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INFLUENCE OF ORGANIC MANURES AND GIBBERELIC ACID ON GROWTH AND YIELD OF STRAWBERRY (*Fragaria X ananassa* DUCH.)

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KEYWORDS

Strawberry

Organic manure

Gibberellic acid

Foliar application

Yield

ABSTRACT

A field experiment was conducted to study the effect of organic manures and growth regulators on the growth and yield of two varieties of strawberry namely 'Sweet Charlie' and 'Winter Dawn'. Six treatments were taken combining three organic manures viz. Vermicompost @ 3.0 t/ha, Mustard oil cake @ 1.0 t/ha and Neem cake @ 1.0 t/ha and two concentrations of gibberellic acid (GA₃) viz. 75 ppm and 100 ppm along with a control. Foliar application of GA₃ was carried out at 40 and 60 days after planting whereas organic manures were applied as basal dose. Results of the study suggested that higher doses *i.e.* 100 ppm of GA₃ along with vermicompost exhibited more vegetative growth whereas 75 ppm GA₃ resulted in higher fruit set and yield in both the varieties. It was found that vermicompost @ 3.0 t/ha combined with 100 ppm GA₃ recorded the highest plant height (24.7 cm and 21.4 cm) and numbers of leaves per plant (46.0 and 68.7) in both Sweet Charlie and Winter Dawn varieties, respectively. Whereas, highest fruit diameter (3.3cm and 3.4cm), fruit length (4.6cm and 4.8cm), fruit weight (18.2 g and 17.9 g), number of fruits per plant (24.6 and 32.0), yield per plant (447.8 g and 572.1 g) and yield per hectare (18.80 t and 24.03 t) were recorded under vermicompost @ 3.0 t/ha in combination with 75 ppm GA₃ in both Sweet Charlie and Winter Dawn varieties, respectively. It was observed that Winter Dawn variety produced a 28.0% higher yield as compared to Sweet Charlie under the best treatment *i.e.* vermicompost @ 3.0 t/ha in combination with 75 ppm GA₃.

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1 Introduction

Strawberry (*Fragaria X ananassa* Duch) belongs to the family Rosaceae and is popular for its attractive and delicious fruits. Fruits of strawberry are consumed as fresh and also used for processing purposes. Fruits are a rich source of antioxidants, vitamin C, and phenolic compounds. Fruits are also a rich source of minerals and nutrients and having anti-cancerous properties. In West Bengal commercial cultivation of strawberry is mainly concentrated in some pockets of North Bengal. But there is good scope for cultivation of few varieties of strawberry in South Bengal condition also as its demand remains high in metro city like Kolkata. Farmers of different parts of West Bengal started growing of strawberry and fetching good remuneration. But due to unavailability of standardized production technology and lack of technical knowhow resulting poor growth and low fruiting, farmers are facing some problems for commercial production of strawberry.

The yield of strawberry crops can be increased through improved varieties, efficient use of fertilizers, and modern agronomic practices. Improper application of nutrients is the major cause of poor growth and fruiting in strawberry crops. Application of sufficient organic matter in the soil is highly needed for successful strawberry cultivation because organic materials in the soils help to improve soil structure, enhance soil fertility, increase microbial activity, improve water holding capacity and thereby increase crop yields and vermicompost might be a suitable option for the same. Most of the plant-available nutrients like nitrates, phosphates, exchangeable calcium, and soluble potassium are present in vermicompost. Atefe et al. (2012) opined that vermicompost is eco-friendly and improves indexes of yield like fruit length, number of fruit, and fruit weight. Like vermicompost, oil cakes are also reached sources of minerals and nutrients. Mustard oil cake has unique properties that make it a favorable fertilizer. Neem cake is also an effective organic fertilizer that can also help to reduce some soil-borne pathogens. Besides, growth-regulating chemicals are also becoming relevant in strawberry cultivation for the modification of their vegetative growth, flowering, and fruiting affecting total yield and quality (Vishal et al., 2016). Foliar application of GA₃ has been reported to have increased the yield and quality of different horticultural crops (Sharma & Singh, 2009). Foliar application of gibberellic acid with optimum concentration increased the yield as compared to traditional farming (Paroussi et al., 2002). Hormones regulate plant growth and increase the yield of strawberry (Kumar et al., 2012; Khunte et al., 2014). Gibberellins promote cell division and elongation. Therefore, for better growth and production of strawberry, the application of proper nutrients and growth regulators at optimum doses and appropriate growth stages is very essential. The present study was conducted by considering the above facts and views,

