



Efficacy of bio-fertilizers and mulching on growth, yield and quality of strawberry (*Fragaria × ananassa*) cv. Chandler

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ABSTRACT

A study was undertaken to examine the efficacy of bio-fertilizers and mulching on growth, yield and quality of strawberry (*Fragaria × ananassa* Duch.) cv. Chandler during two successive years, i.e. 2012-13 and 2013-14 at Kanpur (Uttar Pradesh), India. The experiment was laid out in randomized block design with three replications and ten treatments. One year old runners were used for planting. Significantly increase in plant height (19.20 and 18.70 cm), number of leaves (17.15 and 16.75), number of runners (2.28 and 2.17) and number of crowns (2.78 and 2.64) per plant, whereas minimum number of days (66.00 and 65.33 days) to produce first flower, maximum number of flowers (16.18 and 15.87) and fruits set (15.13 and 14.72) per plant during both the years of experimentation was observed with strawberry plants treated with *Azotobacter* 7 kg/ha+black polythene mulch. Maximum duration of harvesting (67.85 and 67.00 days) with higher yield (109.12 and 107.00 g/plant) of berries was also recorded with *Azotobacter* 7 kg/ha+black polythene mulch treated plants in both the years. As far the quality characters of berries are concerned, strawberry plants produced berries of significantly maximum length (2.92 and 2.90 cm), width (1.83 and 1.79 cm), weight (7.15 and 7.11g), volume (4.39 and 4.36 cc), TSS (7.19 and 7.16 °Brix), total sugars (5.63 and 5.60 %) and ascorbic acid (56.13 and 56.00 mg/100g pulp) with minimum acidity (0.250 and 0.249%) when treated with *Azotobacter* 7 kg/ha+black polythene mulch in northern plains of India.

Key words: *Azospirillum*, *Azotobacter*, Black polythene, Flowering, Growth, PSB, Quality, Strawberry, Yield

The modern cultivated strawberry (*Fragaria × ananassa* Duch.), belonging to the family Rosaceae, is one of the most delicious and refreshing soft fruits of the world, which can be cultivated in temperate, subtropical and tropical climates, wherever irrigation facilities exists. Being a quick growing fruit crop, it is also suitable for kitchen gardening. In addition to fresh consumption, it has a special demand by the fruit processing industries for the preparation of jam, ice-cream, syrups, confectioneries etc.

In the production process, use of inorganic fertilizers has become essential part of crop production to obtain high yield, but these fertilizers are costlier and also pollute the environment and soil water through leaching. Only 50% of available nitrogen is being used by the plants and rest 50% goes waste. To combat with these problems more attention is being paid towards the use of organic fertilizers in crop production, which may be economical and may create a

pollution free environment.

Nitrogen fixing bacteria and phosphate solubilizers are the main bio-fertilizers for horticultural crops. These micro-organism are either free living in the soil or symbiotic with plants and contribute directly or indirectly towards nitrogen and phosphorus nutrition of the plant. They also produce hormones, vitamins and other growth factors required for the growth and development of plants. Mulching protect fruits from soil contact, reduces the number of dirty fruits, prevent the occurrence of fruit rot, reduces the weed population and improves physico-chemical properties of soil. Both organic and inorganic mulches are used in strawberry cultivation, but polythene mulch increase both minimum and maximum temperature and thus increases soil moisture during summer and autumn. Keeping the above facts in view, the present investigation was undertaken to study the efficacy of bio-fertilizers and mulching on growth, yield and quality of strawberry cv. Chandler under north Indian plains.

MATERIALS AND METHODS

One year old healthy runners of strawberry cultivar Chandler were planted on 8-10 cm raised beds of 60 × 60 cm size at 30 × 30 cm spacings on 15 November 2012 and 05 November, 2013 in the Department of Horticulture, C S Azad University of Agriculture and Technology, Kanpur (Uttar

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Pradesh), India. The experiment was laid out in randomized block design with three replications and ten treatments, viz. T₁-*Azotobacter* 5 kg/ha+black polythene mulch, T₂-*Azotobacter* 6 kg/ha+black polythene mulch, T₃-*Azotobacter* 7 kg/ha+black polythene mulch, T₄-*Azospirillum* 5 kg/ha+black polythene mulch, T₅-*Azospirillum* 6 kg/ha+black polythene mulch, T₆-*Azospirillum* 7 kg/ha+black polythene mulch, T₇-PSB 5 kg/ha+black polythene mulch, T₈-PSB 6 kg/ha+black polythene mulch, T₉-PSB 7 kg/ha+black polythene mulch, T₁₀-Control (without bio-fertilizers and mulch). The black polythene used was of 200 µm in thickness. Observations were made on different vegetative and reproductive growth as well as on yield and quality attributes. Other cultural practices including irrigation, insect-pests and disease management were common in all treatments.

