulch provides environmental benefits, increases soil physical health, reduces soil erosion and works as slow release fertilizer (Abdul-Baki and Taesdale 1993). However, strawberry varieties developed in Bangladesh are not yet been tested under mulch condition for their growth and yield performance. Considering these facts a research work has been conducted in order to explore the effects of variety and mulch material on growth and yield of strawberry and to select better variety and the most suitable mulch material for strawberry production in Bangladesh.

MATERIALSAND METHODS

The experiment was carried out at the Horticulture Farm, Department of Horticulture, Bangladesh Agricultural University, Mymensingh during October 2014 to March 2015. The experimental site is located at 24°75' N latitude and 90°50' E longitude at an elevation of 18 m above the mean sea level. The soil of the experimental area was silty loam belonging to the Old Brahmaputra Floodplain Alluvial Tract under the Agro Ecological Zone 9.The selected site was a well-drained medium high land having soil pH 6.8. The working site was situated under the sub-tropical climatic zone characterized by scanty rainfall, low humidity, low temperature and short day period during the experimental season. The experiment comprised two factors, namely (i) variety (Rabi strawberry-1 and Rabi strawberry-3) and (ii) Mulch materials (Control (no mulch), Rice straw (thickness: 8-10 cm), Water hyacinth (thickness: 10-12 cm) and Black polythene (50 micron). The study was laid out in a randomized complete block design with three replications. The size of a unit plot was 1.6 m x 1.0 m. The distance between blocks and plots were 0.5 m to facilitate different intercultural operations. Well decomposed cowdung was applied to the plots at the rate of 15 t $ha^{-1}$and incorporated into soil just after opening the land. TSP, MoP and ZnO were applied at final land preparation at the rate of 250, 150 and25 kg ha^{-1}, respectively according to Fertilizer Recommendation Guide (Anon 2012). Urea at the rate of 90 kg ha^{-1} was applied after one month of transplanting. Finally, the unit plots were prepared on 23 November 2014 as 10 cm raised beds. Healthy and uniform sizes 30-day old seedlings were collected from Akafuji Agro technology Nursery, Namobhadra, Rajshahi and transplanted on 25 November 2014 at a spacing of 50 cm x 40 cm. Light irrigation was provided immediately after transplanting by using a watering can. Mulch treatments were applied on the respective plots as per layout before transplanting of seedlings. Data on various parameters were collected during vegetative growth and fruiting time. The collected data were analyzed using MSTAT-C program. The means of different treatments and varieties were calculated and analysis of variances was performed by F-variance test. The significance of the difference between pairs of means was evaluated by least significant difference test at 1% level of probability as described by Gomez and Gomez (1984).

RESULTS

Leaf number $plant^{-1}$

Significant variation was observed between varieties in respect of number of leaves $plant^{-1}$at 30, 60 and 90 days after transplanting (DAT).Higher number of leaves $plant^{-1}$was observed in Rabi strawberry-1 at all the sampling dates. At 90 DAT, the higher number of leaves $plant^{-1}$was observed in Rabi strawberry-1 (17.42) and the lower in Rabi strawberry-3 (13.17) (Table 1). There were significant variations observed among mulch treatments in case of number of leaves $plant^{-1}$. At 30 DAT, the highest number of leaves $plant^{-1}$was found in black polythene (8.00) and the lowest in water hyacinth (5.58). Similar pattern was also found at 60 DAT. At 90 DAT, the highest number of leaves $plant^{-1}$was observed in water hyacinth (16.02) and the lowest was observed in rice straw (14.50) (Table 1). The interaction effect between variety and mulch treatments on number of leaves $plant^{-1}$ was found significant at 30, 60 and 90 DAT. The maximum number of leaves$plant^{-1}$(14.9) was recorded at 60 DAT from the treatment combination of Rabi strawberry-1 with black polythene mulch, and the minimum number of leaves $plant^{-1}$ (9.00) was recorded from the treatment combination of Rabi strawberry-3 with no mulch (Table 2).

Table 1. Main effects of variety and mulch treatments on number of leaves $plant^{-1}$ at different days after transplanting (DAT), leaf length, plant height, number of inflorescence $plant^{-1}$, number of fruits$plant^{-1}$and fruit length of strawberry

Varieties	Number of leaves $plant^{-1}$ at DAT			Leaf length (cm)	Plant height (cm)	Number of inflorescence $plant^{-1}$	Number of fruits $plant^{-1}$	Fruit length (mm)
	30	60	90					
V1	9.42	14.50	17.42	26.18	20.82	13.92	12.83	52.54
V2	5.58	10.33	13.17	24.45	23.56	5.50	39.50	36.47
LSD (1%)	0.42	0.83	0.99	0.80	0.78	1.75	0.96	0.89
Level of Sig.	**	**	**	**	**	**	**	**
Mulch treatments								
T1	7.50	12.67	16.00	23.92	18.03	7.33	18.33	39.11
T2	7.67	11.33	14.50	25.78	23.08	9.33	23.00	44.11
T3	6.83	13.33	16.00	24.22	21.00	9.67	30.00	43.36
T4	8.00	12.33	14.67	27.35	26.63	12.50	33.00	51.45
LSD (1%)	0.60	1.17	1.41	1.13	1.10	2.47	1.35	1.26
Level of Sig.	**	**	**	**	**	**	**	**