employing three different organic manures in combination with two different concentrations of gibberellic acid to find out the suitable organic manure along with the optimum concentration of gibberellic acid for the improvement of growth, fruit-set, and yield of strawberry.

2 Materials and methods

The field experiment was carried out at the Instructional farm of Hooghly Krishi Vigyan Kendra, Chinsurah, Hooghly district of West Bengal which comes under the subtropical humid region. The trial was conducted from November 2018 to March 2019. From December to January the average temperature range was reported from 15° to 20°C while it reached 25° to 30°C during the March to April of the study time. The soil type of the experimental field was clay loam with high water holding capacity having a pH of around 6.6. Two popular varieties of strawberry viz. 'Sweet Charlie' and 'Winter Dawn' were selected for the experiment. The distinguishing characteristics of the Sweet Charlie variety are earliness, cupped leaves, and tolerance to fruit rot, fruits having a unique shape, size, flavor, and sweet taste. Whereas, somewhat smaller leaves, medium to large fruits with slightly flattened in shape having sweet taste and flavor and high productive nature are some important characters of the variety, Winter Dawn. Six treatments were taken in combination with three organic manures and two concentrations of gibberellic acid (GA₃) along with a control. The details of the formulated treatments are T₁ - Application of Vermicompost @ 3.0 t/ha as basal and followed by the application of GA₃ @ 75 ppm at 40 DAP* and 60 DAP, T₂ - Application of Vermicompost @ 3.0 t/ha as basal and followed by the application of GA₃ @ 100 ppm at 40 DAP and 60 DAP, T₃ - Application of Mustard oil cake @ 1.0 t/ha as basal and followed by the application of GA₃ @ 75 ppm at 40 DAP and 60 DAP, T₄ - Application of Mustard oil cake @ 1.0 t/ha as basal and followed by the application of GA₃ @ 100 ppm at 40 DAP and 60 DAP, T₅ - Application of Neem cake @ 1.0 t/ha as basal and followed by the application of GA₃ @ 75 ppm at 40 DAP and 60 DAP, T₆ - Application of Neem cake @ 1.0 t/ha as basal and followed by the application of GA₃ @ 100 ppm at 40 DAP and 60 DAP and T₇ - Control (application of general dose of fertilizer i.e. FYM @ 12 t/ha, NPK @ 50:80:80 kg/ha** as basal and later top dressing with water soluble NPK (19:19:19) @ 5g/L at 15 to 20 days interval and no growth regulator). Dose of NPK was taken by the following the recommendation of the division of Horticulture, ICAR Research Complex for NEH Region, Meghalaya for strawberry cultivation, and the basal dose is reduced as later water-soluble NPK was applied at a certain interval.

The design of the experiment was a randomized block design with three replications. A dose of NPK @ 50:80:80 kg/ha along with organic manure was applied as basal to all plots. Water-soluble

NPK (19:19:19) @ 5g/L was applied as a foliar spray as top dressing fertilizer at 20 DAP, 35 DAP, 50 DAP, and 70 DAP to all plots. Micronutrient mixture (Zn, B, Mo, Cu) @ 2.0 g/L was applied as a foliar spray to all plots during flowering and fruiting at 45 DAP and 75 DAP. Black/silver plastic mulch was applied to all plots to cover the soil before planting. Saplings were planted at a spacing of 50cm X 40cm during 1st week of November 2018 in an open field to accommodate around 50,000 plants per hectare. Harvesting was started during 1st week of January 2019 and continued till the last week of March 2019. The observations like plant height, number of leaves per plant, days to first flowering, number of fruits per plant, the diameter of fruits, length of fruits, average fruit weight, and yield were recorded and analyzed statistically.

