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Influence of *Azotobacter* and vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler

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ABSTRACT

An experiment was carried out during two subsequent years, *i.e.*, 2009-10 and 2010-11 to study the influence of *Azotobacter*, vermicompost on growth, flowering, yield and quality of strawberry cv. Chandler. There were nine treatments comprising two levels each of *Azotobacter* (6 and 7 kg/ha) and vermicompost (20 and 30 t/ha) and their combinations along with one control, replicated thrice in randomized block design. Five kg of FYM was applied as a basal dose in all the treatments including control. All the doses of *Azotobacter* and vermicompost were applied at the time of planting in the field. The data of both the years of experiment were pooled and analyzed. The combined application of *Azotobacter* at 7 kg/ha + vermicompost at 30 t/ha significantly increased the height of plant (18.70 cm), number of leaves (61.60), crowns (6.77) and runners (4.83) per plant, whereas, maximum number of flowers (56.69), fruits set (25.87) per plant with increased duration of harvesting (66.80 days) and minimum number of days taken to produce first flower (55.17 days) and fruit set (6.19 days) with significantly more yield (322.38 g/plant) were observed with *Azotobacter* at 6 kg/ha + vermicompost at 30 t/ha applied plants. Plants fertilized with *Azotobacter* at 6 kg/ha + vermicompost at 30 t/ha also produced the berries with maximum length (4.76 cm), width (2.49 cm), weight (8.75 g), volume (5.97 cc), TSS (9.80°Brix), total sugars (9.23%), ascorbic acid (54.72 mg/100 g edible portion) with minimum titratable acidity (0.50%) in comparison to other treatments under plains of central Uttar Pradesh.

Key words: *Azotobacter,* flowering, growth, quality, strawberry, vermicompost, yield.

INTRODUCTION

In India, strawberry cultivation is mainly confined to Dehradoon, Nanital (Uttarakhand); Solan, Kullu (HP); Srinagar (Jammu and Kashmir); hills of Darjeeling (WB); the tropical and subtropical area of Gurgaon (Haryana); Meerut, Saharanpur, Muzzaffarnagar, Kanpur (Uttar Pradesh); Jalandhar, Gurdaspur (Punjab); Pune, Mahableshwar (Maharashtra) and Bengaluru (Karnataka). Modern day intensive crop cultivation results with the huge application of chemical fertilizers, which are not only in short supply but also expensive and pollute the environment, soil and water too. Nitrogen fixing bacteria, phosphate solubulizers and vermicompost are main INM component for horticultural crops. These bio-fertilizers having micro-organisms, which are either free living in soil or symbiotic with plants and contribute directly or indirectly towards nitrogen and phosphorus nutrition of plants. They also produce hormones, vitamins and other growth factors required for the growth and development of plants. Atmospheric nitrogen is fixed by both micro-organisms, which are symbiotic and non-symbiotic in nature. When these plants were supplied with *Azotobacter chroococcum,* PSB and vermicompost at the time of transplanting, then there was tremendous increase in growth and yield of crop.

Hence, the dose of *Azotobacter* and vermicompost to produce quality berries with higher yield and huge propagating material needs to standardized in central Indian plains. Therefore, keeping the above facts in view, a field trial was conducted.

MATERIALS AND METHODS

One-year-old runners of strawberry cv. Chandler were planted at 30 cm × 30 cm spacing on 8-10 cm raised beds of 60 cm × 60 cm dimension at the Department of Horticulture, C.S. Azad University of Agriculture and Technology, Kanpur (U.P.) on 24th October, during 2009-10 and 2010-11. There were nine treatments comprising two levels each of *Azotobacter* (6 and 7 kg/ha) and vermicompost (20 and 30 tonnes/ha) and their combinations along with one control, replicated thrice in randomized block design. Five kg of FYM was applied as a basal dose in all the treatments including control. All the doses of *Azotobacter* and vermicompost were applied at the time of planting in the field. The data recorded on different parameters during both the years of experimentation were pooled and analyzed as procedure given by Panse and Sukhatme (8).

