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EFFICACY OF VERMICOMPOST AND AZOTOBACTER ON GROWTH, YIELD AND QUALITY OF STRAWBERRY CV. FESTIVAL

Animesh Sarkar[1] and Ibotui[2]

ABSTRACT

An experiment was conducted to study the efficacy of vermicompost and azotobacter on growth, yield and quality of strawberry cv. Festival in hill eco-system of Nagaland under protected condition at the Experimental Farm, SASRD, Deptt. of Horticulture, Nagaland University. The follow up was laid out in Randomized Block Design with nine treatments using only vermicompost (VC) @ 2 t ha^{-1}, 4 t ha^{-1}, 6 t ha^{-1}, and 8 t ha^{-1} as well as vermicompost (VC) keeping at same doses plus azotobacter @ 4 g plant^{-1} at soil pH 6.6. Planting was done at a spacing of 30 cm x 30 cm apart in 1 m x 1 m in raised bed in month of October, 2014 under sub-humid, subtropics and shade net condition. VC @ 8 t ha^{-1} + azotobacter prominently showed significantly more vegetative growth like leaf area (30.13 cm^2), dry weight (12.51 g) and the number of runners (2.60) in each individual. The plants treated with VC @ 8 t ha^{-1} + azotobacter also improved fruit weight (14.73 g) and size (4.18 cm length and 2.74 cm diameter) but VC @ 6 t ha^{-1} + azotobacter showed the highest number of flowers (15.27), fruits (9.40) and yield (126.56 g) plant^{-1}. The highest biochemical assay of fruits like TSS (7.5 ÚBrix), total sugar (5.17%), reducing sugar (2.86%) and vitamin C content (52.48 mg 100 g^{-1} pulp) was found in plants applied with VC @ 8 t ha^{-1} + azotobacter followed by VC @ 6 t ha^{-1} + azotobacter with TSS (7.33 ÚBrix), total sugar (4.94%), reducing sugar (2.84%) and ascorbic acid content (50.74 mg 100 g^{-1} pulp) in fruit. Vermicompost @ 6 t ha^{-1} + azotobacter showed the highest benefit: cost ratio (3.51) among all the treatments. Through this experiment, it was concluded that application of vermicompost @ 6 to 8 t ha^{-1} in combination with azotobacter may be effective in respect of yield and quality of strawberry in foot hill condition of Nagaland.

(Key words: Vermicompost, Azotobacter, growth, yield, quality)

INTRODUCTION

Strawberry (*Fragaria X ananassa* Duch) belonging to family rosaceae is one of the most attractive, delicious and nutritious fruit with pleasant aroma. Strawberries are unique with highly desirable taste, flavour and excellent source of vitamins, potassium, fibre and sugars (Sharma and Sharma, 2004). Due to its high remunerative and lucrative value, it has a great potential in respect of production and marketing. Among the fruit crops, strawberry gives the quickest returns in shortest possible time. Many progressive farmers in the North East region including Nagaland have started diversifying their farming by undertaking the cultivation of strawberry on limited scale with meagre conventional knowledge without assured package of scientific practices. However, most of research work has been conducted by use of vermicompost along with chemical fertilizer under open as well as protected condition. Therefore, to determine the effect of vermicompost and in combination with azotobacter on growth, yield, quality of fruits and economics of various treatments were undertaken in hill ecosystem of Nagaland.

MATERIALS AND METHODS

The experiment was conducted at the Experimental Farm, Deptt. of Horticulture, SASRD, Nagaland University, Medziphema Campus during 2014 to 2015. The research field was situated at an altitude of 310 meters above mean sea level in the foothill of Nagaland with geographical location of 25Ú 45' N latitude and 93Ú 53' E longitude. The site has a sub-tropical and sub-humid condition prevailing temperature variation within 7 ^{0}C (minimum) to 31 ^{0}C (maximum), average annual rainfall ranges from 150 cm to 200 cm and relative humidity ranges from 65% to 85%. The soil of the experimental site was sandy-loam and slightly acidic in nature with soil pH 6.6 with moderate water holding capacity. Before commencement of experiments, soil samples were collected randomly from the different spots of the experimental plot at a depth of 0 to 12 cm for physico-chemical analysis. It was laid out in Randomized Block Design with nine treatments and three replications following Gomez and Gomez (2012). The treatments details were T_1: VC @ 2 t ha^{-1}, T_2: VC @ 4 t ha^{-1}, T_3: VC @ 6 t ha^{-1}, T_4: VC @ 8 t ha^{-1}, T_5: VC @ 2 t ha^{-1} + Azotobacter, T_6: VC @ 4 t ha^{-1}+