3 Results

3.1 Vegetative growth characters

Different treatments of organic manure and gibberellic acid influenced vegetative growth of strawberry like plant height and number of leaves per plant significantly over control in both the varieties (Table 1). It was found that plant height and the number of leaves per plant at 70 days after planting (DAP) was increased remarkably by different doses of gibberellic acid application and highest plant height (24.7 cm and 21.4 cm) and the number of leaves per plant (46.0 and 68.7) was observed by vermicompost combined with 100 ppm GA₃ treatment (T₂) in both Sweet Charlie and Winter Dawn, respectively followed by T₁ in case of Sweet Charlie and T₄ in case of Winter Dawn. Whereas, under control (T₇) significantly lowest plant height (19.4 cm and 17.6 cm) and the number of leaves per plant (34.0 and 52.7) was recorded in Sweet Charlie and Winter Dawn, respectively. But the influence on days required for the opening first flower was not so prominent by the treatments in both the varieties, however, the Winter Dawn variety produced flowers slightly earlier (lowest 27.7 days in T₄) than Sweet Charlie (lowest 31 days in T₂) indicating this is varietal character.

3.2 Fruit characters

Different treatment combinations significantly affected fruit characters like fruit diameter and fruit length for both the varieties (Figure 1 & 2). The diameter and length of fruits were significantly increased by application of GA₃ over control and the dose of 75 ppm GA₃ resulted in a higher fruit size than 100 ppm GA₃ in combination with all corresponding organic manure treatments. The highest fruit diameter (3.3cm and 3.4cm) and fruit length (4.6cm and 4.8cm) were observed under vermicompost in combination with 75 ppm GA₃ treatment (T₁) in both Sweet Charlie and Winter Dawn varieties respectively, followed by T₃. Whereas smaller fruits viz. lower fruit diameter (2.8cm and 3.0cm) and fruit length (4.1cm and 4.0cm) were recorded under control treatment *i.e.* without application of growth regulator in Sweet Charlie and Winter Dawn varieties, respectively.

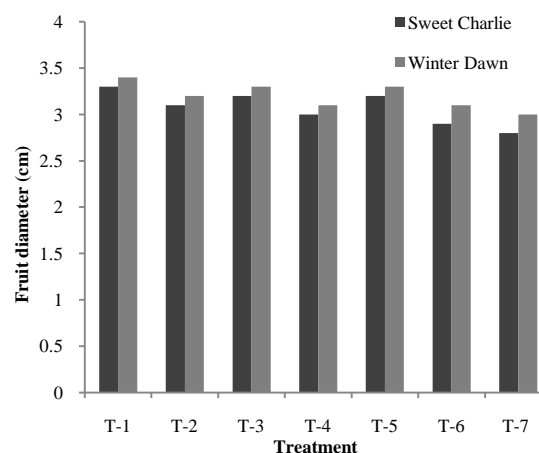


Figure 1 Effect of organic manure and gibberellic acid on fruit diameter of strawberry

Table 1 Effect of organic manure and gibberellic acid on vegetative growth of strawberry

Treatments	Plant height at 70 DAP (cm)		Number of leaves/plant at 70 DAP		Days to first flowering	
	Sweet Charlie	Winter Dawn	Sweet Charlie	Winter Dawn	Sweet Charlie	Winter Dawn
T ₁	23.9	19.0	38.0	63.7	34.0	31.0
T ₂	24.7	21.4	46.0	68.7	31.0	27.7
T ₃	22.9	19.0	36.7	63.3	37.0	29.7
T ₄	23.6	20.9	37.3	76.3	34.0	27.7
T ₅	20.4	19.4	36.0	56.3	38.0	32.3
T ₆	23.3	20.6	38.7	71.7	34.7	28.7
T ₇ (Control)	19.4	17.6	34.0	52.7	39.3	34.0
SEm (±)	0.287	0.244	1.067	1.616	0.603	0.863
CD (at 5%)	0.89	0.75	3.29	4.98	1.86	2.66

