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RESEARCH ARTICLE

EFFECT OF DIFFERENT BIOFERTILIZERS AND MULCHING MATERIALS ON GROWTH AND YIELD OF STRAWBERRY (*FRAGARIA × ANANASSA* DUCH) CULTIVAR RANIA

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ABSTRACT

The present studies were carried out at Experimental Farm of the Guru Kashi University, Talwandi sabo during 2021 and 2022 to find out the "Effect of different biofertilizers and type of mulching on growth and yield of strawberry cv.Rania". The experiment laid out in split plot design (SSD) with three replications comprising of 10 treatments viz., T_1 (*FYM + Azotobacter.* + Phosphate Solubilizing Bcateria), T_2 (*FYM + Azospri.* + Vascular Abuscular Mychorhiza), T_3 *(Azotobacter* + Phosphate Solubilizing Bcateria), T_4 *(*Vascular Abuscular Mychorhiza + Phosphate Solubilizing Bcateria) T_5 (*Azosprillium + Azotobacter* + Phosphate Solubilizing Bcateria), T_6 (Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza), T_7 (Vascular Abuscular Mychorhiza + T4), T_8 (*Azotobacter + T3)* and T_9 (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria and Vascular Abuscular Mychorhiza) and three mulches (M_0- Unmulched, M_1- Paddy straw, M_2 – Black mulch, M_3 – White mulch). Among type of mulches, the result revealed that the growth parameters like plant height, plant spread, number of leave per plant and yield per plant and quality parameters like TSS were significantly higher with M_2 treatment (Black mulch). Among the different biofertilizers T_9 treatment (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria and Vascular Abuscular Mychorhiza) were recorded to be the best among all parameters (plant height, fruit weight, fruit diameter, fruit length, yield per plant, TSS and titrable acidity) respectively. The interaction viz., biofertilizer and mulch were significantly affected most of the characters under study. Maximum plant height, plant spread, number of leaves per plant, fruit weight, fruit yield, TSS and minimum titrable acidity was obtained with treatment combination of M_2T_9 (Black polythene mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria and Vascular Abuscular Mychorhiza).

INTRODUCTION

Strawberry (*Fragaria × ananassa* Duch.) belonging to the family Rosaceae. The cultivated strawberry (*F. × ananasaa* Duch.) is a hybrid of two largely dioecious, octoploid species, was originated from the hybridization of two American species *viz., Fragaria chilioensis* Duch and *Fragaria verginiana* Duch. In nature, All the cultivated varieties of strawberry are octaploid (2n = 8x = 56). The word "strawberry" come from the practice of using straw mulch for cultivation or acc. to Anglo-Saxon word known as strew meaning to spread. Botanically, the strawberry fruit is an aggregate fruit which are highly perishable by (Finn and Strike, 2008). The crop is mainly grown in temperate climate, but now it is being successfully grown under subtropical and tropical climate. It is herbaceous crop with prostate growth habit, which behaves as an annual in sub-tropical region and perennial in temperature region. Mulching is an essential practice in strawberry cultivation as it helps in conservation of soil moisture, moderates hydrothermal regimes, improves nutrient uptake, suppresses infestation of weeds and diseases, improves physical and biohealth of soil. Improved performance of strawberry under mulches is widely reported (Tariq *et al*., 2016). Biofertilizers are a cost effective renewable energy source and play a crucial role in reducing the inorganic fertilizer application and at the same time increasing the quality and yield of flowers besides maintaining soil fertility (Kumari *et al*., 2016). The excessive use of nitrogenous fertilizers and imbalanced use of other fertilizers has resulted in yield saturation and deterioration of soil health. Proper and regular incorporation of farm organic wastes and bio-inoculants are of utmost importance in maintaining the fertility and productivity of agricultural soils (Yadav, 2009). Hence, there is urgent need for use of mulches to regulate the soil moisture and application of biofertilizers to enhance the production and quality of strawbeery under open field condition. Therefore keeping in view the above fact in mind an attempt has been made in the present investigation to study the effect of different biofertilizers and type of mulching on growth and yield of strawberry cv. Rania.