1. Asstt. Professor, Deptt. of Horticulture, SASRD, Nagaland University, Medziphema-797106 (email: asarkar1919@rediffmail.com)
2. P.G. Student, Deptt. of Horticulture, SASRD, Nagaland University, Medziphema -797106

Azotobacter, T_7: VC @ 6 t ha^{-1} + Azotobacter, T_8: VC @ 8 t ha^{-1} + Azotobacter, T_9: Control (NPK @ 100:80:60 kg ha^{-1}). Prior to planting, recommended doses of vermicompost from T_1 to T_4 treatments were applied directly in the experimental plots. In treatments T_5 to T_8, *Azotobacter chrococcum* (4 g $plant^{-1}$) were mixed thoroughly with vermicompost and kept in shade condition for 4 to 5 days for proper growth of micro sites and microbial activity. Planting was done at a spacing of 30 cm x 30 cm apart in 1 m x 1 m raised bed of 10 cm height in October, 2014 under shade net condition. The runners used for the experiment (*Fragaria X ananassa* Duch cv. Festival) were collected from Zopar Export Pvt. Ltd, Airport road, Bangalore -560008. The parameters like leaf area (at flowering), emergence of runners, dry weight at flowering, flowering date, days taken from flowering to fruit set and from fruit set to maturity, number of initial fruit set, average fruit weight, fruit yield etc. were recorded. Biochemical attributes like TSS, total sugar, reducing sugar, acidity, Vit-C and TSS:acid ratio of fruits were estimated under the investigation. Total soluble solids (TSS) were determined with the help of hand refractometer calibrated in ^{0}Brix at 20 ^{0}C with necessary correction factor. Total sugar and reducing sugar were estimated by standard procedure of A.O.A.C. (1984) using Fehling's A and Fehling's B reagents with methylene blue as an indicator through copper reduction method. Total titratable acidity was determined by titrating the extracted juice against N/10 NaOH using phenolphthalein as indicator and expressed in percentage (A.O.A.C., 1984). 2, 6- dichlorophenol indophenol dye titration method was used to estimate the ascorbic acid content of the fruit and expressed as mg 100 g^{-1} of pulp.

RESULTS AND DISCUSSION

Performance of growth attributes

With regard to growth parameters there was a considerable variation among different treatments in a particular set of agro climatic condition in respect of leaf area at flowering, number of runners produced by plant under shade net condition. Application of vermicompost at both the amount @ 8 t ha^{-1} and 6 t ha^{-1} in combination with azotobacter caused the maximum leaf area of 30.13 cm^2 and 29.59 cm^2 respectively compared with 20.64 cm^2 in VC @ 2 t ha^{-1} (Table 1). Similarly it has been noticed that the number of runner production from planting to harvesting stage varied in 0.93 to 2.60 $individual^{-1}$ with much progress in T_8 (VC @ 8 t ha^{-1} + Azotobacter). A lot of variation may be due to different doses of vermicompost alone and in combination with azotobacter. Gupta and Tripathi (2012) showed that combined application of azotobacter @ 7 kg ha^{-1} and VC @ 30 t ha^{-1} significantly increased the number of crowns and runners $plant^{-1}$ in strawberry. The runners production increased as flowering was about to stop. The fact was also noticed by Sharma and Yamdagni (2000), who reported that poor runner production was a major issue in ever bearing strawberry cultivars due to continues development of floral buds throughout the growing season. To overcome this problem, they suggested removing the floral buds in summer to prevent fruiting and to enhance runner production. The significant increase in volume of dry weight matter at flowering stage was determined by VC @ 8 t ha^{-1} + Azotobacter (12.51 g) followed by NPK @ 100:80:60 kg ha^{-1} (11.44 g) and VC @ 4 t ha^{-1} + Azotobacter (11.27 g). Increase in vermicompost amended treatments with azotobacter showed consistently better growth and showed significant influence on growth parameters of strawberry. It may be attributed to the positive effects of vermicompost and azotobacter on plant growth due to better availability of plant growth influencing materials such as plant growth regulators and humic acids produced by the increased activity of microbes (Arancon *et al*., 2004). It has been scientifically demonstrated that microbes like fungi, bacteria, yeast, algae etc. are capable of producing plant growth promoting substances like auxin, gibberellins etc. in appreciable quantity during vermicomposting which might have affected the plant growth appreciably (Atiyeh *et al*., 2002 and Arancon *et al*., 2004).

