Acta Scientific AGRICULTURE (ISSN: 2581-365X)

Volume 8 Issue 6 June 2024

Research Article

Effect of Planting Materials and Sources of Nutrients on Growth, Yield and Quality of Banana

Sika Mustaki, Nazrul Islam and Shormin Choudhury*

Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh

***Corresponding Author:** Shormin Choudhury, Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh.

DOI: 10.31080/ASAG.2024.08.1380

Received: May 02, 2024

Published: May 27, 2024

Abstract

The organic nutrient is considered an excellent soil amendment for soil quality and productivity and is more eco-friendly than chemical fertilizers. Improved banana propagation techniques, such as corm and tissue culture, increase banana production and quality more than traditional methods. The present study was undertaken to determine the performance of planting materials and organic and inorganic sources of nutrients on the growth, yield, and quality of banana. The two factors experiment consisted of two planting materials of banana, tissue culture plantlet (P_1), corm (P_2), and sources of nutrients; cowdung (M_1), vermicompost (M_2), spent mushroom compost (M_3) and inorganic fertilizers (M_4); which were outlined in a randomized Complete Block design with 3 replications. The banana plants propagated through corm demonstrated superior yield and quality characteristics. Furthermore, vermicompost is the most effective nutrient source, enhancing yield and quality parameters of banana. Maximum number of fingers (150.7), yield/plant (22.45 kg), total soluble solid (23.11) reducing sugar (17.38%), and total sugar (26.96%) were found in P_2M_2 treatment. In view of overall performance, this study suggests that corm as a planting material and vermicompost as a potential source of nutrients for banana production.

Keywords: Banana; Planting Materials; Nutrients, Yield; Fruit Quality

Introduction

The lack of suitable planting material is the main barrier to the growth of banana farming. Suckers are used in vegetative propagation for more than 95% of bananas [1]. This is typically a long procedure that results in fewer planting materials contaminated with soil-borne diseases, insect pests, and nematodes. Furthermore, transplanting contaminated material frequently spreads illnesses and reduces the lifespan of crops [2]. Furthermore, new techniques are needed to meet the demands because traditional ways of propagating bananas are inadequate to produce the vast numbers of genetically superior individuals needed by cultivar development programs [3]. Under the above circumstances, macro propagation (corm) and tissue culture banana have been proposed as suitable planting materials for producing vast quantities of high-quality bananas.

Banana is a heavy nutrient feeder, requiring substantial amounts for growth and development [4]. Inorganic fertilizers were used to provide the majority of banana's nutrient requirements. In addition to their negative impact on soil, inorganic fertilizers have a detrimental influence on the quality of fruit [5]. However, applying both organic and inorganic sources of nutrients has the benefit of releasing nutrients gradually and consistently while preserving the optimal C: N ratio, improving the soil profile's ability to store water, and increasing the microbial biomass [6]. fruits that were harvested from plants that received organic matter had higher TSS and ascorbic acid, were firmer, had lower acidity, and an attractive color [7]. They also had a better quality and increased marketable fruit yield up to 58.6%. Some research has revealed that organic manures improve fruit quality and post-harvest life when compared to inorganic nutrient sources in bananas [8].

Banana (Musa x paradisiaca) is a well-known sweet fruit enjoyed by people of all ages. It is very nutritious and a good source of energy (89 kcal/100g) [9]. Banana farming is a popular agricultural practice in Bangladesh all year round. Planting materials and fertilization methods have a significant impact on banana yield and quality [10]. A total of 8, 33, 309 metric tons of bananas were produced in Bangladesh in 2018–2019 from farmed areas of about 48,849 hectares [11]. Several researches have examined the impact of organic and inorganic fertilizers on banana growth, production, and quality. However, there are far fewer studies on planting material and fertilizer for banana production in Bangladesh. Exploring the impacts of fertilizer and planting material, as well as completing a full evaluation, is required for sustainable banana production practices.