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MATERIALS AND METHOD

The present investigation was carried out at Department of Fruit Science, Guru Kashi University, Talwandi Sabo, (Bathinda) Punjab during the year 2021-2022. The soil of experiment field was sandy loam in texture with pH 8.5, available Nitrogen-215.8 $kgha^{-1}$ (medium), Available P- 14.6 $kgha^{-1}$ (medium), Available K- 360.0 $kgha^{-1}$ (high) and organic matter- 0.26%. The well rooted runners of uniform size were planted on well prepared raised beds with 200 plants were planted in each replication on 23 oct 2021. To prevent desiccation the plants were transplanted in the evening time and runners were treated with fungicide (Azoxystrobin) and well pressed in the soil taking care that the crown of the runners lies just at the surface of soil .The beds were irrigated with sprinkler immediately after planting, which is help to maintain the optimum soil moisture. The experiment were conducted under split plot design (SPD) with three replication and consisting of 10 treatments of different Biofertilizers - Azotobacter (each 2 kg/acre), Azosprillium (each 1.4 kg/acre), Phosphate Solubilizing Bacteria (each 2.5 kg/acre) and Vascular Abuscular Mychorhiza (2.8 kg/acre) were uses as a source of nutrients. The recommended dose of biofertilizers were mixed (according to the treatment wise) with 15 tonnes/acre of FYM. This mixture is incorporated in the soil at the time of planting. Different types of organic and inorganic mulches such as paddy straw, black polyethylene (30 microns), white polyethylene sheets (30 microns) were spread manually on the beds and fixed tightly into the soil. Holes of 10 cm diameter were made at 30 x 30 cm spacing by using a plastic pipe. Mother runners were planted in the centre of holes made on black and white polythene mulch sheets. The organic mulches like paddy straw were applied upto 10cm thickness at 2 days after planting of runners. The observations were recorded on five randomly selection plant from each treatment. Growth characters (plant height, plant spread, number of leave $plant^{-1}$), floral characters (number of flower $plant^{-1}$), yield characters (number of fruit $plant^{-1}$, fruit weight, fruit yield $plant^{-1}$), biochemical characters (Total soluble solids, titrable acidity) were recorded. The data recorded during the course of investigation was subjected to statistically analyzed as proposed by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Plant height: The data presented in Table.1 revealed that different biofertilizers , mulching material and their interaction have significantly affect on plant height. The application of M_2 treatment (Black polythene) was found to be best mulch in recording maximum plant height (7.06cm) which was significantly superior over rest of treatments and it was followed by M_1 (Paddy Straw) (6.22 cm) and M_0 (Unmulched) (5.85 cm), while minimum plant height (5.29 cm) was notice in M_3 (White polythene mulch). Among the different bio fertilizers, T_9 (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria and Vascular Abuscular Mychorhiza) was recorded significantly highest in plant height (6.77 cm) which was at par with T_3 *(Azotobacter* + Phosphate Solubilizing Bcateria) (6.57 cm) , T_1 *(FYM + Azotobacter.* + Phosphate Solubilizing Bcateria) (6.26 cm) , T_4 *(* Vascular Abuscular Mychorhiza + Phosphate Solubilizing Bcateria) (6.17 cm) , T_2 (*FYM + Azospri.* + Vascular Abuscular Mychorhiza) (6.16 cm) and T_8 (*Azotobacter + T3)* (6.10 cm) followed by T_6 (Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) (6.01 cm) , T_7 (Vascular Abuscular Mychorhiza + T4) (5.58 cm) and T_0 (Control) (5.91 cm) whereas, lowest plant height (5.45 cm) was recorded in T_5 (*Azosprillium + Azotobacter* + Phosphate Solubilizing Bcateria). The biofertilizers and mulching material indicated significant interaction with respect to combination of M_2T_9 (Black polythene and *FYM + Azotobacter.* + *Azospirillium* + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) registered maximum plant height (7.94 cm). The possible reasons for higher plant height with *Azotobacte* + *Azospirillium* + PSB +VAM inoculation may be because of enhanced biological nitrogen fixation which ultimately shows positive effect on vegetative growth of plant (Nkansah *et al.* (2003). These findings are similar with Patra *et al.,* (2004). In addition, Black polythene mulch with *Azotobacter + Azospirillium + PSB + VAM* also show positive effect on growth parameters. Mulching help in improving the microclimatic condition of the soil which might have provided a suitable condition for better plant growth. This result correlated with the study of Sharma *et al.,(*2007) , Singh *et al.* (2015), Char Giriraj *et al*.,(2020) in strawberry.