Flowering and fruit set

Significant difference was noticed on flowering, fruit set, days taken from fruit set to maturity by the application of vermicompost and azotobacter. The plants applied with vermicompost @ 6 t ha^{-1} + azotobacter was found to have set maximum number of flowers (15.27) and initial fruits (11.20) $plant^{-1}$ followed by VC @ 8 t ha^{-1}+ Azotobacter with 12.87 flowers and 9.86 initial fruit set $plant^{-1}$ as compared to VC @ 2 t ha^{-1} producing the lowest flowers (9.27) and fruit set (7.20) $plant^{-1}$. Days required from fruit set to maturity was observed to have significant variation but there was no considerable variation with regard to days required to from flowering to fruit set. Vermicompost (both @ 6 and 8 t ha^{-1}) in combination with azotobacter significantly reduced the number of days from fruit set to maturity (29.40 to 29.93 days). These findings were in close proximity to the findings of Gupta and Tripathi (2012), who obtained maximum number of flowers and fruits set $plant^{-1}$ with minimum number of days taken to produce first flower and fruit set with significantly more yield by applying Azotobacter at 6 kg ha^{-1} + vermicompost at 30 t ha^{-1}. However, flower production and fruit set may also vary due to agro-climactic condition and day length period (Das *et al*., 2007 and Dwivedi *et al*., 2004).

Yield and economy

The present experiment showed significant variation in the fruit weight and fruit size that has the positive effect on total yield. The number of flowers $plant^{-1}$ certainly has positive relationship with the number of fruit set i.e. more the number of flowers $plant^{-1}$, more the number of fruits to be harvested $plant^{-1}$ if favourable condition prevailed. But the total yield $plant^{-1}$ may vary due to fruit weight (Chandel and Badiyala, 1996). High performance of harvested fruits (9.40) and consequently yield (126.56 g) $plant^{-1}$ were recorded appreciably by vermicompost @ 6 t ha^{-1} + azotobacter followed by vermicompost @ 8 t ha^{-1} +

Table 1. Effect of different doses of vermicompost and azotobacter on growth attributes of strawberry cv. Festival

Treatments	Leaf area at flowering (cm^2)	No. of runners produced by plants	Dry weight at flowering stage (g)	No. of flowers produced $plant^{-1}$	Days required from flowering to fruit set	Days taken from fruit set to maturity
T_1	20.64	0.93	8.46	9.27	16.34	34.33
T_2	20.89	1.13	9.98	9.73	15.39	32.53
T_3	23.34	1.27	11.12	10.47	16.40	31.60
T_4	24.64	1.87	10.87	10.13	16.25	31.40
T_5	23.35	0.80	10.55	10.93	16.67	31.53
T_6	28.14	1.13	11.27	11.47	14.97	30.67
T_7	29.59	1.87	11.13	15.27	15.45	29.93
T_8	30.13	2.60	12.51	12.87	15.01	29.40
T_9	22.37	1.47	11.44	10.33	15.96	32.93
SE(m)±	1.52	0.16	0.36	0.56	0.57	0.52
CD at 5%	4.56	0.47	1.09	1.69	-	1.54

T_1: VC @ 2 t ha^{-1}, T_2: VC @ 4 t ha^{-1}, T_3: VC @ 6 t ha^{-1}, T_4: VC @ 8 t ha^{-1}, T_5: VC @ 2 t ha^{-1} + Azotobacter, T_6: VC @ 4 t ha^{-1}+ Azotobacter, T_7: VC @ 6 t ha^{-1} + Azotobacter, T_8: VC @ 8 t ha^{-1} + Azotobacter, T_9: Control (NPK @ 100:80:60 kg ha^{-1})

Table 2. Effect of different doses of vermicompost and azotobacter on yield attributes and B:C ratio in strawberry cv. Festival

Treatments	No. of initial fruit set $plant^{-1}$	No. of harvested fruits $plant^{-1}$	Average fruit weight (g)	Fruit size		Yield $plant^{-1}$ (g)	B:C ratio
				Length (cm)	Diameter (cm)		
T_1	7.20	5.84	9.12	3.64	2.56	55.29	1.24
T_2	7.86	6.46	9.47	3.69	2.55	58.89	1.27
T_3	8.40	6.60	11.65	3.76	2.49	76.87	1.83
T_4	8.26	6.50	12.34	3.90	2.66	80.21	1.82
T_5	9.40	7.82	11.96	3.50	2.57	93.57	2.65
T_6	9.62	8.06	12.65	3.92	2.64	101.94	2.80
T_7	11.20	9.40	13.46	4.13	2.68	126.56	3.51
T_8	9.86	8.22	14.73	4.18	2.74	121.08	3.14
T_9	8.40	6.48	11.67	3.82	2.50	75.58	2.10
SE(m)±	0.45	0.26	0.51	0.12	0.08	2.50	-
CD at 5%	1.35	0.79	1.53	0.36	-	7.49	-

Table 3. Effect of different doses of vermicompost and azotobacter on biochemical composition of strawberry cv. Festival