V_1 = Rabi strawberry-1, V_2 = Rabi strawberry-3, T_0 = Control (no mulch); T_1 = Rice straw; T_2 = Water hyacinth; T_3 = Black polythene, ** = Significant at 1% level of probability

Table 2. Combined effects of variety and mulch treatments on number of leaves plant^{-1} at different days after transplanting (DAT), leaf length, plant height, fruit length, fruit fresh weight and fruit yield plant^{-1}

Treatment combinations	Number of leaves plant^{-1} at different DAT			Leaf length (cm)	Plant height (cm)	Number of inflorescence plant^{-1}	Number of fruits plant^{-1}	Fruit length (mm)	Fruit fresh weight (g)	Fruit yield (gplant^{-1})
	30	60	90							
V_1T_0	10.00	16.33	19.33	25.60	17.17	9.67	9.33	48.20	22.06	204.71
V_1T_1	9.33	13.67	16.00	26.97	21.17	13.00	12.33	53.38	25.01	302.71
V_1T_2	9.00	13.33	17.00	24.93	18.83	13.67	12.33	50.90	27.58	339.15
V_1T_3	9.33	14.67	17.33	27.23	26.10	19.33	17.33	57.67	32.74	569.62
V_2T_0	5.00	9.00	12.67	22.24	18.90	5.00	27.33	30.01	5.13	141.27
V_2T_1	6.00	9.00	13.00	24.60	25.00	5.67	33.67	34.84	6.89	230.85
V_2T_2	4.67	13.33	15.00	23.50	23.17	5.67	48.33	35.82	8.12	401.91
V_2T_3	6.67	10.00	12.00	27.47	27.17	5.67	48.67	45.22	13.28	657.12
LSD $_{(1\%)}$	0.85	1.65	1.99	1.59	1.56	3.49	1.91	1.79	1.68	4.30
Level of sign.	**	**	**	**	**	**	**	**	**	**

V_1 = Rabi strawberry-1, V_2 = Rabi strawberry-3, T_0 = Control (nomulch); T_1 = Rice straw; T_2 = Water hyacinth; T_3 = Black polythene, ** = Significant at 1% level of probability

Leaf length

In respect of leaf length, the varieties showed significant variation. Leaf length of Rabi strawberry-1 was found higher (26.18cm) than Rabi strawberry-3 (24.45cm) (Table 1). Mulch treatments showed significant effects on leaf length. Leaf length was significantly the highest (27.35 cm) in black polythene mulch treatment followed by rice straw (25.78 cm), water hyacinth (24.22 cm), and minimum length (23.92cm) was obtained from no mulch treatment (Table 1). Varieties and mulch treatments had significant interaction effects on leaf length of strawberry. The highest leaf length (27.47 cm) was recorded from the treatment combination of Rabi strawberry-3 with black polythene mulch and lowest (22.24 cm) one was found from Rabi strawberry-3 with water hyacinth mulch treatment combination (Table 2).

Plant height

Strawberry variety showed significant variation in respect of plant height. The taller plants was observed in the variety Rabi strawberry-3 (23.56 cm) than in Rabi strawberry-1 (20.82 cm) (Table 1). Plant height varied significantly due to the effect of different mulch treatments. The highest plant height (26.63cm) was achieved in black polythene mulch followed by rice straw (23.08 cm), water hyacinth (21.00 cm) and minimum height (18.00cm) was obtained from no mulch treatment (Table 1). The interaction effect of variety and mulch treatments were found significant. The highest plant height (27.17 cm) was recorded in Rabi strawberry-3 with black polythene mulch and the lowest one (17.17 cm) was observed in Rabi strawberry-1 with no mulch treatment combination (Table 2).

Number of inflorescences plant^{-1}

Number of inflorescences plant^{-1}varied significantly between two varieties. It was higher in Rabi strawberry-1 (13.92) and lower in Rabi strawberry-3 (5.50) (Table 1).Number of inflorescences plant^{-1} varied significantly due to different mulch treatments. Number of inflorescences plant^{-1} was highest (12.50) in black polythene mulch followed by water hyacinth mulch (9.67), rice straw mulch (9.33) and the lowest one (7.33) in no mulch treatment (Table 1). The interaction effect of variety and mulch treatments on number of inflorescences plant^{-1}were found significant. The maximum inflorescences plant^{-1}(19.33) was recorded from the treatment combination of Rabi strawberry-1 with black polythene mulch and the minimum inflorescences plant^{-1}(5.00) was recorded from the treatment combination of Rabi strawberry-3 with no mulch treatment (Table 2).