Plant spread: A perusal of data in Table.2 also indicated that maximum values for canopy spread N-S & E-W (10.43 cm & 10.61 cm) was recorded in M_2 treatment (Black polythene mulch), whereas lowest canopy spread (9.16 cm & 8.78 cm) were observed in M_3 treatment (White polythene mulch),respectively. Among the different biofertilizers, the widest spread of plant N-S & E-W (10.90 cm & 11.29 cm) were measured with the application of T_3 treatment (*Azotobacter* + Phosphate Solubilizing Bcateria) which was followed by other rest of treatments.The interaction between different biofertilizers and mulching materials recorded maximum canopy spread N-S & E-W (12.33 & 12.93 cm) was observed in M_2T_9 (Black polythene mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria and Vascular Abuscular Mychorhiza) while, minimum canopy spread N-S & E-W (6.11cm & 7.35 cm) recorded in M_0T_0 (Unmulched + Control). The more spread of plant in the interaction M_2T_9 treatment might be due to the fact of mulching had ensured congenial environment for better root growth and development of plants through the moderation of hydrothermal regimes of rhizosphere. Moreover, the application of biofertilizers had increased the availability and continuous supply of nutrients due to the action of *Azotobacter* sp., Azosprillium ., which fixes the atmospheric nitrogen as well as make the soil nitrogen and phosphorus available to the plants by catalyzing phosphate solubilising activity (Pandove *et., 2016).*

Number of leaves $plant^{-1}$: The data enumerated in Table.3 elucidated that among the type mulches, maximum number of leaves $plant^{-1}$ (4.43) were observed in M_2 (Black polythene mulch) and it is at par with M_1 (Paddy straw) (4.27). Whereas minimum number of leaves (3.19) was recorded in M_0 (Unmulched) followed by M_3 (White polythene mulch) (3.93). Also, plant treated with biofertilizer, the result was found to be significant with maximum number of leaves (4.84) per plant were obtained from T_3 (*Azotobacter* + Phosphate Solubilizing Bcateria) which was significantly better than all treatments. While minimum number of leaves (3.38) were recorded in T_0 (Control). Among the treatment combinations, the result were revealed the significant difference with respect to number of leaves per plant. But the higher value for the number of leaves (6.06) was recorded in M_2T_9 (Black polythene mulch and FYM

Table.1 Effect of different bio fertilizers and mulching materials on plant height (cm)

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	5.21	4.78	5.21	6.65	6.07	5.27	6.25	6.02	6.86	6.22	5.85
M_1 (Paddy straw)	5.44	4.98	6.97	6.50	7.22	6.62	6.61	5.63	5.93	5.99	6.22
M_2 (Black polythene)	6.70	7.89	7.18	7.52	6.45	6.27	7.45	6.55	7.27	7.94	7.12
M_3 (White polythene)	6.31	7.34	5.27	5.61	4.94	3.66	3.71	4.11	4.36	6.99	5.23
Mean B	5.91	6.24	6.16	6.57	6.17	5.45	6.01	5.58	6.10	6.78	
C.D at 5% (Main Treatment)					0.83						
CD at 5% (Sub Treatment)					0.69						
CD at 5% (Main Treatment × Sub Treatment)					1.46						

Table 2. Effect of different bio fertilizers and mulching material on plant spread (N-S direction)

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	5.21	4.78	5.21	6.65	6.07	5.27	6.25	6.02	6.86	6.22	5.85
M_1 (Paddy straw)	5.44	4.98	6.97	6.50	7.22	6.62	6.61	5.63	5.93	5.99	6.22
M_2 (Black polythene)	6.70	7.89	7.18	7.52	6.45	6.27	7.45	6.55	7.27	7.94	7.12
M_3 (White polythene)	6.31	7.34	5.27	5.61	4.94	3.66	3.71	4.11	4.36	6.99	5.23
Mean B	5.91	6.24	6.16	6.57	6.17	5.45	6.01	5.58	6.10	6.78	
C.D at 5% (Main Treatment)					0.83						
CD at 5% (Sub Treatment)					0.69						
CD at 5% (Main Treatment × Sub Treatment)					1.46						

Table 3. Effect of different bio fertilizers and mulching material on plant spread (E-W direction)

