Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(5): 2841-2844
Received: 13-07-2018
Accepted: 15-08-2018

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Effect of organic manures and bio-fertilizers on vegetative growth and yield of strawberry cv. chandler

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Abstract
An experiment was conducted at the Experimental Unit, Department of Horticulture, Tilak Dhari Post Graduate College, Jaunpur during 2017-18 to study the effect of organic manure and bio-fertilizers on vegetative growth and yield of strawberry (*Fragaria* × *ananassa* Duch.) cv. Chandler. The runners of strawberry were planted in the last week of October with a spacing of 40×40 cm. The experiment was laid out in Randomized Block Design with ten treatments replicated thrice. Result indicated that there was a steady rise in plant height, spread of plant, and leaves/plant with age of the crop, which continued till 120 days. The maximum height of the plant (19.80 cm), spread of the plant (24.81 cm) and leaves/plant (17.81) were recorded at last stage of growth with Vermicompost + *Azotobacter* + PSB application followed by plant height (16.11 cm), plant spread (22.19) and leaves/plant (16.80) in FYM + Vermicompost + Poultry manure + *Azotobacter* + PSB and minimum in control. Length of leaves (8.22 cm), width of leaves (11.37 cm) and leaf area (97.72 cm^2) were recorded maximum with Vermicompost + *Azotobacter* + PSB. The maximum runners/plant (6.77) and crowns/plant (5.16) were recorded with Vermicompost + *Azotobacter* + PSB treatment. Maximum yield/plant (290.56 g) yield/plot (2.90 kg) and yield/ha (145.26 q) was recorded with Vermicompost + Azotobacter + PSB. The values of these parameters were recorded minimum under control.

Keywords: Vegetative growth, organic manure, bio-fertilizers, vermicompost, *Azotobacter*

Introduction
The cultivated strawberry (*Fragaria x ananassa* Duch.) is one of the luscious and soft fruits of the world. It is a hybrid of two Native American species *Fragaria chiloensis* and *Fragaria virginiana* and belongs to the Rosaceae family. All cultivated varieties are octaploid (2n=56). Botanically it is an aggregate fruit which is highly perishable in nature. In temperate climate condition, its plants behave like a small perennial herb with shallow root system whereas in sub-tropical climate it behaves as annuals. It has short stem know as crown. The crown produces leaves at very close interval along the stem axis and flowers at terminal position on stem axis. The edible portion of strawberry includes the ripened receptacle and achenes (true fruit and seed). Strawberry is usually propagated through runners. Strawberry is rich source of vitamins and minerals and coupled with delicate flavour, the red colour of the fruit is mainly due to the presence of the anthocyanin, pelarogonidin, 3 –monoglucoside and traces of cyaniding (Pathak and Singh, 1971) [10]. In India commercially and widely cultivated in Himachal Pradesh, Uttrakhand, Maharashtra, West Bengal, Nilgiri hills, Delhi, Haryana, Jammu and Kashmir Punjab and Rajasthan (Baba, 2010) [3].

Among various aspect that contributed on growth, development and quality of strawberry, nutrition is one of the important element of crop production (Sinha, 2009) [14]. The use of organic manures viz. farmyard manure, vermicompost and biofertilizers viz. *Azotobacter*, Phosphate solublizing bacteria reduce the cost of cultivation and supplement the secondary and micronutrients to crops. Organic manures improve the physical properties of soil (water holding capacity, soil aeration, drainage and water retention capacity), prevent soil degradation and increase important beneficial micro-organism population. Vermicompost significantly enhance the growth, development and productivity of plants. It improves the yield of strawberry due to their essential elements, vitamins, enzymes and hormone (Makulec, 2002) [8].

Many studies have confirmed that application of organic manure to strawberry fields improved plant nutrition and stimulate plant growth (Hargreaves *et al*., 2009) [5]. Wang and Lin (2002) [2] used 100% compost, manure as a soil supplement in strawberry growing cv. Allstar and Honeoye, indicated a significantly enhanced strawberry plant growth.

higher vegetative growth and the production increased in Organic cultured in comparing to

conventionally cultured strawberries (Palomaki *et al*., 2002 and Shehata *et al*. 2011) [9, 11].