RESULTS AND DISCUSSION

Vegetative growth characters

Data presented in Table 1 clearly revealed that various treatments differed significantly in respect of different vegetative growth characters. The tallest plants (19.20 and 18.70 cm, respectively) with maximum number of leaves (17.15 and 16.75, respectively) per plant were obtained with *Azotobacter* 7 kg/ha+black polythene mulch (T₃) treated plants during both the years of experimentation. The height

of plants and number of leaves/plant get reduced with the reduction in doses of *Azotobacter*, *Azospirillum* and PSB with black polythene mulch and the smallest plants (14.00 and 13.54 cm, respectively) with minimum number of leaves (12.20 and 11.83, respectively) were recorded under control. The increase in height of plant and number of leaves/plant might be due to production of more chlorophyll content with inoculation of N₂ fixers and reduction in weed competition. Increased chlorophyll content may have increased rate of photosynthesis and, therefore, increased carbohydrates level could be expected to increase the vegetative growth. The other reason for increased vegetative growth may be the production of the plant growth regulators by bacteria in the rhizosphere, which are absorbed by the roots. Therefore, increased vegetative growth may be attributed to the increased biological N₂ fixation, better development of root system and the possible synthesis of plant growth hormones like IAA, GA₃ and cytokinins. Better response in plant growth with black polythene mulching may also be due to insured higher soil temperature, reduced weed growth and better moisture availability that increased root activities which might have resulted better nutrient uptake. The increase in plant height and number of leaves/plant with *Azotobacter* and black polythene mulch treatment during the entire course of investigation get the support the findings of Mishra and Tripathi (2011), Rana and Chandel (2003) and Wange *et al.* (1998), who obtained increase in petiole

Table 1 Efficacy of different levels of *Azotobacter*, *Azospirillum*, PSB and black polythene mulch on vegetative growth and flowering in strawberry cv. Chandler

Treatment	Height of plants (cm)		Number of leaves/plant		Number of runners/plant		Number of crowns/plant		Days taken to produce first flower		Number of flowers/plant	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
<i>Azotobacter</i> 5 kg/ha + Black polythene mulch (T ₁)	17.05	16.55	15.10	14.70	1.98	1.87	2.20	2.06	82.33	80.33	14.02	13.70
<i>Azotobacter</i> 6 kg/ha + Black polythene mulch (T ₂)	18.15	17.60	15.95	15.55	1.80	1.67	2.21	2.07	76.00	74.00	15.18	14.86
<i>Azotobacter</i> 7 kg/ha + Black polythene mulch (T ₃)	19.20	18.70	17.15	16.75	2.28	2.17	2.33	2.18	66.00	65.33	16.18	15.87
<i>Azospirillum</i> 5 kg/ha + Black polythene mulch (T ₄)	16.20	15.72	13.50	13.10	1.98	1.88	2.18	2.04	86.00	84.33	13.70	13.38
<i>Azospirillum</i> 6 kg/ha + Black polythene mulch (T ₅)	16.60	16.10	14.50	14.10	2.15	2.04	2.36	2.22	84.00	82.20	13.93	13.61
<i>Azospirillum</i> 7 kg/ha + Black polythene mulch (T ₆)	16.50	16.00	14.00	13.62	1.85	1.74	2.23	2.09	82.00	80.00	14.50	14.19
PSB 5 kg/ha + Black polythene mulch (T ₇)	16.20	15.70	13.80	13.40	1.98	1.87	2.31	2.18	87.17	85.00	14.80	14.48
PSB 6 kg/ha + Black polythene mulch (T ₈)	16.80	16.33	14.65	14.25	2.05	1.95	2.60	2.46	81.00	79.00	14.90	14.59
PSB 7 kg/ha + Black polythene mulch (T ₉)	17.25	16.75	15.75	15.35	1.90	1.79	2.78	2.64	77.00	74.00	15.30	14.99
Control (T ₁₀)	14.00	13.54	12.20	11.83	1.75	1.66	1.16	1.03	91.00	89.00	12.00	11.70
SE	0.32	0.31	0.23	0.22	0.13	0.12	0.02	0.02	1.05	1.29	1.05	1.03
CD (P=0.05)	0.64	0.62	0.68	0.66	0.39	0.34	0.07	0.06	3.12	3.83	3.13	3.10