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	7.35	7.54	8.85	10.53	9.87	10.73	10.00	10.97	11.18	9.06	9.60
M_1 (Paddy straw)	10.35	8.69	13.20	10.60	10.09	11.13	9.37	8.76	9.06	8.89	10.00
M_2 (Black polythene)	8.59	10.80	10.16	11.85	10.60	9.51	9.78	11.27	10.67	12.93	10.61
M_3 (White polythene)	7.88	11.69	9.13	10.64	11.22	8.40	5.88	6.11	6.42	10.75	8.78
Mean B	8.54	9.68	10.33	10.90	10.44	9.94	8.75	9.25	9.44	10.40	
C.D at 5% (Main Treatment)					N/S						
CD at 5% (Sub Treatment)					N/S						
CD at 5% (Main Treatment × Sub Treatment)					N/S						

Table.4 Effect of different bio fertilizers, mulching material and their interaction on number of leaves plant $^{-1}$

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	2.43	3.07	3.55	5.64	3.54	4.52	3.86	4.15	3.83	3.04	3.76
M_1 (Paddy straw)	4.45	3.63	5.43	5.00	4.30	3.98	3.94	4.30	3.91	3.86	4.27
M_2 (Black polythene)	3.37	4.39	3.31	5.03	4.71	4.62	4.27	4.23	4.05	6.06	4.43
M_3 (White polythene)	2.52	5.24	3.74	3.80	4.29	3.84	2.59	3.20	3.48	5.74	3.93
Mean B	3.19	4.08	4.00	4.84	4.21	4.24	3.66	3.97	3.81	4.47	
C.D at 5% (Main Treatment)					0.39						
CD at 5% (Sub Treatment)					0.43						
CD at 5% (Main Treatment × Sub Treatment)					0.88						

Table 5. Effect of different bio fertilizers and mulching materials on number of flower per plant

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	14.00	17.00	17.33	22.33	21.66	20.66	18.33	20.00	30.66	27.66	20.96
M_1 (Paddy straw)	22.33	25.00	26.33	24.66	22.00	21.33	22.66	21.33	23.33	31.33	23.03
M_2 (Black polythene)	11.66	19.33	18.66	18.96	15.33	18.66	23.33	19.66	18.33	19.33	18.32
M_3 (White polythene)	14.66	21.00	17.66	15.00	18.33	14.66	14.66	16.33	15.33	19.00	16.66
Mean B	15.66	19.08	18.75	20.23	19.33	18.83	18.25	19.08	21.91	24.33	
C.D at 5% (Main Treatment)					2.96						
CD at 5% (Sub Treatment)					2.08						
CD at 5% (Main Treatment × Sub Treatment)					N/S						

+ Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria and Vascular Abuscular Mychorhiza) whereas lower value for the number of leaves per plant (2.43) were observed in M_0T_0 (Unmulched + Control) which was closely followed by M_3T_0 (White polythene mulch + Control) (2.52) and M_3T_6 (White polythene mulch + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) (2.59). The maximum number of leaves per plant may be attributed to the fact that the conjoint use of mulching M_2 and feeding of plants with the required biofertilizer (T_3) might have helped in promoting better growth of the plants leading to greater vegetative biomass production mainly due to

Table.6 Effect of different bio fertilizers, mulching material and their interaction on number of fruits per plant

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	10.01	10.26	10.13	10.26	10.83	11.50	12.20	12.53	13.63	17.46	11.88
M_1 (Paddy straw)	11.13	11.96	11.93	14.46	13.96	13.86	14.80	13.93	15.16	15.96	13.72
M_2 (Black polythene)	12.93	15.60	13.86	15.62	14.76	16.16	16.33	17.26	18.03	18.53	15.91
M_3 (White polythene)	11.03	10.73	11.71	12.36	10.33	11.71	12.00	11.70	12.81	13.20	11.75
Mean B	11.26	12.14	11.90	13.17	12.47	13.30	13.83	13.85	14.90	16.29	
C.D at 5% (Main Treatment)					1.21						
CD at 5% (Sub Treatment)					0.75						
CD at 5% (Main Treatment × Sub Treatment)					1.63						

Table.7 Effect of different bio fertilizers, mulching material and their interaction on fruit weight (gm)