As a result, the purpose of this study is to assess the effectiveness of planting materials as well as the impact of both organic and inorganic nutrient sources. This assessment will be based on a thorough analysis of the morphological and physiological characteristics of the plant, as well as its photosynthetic pigment, yield, and quality features.

Materials and Methods

Plant materials and soil properties

The experiment took place in the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka 1207, Bangladesh, from March 2020 to April 2021. The banana variety BARI kola-1 was planted in pits measuring 60 cm x 60 cm x 60 cm, with a spacing of 1.5 m x 1.5m. To measure soil pH, organic matter content, and macro and micro nutrients, composite soil samples were obtained from the experimental field and examined at the Soil Resource Development Institute (SRDI), Soil Resource Development Institute (SRDI), soil testing laboratory in Dhaka, Bangladesh.

Parameters	Soil
pH	6.0
Organic matter (%)	2.10
N (%)	0.13
P (μg/g soil)	13.58
S (μg/g soil)	92.87
K (mEq/100g soil)	0.10
Ca (mEq/100g soil)	17.8
Mg (mEq/100g soil)	2.20
Be (μg/g soil)	0.64
Cu (μg/g soil)	2.42
Fe (μg/g soil)	51.52
Zn (μg/g soil)	6.69
Mn (μg/g soil)	8.47

Table 1: Chemical properties of soil collected from the experimental site.

Treatments and experimental design

The treatments consisted of two factors: planting materials- tissue culture plantlet (P_1) and corm (P_2) and organic and inorganic fertilizers- cowdung (M_1) @ 60 kg per plant, vermicompost (M_2) @ 20 kg per plant, spent mushroom compost (M_3) @ 30 kg per plant, inorganic fertilizers (M_4) @ 780 g Urea: 720 g TSP: 1000 g MP per plant.. The experiment was set in a randomized complete block design with 3 replications and 8 treatments were used in this experiment.

Quantities of organic and inorganic fertilizers

N, P and K were applied in the form of Urea, TSP and MP respectively. Inorganic fertilizers were applied @ 780 g urea, 720 g TSP and 1000 g MP respectively per pit. Organic manures @ 60 kg cowdung, 20 kg vermicompost and 30 kg spent mushroom compost were applied per pit at 10-15 days before planting of corm and tissue culture plantlets. The amount of organic manures required were calculated as per the available nitrogen content in the organic source as in Table 2 and were applied as per the treatments. Calculated quantities of cowdung, vermicompost and spent mushroom compost were applied during pit preparation as basal application followed by light irrigation. Full amount of TSP were applied as basal dose during pit preparation. Urea and MP were applied in four splits as top dressing around the plants and mixed thoroughly with soil followed by irrigation. The first top dressing were done after 2 months of plantings and continued at every two months and last top dressing of urea and MP were done after the emergence of inflorescence.

Organic manures	Nutrient %		
	N	P	K
Cow dung	0.7	0.8	1.2
Vermicompost	2.6	1.8	1.4
Spent mushroom compost	1.2	0.6	1.3

Table 2: Nutrient composition of organic manures.

Source: Soil Resource Development Institute (SRDI).

Measurement of morphological and physiological traits

Pseudo-stem length, number of leaves, pseudo-stem diameter of banana was measured during harvesting stage. Pseudo-stem height was measured from the base of the pseudo-stem to the base of the peduncle, number of leaves per plant was determined by manual counting and pseudo-stem diameter was measured at 30 cm above the ground level and expressed in centimeter (cm) through the measuring tape. The chlorophyll content of the first fully opened leaves was measured using a SPAD-502 chlorophyll meter (Minolta, Tokyo, Japan). In each treatments, measurements were taken from the middle of the leaf lamina of five randomly chosen plants.

Measurement of yield and yield contributing parameters

Days to inflorescence initiation (visual observation) was counted the days from the date of corm and tissue culture plantlets planting and days to maturation was counted the days after inflorescence initiation of banana. First hand to last hand length was measured from the first hand at the top up to last hand through measuring tape. The number of total fingers was recorded by counting all the fingers in each bunch and the average number of fingers per bunch were calculated and expressed in number. After harvesting of the bunch, the fingers were separated from the bunch carefully with the help of knife and finger weight was measured by taking weight of six individual fingers on electric balance and average fruit weight was calculated and expressed in grams.

