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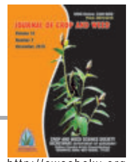

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Effect of plant growth promoting micro-organisms on the performance of strawberry

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ABSTRACT

The present investigation was conducted at Uttar Banga Krishi Viswavidyalaya, Pundibari, West Bengal during 2020-21 and 2021-22 to assess the influence of plant growth promoting micro-organisms on the performance of strawberry. It was laid out in Randomized Block Design with eight treatments and three replications. The results revealed that, highest plant height (6.64 cm) was recorded with T_8 (Azotobacter + PSB + Trichoderma) at 30 days after planting, fresh weight of root (9.57 g), dry weight of roots (2.78 g) and number of crowns/plant (9.15). Whereas, T_6 (Azotobacter + Trichoderma) produced maximum number of leaves plant^{-1} (5.50), shoot length (6.63 cm) at 30 days after planting, fresh weight of shoot (27.99 g) and dry weight of shoot (6.24 g) as compared to the control (T_1). Estimated fruit yield (27.29 t ha^{-1}) was recorded highest with T_8 (Azotobacter + PSB + Trichoderma), followed by T_6 (26.50 t ha^{-1}) treated plants, and minimum in control T_1 (21.27 t ha^{-1}).

***Keywords*:** *Azotobacter,* fruit yield, growth, plant growth promoting micro-organisms, strawberry.

Strawberry (*Fragaria* × *ananassa* Dutch) is a fruit crop of major significance worldwide and has a basic chromosome number x=7. It belongs to the family Rosaceae (Ruiz *et al.,* 2011). Strawberry has drawn most growers' attention due to its nutrient value and importance in human diet (Giovannoni, 2004). The area under strawberry cultivation is increasing because of its diverse ecological state and cultivars having adaptability in diverse environmental conditions. In India, the crop is grown in West Bengal, Uttar Pradesh, Rajasthan, Punjab, Meghalaya, Mizoram, Maharashtra, Himachal Pradesh, Haryana, and Delhi. Sub-tropical regions in Jammu have also the potential to raise the crop under irrigated condition.

Strawberry grown best in a temperate climate and some of the varieties grown in milder subtropical climate. It is a short-day plant and fruits are highly perishable. Generally, the farmers are using chemical fertilizers to increase strawberry yield, resulted to affects the human body (Islam *et al.,* 2005). To overcome this problem, intensified use of beneficial micro-organisms and balanced integrated nutrient management improves the growth, flowering, and crop yield (Fernandes *et al.,* 2012; Cvijanovic *et al.,* 2007; Bhagat and Panigrahi, 2020). Beneficial micro-organisms enhances growth of plant and improves the soil health. Bio-fertilizers such as Arboscular Mycorrhiza Fungi, *Trichoderma harzianum*, Phosphorous Solubilizing Bacteria, along with organic manures like vermicompost improves yield, mainly in reclaimed soils by overcoming salt, drought, and some pathogenic stress in addition to reducing the applied fertilizers and enhancing the macro and micro elements availability (Estiken *et al.,* 2005; Balakrishna *et al., 2005*; Mia *et al.,* 2005 and Sabarad *et al.,* 2004). Bio-fertilizers improves the physical properties of soil, enrich the soil nutrients, and enhance their effective plant absorption (Hazarika *et al.,* 2014).

Generally, Bio-fertilizers containing living micro-organisms, which improves the nutrient uptake capacity of the plant. Use of nitrogen fixing bacteria and phosphorous solubilizing bacteria supplying the essential nutrients like nitrogen and phosphorous by plant roots (Singh *et al.,* 2011). Biofertilizers keep the soil environment rich, increasing nutrient availability in soils and promote plant growth. Biofertilizers are preferred over synthetic fertilizers due to excess use of chemical which are harmful to the humans and biofertilizers do not reduce the soil fertility while continuous use (Umar *et al.,* 2009; Kumari *et al.,* 2018). Therefore, the present experiment has been made to study the influence of plant growth promoting micro-organisms on the performance of strawberry.