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	16.63	16.86	17.36	17.33	17.43	17.13	17.16	17.76	17.96	18.03	17.37
M_1 (Paddy straw)	17.03	18.06	17.86	18.13	18.23	18.36	17.86	18.26	18.56	18.86	18.12
M_2 (Black polythene)	17.43	17.73	18.76	19.96	19.86	20.43	19.73	20.73	20.93	21.13	19.67
M_3 (White polythene)	17.63	17.36	18.56	19.06	18.93	19.26	19.46	19.33	20.53	20.76	19.09
Mean B	17.18	17.50	18.14	18.62	18.61	18.80	18.55	19.02	19.50	19.70	
C.D at 5% (Main Treatment)					0.16						
CD at 5% (Sub Treatment)					0.37						
CD at 5% (Main Treatment × Sub Treatment)					0.76						

Table 8. Effect of different bio fertilizers, mulching material and their interaction on yield plant^{-1} (gm)

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	165.99	173.02	175.70	177.96	188.75	197.15	209.21	222.35	244.47	314.04	206.86
M_1 (Paddystraw)	192.56	212.58	223.00	288.11	277.84	282.16	292.00	289.47	316.11	337.42	271.12
M_2 (Black polythene)	220.27	281.73	247.80	283.50	269.28	296.20	292.80	315.30	322.89	349.54	287.93
M_3 (White polythene)	193.83	186.14	217.59	234.95	193.99	225.51	232.31	225.72	263.06	273.05	224.61
Mean B	193.16	213.36	216.02	246.13	232.47	250.26	256.58	263.21	286.63	318.51	
C.D at 5% (Main Treatment)					1.49						
CD at 5% (Sub Treatment)					1.29						
CD at 5% (Main Treatment × Sub Treatment)					2.86						

Table 9. Effect of different bio fertilizers, mulching material and their interaction on fruit TSS (°Brix)

Sub Treatment Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	5.83	5.80	6.00	6.16	6.36	6.66	6.43	5.66	6.33	6.36	6.16
M_1 (Paddy straw)	5.73	6.40	5.80	5.73	7.23	6.30	6.23	6.06	6.43	6.73	6.26
M_2 (Black polythene)	6.73	6.96	6.66	7.43	7.20	7.06	6.16	7.13	7.30	7.53	7.02
M_3 (White polythene)	6.46	6.60	6.43	6.13	6.03	6.50	6.36	6.53	7.33	7.50	6.69
Mean B	6.19	6.44	6.22	6.36	6.70	6.63	6.30	6.35	6.85	7.03	
C.D at 5% (Main Treatment)					0.40						
CD at 5% (Sub Treatment)					0.37						
CD at 5% (Main Treatment × Sub Treatment)					0.78						

Table 10. Effect of different bio fertilizers, mulching material and their interaction on fruit Acidity (%)

Sub Treatment / Mulch material	T_0	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	Mean M
M_0 (Unmulched)	0.87	0.85	0.86	0.91	0.88	0.92	0.92	0.90	0.82	0.77	0.87
M_1 (Paddy straw)	0.84	0.84	0.89	0.87	0.82	0.89	0.87	0.87	0.84	0.81	0.85
M_2 (Black polythene)	0.80	0.76	0.74	0.75	0.79	0.75	0.75	0.78	0.78	0.70	0.76
M_3 (White polythene)	0.86	0.85	0.81	0.83	0.83	0.86	0.82	0.82	0.80	0.83	0.83
Mean B	0.84	0.82	0.82	0.84	0.83	0.86	0.84	0.84	0.81	0.78	
C.D at 5% (Main Treatment)					0.02						
CD at 5% (Sub Treatment)					0.04						
CD at 5% (Main Treatment × Sub Treatment)					1.46						

moderation of the soil moisture, temperature and enhancing biological activities besides higher supply and uptake of nutrients including other organic substances which ultimately increased the number of leaves per plant. results got the support of research work carried out by Char *et al.*,(2020).

Number of flower plant^{-1}: The data indicated Table.5 that, significant differences were observed among the different mulching materials on number of flowers per plant. Maximum number of flower per plant (23.03) was recorded in M_1 (Paddy straw) and result was found to be significant over others, whereas M_0 (Unmulched) showed at par value (20.96).