Flowering date advanced by organic matter, while it was delayed in the conventional treatment, while the highest fruit weight and total yield/plant were produced in conventional treatment. (Abu-Zahra and Tahboub, 2008) [1]. Thus, in this experiment an attempt has been made to assess the effect of organic manure and bio-fertilizers practices on the vegetative growth parameters of strawberry *cv.* Chandler.

Materials and method

The present investigation was carried out at the Experimental Unit of the Department of Horticulture, Tilak Dhari Post Graduate College, Jaunpur, Uttar Pradesh, India during year 2017-18. Runners of strawberry *cv.* Chandler were procured from Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, (Solan), H.P. The climatic condition of Jaunpur is sub-tropical with three distinct seasons *i.e.,* winter, summer and rainy. During the winter season (December-January) temperature fall, 5 ^{o}C or even low, while in summer season (May-June) it reaches as high as 45 ^{o}C. Occasional spell of frost and precipitation may occur during winter. The mean temperature is minimum 15-20 ^{0}C and maximum 18-32 ^{0}C, maximum relative humidity 95% and minimum 55% with annual rainfall of 850-1100 mm. The strawberry runners of uniform size were transplanted 2-5 cm depth at a spacing of 40×40 cm. in last week of October. FYM, Vermicompost, Poultry Manure, *Azotobacter* and PSB were applied in the concerned plots as per the treatment. The treatments *viz*., T_1 - Control (Untreated), T_2 - Farm Yard Manure, T_3 - Vermicompost, T_4 - Poultry Manure, T_5 - *Azotobacter*, T_6 - PSB (Phosphorus Solublizing Bacteria), T_7 - FYM + *Azotobacter* + PSB, T_8 - Vermicompost + *Azotobacter* + PSB, T_9 - Poultry Manure + *Azotobacter* + PSB, T_{10} - FYM + Vermicompost + Poultry Manure + *Azotobacter* + PSB were evaluated in Randomized Block Design with three replications. The required quantity of organic manures as per treatments was applied at the time of land preparation. *Azotobactor*, phosphorus solubilising bacteria solutions were made by dissolving 50 ml + 500 g juggery in 20 litres of water. The roots of the strawberry runners were thoroughly dipped in the solution for about 30 minutes and then planting were done. Black polythene of 200 gauges was used as mulch material. Other cultural practices like weeding, hoeing, irrigation, insect pest and disease management were done as and when required. Observations on vegetative growth parameters were recorded at 15 days interval, whereas, numbers of runners/plant was recorded one month after final harvesting of the fruits. Yield/plant and/hectare were recorded at physiological maturity. Data were analyzed by analysis of variance (ANOVA) using the statistical program and means were compared using LSD test at 5 % of probability.

Result and discussion

The data (Table 1) revealed that there was a steady rise in plant height, spread of plant and number of leaves/plant with increase the age of the crop. However rate of increase in these characters was slow at later stages of growth. The maximum height of the plant (8.18, 10.87, 13.58, 14.54, 16.56, 17.97 and 19.80 cm) and spread of the plant (14.32, 16.90, 18.44, 20.22, 21.72, 23.74 and 24.81 cm) were encountered with Vermicompost + *Azotobacter* + PSB alone followed by plant height (6.95, 9.57, 11.37, 12.29, 13.19, 14.40 and 16.11) and plant spread (12.40, 15.16, 16.39, 18.93, 20.04, 22.02 and 22.19) in FYM + Vermicompost + Poultry manure + *Azotobacter* + PSB at all the stage of growth. The minimum height of plant (3.69, 5.29, 6.12, 6.65, 7.06, 8.03 and 8.96 cm) and spread of plant (7.14, 9.35, 10.29, 12.19, 13.33, 15.53 and 16.81 cm) were recorded in control.

Table 1: Effect of organic manure and bio-fertilizer on plant height/plant and plant spread/plant (cm) of strawberry *cv.* Chandler.