Measurement of quality parameters

Total Soluble Solids (TSS) Content

The TSS concentration of bananas was determined using a digital refractometer (MA871; Bucharest, Romania). A drop of banana pulp was put on the refractometer prism. The refractometer indicated total soluble solids.

pH Determination

Individual treated banana fruit juices were filtered individually, and pH was determined with a digital pH meter (HI 2211, Bucharest, Romania).

Total sugar content

The Phenol-sulfuric acid method was used to determine the total sugar content of banana pulp [12]. Thus, 5 gm of ripened fruit was with 45 ml 80% ethanol, transferred to 100 ml beaker. Then, it was heated for 15 minutes in water bath at 80^0C. After cooling for few minutes, the solution was filtered into 100 ml volumetric flask and made volume up to the mark with distilled water. After that, 0.2 ml supernatant and 0.8 ml distilled water were taken in a test tube. Subsequently, 1 ml phenol and 5 ml H_2SO_4 were added to the mixture rapidly and shaken well. After 10 minutes of shaking, the content was placed in water bath at 25-30^0C for 20 minutes for color development. The reading was recorded with the spectrophotometer at a wavelength 490 nm and results were obtained from the standard curve.

Reducing sugar content

The dinitro-salicylic acid technique was used to measure the reducing sugar content of banana pulp [13]. Thus, 5 gm of fruit was with 45 ml of 80% ethanol transferred to 100 ml beaker. Then, it was heated for 15 mints in water bath at 80^0C. After cooling for few mints, the solution was filtered into 100 ml volumetric flask and made volume up to the mark with distilled water. After that, 3 ml of extract was taken into test tube and added 3 ml of DNS reagent. After mixed well, the solution was heated in water bath for 15 mints. After color development, 1 ml of 40% Rochelle salt was added at warm condition. Subsequently, the solution was cooled under tape water. Light absorption was recorded with the spectrophotometer at wavelength 540 nm for green, 510 nm for red, 575 nm for yellow.

Statistical analysis

The collected data were statistically analyzed by SPSS software. When $P < 0.05$, the value was deemed statistically significant. The mean ± SE of the replicates was used to present all the results.

Results and Discussion

Morphological and physiological parameters

Pseudo-stem length was significantly affected by the planting materials and nutrients. Maximum pseudo-stem length was recorded in P_2M_2 (185.2 cm) treatment combination which was significantly superior from all other treatments and minimum (155.2 cm) was found in P_1M_1 treatment combination. This result obtained from this study was similar with the result of [14] who reported that the growth characteristics (plant height) raised from mother corm were significantly better than those banana plants raised from tissue culture plants. Pseudo-stem length of banana significantly affected by the fertilizers treatment during harvesting stage. This might be due to the ability of humic acids present in vermicompost to act as plant growth regulators which could contribute significantly to enhancement of pseudo-stem height of banana [15].

Number of leaves was found statistically significant by combined effect of planting materials and nutrients. Maximum number of leaves was counted in P_2M_2 (13.00) and the lowest (9.33) in P_1M_4 treatment. This could be because corms have a higher concentration of stored food material than tissue culture plantlets. [16] had previously found similar results in terms of leaf count. The number of leaves was increased in M_2 due to the presence of plant growth regulating substance in vermicompost. Moreover, it improves soil biological function which increases nutrient availability thereafter enhanced plant growth [17].