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Observations on plant height, number of leaves, crowns and runners per plant were recorded at the end of fruiting season, whereas days taken to produce first flower, fruit set and duration of harvesting were recorded as suggested by Kidmose *et al.* (5). Number of flowers and fruits per plant were counted at five days interval during entire cropping season. At each picking, data on berry weight and yield per plant were recorded. The length and width of ten randomly selected berries was measured with Vernier callipers. These berries were also used for measuring volume by water displacement method. The TSS of berries was recorded with the help of hand refractometer. The titratable acidity, total sugars and ascorbic acid contents were determined by the methods as suggested by AOAC (1).

RESEARCH AND DISCUSSION

The height of plants and number of leaves were increased significantly with the use of *Azotobacter* and vermicompost at different levels alone and in combination. The maximum height of plants (18.70 cm) and number of leaves per plant (61.60) were obtained with the application of *Azotobacter* 7 kg/ha + vermicompost 30 t/ha. The height of plants and number of leaves per plant get reduced with the reduction in doses of *Azotobacter,* vermicompost and their combinations and they were minimum under control (13.18 and 34.48 cm, respectively) (Table 1). The increase in plant height and number of leaves might be due to the production of more chlorophyll with inoculation of nitrogen fixers. It may also be due to the production of plant growth regulators by bacteria in rhizosphere, which are absorbed by the roots. Therefore, increased vegetative growth may be attributed to the increased biological nitrogen fixation (Mohandas, 6). The increase in height of plants and number of leaves per plant with the application of *Azotobacter* and vermicompost has also been reported by Nazir *et al.* (7) and Tripathi *et al.* (12 & 13) in strawberry.

The number of crowns and runners per plant were significantly increased with the application of *Azotobacter* and vermicompost at different levels (Table 1). The maximum number of crowns (6.77) and runners (4.83) per plant were produced in the plants supplied with *Azotobacter* 7 kg/ha + vermicompost 30 t/ha, whereas the minimum number of crowns and runners (3.05 and 1.79, respectively) were produced under control treatment. These findings are in agreement with that of Nazir *et al.* (7), who found that highest runners per plant in strawberry with poultry manures + *Azotobacter* + wood ash + vermicompost + oil cake application. Increased number of crowns and runners per plant was might be due to increased growth of plant in the form of height and number of leaves, which accumulated more photosynthates and thereby increased crowns and runners per plant.

The minimum number of days taken to produce first flower (55.17 days) was recorded in the plants which were applied with *Azotobacter* 6 kg/ha +

Table 1. Influence of different levels of *Azotobacter* and vermicompost on vegetative growth and flowering of strawberry cv. Chandler.

Treatment	Plant height (cm)	No. of leaves/ plant	No. of crowns / plant	No. of runners/ plant	Days taken to produce first flower	No. of flowers / plant	Days taken to fruit set	No. of fruits set/ plant	Duration of harvesting (days)
Vermicompost 20 t/ha	13.94	43.05	4.78	3.64	66.89	38.72	8.01	20.74	60.46
Vermicompost 30 t/ha	15.40	47.77	5.18	3.98	63.85	43.14	7.33	23.22	62.86
Azotobacter 6 kg/ha	16.39	50.62	4.99	3.88	63.46	46.33	7.48	18.72	64.01
Azotobacter 7 kg/ha	16.44	50.62	5.59	3.90	61.22	47.70	7.04	22.53	64.97
Azotobacter 6 kg/ha + Vermicompost 20 t/ha	17.39	51.63	5.68	3.97	61.37	50.56	6.96	23.46	65.40
Azotobacter 7 kg/ha + Vermicompost 20 t/ha	17.79	54.16	5.86	4.04	60.82	58.78	6.72	30.54	67.37
Azotobacter 6 kg/ha + Vermicompost 30 t/ha	17.92	59.08	6.08	3.98	55.17	65.99	6.19	37.70	70.03
Azotobacter 7 kg/ha + Vermicompost 30 t/ha	18.70	61.60	6.77	4.83	58.07	56.69	6.83	25.87	66.80
Control (untreated)	13.18	34.48	3.05	1.79	75.35	28.43	8.51	16.34	52.49
$CD_{0.05}$	1.38	2.78	0.45	0.20	1.22	2.40	0.87	1.63	1.83