While minimum number of flower per plant (16.66) were observed in M_3 (White polythene mulch) which was followed by M_2 (Black polythene mulch) (18.32). Among the different biofertilizers, the result was found to be significant with maximum number of flower per plant (24.33) were obtained from T_9 (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular) which was significantly better than all treatments, while minimum number of flower per plant (15.66) were recorded in T_0 (Control). The interaction effect of different biofertilizers and mulching materials was found to be non significant in term of number of flower per plant. The recorded data showed that M_1T_9 (Paddy straw and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular) gave the highest number of flower (31.33) per plant and in M_2T_0 (Black polythene mulch) were found to be lowest number of flower per plant (11.66) in strawberry. This effect may be due to better efficiency to control weeds, more moisture retention and increased the flower primordia, carbohydrates and essential nutrients to promote number of flower per plant. Some other workers like Ghosh and Bauri (2003) observed maximum flower per plant in mango cv. Himsagar with straw mulch and minimum with control. Similar were the findings of Mandal and Chattopadhyay (2004) in custard apple, B.Rui (2005) in sweet cherry (Prunus avium) cv. Hongdeng, and Iqbal *et al*., (2016) in aonla.

Number of fruits per plant: The data clearly indicated table.6, that mulching materials exerted a significant influence on the number of fruits per plant. Maximum number of fruit per plant (15.91) was recorded in M_2 (Black polythene mulch) and result was found to be significant followed by M_1 (Paddy straw) (13.72) and M_0 (Unmulched) (11.88). In term of different biofertilizers the maximum number of fruit per plant (16.29) was observed in T_9 (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular) found significantly superior over all other treatments which was followed by T_8 (*Azoto*bacter + T_3) (14.90) and T_7 (Vascular Abascular Mychorhiza + T_4) (13.85). While T_0 (Control) recorded minimum number of fruit per plant (11.26). As per the interaction between biofertilizers and mulching materials result were found to be significant. The highest number of fruits per plant (18.53) was recorded in M_2T_9 (Black polythene mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular) and lowest number of fruits per plant (10.01) was noticed in M_0T_0 (Unmulched + Control). The possible reason may be better proliferation of roots in organic manure, which helped in increased uptake of nutrients as well as plant growth hormones produced by microbes at root zone and also enhanced biological nitrogen fixation by the application of biofertilizers (Bala *et al*., 2012 and Thakur *et al*., 2015). Similar observations were also reported by Singh *et al.,* (2017) in tomato, who found that combination application of Black polythene + 75% NPK + *Azotobacter* (1g/plant) + PSB(1g/plant) increased the number of fruits per plant.

Fruit weight (gm): The data indicated in Table. 7, significant differences were observed among the mulching materials on fruit weight of strawberry plants. The maximum fruit weight (19.67) was observed in M_2 (Black polythene mulch) which was statistically at par with M_3 (White polythene mulch) (19.09) treatment. Influence of biofertilizers was also found significant in the term of fruit weight. The highest fruit weight (19.70) was observed in T_9 (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular) which was at par with T_8 (*Azoto*bacter + T3) (19.50) treatments and lowest fruit weight (17.18) were recorded in T_0 (Unmulched). The interaction between biofertilizers and mulching materials showed significant with respect to the fruit weight. The heavier fruit weight (21.13) was registered with combination M_2T_9 (Black polythene mulch and and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular) whereas, lower fruit weight (16.63) was noticed in M_0T_0 (Unmulched and Control). Fagwalawa *et al*., (2016) observed that the increase in fresh fruits weight might be due to presence of bio fertilizer and mulch could be attributed to easy solubilization and release of plant nutrient leading to improve nutrient status and water holding capacity of the soil. The results obtained were in agreement with the findings of Sanwal *et al*. (2017) in turmeric and Rannu Parvin Rahena (2018) in strawberry.

Yield per plant (gm): A perusal data given in Table.8 & indicates different mulching materials had significant effect on fruit yield. Significantly maximum fruit yield (287.93 g) was obtained in M_2 (Black polythene mulch), it was followed by M_1 (Paddy straw) (271.12 g) and M_3 (White polythene mulch) (224.61 g). The minimum fruit yield (20.6.86g) was obtained in M_0 (Unmulched). There was significant difference among the different biofertilizers with respect to fruit yield per plant. Maximum yield per plant (318.51 g) was obtain from T_9 (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) followed by T_8 (*Azoto*bacter + T3) (286.63 g) and T_7 (Vascular Abuscular Mychorhiza + T4) (263.21 g).The minimum yield per plant (193.16) were observed in T_0 (Control). Among interactions significant variation was found with respect to fruit yield per plant, with maximum fruit yield per plant (349.54 g) was recorded in M_2T_9 (Black polythene Mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) , whereas the minimum fruit yield (165.99 g) was obtained in M_0T_0 (Unmulched and Control). It might due to balanced supply of required nutrients, moisture, plant growth regulators and inhibition of weed growth that created congenial environment for balanced plant growth and ultimately subsequent increase in yield per plant. Singh *et al*.,(2017) reported that the treatment combination Black polythene + 75% NPK + *Azotobacter* (1g/plant) + PSB(1g/plant) recorded maximum yield (3.22 kg/plant, 57.90 kg/plot and 953.09 q/ha) in tomato. These findings are in conformity with Basfore *et al*.,(2018) in okra and singh *et al*., (2019) in cauliflower.