Treatments	Pseudo-stem length (cm)	Number of leaves	Pseudo-stem diameter (cm)	SPAD value
P_1M_1	155.17f	10.33 e	60.00 cd	46.56 ab
P_1M_2	167.83 d	12.00 b	65.33 b	47.00 ab
P_1M_3	170.83c	11.00 cde	59.16 cd	44. 17 b
P_1M_4	161.83 e	9.33 f	55.00 e	43.60 b
P_2M_1	162.17e	11.67 bc	66.50 b	46.30 ab
P_2M_2	185.17 a	13.00 a	71.00 a	49.15 a
P_2M_3	179.33 b	11.33 bcd	61.50 c	46.30 ab
P_2M_4	170.33 c	10.67 de	57.00 de	46.80 ab
CV%	0.36	3.97	3.51	4.54
$LSD_{0.05}$	1.0531	0.7761	3.80	3.67

Table 3: Effect of Planting materials and sources of nutrients on morphological and physiological parameters of banana.

^{z}Means within columns followed by different letters are significantly different according to Duncan's multiple range tests at $p < 0.05$ (n = 9). P_1 = Tissue culture plantlet, P_2 = Corm, M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK. Means with different letters significantly differ at 5% level of LSD.

The maximum pseudo-stem diameter was found in P_2M_2 (71.00cm) treatment and minimum was found in P_1M_4 (55.00cm) treatment. Corm propagated plants exhibited considerably larger pseudo-stem diameters. This could be attributed to increased availability of photosynthates as a result of faster growth rates of vegetative plant parts following corm treatment. These results are consistent with those reported [18]. Vermicompost-treated plants had the largest pseudo-stem diameter. In this study, pseudo-stem diameter was assessed during the harvesting stage, and vermicompost-treated plants exhibited a statistically superior pseudo-stem iameter compared to all other treatments. The treatment of the pseudo-stem with vermicompost may have improved the physical properties of the soil, increased nutrient uptake, and activated microorganisms, which showed up as increased growth and higher production of carbohydrates [19].

P_2M_2 (49.15) treatment had the highest SPAD value during harvesting stage and lowest was found in P_1M_4 (43.60) treatment combination. Compared to tissue culture seedlings, bananas grown from corms have more reserved food and have absorbed more sunlight. These results support the gladiolus research conducted [20]. Maximum SPAD value was observed in vermicompost treated plants. Vermicompost application increased the mineral uptake, such as, nitrogen and phosphorus [21]. N is the primary ingredient of chlorophyll, proteins, and amino acids, and increasing N availability accelerates their synthesis [22]. Vermicompost includes both major and micronutrients, which contributed to the increased chlorophyll levels. Increase in SPAD value on account of vermicompost application is in accordance with the previous observations of [23].

Yield contributing parameters

Days to inflorescence initiation

Longest period was required for P_2M_2 (234.9 days) treatment combination whereas shortest period for P_1M_1 (204.9 days) treatment combination for inflorescence initiation. The shorter crop cycles associated with tissue culture plants may have resulted from the earlier inflorescence initiation in these plants, which may have been caused by their quicker development as compared to corm propagated plants, [1].

Length of inflorescence (cm)

P_2M_2 (154.0 cm) had the maximum inflorescence length and minimum was found in P_1M_3 (110.8cm) treatment combination. P_2M_2 and P_1M_3 were significantly different from each other. This suggests that corm-propagated bananas develop more quickly than tissue-cultured plants. Inflorescence length may be associated with the beneficial effects of vermicompost and microorganisms on root surface area per unit soil volume, water use efficiency, and photosynthetic activity [24]. This parameter has a direct effect on physiological processes and carbohydrate utilization [25].

Total no. of hands

The maximum number of hands was found in P_2M_2 (10.33) whereas minimum hand numbers was counted in P_1M_3 (6.00). P_2M_2 treatment combination was statistically superior from all other treatment combination. The reason for this could be that while tissue-cultured plants are very delicate and difficult to establish in the field, corm-propagated plants are more suited to the environment because they are photo synthetically active and produce more bunches and hands [26]. Vermicompost-treated plants had the greatest number of hands among all the fertilizers. The increased number of hands in vermicompost treatment may be linked to a rise in the level of quickly converted available forms of important micro and macronutrients in the presence of either dead or living worms, resulting in higher yield metrics. Vermicompost also improves physical and chemical soil structure, as well as water uptake, which leads to increased plant growth and production. The current findings are consistent with those published [27] in banana.