length of strawberry when treated with higher concentration of *Azotobacter*.

In present investigation the number of runners and crowns/plant were significantly increased by *Azotobacter*, *Azospirillum* and PSB at different concentrations with black polythene mulch. The maximum number of runners (2.28 and 2.17, respectively) were recorded with *Azotobacter* 7 kg/ha+black polythene mulch, whereas maximum number of crowns (2.78 and 2.64, respectively) per plant were recorded with PSB 7 kg/ha+black polythene mulch treatment during both the years of experimentations. However, the minimum number of runners (1.75 and 1.66, respectively) and crowns (1.16 and 1.03, respectively) were recorded under untreated plants (Table 1). This increase in number of runners and crowns production/plant might be due to the increased N₂ fixation and possibly the ability of organism to secrete growth promoting substances especially cytokinins. These results have got the support of the findings of Mishra and Tripathi (2011) and Tripathi *et al.* (2015) in strawberry.

Flowering and yield characters

From the data presented in Table 1, it is clearly revealed that less time taken to produce first flower (66.00 and 65.33 days, respectively) was recorded with the application of higher dose of *Azotobacter* 7 kg/ha+black polythene mulch (T₃) treatments. However, the maximum number of days (91.00 and 89.00 days, respectively) were recorded in plants kept under control. This phenomenon may be on account of prolonged growth in the presence of *Azotobacter*. *Azotobacter* application also increases the level of endogenous auxins and plays an important role in nitrogen fixation. These results have got the support of the findings of Wange (1966), Mishra and Tripathi (2011), and Tripathi *et al.* (2015) in strawberry.

It is further observed that during both the years of present investigation, the maximum number of flowers/plant (16.18 and 15.87, respectively) were recorded in *Azotobacter* 7 kg/ha+black polythene mulch treated plants, whereas the minimum number of flowers (12.00 and 11.70, respectively) were found in untreated plants. This may possibly be due to the reason that *Azotobacter* application accelerated the development of inflorescence, leaf number in the autumn, which is positively correlated with the number of flowers and fruits in the following spring. Increased number of flowers might have also resulted because of increase in number of crowns/plant. These reports are in line with the findings of Wange *et al.* (1998), Gupta and Tripathi (2012) and Tripathi *et al.* (2015) in strawberry. Gupta and Acharya (1993) also reported that mulch could be useful in altering the hydro-thermal condition of soil and provides favourable soil environment for plants to go in reproductive phase and black plastic mulch provided more advantageous conditions for flowering.

The maximum number of fruits set/plant (15.11 and 14.72, respectively) were observed in plants treated with *Azotobacter* 7 kg/ha+black polythene mulch followed by (14.90 and 14.50, respectively) with PSB 7 kg/ha+black

polythene mulch, whereas the minimum number of fruits set (10.00 and 9.64, respectively) per plant was noticed in untreated plant (T₁₀) during both the years of experimentation (Table 2). Similar results in strawberry have also been reported by Wange *et al.* (1998) and Mishra and Tripathi (2011), who noted that increase in *Azotobacter* concentration, resulted in heavier fruiting. *Azotobacter* is expected to hasten plant development and thereby play some role in promoting fruit production and black polythene suppressed weed growth and reduced weed competition with the main plants.