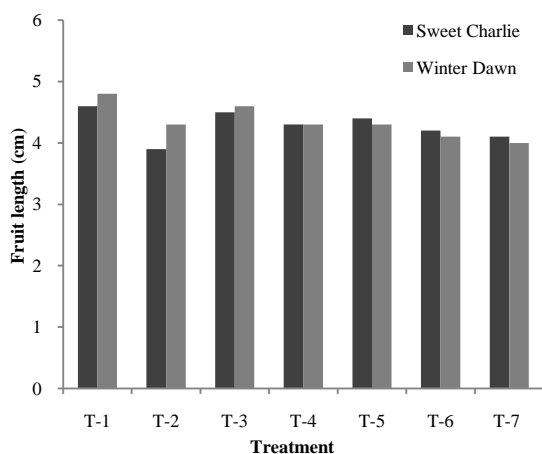


Figure 2 Effect of organic manure and gibberellic acid on fruit length of strawberry

3.3 Yield components and yield

Gibberellic acid treatments significantly increased the yield components and yield and the results showed that average fruit weight, the number of fruits, and yield were increased significantly by all treatment combinations over control (Figure 3, 4, 5 & 6). Vermicompost combined with GA₃ 75 ppm treatment (T₁) recorded the highest fruit weight (18.2 g and 17.9 g), the number of fruits per plant (24.6 and 32.0), yield per plant (447.8 g and 572.1 g), and yield per hectare (18.80 t and 24.03 t) in both Sweet Charlie and Winter Dawn variety, respectively followed by the treatment T₃ in case of Sweet Charlie and T₂ in case of Winter Dawn variety. The lowest values in these parameters, *i.e.* fruit weight (15.8 g and 16.0 g), number of fruits per plant (17.7 and 24.6), yield per plant (278.5 g and 394.1 g), and yield per hectare (11.69 t and 16.55 t) was found under the control treatment in both Sweet Charlie and Winter Dawn variety, respectively.

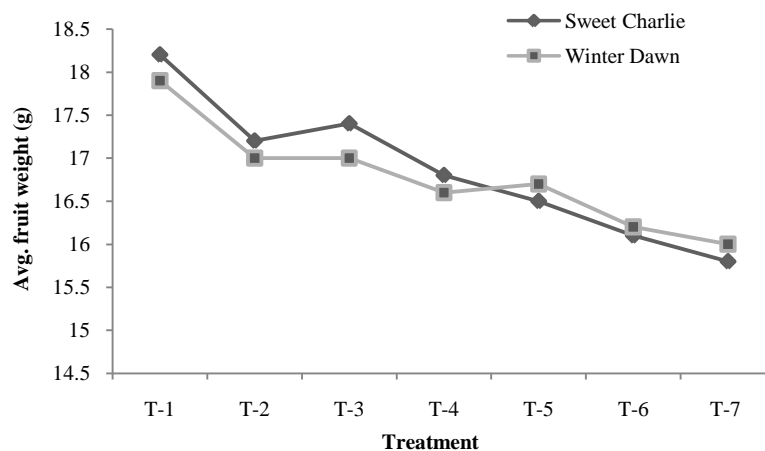


Figure 3 Effect of organic manure and gibberellic acid on avg. fruit weight of strawberry

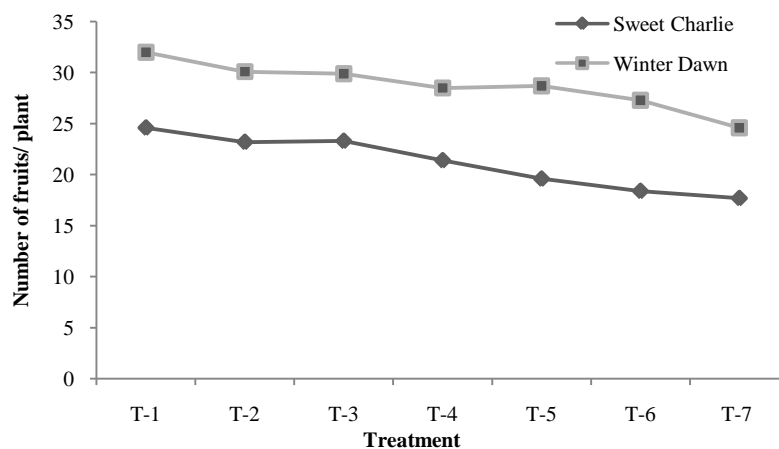


Figure 4 Effect of organic manure and gibberellic acid on number of fruits/ plant of strawberry