Total no. of fingers

The combined effects of fertilizers and planting materials caused a substantial variation in the total number of fingers. The total number of fingers was greatly enhanced by the treatment combination P_2M_2 (150.7), whereas P_1M_3 (109.0) had the least number of fingers. Certainly, the leaves generate photosynthates that are used to grow the reproductive organs as a place to store energy for future reproduction. The quantity of leaves on a banana plant determines the weight, size, and features of the fingers [28]. According to the findings, bananas propagated via corms had the most leaves during the harvesting stage, which led to the production of more photosynthates and an increase in the number of fingers. Increased N levels may be the cause of the effect of vermicompost on the number of fingers. Microbial activity during the addition of vermicompost promotes greater root expansion, which in turn promotes greater uptake of nutrients, water, and photosynthesis rate, ultimately increasing the total number of fingers [29].

Individual fruit weight (g)

Maximum fruit weight of banana per plant was recorded in P_1M_2 (161.2g) whereas minimum was found in P_2M_3 (126.5g). Tissue culture plants already have numerous leaves when planted. Tissue culture plants have higher leaf area, resulting in an enhanced active photosynthetic rate and dry matter accumulation rate, and hence increased banana fruit weight [30]. Individual fruit weight significantly affected by the fertilizers treatment. Vermicompost has a high nutrient content, which leads to increased uptake of NPK nutrients, allowing the plant to obtain appropriate food and nutrients, perhaps increasing fruit weight [31].

Yield/plant (kg)

Significant variation was found on yield per plant of banana due to combined effect of planting materials and nutrients. Maximum yield per plant (22.45 kg) was recorded from the treatment combination P_2M_2 which was significantly superior over the other treatment combinations whereas the minimum yield per plant (14.73 kg) was found from P_1M_3 treatment combination which was statistically identical to P_2M_3 treatment combination. The vigorous and rapid growth seen in plants propagated from corms could be attributed to their effective utilization of the initial stored food resources, consequently leading to an enhanced yield [32]. The beneficial impact of incorporating vermicompost into agricultural practices has been documented in bell peppers [33], and eggplants [34],aligning with our findings. This can be attributed to the nutrient-rich composition of vermicompost, containing essential macro and micronutrients, enzymes, and growth hormones, all of which contribute to enhancing plant growth and fruit yield [35].

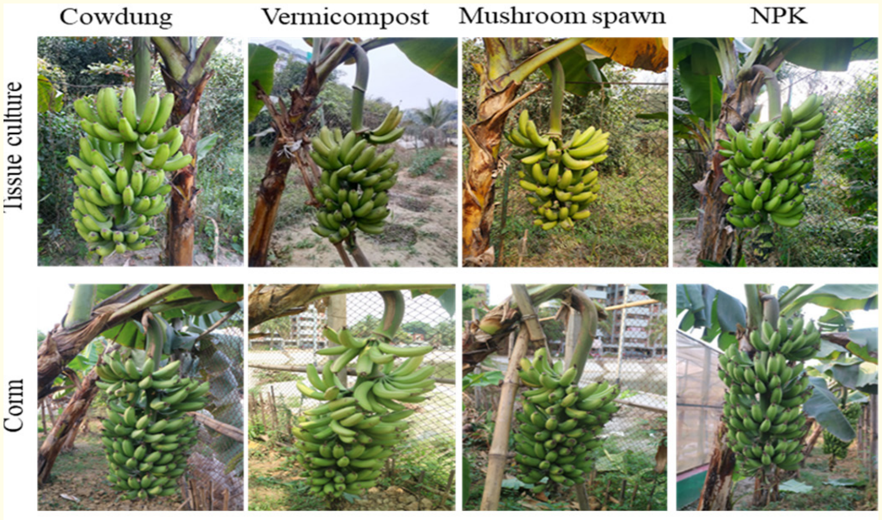

Figure 1: Banana fruits are grown with different propagating materials and fertilizers.