Treatments	Plant height (cm) at DAP							Plant spread (cm) at DAP						
	30	45	60	75	90	105	120	30	45	60	75	90	105	120
T_1	3.69	5.29	6.12	6.65	7.06	8.03	8.96	7.14	9.35	10.29	12.19	13.33	15.53	16.81
T_2	5.67	8.68	9.53	10.30	10.73	11.42	12.96	10.50	13.13	14.15	16.72	17.83	19.62	20.41
T_3	6.18	9.36	10.51	11.25	12.29	13.80	15.15	12.15	14.92	16.13	18.44	19.72	21.33	22.85
T_4	5.29	7.94	8.68	9.53	10.12	10.40	12.32	9.92	12.23	13.56	15.48	16.11	19.19	19.44
T_5	4.30	6.50	8.20	8.97	9.42	9.91	11.95	8.95	12.00	12.78	14.10	15.58	17.49	19.03
T_6	4.19	6.29	7.34	8.10	8.56	9.78	11.07	8.60	11.12	12.23	13.83	14.73	17.13	18.73
T_7	5.97	8.95	9.98	10.51	11.20	12.18	13.19	11.26	13.79	15.11	16.98	18.93	20.11	21.72
T_8	8.18	10.87	13.58	14.54	16.56	17.97	19.80	14.32	16.90	18.44	20.22	21.72	23.74	24.81
T_9	5.59	8.59	9.42	10.20	10.63	11.37	12.89	10.42	13.08	14.10	16.65	17.76	19.55	20.35
T_{10}	6.95	9.57	11.37	12.29	13.19	14.40	16.11	12.40	15.16	16.39	18.93	20.04	22.02	22.19
CD at 5%	0.659	0.592	0.908	0.789	0.687	0.940	0.728	0.925	0.704	0.770	0.602	0.800	0.727	0.552

The data (Table-2) showed that maximum number of leaves/plant (9.92, 12.49, 15.66, 16.77, 16.95, 17.42 and 17.81) were recorded with Vermicompost + *Azotobacter* + PSB and minimum number of leaves/plant (5.53, 7.71, 10.44, 11.35, 12.15, 12.30 and 12.55) was recorded in control at 30, 45, 60, 75, 90, 105 and 120 DAP. The utmost augment in vegetative growth attributes of Chandler strawberry under these treatments combination is supported by nitrogen supply through vermicompost. Vermicompost is the builder of protein and is the main constituent of protoplasm in plants thus; the increase in nitrogen supply accelerates synthesis of amino acids which might have indirectly exhibited increase in plant height of strawberry plant. Further, Phosphorus Solublizing Bacteria also helpful in cell elongation and cell division in meristmatic region of plant, this was due to the production of plant growth substances (IAA and GA) by Phosphorus Solublizing Bacteria. Application of bio-fertilizers such as Phosphorus Solublizing Bacteria helps to increase the biological nitrogen fixation and availability of phosphorus which is required for strong vegetative growth (Deshmukh *et al*. 2014) [4]. Similar results have been reported by Arancon *et al*. (2004) [4] in strawberry.

The number of runners/plant and crowns/plant were significantly affected by various organic sources of nutrients and bio-fertilizers (Table 2).

Table 2: Effect of organic manure and bio-fertilizer on number of leaves/plant, number of runners/plant, number of crowns/plant, leaf length (cm), leaf width (cm), leaf area (cm^2), yield/plant, yield/plot and yield/ha of strawberry *cv*. Chandler.