Number of fruits plant^{-1}

Number of fruits plant^{-1} was highly significant between two varieties. Number of fruits plant^{-1} was higher in Rabi strawberry-3 (39.50) than in Rabi strawberry-1 (12.83) (Table 1).Number of fruits plant^{-1} was highly significant among the mulch treatments. Number of fruits plant^{-1} was highest (33.00) in black polythene followed by water hyacinth (30.33), rice straw (23.00) and lowest (18.33) in no mulch treatment (Table 1). The interaction effect between variety and mulch treatments on number of fruits plant^{-1} was found significant. The highest number of fruits plant^{-1}(48.67) was observed in Rabi strawberry-3 with black polythene mulch and the lowest number of fruits plant^{-1}(9.33) was observed in Rabi strawberry-1 with no mulch treatment combination (Table 2).

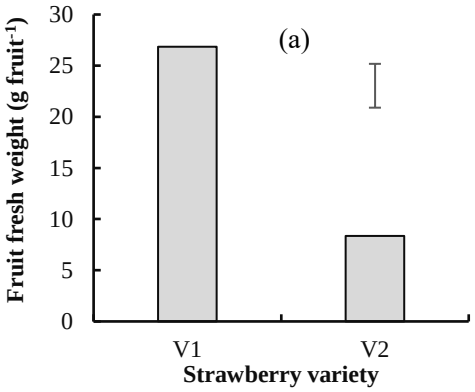
Fruit length

Fruit length was varied significantly between two varieties. Fruit length was found higher in Rabi strawberry-1 (52.54 mm) and lower in Rabi strawberry-3 (36.47 mm) (Table 1).Fruit length was varied significantly due to different mulch treatments. Fruit length was found highest (51.45 mm) in black polythene mulch followed by rice straw (44.11 mm), water hyacinth(43.36 mm) and lowest (39.11) in no mulch treatment (Table 1).Variety and mulch treatments had significant interaction effects on fruit length of strawberry. The highest fruit length (57.67 mm) was recorded from the treatment combination of Rabi strawberry-1 with black polythene mulch and lowest one (30.01 mm) was found from Rabi strawberry-3 with no mulch treatment combination (Table 2).

Fresh weight of fruits

Individual fruit fresh weight varied significantly between two varieties. It was found that fruit fresh weight was higher in Rabi strawberry-1 (26.85 g fruit^{-1}) than in Rabi strawberry-3(8.35 g fruit^{-1}) (Figure 1a). Fresh weight of fruits was highly significant among the mulch treatments. Highest fresh weight of fruits (23.01 g fruit^{-1}) was found in black polythene mulch followed by water hyacinth (17.85 g fruit^{-1}), rice straw (15.95 g fruit^{-1}) and lowest (13.60 g fruit^{-1}) in no mulch treatment (Figure 1b). The interaction effect between variety and mulch treatments on fresh weight of fruits was found significant. The maximum fresh weight of fruits (32.74 g fruit^{-1}) was recorded from the treatment combination of Rabi strawberry-1 with black polythene mulch

and the minimum one (5.13 g fruit^{-1}) was recorded from the treatment combination of Rabi strawberry-3 with no mulch treatment (Table 2).



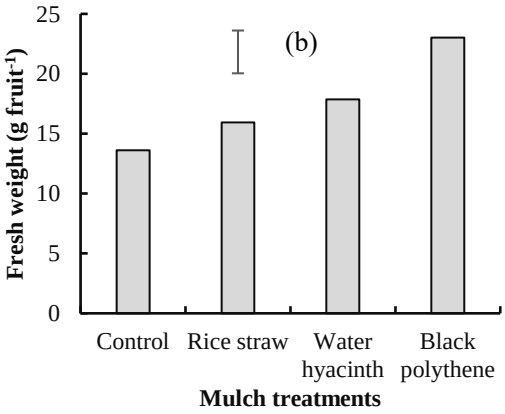


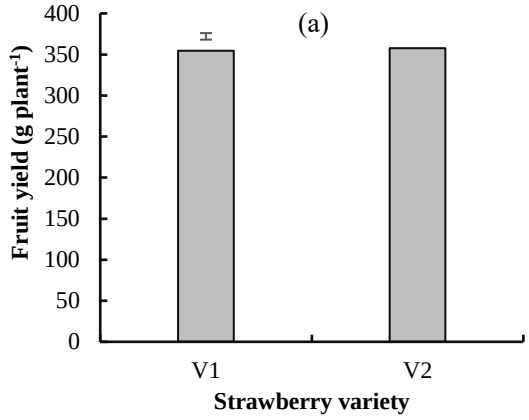
Figure 1. Effect of variety (a) and mulch treatments (b) on fresh weight of individual strawberry fruit (Vertical bar represents significant at 1% level of probability. V_1 = Rabi strawberry-1, V_2 = Rabi strawberry-3).