Treatments	Days to inflorescence initiation	Length of inflorescence (cm)	Total number of hands	Total number of fingers	Individual fruit weight (g)	Yield/plant. (kg)
P_1M_1	204.9d	137.3 bc	6.33 de	113.7 f	149.5 c	16.99 e
P_1M_2	219.0 bc	132.3 c	7.33 c	129.3 c	161.2 a	20.84 b
P_1M_3	208.8 cd	110.8 f	6.00 e	109.0 f	135.2 f	14.73 f
P_1M_4	210.9 cd	116.0 ef	6.67 d	125.7 d	156.3 b	19.65 c
P_2M_1	225.0 ab	143.8 ab	7.67 c	130.7 c	142.2 de	18.58 d
P_2M_2	234.9 a	154.0 a	10.33 a	150.7 a	149.0 d	22.45 a
P_2M_3	234.0 a	121.3 de	7.33 c	116.7 e	126.5 g	14.76 f
P_2M_4	231.0 ab	128.1 cd	9.00 b	143.3 b	145.0 e	20.78 b
CV%	3.31	4.76	4.88	1.39	0.92	1.46
$LSD_{0.05}$	0.427	10.86	0.64	3.10	2.33	0.48

Table 4: Effect of Planting materials and sources of nutrients on yield contributing parameters of banana

[z]Means within columns followed by different letters are significantly different according to Duncan's multiple range tests at $p < 0.05$ (n = 9). P_1 = Tissue culture plantlet, P_2 = Corm, M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK. Means with different letters significantly differ at 5% level of LSD.

Quality parameters

Total soluble solid (TSS)

The highest content of TSS was found in P_2M_2 (23.11%) treatment combination and lowest TSS content was recorded in P_1M_4 (18.00%). Total soluble solid was higher in corm propagated plants due to increased assimilate translocation and mobilization, resulting in sweeter fruits [36]. On the other hand, the increased total soluble solid content was caused by the addition of various organic manures to the soil and, as a result, to plants, which may have improved glucose biosynthesis and translocation into fruits [37].

pH

The treatment combination P_2M_1 (5.32) increased the pH values whereas minimum was recorded in P_1M_4 (4.62). P_2M_1 significantly different from the all other treatment combination. The high pH in corm-propagated plants was most likely caused by an increase in organic acid content in the fruits. The addition of cowdung increased the water-soluble organic carbon. Vitamin C, pH, and soluble sugar concentration in fruit were all significantly positively linked with water-soluble organic carbon, showing that adding vermicompost and cowdung could improve banana fruit quality [38].

Total sugar (%)

The combination treatment P_2M_2 (26.96%) had the highest total sugar concentration, while P_1M_4 (21.24%) had the lowest total sugar content. Different planting materials were found to considerably alter the total sugar content [39]. Higher sugar content and better fruit quality may be attributed to the increased availability of nutrients, particularly exchangeable potassium, which is made more readily available by vermicompost. According to [40], potassium played a significant role in the synthesis of proteins, the breakdown and translocation of starch, the synthesis of carbohydrates, and the neutralization of organic acids that are vital to physiological processes.

Reducing sugar (%)

The combination of planting materials and fertilizers had a considerable impact. The P_2M_2 treatment combination (17.38%) had the highest reducing sugar content, while the P_1M_4 treatment combination (11.88%) had the lowest reducing sugar content. The differences in reducing and non-reducing sugar content of bananas were caused by varietal differences and the use of different planting materials [41].

Fertilizers showed significant differences in the reducing sugar content of banana. The maximum reducing sugar concentration was discovered in vermicompost-treated plants. The availability of nitrogen from vermicompost may have boosted leaf area and assimilate synthesis, hence increasing photosynthesis rate. Such effects have been related to an increase in the rate of photosynthetic product translocation from leaves to developing fruits, resulting in increased reducing sugars in bananas. These findings are consistent with [42].