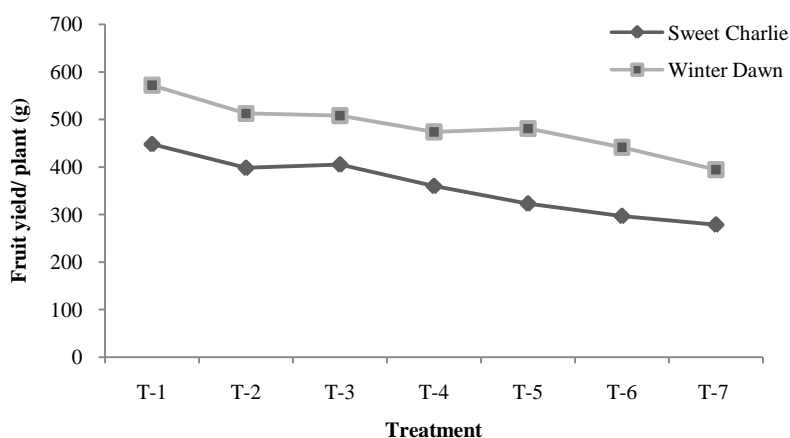


Figure 5 Effect of organic manure and gibberellic acid on fruit yield/ plant of strawberry

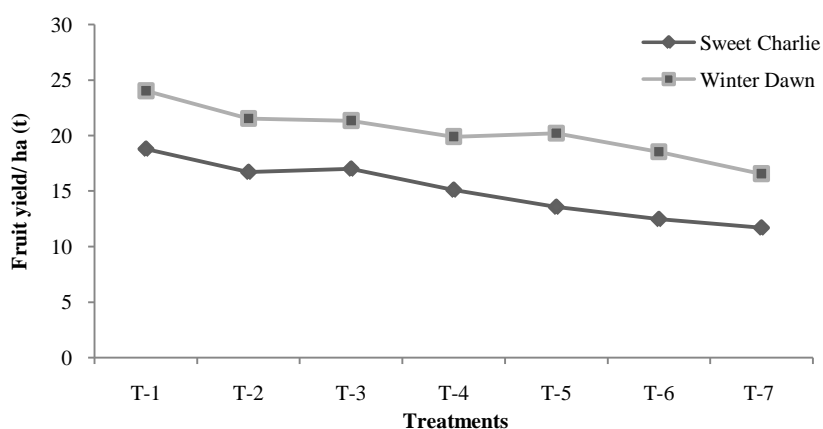


Figure 6 Effect of organic manure and gibberellic acid on fruit yield/ ha of strawberry

4 Discussion and conclusion

Application of GA₃ exhibited higher plant height and number of leaves production which might be due to increased vegetative growth through increasing cell division and cell elongation and higher doses of GA₃ influenced more. Khalid et al. (2013) reported that farmyard manure (FYM) and vermicompost-based organic amendments enhanced vegetative growth and improved the quality of strawberry fruits. Mafizur Rahman (2015) reported that among the organic fertilizers, vermicompost treated plants showed the greatest vegetative growth (plant height, number of leaves, leaf area), early flowering, and fruiting. Application of RDF + Vermicompost 5t/ha + Neem Cake 4t/ha was found significantly effective for strawberry in terms of plant height (21.20 cm) and the number of leaves per plant (16.23) as per the findings of Kumar et al. (2017). Kumar & Tripathi (2009) revealed that strawberry plants treated with GA₃ at 100 ppm produced maximum plants height (20.50 cm) with the highest number of leaves (18.75) which confirms the present investigation. Whereas, the best effect by 75 ppm GA₃ to increase vegetative growth like plant height and leaf

number of strawberry was found by Kumar et al. (2011), Sekhar et al. (2016), and Jamaluddin et al. (2012).