Fruit yield plant^{-1}

There was a significant variation between the varieties in respect of fruit yield plant^{-1}. It was found that Rabi strawberry-1 produced higher fruit yield (354.05 g plant^{-1}) than Rabi strawberry-3 (257.73 g plant^{-1}) (Figure 2a).Significant variation was observed among the mulch treatments in response to fruit yield plant^{-1}. Highest fruit yield (613.37 g plant^{-1}) found in black polythene mulch followed by water hyacinth (370.53 g plant^{-1}), rice straw (266.78 g plant^{-1}) and lowest yield (172.99 g plant^{-1}) found from no mulch treatment (Figure 2b).There were significant interactions between variety and mulch treatments in respect of fruit yield plant^{-1}. The maximum fruit yield (569.62 g plant^{-1}) was obtained in Rabi strawberry-1 with black polythene mulch and the minimum fruit yield (141.27 g plant^{-1}) in Rabi strawberry-3 with no mulch treatment combination (Table 2).

DISCUSSION

The results of this experiment reveled that different mulch treatments have significant influence on growth and yield performances of strawberry. It is observed that all the parameters studied in this study exhibited superiority under mulch treatments to the control (no mulch).Mulching serves as a barrier to protect the top soil which helps to retain soil moisture and appropriate mulching was quite useful to accelerate growth and fruit yield of strawberry (Taparauskiene and Miseckaite 2014).



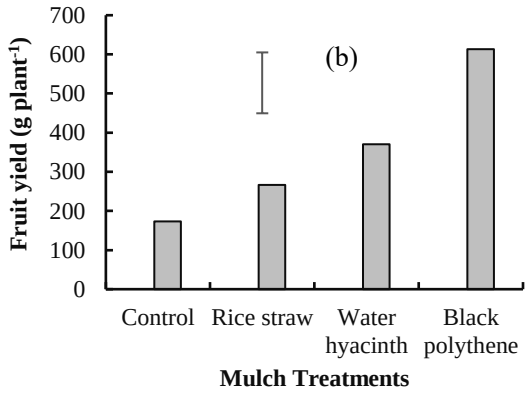


Figure 2. Effect of variety (a) and mulch treatments (b) on fruit yield of strawberry (Vertical bar represents LSD at 1% level of probability. V_1 = Rabi strawberry-1, V_2 = Rabi strawberry-3).

Leaves are the vital indicators of effective plant growth and development. In this experiment, leaf number and length were increased due to application of mulch treatments in the field. Similarly, mulch treatment also enhanced the plant height of strawberry this might be due to increasing root activity in the soil because soil under the mulch remained loose and well aerated thus significantly improved plant height. On the other hand, weed infestation was suppressed in mulch treated plants due to reduced light penetration which improved nutrient uptake by plants to a great extend thus plant height increased significantly compared to control treatment. In this experiment, black polythene mulch exhibited better performances in terms of plant growth and yield contributing characters of strawberry. Kabir et al. (2007) noticed the similar performance of mulch materials in case of Dianthus (*Dianthus chinensis* L.). They reported that highest plant height, early flowering and maximum number of flowers were obtained from black plastic mulch followed by water hyacinth and straw mulch. Number of inflorescence and fruits plant^{-1} were the maximum in this experiment. Similar result was also reported by Ali and Redwan (2008), who observed that number of flower trusses and flowers plant^{-1} significantly increased due to black and silver polythene mulches. They also stated that mulch might increase number of crowns which increased number of inflorescences and flowers plant^{-1} thus ultimately increased fruit yield. Becky et al. (2012) noticed that greatest total yield and marketable yield of strawberry were obtained from the white-on-black and silver-on-black plastic mulch treatments. Similar responses of strawberry yield to mulch treatments were also reported by many other researchers (Shiow et al. 1998; Vander Meulen et al. 2006). In

this experiment, fruit fresh weight was highest in mulch treated plants as compared to no mulched plants. This finding is also corroborated with the results of Baumann et al. (1995). They found larger fruits in case of black polythene mulch as compared to no mulched plants. Thus present finding confirms that strawberry plants would give quality fruit yield if they grow under any kind of mulch materials on the top soil.

CONCLUSION

Strawberry plants gave better growth and higher fruit yield when they were grown with any kind of mulches on top soil. It is found that black polythene mulch performed better in respect of all parameters studied in this experiment. Based on the results of this study it can be concluded that Rabi strawberry-1 is better variety than Rabi strawberry-3 and black polythene mulch is most suitable for strawberry production in Bangladesh.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this paper.

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