Treatments	TSS (°Brix)	pH	Total sugar (%)	Reducing sugar (%)
P_1M_1	20.22 d	4.80 d	23.44 d	14.85 bc
P_1M_2	21.55 c	5.08 b	25.58 ab	14.84 bc
P_1M_3	22.86 ab	4.77 de	21.62 e	13.10 e
P_1M_4	18.00 e	4.62 e	21.24 e	11.88 f
P_2M_1	22.33 b	5.32 a	25.30 bc	15.03 b
P_2M_2	23.11 a	5.00 bc	26.96 a	17.38 a
P_2M_3	21.33 c	4.98 bc	23.76 cd	14.32 c
P_2M_4	20.16 d	4.87 cd	24.39 bcd	13.74 d
CV%	2.14	1.74	3.94	2.42
$LSD_{0.05}$	0.794	0.149	1.65	0.609

Table 5: Effect of planting materials and sources of nutrients on quality attributes of banana.

^{z}Means within columns followed by different letters are significantly different according to Duncan's multiple range tests at $p < 0.05$ (n = 9). P_1 = Tissue culture plantlet, P_2 = Corm, M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK.

Conclusion

Regard as the above results, planting materials and nutrients significantly influenced growth, yield and quality of banana. Banana treated with vermicompost had the highest total soluble solid, reducing sugar and total sugar content. Additionally, yield and quality parameters showed best results in corm propagated bananas. Finally, it can be concluded that, the results of this study offer fundamental insights that can be utilized to enhance both yield and quality of banana.

Acknowledgments:

The present work was financially supported by the National Agricultural Technology Program Phase-II Project (NATP-2), Bangladesh.

Bibliography

1. Manju PR and Pushpalatha PB. "Macropropagated plantlets in banana: Performance evaluation with suckers and tissue culture plants in Grand Naine and Nendran". *Journal of Tropical Agriculture* 58.2 (2020): 263-268.
2. Njukwe E., *et al*. "Challenges and opportunities for macropropagation technology for Musa spp. among small holder farmers and small- and mediumscale enterprises". In: Blomme, G., Van Asten, P. and Vanlauwe, B. (eds.), Banana Systems in the Humid Highlands of Sub-Saharan Africa". *CABI* (2013): 66-71.
3. Nayak PK., *et al*. "Yield performance of commercial banana cultivars propagated through different methods". *Journal of Pharmaceutical Innovation* 8.10 (2019): 61-63.
4. Hazarika TK., *et al*. "Economic analysis of tissue cultured banana production under the influence of integrated nutrient management". *The Indian Journal of Agricultural Sciences*. 84.5 (2014): 656-660.
5. Dutta P., *et al*. "Integrated nutrient management in litchi cv. Bombai in new alluvial zone of west Bengal". *Indian Journal of Horticulture* 67 (2010): 181-184.
6. Yadav SK., *et al*. "Integrated nutrient management for strawberry cultivation". *Indian Journal of Horticulture* 67 (2010): 445-449.
7. Singh R., *et al*. "Vermicompost substitution influences growth, physiological disorders, fruit yield and quality of strawberry (Fragaria 9 ananassa Duch.)". *Bioresource Technology* 99 (2008): 8507-8511.
8. Patel PS., *et al*. "Quality of banana as influence by organic farming". *International Journal of Biosciences* 8 (2010): 175-176.
9. Sidhu JS and Zafar TA. "Bioactive compounds in banana fruits and their health benefits". *Food Quality and Safety* 2.4 (2018): 183-188.

10. Brunetti G., *et al*. "Short term effects of synergistic inorganic and organic fertilization on soil properties and yield and quality of plum tomato". *Scientia Horticulturae* 252 (2019): 342-347.

11. BBS. "Bangladesh Bureau of Statistics". Yearbook of Agricultural Statistics-2020 (2020): 1-648.

12. Dubois M., *et al*. "Colorimetric method for determination of sugars and related substances". *Analytical Chemistry* 28 (1956): 350-356.