MATERIALS AND METHODS

The field experiment was conducted at Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India during 2020-21 and 2021-22, which is located at 42 meters above mean sea level, longitude 89°23′5″ E and latitude 26°19′86″ N, under the Sub-Himalayan Terai region of West Bengal. Chemical

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fertilizers such as nitrogen (100 kg ha^{-1}), phosphorous (80 kg ha^{-1}), potassium (100 kg ha^{-1}) and FYM (5 t ha^{-1}) were applied into the soil one week before planting. Planting was performed at a distance of 25 × 50 cm and each bed was 2 × 1m apart. The strawberry planting materials were collected from a reputed nursery and the plant growth promoting micro-organisms were collected from Bio-Control Laboratory, Dept. of Plant Pathology, UBKV, Pundibari. Eight treatments and replicated thrice in a Randomized Block Design (RBD). Treatment details such as T_1 (Control), T_2 (*Azotobacter)*, T_3 (Phosphate Solubilizing Bacteria), T_4 (*Trichoderma),* T_5 (*Azotobacter* + PSB) T_6 (*Azotobacter* + *Trichoderma*), T_7 (PSB + *Trichoderma*), T_8 (*Azotobacter* + PSB + *Trichoderma*) applied by soil drenching method at 15 days after planting (DAP). The parameters were subjected to analysed with the help of OPSTAT statistical package.

RESULTS AND DISCUSSION

Growth attributes

There was a significant enhancement in all growth attributes of strawberry due to use of beneficial micro-organisms (Table 1). The highest plant height (6.64 cm) was recorded in T_8 at 30 days after planting (DAP) followed by T_6 (6.37 cm), highest number of leaves (5.50) was observed in T_6 at 30 days after planting and lowest number of leaves (4.40) from treatment T_1 (Control). Shoot length was significant increase in T_6 (6.63 cm) and lowest from T_1 (5.28 cm) at 30 days after planting was recorded. Strawberry plants inoculated with *Azotobacter* + PSB + *Trichoderma* promotes the plant growth due to supplying the essential plant nutrients by the roots. Comparable results were observed in strawberry (Tripathi *et al.,* 2015; Rana and Chandel, 2003; Mishra and Tripathi, 2011; Kumar and Tripathi, 2020). Furthermore, pooled data (Table 2) revealed that,

Table 1: Effect of plant growth promoting micro-organisms on the plant height, number of leaves and shoot length of strawberry

Treatments	Plant height (cm) 30 DAP			Number of leaves plant^{-1} 30 DAP			Shoot length (cm) 30 DAP		
	200-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	5.19	5.12	5.15	4.17	4.63	4.40	5.29	5.26	5.28
T_2	5.76	5.23	5.49	4.80	4.47	4.63	5.75	5.55	5.65
T_3	5.54	5.48	5.51	4.73	4.13	4.43	5.43	5.37	5.40
T_4	5.88	5.77	5.82	4.90	4.73	4.82	5.91	5.88	5.89
T_5	6.01	5.97	5.99	5.03	4.87	4.95	6.17	6.12	6.14
T_6	6.15	6.60	6.37	5.20	5.80	5.50	6.35	6.90	6.63
T_7	6.10	6.40	6.25	5.10	5.13	5.12	6.26	6.19	6.23
T_8	6.26	7.02	6.64	5.50	5.40	5.45	6.49	6.49	6.49
SEm(±)	**0.16**	**0.08**	**0.20**	**0.213**	**0.31**	**0.20**	**0.07**	**0.14**	**0.11**
LSD(0.05)	**0.51**	**0.25**	**0.68**	**0.653**	**0.94**	**0.67**	**0.21**	**0.43**	**0.38**

Table 2: Effect of plant growth prompting micro-organisms on the shoot fresh weight, root fresh weight and shoot dry weight of strawberry