vermicompost 30 t/ha (Table 1). However, the maximum number of days (75.35 days) taken to produce first flower was recorded under control. This phenomenon may be on account of prolonged growth of plant in the presence of *Azotobacter* and vermicompost bio-fertilizers. These results have got the support of the findings of Shukla *et al.* (9), who also recorded earliest flowering with NPK + PSB and NPK + *Azotobacter* treatments and Tripathi *et al.* (13) in strawberry. Significantly, minimum number of days taken to fruit set (6.19 days) were recorded in plants applied with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha, whereas, unfertilized (control) plants took maximum days (8.51 days) for fruit set. Research reports are lacking on this aspect and thus warrant further studies.

The maximum number of flowers per plant (65.99) was recorded in *Azotobacter 6* kg/ha + vermicompost 30 t/ha applied plants, whereas, the minimum number (28.43) were observed in the untreated (control) plants (Table 1). It may be possible due to the fact that *Azotobacter* and vermicompost application accelerated the development of inflorescence, leaf number in autumn, which are 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 per plant. Similar observations were also reported by Tripathi *et al.* (12) in strawberry, who noticed that higher doses of *Azotobacter* and PSB (7 kg/ha) increase the number of flowers per plant.

The maximum number of fruit set per plant (37.70) was observed when the plants were applied with *Azotobacter 6* kg/ha + vermicompost 30 t/ha, followed by *Azotobacter 7* kg/ha + vermicompost 20 t/ha (30.54), whereas the least number of fruit set was recorded in unfertilized (control) plants (16.34). These results are in conformity with the finding of Gajbhiye *et al.* (5), who noted that increase in *Azotobacter* and PSB concentration resulted in higher fruit set in tomato. *Azotobacter* is expected to hasten plant development; hence an increase in fruit set in the present study is due to the cumulative effect of *Azotobacter* and vermicompost. During the present investigation the duration of harvesting was significantly increased with the application of *Azotobacter* and vermicompost alone and in combined applications. The maximum duration of harvest, *i.e.* from18th January to 30th March (70.03 days) was observed when the plants were supported with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha (Table 1). Similar results were also recorded by Tripathi *et al.* (12), Singh and Singh (10) in strawberry, who got advanced duration of harvesting (earliness) by approximately one month, which obviously extended the period of harvesting.

Azotobacter and vermicompost has given remarkable increase in the yield of strawberry fruits (Table 2). The maximum yield per plant (322.38 g) was recorded in the plants supplied with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha followed by 233.56 g from the application of *Azotobacter* 7 kg/ha + vermicompost 20 t/ha, whereas, the minimum yield

Table 2. Influence of different levels of *Azotobacter* and vermicompost on yield and quality of strawberry fruit cv. Chandler.

Treatment	Yield/ plant (g)	Berry length (cm)	Berry width (cm)	Berry weight (g)	Berry volume (cc)	TSS (ºBrix)	Titratable acidity (%)	Total sugars (%)	Ascorbic acid (mg/ 100 g edible portion)
Vermicompost 20 t/ha	123.54	2.69	1.78	6.00	4.51	7.44	0.65	6.36	51.20
Vermicompost 30 t/ha	165.71	2.96	1.94	6.55	4.97	7.85	0.62	6.46	51.89
Azotobacter 6 kg/ha	155.72	3.34	2.03	6.61	4.99	7.97	0.63	7.00	52.02
Azotobacter 7 kg/ha	170.45	3.48	2.08	7.25	5.06	8.09	0.61	7.35	52.76
Azotobacter 6 kg/ha + Vermicompost 20 t/ha	185.24	3.88	2.12	7.54	5.19	8.32	0.59	7.54	53.04
Azotobacter 7 kg/ha + Vermicompost 20 t/ha	233.56	4.21	2.40	8.65	5.44	9.19	0.55	8.90	54.72
Azotobacter 6 kg/ha + Vermicompost 30 t/ha	322.38	4.76	2.49	8.75	5.97	9.80	0.50	9.23	55.22
Azotobacter 7 kg/ha + Vermicompost 30 t/ha	211.10	4.02	2.25	6.34	5.37	8.92	0.56	7.85	53.85
Control (untreated)	89.08	2.18	1.29	4.41	3.83	6.54	0.67	6.16	45.91
$CD_{0.05}$	8.91	0.08	0.05	0.31	0.17	0.12	0.006	0.12	0.78