The duration of harvesting in present investigation was significantly increased with the treatments of *Azotobacter*, *Azospirillum* and PSB with black polythene mulch (Table 2). The maximum duration of harvesting (67.85 and 67.00 days, respectively) was observed in plants treated with *Azotobacter* 7 kg/ha+black polythene mulch (T₃) during both the years. These results are in conformity with the findings of Sahoo and Singh (2005), Mishra and Tripathi (2011) and Gupta and Tripathi (2012) in strawberry. They also got advanced duration of harvesting (earliness) by approximately one month, which obviously extended the period of harvesting.

From the data presented in Table 2, it is clear that the maximum yield/plant (109.12 and 107.00 g, respectively) was recorded in the plants fertilized with *Azotobacter* 7 kg/ha+black polythene mulch (T₃), whereas minimum yield/plant (72.15 and 71.45 g, respectively) was recorded under control (T₁₀) during both the years of experimentation. The increase in strawberry yield in present investigation might be due to the increased berry set and better berry size and weight beside better vegetative growth. The present findings are in accordance with the findings of Mishra and Tripathi (2011) and Tripathi *et al.* (2015) in strawberry.

Physico-chemical characters

Size, weight and volume of berries were also increased significantly with the treatments of plants with bio-fertilizers and mulching during both the years of experimentation. On the basis of data presented in Table 2 and 3, it is clear that during both the years maximum berry length (2.92 and 2.90 cm, respectively), width (1.83 and 1.79 cm), weight (7.15 and 7.11 g, respectively) and volume (4.39 and 4.36 cc, respectively) were recorded in the plants treated with *Azotobacter* 7 kg/ha+black polythene mulch (T₃) followed by PSB 7 kg/ha+black polythene mulch (T₉). The increase in berry size, weight and volume may be due to the increased photosynthetic ability, which in turn might have favoured more accumulation of dry matter and less competition with weed plants. An increase in size, weight and volume of strawberry fruits with the microbial inoculation was also reported by Wange (1966), Gupta and Tripathi (2012) and Tripathi *et al.* (2014).

Data presented in Table 3 clearly revealed that during both the years of experimentation, the maximum total soluble solids (7.19 and 7.16 °Brix, respectively) and total sugars (5.63 and 5.60 %, respectively) contents were recorded in

Table 2 Efficacy of different levels of *Azotobacter*, *Azospirillum*, PSB and black polythene mulch on fruiting and berry characters in strawberry cv. Chandler

Treatment	Number of fruits set/plant		Duration of harvesting (days)		Yield/plant (g)		Berry length (cm)		Berry width (cm)		Berry weight (g)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
<i>Azotobacter</i> 5 kg/ha + Black polythene mulch (T ₁)	13.20	12.79	63.15	62.15	96.31	95.20	2.55	2.50	1.65	1.61	6.85	6.81
<i>Azotobacter</i> 6 kg/ha + Black polythene mulch (T ₂)	14.33	13.92	64.56	63.55	100.80	99.10	2.76	2.71	1.75	1.71	6.96	6.92
<i>Azotobacter</i> 7 kg/ha + Black polythene mulch (T ₃)	15.13	14.72	67.85	67.00	109.12	107.00	2.92	2.90	1.83	1.79	7.15	7.11
<i>Azospirillum</i> 5 kg/ha + Black polythene mulch (T ₄)	11.43	11.02	61.10	60.10	89.98	88.18	2.28	2.22	1.60	1.56	5.90	5.87
<i>Azospirillum</i> 6 kg/ha + Black polythene mulch (T ₅)	12.13	11.72	62.89	62.10	94.10	93.00	2.40	2.36	1.62	1.59	6.07	6.03
<i>Azospirillum</i> 7 kg/ha + Black polythene mulch (T ₆)	13.06	12.66	64.90	64.00	92.15	91.52	2.49	2.45	1.69	1.64	6.32	6.29
PSB 5 kg/ha + Black polythene mulch (T ₇)	12.90	12.52	62.15	61.15	93.45	92.15	2.41	2.37	1.50	1.47	6.28	6.24
PSB 6 kg/ha + Black polythene mulch (T ₈)	13.20	12.80	63.25	62.15	99.90	98.75	2.65	2.60	1.63	1.60	6.42	6.38
PSB 7 kg/ha + Black polythene mulch (T ₉)	14.90	14.50	66.18	65.20	107.10	106.15	2.82	2.78	1.79	1.76	6.62	6.57
Control (T ₁₀)	10.00	9.64	54.00	53.00	72.15	71.45	1.58	1.54	1.03	1.00	5.38	5.35
SE	0.42	0.40	4.60	4.40	0.10	0.01	0.11	0.10	0.01	0.01	0.01	0.01
CD (P=0.05)	1.26	1.21	1.65	1.55	0.28	0.21	0.31	0.30	0.03	0.03	0.02	0.02