Treatments	Shoot fresh weight (g)			Root fresh weight (g)			Shoot dry weight (g)		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	25.60	26.21	25.91	7.08	8.26	7.67	5.05	5.21	5.13
T_2	26.26	26.66	26.46	7.51	8.62	8.07	5.38	5.44	5.41
T_3	25.87	26.57	26.22	7.34	8.47	7.91	5.21	5.26	5.24
T_4	26.33	26.96	26.65	7.63	8.73	8.18	5.29	5.50	5.40
T_5	26.45	27.45	26.95	8.07	8.94	8.51	5.67	5.78	5.72
T_6	27.94	28.04	27.99	8.89	9.69	9.29	6.21	6.28	6.24
T_7	26.89	27.59	27.24	8.65	9.52	9.08	5.86	5.94	5.90
T_8	27.22	27.80	27.51	9.37	9.78	9.57	5.91	6.15	6.03
SEm(±)	**0.40**	**0.32**	**0.13**	**0.15**	**0.14**	**0.12**	**0.13**	**0.13**	**0.04**
LSD(0.05)	**1.21**	**0.99**	**0.44**	**0.46**	**0.42**	**0.43**	**0.40**	**0.41**	**0.12**

Table 3: Effect of plant growth promoting micro-organisms on root dry weight, number of crowns plant^{-1} and estimated fruit yield (t ha^{-1}) yield plant^{-1} of strawberry

Treatments	Root dry weight (g)			Number of crowns plant^{-1}			Estimated fruit yield (t ha^{-1})		
	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled	2020-21	2021-22	Pooled
T_1	1.08	1.19	1.14	7.37	7.53	7.45	20.67	21.88	21.27
T_2	1.81	1.87	1.84	7.73	7.97	7.85	23.06	23.98	23.52
T_3	1.64	1.76	1.70	7.50	7.60	7.55	21.81	23.38	22.60
T_4	2.06	2.17	2.12	7.80	8.57	8.18	23.87	24.42	24.15
T_5	2.26	2.34	2.30	8.17	8.87	8.52	24.74	25.07	24.90
T_6	2.49	2.72	2.61	8.30	9.63	8.97	26.30	26.69	26.50
T_7	2.33	2.48	2.40	8.23	9.20	8.72	25.62	25.77	25.70
T_8	2.67	2.88	2.78	8.43	9.87	9.15	27.06	27.51	27.29
SEm(±)	**0.06**	**0.12**	**0.03**	**0.10**	**0.20**	**0.26**	**5.03**	**6.66**	**2.44**
LSD(0.05)	**0.17**	**0.36**	**0.10**	**0.29**	**0.61**	**0.88**	**15.41**	**20.40**	**8.31**

maximum shoot fresh weight after harvest (27.99 g) was found significantly in T_6 followed by T_8 and T_7 (27.51 g, 27.24 g) respectively. The maximum root fresh weight (9.57 g) was observed from T_6 followed by T_8 (9.57 g). Under T_6 the maximum shoot dry weight (6.24 g) was recorded (Table 2). The maximum root dry weight (2.78 g) in T_8 followed by T_6 (2.61 g) and minimum in T_1 (1.14 g). The treatment T_8 (9.15) recorded maximum crowns per plant than treatment T_1 (7.45). This expansion in vegetative development in plants might be due to the root framework of plant as suggested in strawberry (Tripathi *et al.,* 2010; Kumar and Tripathi, 2020; Singh and Kaur, 2020; Mishra and Tripathi, 2011; Negi *et al.,* 2021).

Fruit yield

Pooled data (Table 3) clearly indicated that, estimated fruit yield (27.29 t ha^{-1}) was observed maximum with T_8, followed by T_6 treated plants (26.50 t ha^{-1}), while least estimated fruit yield (21.27 t ha^{-1}) was recorded under control T_1. The prolonged photosynthetic capacity of strawberry plants supplied with *Azotobacter* + PSB + *Trichoderma* may have resulted in accumulation of dry matter. Similar findings were obtained in strawberry (Wange *et al.,* 1998; Anonymous, 2022; Tripathi *et al.,* 2010). Biofertilizer containing a living micro-organism that enrich the nutrient status of soil and significantly improves the crop yield.

CONCLUSION

Based on the results obtained in the present experiment, performance of strawberry plants exhibits best when treated with *Azotobacter* + PSB + *Trichoderma* (T_8) as compared to control in order to stimulate growth and yield of strawberry.

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