per plant (89.08 g) was recorded from the untreated (control) plants. These findings are in line with the findings of Tripathi *et al.* (12) in strawberry, who recorded higher yield with *Azotobacter* application. The increase in yield might be due to increased fruit set per plant, berry length and width as well as berry weight. Moreover, it may also be due to the fact that nitrogen fixers and vermicompost not only increased the availability of nitrogen to the plants but also increased their translocation from root to flower through plant foliage (Singh and Singh, 10).

In the present investigation, the berry size (length and width), weight and volume were significantly increased with the use of *Azotobacter* and vermicompost (Table 2). The maximum berry length (4.76 cm), width (2.49 cm), weight (8.75 g) and volume (5.97 cc) were recorded in the plants applied with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha followed by *Azotobacter* 7 kg/ha + vermicompost 20 t/ha (4.21 cm, 2.40 cm, 8.65 g and 5.44 cc, respectively), whereas, the minimum berry size, weight and volume were recorded under control (2.18 cm, 1.29 cm, 4.41 g and 3.83 cc, respectively). Similar results were obtained by Gajbhiye *et al.* (4) and Shukla *et al.* (9) in tomato. The increase in berry size, weight and volume during the present investigation might be due to the increased photosynthetic ability of plants fertilized with *Azotobacter* and vermicompost, which in turn might have favoured and increased the accumulation of dry matter. Berry size, weight and volume are highly correlated with the dry matter content and balanced level of hormone. Nitrogen fixers are also known for accumulation of dry matter and their translocation as well as favours synthesis of different growth regulators (Awasthi *et al.*, 3).

On the basis of present investigation, it was observed that the TSS and total sugars content of berries were significantly increased by different level of *Azotobacter* and vermicompost applications alone and in combination (Table 2). The maximum TSS (9.80^0Brix) and total sugars (9.23%) contents were recorded in the berries produced from the plants supplied with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha followed by *Azotobacter* 7 kg/ha + vermicompost 20 t/ha (9.19^0Brix and 8.90%, respectively) and the minimum (6.54^0Brix and 6.16%, respectively) under control, *i.e.*, in unfertilized plants. An increase in TSS and total sugars contents with *Azotobacter* and vermicompost application might be due to the quick metabolic transformation of starch and pectin into soluble compounds and rapid translocation of sugars from leaves to the developing fruits. These findings are in agreement with the results of Singh *et al.* (11) in *ber* and Attia *et al.* (2) in banana.

The maximum titratable acidity (0.67%) was recorded in the berries which were produced from the control (unfertilized) plants, whereas the minimum acidity (0.50%) was recorded with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha treated plants. The results are in conformity with the observations of Singh *et al.* (11) in *ber* and Attia *et al.* (2) in banana.

The maximum amount of ascorbic acid content was recorded in the berries produced from the plants applied with *Azotobacter* 6 kg/ha + vermicompost 30 t/ha (55.52 mg/100 g edible portion) closely followed by *Azotobacter* 7 kg/ha + vermicompost 20 t/ha (54.72 mg/100 g edible portion), whereas the minimum ascorbic acid content (45.91 mg/100 g edible portion) was recorded in fruits produced from untreated (control) plants. This result got the support with the findings of Singh *et al.* (11) in *ber*, Tripathi *et al.* (12), and Yadav *et al.* (14) in strawberry. The respective 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.

From the results obtained it can be concluded that for getting substantial higher yield of quality berries with more propagating materials, the plants of strawberry cv. Chandler should be fertilized with a combination of *Azotobacter* 6 kg/ha + vermicompost 30 t/ha in the plains of central Uttar Pradesh, India.

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