Table 3 Efficacy of different levels of *Azotobacter*, *Azospirillum*, PSB and black polythene mulch on quality characters in strawberry cv. Chandler

Treatment	Berry volume (cc)		T.S.S. (°Brix)		Total sugars (%)		Titratable acidity (%)		Ascorbic acid (mg/100 g pulp)	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
<i>Azotobacter</i> 5 kg/ha + Black polythene mulch (T ₁)	4.15	4.12	7.03	7.01	5.30	5.27	0.280	0.279	53.10	53.00
<i>Azotobacter</i> 6 kg/ha + Black polythene mulch (T ₂)	4.30	4.27	7.12	7.10	5.43	5.40	0.272	0.270	54.30	54.20
<i>Azotobacter</i> 7 kg/ha + Black polythene mulch (T ₃)	4.39	4.36	7.19	7.16	5.63	5.60	0.250	0.249	56.13	56.00
<i>Azospirillum</i> 5 kg/ha + Black polythene mulch (T ₄)	3.45	3.42	7.03	7.00	5.30	5.28	0.275	0.274	52.19	52.08
<i>Azospirillum</i> 6 kg/ha + Black polythene mulch (T ₅)	3.55	3.52	7.09	7.05	5.35	5.32	0.270	0.270	54.10	54.00
<i>Azospirillum</i> 7 kg/ha + Black polythene mulch (T ₆)	3.69	3.66	7.12	7.09	5.45	5.42	0.256	0.255	54.30	54.21
PSB 5 kg/ha + Black polythene mulch (T ₇)	3.85	3.82	7.12	7.09	5.33	5.30	0.278	0.276	52.00	51.03
PSB 6 kg/ha + Black polythene mulch (T ₈)	3.95	3.92	7.13	7.10	5.45	5.42	0.275	0.274	53.00	52.02
PSB 7 kg/ha + Black polythene mulch (T ₉)	4.03	4.00	7.16	7.13	5.50	5.47	0.269	0.268	54.50	53.12
Control (T ₁₀)	3.22	3.18	6.75	6.71	5.05	5.02	0.350	0.348	49.10	49.00
SE	0.23	0.23	0.038	0.037	0.21	0.21	0.50	0.50	0.08	0.08
CD (P=0.05)	0.68	0.67	1.11	1.10	0.64	0.63	1.49	1.48	0.23	0.22

the berries produced from the plants treated with *Azotobacter* 7 kg/ha+black polythene mulch (T₃). These findings are in conformity with the results of Mishra and Tripathi (2011) and Tripathi *et al.* (2015) in strawberry. The increase in TSS and total sugars contents of berry in *Azotobacter* and PSB with black polythene mulch treatments might be due to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to developing fruits.

During both the years of experimentation, the minimum titratable acidity (0.250 and 0.249%, respectively) was recorded in the berries which were produced from the *Azotobacter* 7 kg/ha+black polythene mulch (T₃) treated plants (Table 3). The view was corroborated with the observations of Singh *et al.* (2009) in ber, Gupta and Tripathi (2012) and Tripathi *et al.* (2014) in strawberry.

The maximum amount of ascorbic acid (56.13 and 56.00 mg/100g of pulp, respectively) was recorded in the berries produced from the plants treated with *Azotobacter* 7 kg/ha+black polythene mulch (T₃).

These observations are in conformity with the findings of Yadav *et al.* (2010), Mishra and Tripathi (2011) and Tripathi *et al.* (2015) in strawberry, who reported that inoculation with different doses of *Azotobacter* and PSB in soil resulted in higher vitamin C content in strawberry. An increase in ascorbic acid content might be due to the increased efficiency of microbial inoculants to fix atmospheric nitrogen, increase in availability of phosphorous and secretion of growth promoting substances which accelerates the physiological process like carbohydrates synthesis etc. and reduced weed competition.

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