Increased cell division and cell elongation leading to larger fruits, *i.e.* increased fruit diameter and length by application of GA₃ might be due to increased carbohydrate level and dry matter content because of higher photosynthesis rate. Again in combination with vermicompost 75 ppm GA₃ accelerated higher fruit growth and development as compared to 100 ppm GA₃. As reported by Mafizur Rahman (2015) the number of flowers, fruits, fruit length, fruit diameter, single fruit weight, total fruit weight/plant and yield/ha was also superior to vermicompost application. According to Saima et al. (2014) fruit, the volume and weight of strawberry were increased by growth regulators.

Higher fruit set ability by GA₃ treatments might be the cause of the increasing number of fruits and higher yield might be due to the increased fruit set per plant, fruit length, and fruit diameter as well as fruit weight. Faster translocation and mobilization of stored metabolites or photosynthates from source to sink with the

application of GA₃ might be the cause of the increased number of fruits per plant. Higher fruit weight due to accelerated fruit growth and size might be due to increased cell elongation or enlargement by the exogenous application of GA₃. Again, the growth of all vegetative parts were promoted by GA₃ application and consequently, more food material for fruit development was produced by such plants to result in more fruit weight under the present investigation. The variety Winter Dawn produced a higher number of fruits per plant and yield as compared to Sweet Charlie though the individual fruit weight is slightly lesser in Winter Dawn. Arancon et al. (2006) reported that vermicompost application increased the growth and yields of strawberries significantly (35% in marketable fruit weights). Application of RDF + Vermicompost 5 t/ha + Neem Cake 4 t/ha was found significantly superior for strawberry in terms of yield parameters like the number of fruits per plant (14.20), average fruit weight (19.51 g), fruit yield per plant (286.56 g) and fruit yield per hectare (17.19 t/h) as reported by Kumar et al. (2017). Sarita Paikra (2018) also reported that the foliar application of Gibberellic acid @ 100 ppm along with a recommended dose of fertilizers was found best treatment by significantly increased the plant growth, whereas plants treated with Gibberellic acid @ 75 ppm were found best in terms of yield and yield attributing parameters which conform with the present study. Saima et al. (2014) also found that the number of flowers per plant (30.22) and the number of berries (24.80) were also recorded maximum with the application of GA₃ at 75 ppm concentration. Yadav et al. (2017) reported that foliar spray of GA₃ 75 ppm after 45 days of transplanting was found superior over all other treatments for various parameters to enhance strawberry yield. The maximum number of fruits (25.9/plant), fruit weight (13.2 g), and yield (336.6 g) per plant were obtained with foliar application of 75 ppm GA₃ as observed by Jamaluddin et al. (2012). Whereas some other researchers like Tripathi & Shukla (2010), Singh & Singh (2009), and Kumar & Tripathi (2009) have reported better results in terms of yield with the higher dose, *i.e.* 100 ppm of GA₃.

Based on experimental results, it can be concluded that along with different organic manures applications GA₃ treatments can increase the growth and yield of strawberry significantly. Along with vermicompost @ 3.0 t/ha as basal dose application of GA₃ @ 75 ppm twice at 40 DAP and 60 DAP had the best effect to increase fruit-set, number of fruits per plant, fruit size, and yield. Other organic manures had also some positive effects to increase total fruit number per plant and yield. Under the best treatment, the Winter Dawn variety produced 28% higher yield as compared to Sweet Charlie. Therefore, cultivation of strawberry with the application of 75 ppm GA₃ along with vermicompost @ 3.0 t per hectare can bring ample scope for increasing crop yield in strawberry and fetch more economic return for the farmers. Again, to achieve more yields for getting better remuneration the variety Winter Dawn may be selected for commercial cultivation.

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Conflict of Interest: The authors declare no conflict of interest.

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