Total Soluble Solids (°Brix): Data presented in Table.9 and reveals that significant variation was found among the different mulching materials studied for total soluble solids . The M_2 (Black polythene mulch) produced significantly maximum (7.02 ºBrix) total soluble solid and found superior over rest of the treatments except M_3 (White polythene mulch) which was at par (6.69 ºBrix) .While minimum (6.16 ºBrix) total soluble solid was obtained from M_0 (Unmulched). Influence of different biofertilizers was also found significant in the term of total soluble solid. The highest total soluble solids (7.03 °Brix) was found with T_9 (Black polythene Mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) and it was at par with T_8 (*Azoto*bacter + T3) (6.85 ºBrix) and T_4 (Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) (6.71 ºBrix).Whereas lowest total soluble solids were observed in T_0

(Control). The interaction between biofertilizers and mulching materials were found to be significant variation with respect to total soluble solids. Maximum total soluble solids (7.53 ºBrix) was recorded in M_2T_9 (Black polythene Mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza), whereas the minimum total soluble solids (5.83 ºBrix) were obtained in M_0T_0 (Unmulched and Control). This may be due to high nutrients uptake and increase photosynthesis rate besides, physiological and biochemical activities were also affected (Thilakavathy and Ramaswamy, 2001). The view was corroborated with the observations of Kulkarni *et al*.,(2005) and Fawole *et al*.,(2013) in pomegranate.

Acidity%: It is clear from the data presented in Table.10 and indicated that fruit acidity was significantly affected by different mulching materials. The minimum acidity (0.76 %) was observed in M_2 (Black polythene mulch) found significantly superior over rest of treatments. whereas maximum acidity (0.87 %) were recorded in M_0 (Unmulched). Significant difference was observed among the different biofertilizers with respect to acidity. The minimum acidity (0.78 %) was recorded with T_9 (Black polythene Mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) which was at par with T_1 (FYM + *Azotobacter.* + Phosphate Solubilizing Bcateria) (0.82 %) and T_2 (FYM + *Azosprillium* + Vascular Abuscular Mychorhiza) (0.82 %). The minimum acidity in plants treated with biofertilizers was due to maximum uptake of nutrients, which increased respiration and reduced fruit organic acids and accumulation of additional acids in vacuole (Kim et al., 2003). The view was corroborated with the observations of Singh *et al*., (2009) in Ber, Mishra and Tripathi (2011) and Chandramohan and Goyal (2021) in Strawberry. Among interactions effect, significant variation was found with respect to acidity percentage, with minimum acidity (0.70 %) was recorded in M_2T_9 (Black polythene Mulch and FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) and the maximum acidity (0.92 %) were obtained in M_0T_5 (Unmulched and T_5 Azosprillium + Azotobacter + Phosphate Solubilizing Bcateria) which was closely followed by M_0T_3 (Unmulched and *Azotobacter* + Phosphate Solubilizing Bcateria) (0.91 %), respectively.

CONCLUSION

Based on the results obtained from the present investigation, it is concluded that among different mulches used in this experiment for e.g.- (paddy straw, black polythene mulch , white polythene mulch) whereas, black polythene mulch was found to be superior in term of yield as compared to other mulches. However, maximum no. of flowers was observed on paddy straw but reduced weight of fruit, it could not result into overall yield of the experiment. In terms of bio fertilizer, T_9 treatment (FYM + Azotobacter. + Azosprillium + Phosphate Solubilizing Bcateria + Vascular Abuscular Mychorhiza) performed overall better in among all other treatments which could be due to the combined additive effect of each bio fertilizer used. Among different mulching materials and biofertilizers combinations Black polythene mulch and FYM + Azotobactor + Azospirillium + Phosphate solublizing bacteria + Vesicular Arbuscular Mycorrhizal bacteria noticed as most excellent for growth, improved the yield and biochemical attributes of strawberry cv. Rania.

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