Treatments	TSS (°Brix)	Total sugar (%)	Reducing sugar (%)	Titratable acidity (% fresh wt.)	Ascorbic acid (mg 100 g^{-1} pulp)	TSS:acid ratio
T_1	6.8	3.93	2.32	0.74	47.67	9.19
T_2	6.83	4.06	2.41	0.71	47.88	9.62
T_3	7.10	4.20	2.50	0.70	48.44	10.24
T_4	7.13	4.31	2.57	0.69	50.48	10.34
T_5	7.10	4.17	2.60	0.72	47.85	9.86
T_6	7.26	4.72	2.83	0.71	48.67	10.23
T_7	7.33	4.94	2.84	0.70	50.74	10.78
T_8	7.50	5.17	2.86	0.68	52.48	11.03
T_9	7.09	4.42	2.36	0.82	46.49	8.70
SE(m)±	0.10	0.08	0.05	0.03	0.58	-
CD at 5%	0.31	0.23	0.16	-	1.75	-

azotobacter with 8.22 number of fruits and 121.08 g fruit plant^{-1} respectively and the lowest in vermicompost @ 2 t ha^{-1} (5.84 fruits and 55.29 g) in table 2. Whereas the plants received with vermicompost @ 8 t ha^{-1} + azotobacter showed the maximum fruit weight (14.73 g) and size (4.18 x 2.74 cm^2) and the lowest by VC @ 2 t ha^{-1} (9.12 g and size 3.64 x 2.56 cm^2) which had a close proximity with the findings of Singh *et al.* (2010) obtained 29.1% more total marketable fruit yield over control by the application of vermicompost @ 10 t ha^{-1} and beyond the dose @ 7.5 t ha^{-1}, there was no significant influence on fruit quality parameters. Plants responded differently to different doses of vermicompost with significantly higher growth when vermicompost was at 8 t ha^{-1} with azotobacter and lower growth at 2.5 t ha^{-1} such differential response of plants to different doses of vermicompost may be due to the fact that lower doses of vermicompost might have produced growth substance in lesser amount than higher doses. However, the growth of plants with vermicompost @ 8 t ha^{-1} + azotobacter was significantly at par with that of vermicompost @ 6 t ha^{-1} +azotobacter indicating that the dose VC @ 6 to 8 t ha^{-1} + azotobacter was enough for supplying the desirable amount on growth promoting substances for higher fruit growth and yield. All the treatments used in this investigation considerably increased the benefit : cost ratio but vermicompost @ 6 t ha^{-1} + azotobacter recorded the highest benefit : cost ratio of 3.51 among all the treatments.

Bio-chemical attributes

Vermicompost alone and in combination with azotobacter at different doses had significantly influenced the biochemical composition of the fruits. The ripened fruits collected from the plants showed a variation in TSS from 6.80 to 7.50 ^{0}Brix, 3.93 to 5.17% in total sugar and 2.32 to 2.86% in reducing sugar. The highest value of TSS (7.5 ^{0}Brix), total sugar (5.17%), reducing sugar (2.86%) and vitamin C content (52.48 mg 100 g^{-1} pulp) were determined in fruit treated with VC @ 8 t ha^{-1} + azotobacter followed by VC @ 6 t ha^{-1} + azotobacter being TSS with 7.33 ^{o}Brix, total sugar with 4.94%, reducing sugar with 2.84% and ascorbic acid content with 50.74 mg 100 g^{-1} pulp. The plants treated with vermicompost @ 6 to 8 t ha^{-1} had proved more effective in increasing TSS and sugar content of fruit that findings are in complete agreement with earlier findings of Singh *et al.* (2010), who noticed the fruits with higher TSS, ascorbic acid content and lower acidity harvested from the plant receiving vermicompost @ 7.5 to 10.0 t ha^{-1} over inorganic fertilizer (control) in strawberry. Sahoo and Singh (2005) also found that application of azotobacter @ 6 kg ha^{-1} enhanced the total soluble solids (8.6) content in Sweet Charley cultivar of strawberry. Plants receiving vermicompost @ 8 t ha^{-1} + azotobacter produced fruits with lower value of titrable acidity (0.68%) and higher ascorbic acid (52.48 mg 100 g^{-1} pulp) and higher TSS/Acid ratio (11.03) as compared to others. Singh *et al.* (2008) harvested fruits from strawberry plant receiving vermicompost @ 7.5 t ha^{-1} with higher TSS, ascorbic acid content and lower acidity. Interestingly, plants receiving vermicompost and azotobacter have produced better fruit quality attributes which can be attributed due to better growth of the plants under different doses of vermicompost with azotobacter which might have favoured accumulation of higher sugars, less acidity and better ascorbic acid content.

From the results of investigation it was suggested that application of vermicompost @ 6 to 8 t ha^{-1} with

azotobacter might be effective in respect of yield and quality of strawberry fruits in foot hill condition of Nagaland.

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