Treatments	Number of leaves/plant DAP							Runners /plant	Crowns/ plant	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Yield/ plant (g)	Yield /plot (kg)	Yield (q/ha)
	30	45	60	75	90	105	120								
T_1	5.53	7.71	10.44	11.35	11.35	11.35	12.55	2.87	2.39	5.27	7.77	85.01	143.99	1.44	71.98
T_2	6.50	9.78	12.66	14.39	14.39	14.39	15.46	4.38	4.04	7.62	9.37	94.82	258.67	2.58	129.31
T_3	7.47	11.06	13.91	15.18	15.18	15.18	16.48	5.30	4.24	7.81	10.18	96.10	276.93	2.76	138.43
T_4	6.14	8.86	12.18	13.91	13.91	13.91	14.90	3.75	3.23	6.73	8.70	92.86	252.81	2.52	126.38
T_5	5.93	8.16	11.35	13.28	13.28	13.28	13.52	3.34	3.07	6.21	8.25	90.17	189.53	1.89	94.73
T_6	5.81	7.99	11.06	13.04	13.04	13.04	13.46	3.26	2.99	6.14	8.06	86.79	171.71	1.71	85.83
T_7	7.07	10.09	13.37	14.76	14.76	14.76	15.77	4.65	4.13	7.76	9.43	95.29	272.96	2.72	136.46
T_8	9.92	12.49	15.66	16.77	16.77	16.77	17.81	6.77	5.16	8.22	11.37	97.72	290.56	2.9	145.26
T_9	6.40	9.69	12.61	14.32	14.32	14.32	15.37	4.22	3.89	7.57	9.34	93.44	256.61	2.56	128.28
T_{10}	8.51	11.31	14.39	15.76	15.76	15.76	16.80	5.69	4.46	7.91	10.79	97.11	287.45	2.87	143.71
CD at 5%	0.438	0.520	0.594	0.474	0.281	0.438	0.396	0.405	0.263	0.475	0.529	0.676	0.995	0.010	0.487

The number of runners/plant varied from 2.87 to 6.77. The corresponding range for crowns/plant was from 2.39 to 5.16. The maximum number of runners/plant (6.77) and crowns/plant (5.16) were recorded with Vermicompost + *Azotobacter* + PSB treatment whereas, runners/plant (2.87) and crowns/plant (2.39) minimize under control. The higher values of runners/plant and crowns/plant may be due to the improvement in physio-chemical properties of soil, increase in enzymatic activity, microbial population and also increase in plant growth hormones by application of vermicompost. (Singh *et al.*, 2010) [12] Similar results were reported by Kumar *et al.* (2015) [7] in strawberry.

Leaf length, leaf width and leaf area were significantly influenced by different treatments (Table 2). Averaged, leaf length ranged from 5.27 to 8.22 cm. The maximum and minimum leaf length of strawberry was recorded with T_1 (Control) and T_8 (Vermicompost + *Azotobacter* +PSB) treatments, respectively. Most of treatments proved significantly superior to control in respect of leaf length. Among the treatments, leaf width ranged between 7.77 and 11.37 cm for the control and Vermicompost + *Azotobacter* +PSB. Almost all the treatments produced significantly wider leaves over control. The difference in leaf area reflected a similar trend with Vermicompost + *Azotobacter* +PSB producing higher leaf area. The significantly improvement in these parameters (leaf length, leaf width and leaf area) may be due to better and increased availability of nutrients under organic manure and bio-fertilizer. Kumar *et al.* (2015) [7] also reported similar results.

Data analysis revealed that yield/plant, yield/plot and yield/ha responded significantly to various treatments (Table 2). The yield/plant ranged from 143.99 g to 290.56 g. The yield/plot ranged from 1.44 kg to 2.90 kg. The corresponding range for yield/ha was from 71.98 q. to 145.26 q. The maximum yield/plant (290.56 g), yield/plot (2.90 kg) and yield/ha (145.26 q) were recorded with Vermicompost + *Azotobacter* + PSB followed by yield/plant (287.45 g), yield/plot (2.87 kg) and yield/ha (143.71q) FYM + Vermicompost + Poultry manure + *Azotobacter* + PSB. The minimum yield/plant (143.99 g), yield/plot (1.44 kg) and yield/ha (71.98 q) were recorded under control. Application of organic sources might have increased the activities of beneficial micro-organisms due to increased organic pool in soil, which resulted in production of growth promoting substances and improved nutrient availability for longer period throughout the crop growth. Herencia *et al.* (2011) [6] reported that composts contained nitrogen and phosphorus which enhanced vegetative growth and flower bud initiation. Singh *et al.* (2008) [13] and Kumar *et al.* (2015) [7] also found significant increase in fruit yield and flowering of strawberry with vermicompost based fertilizer.

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