13. Miller GL. "Use of Dinitrosalicylic Acid Reagent for Determination of Reducing Sugars". *Analytical Chemistry* 31 (1972): 426-428.

14. Dhatt AS., *et al*. "Effect of planting material on plant growth, yield and rhizome size of turmeric". *Indian Journal of Horticulture* 65.2 (2008): 193-195.

15. Meenakumari T and Shehkar M. "Vermicompost and other fertilizers effects on growth, yield and nutritional status of Tomato (*Lycopersicon esculentum*) plant". *World Research Journal of Agricultural Biotechnology* 1.1 (2012): 14-16.

16. Singh J., *et al*. "Effcet of size of seed rhizome and plant spacing on growth and yield of turmeric (*Curcuma longa* L)". *Haryana Journal of Horticultural Sciences* 29 (2000): 258-260.

17. Lazcano C and Domingue J. "The use of vermicompost in sustainable agriculture: impact on plant growth and soil fertility". *Soil Nutrients* 10.1-23 (2011): 187.

18. Sharma JR and Gupta RB. "Effect of corm size and spacing on growth, flowering and corm production in gladiolus". *The Asian Journal of Horticulture* 6.4 (2003): 352-356.

19. Kumar D., *et al*. "Effect of planting density and nutrient management on growth, yield and quality of micro propagated banana cv. Rasthali (AAB-Pathkapoora)". *Indian Journal of Horticulture*65 (2008): 272-276.

20. Uddin MF., *et al*. "Effect of corm size and depth of planting on the growth and flowering of gladiolus". *Pakistan Journal of Biological Sciences* 5 (2002): 553-555.

21. Zaller JG. "Vermicompost as a substitute for peat in potting media: Effects on germination, biomass allocation, yields and fruit quality of three tomato varieties". *Scientia Horticulturae* 112.2 (2007): 191- 199.

22. Jahanshahi S., *et al*. "Effect of planting date and vermicompost on growth and chlorophyll content of dill (*Anethum graveolens* L.)". *Research on Crops* 15.1 (2014): 232-236.

23. Anwar M., *et al*. "Effect of organic manures and inorganic fertilizer on growth, herb and oil yield, nutrient accumulation, and oil quality of French basil". *Communications in Soil Science and Plant Analysis* 36 (2005): 1737-1746.

24. Ogero KO. "Low cost tissue culture of selected cassava (*Manihot esculenta* Crantz) and sweet potato (*Ipomea batatas* (L) Lam.) varieties. M.sc Thesis, Department of Agricultural Sciences and Technology, Kenyatta University, Nairobi, Kenya (2012).

25. Rahman MA., *et al*. "Effect of bio compost, Cowdung compost and NPK fertilizers on growth, yield and yield components of chili". *International Journal of Biosciences* 2.1 (2012): 51-55.

26. Tenkouano A., *et al*. "Clean planting materials and management practice for sustainable production of banana and plantain in Africa". *Chronica Horticulturae* 46.2 (2006): 14-18.

27. Hussain SF., *et al*. "The growth, yield and quality parameters of banana cultivar Grand naine (AAA) as influenced by different organic amendments". *Pl. Archives* 15.2 (2015): 723-727.

28. Suryanarayana P., *et al*. "Morphological and yield attributing parameters of macro-propagated cultivars of banana (Musa spp L.)". *Journal of Pharmaceutical Innovation* 7.8 (2018): 240-245.

29. Taleshi K., *et al*. "Effect of vermicompost and nitrogen levels on yield and yield component of safflower (*Carthamus tinctorius* L.) Under late season drought stress". *The International Journal of Agronomy and Plant Production* 2.1 (2011): 15-22.

30. Patel MK and Rath SS. "Standardization of Macro Propagation in Banana cultivars - A Review". *International Journal of Current Microbiology and Applied Sciences* 7.9 (2018): 390-400.

31. Mamta KA., *et al*. "Effect of vermicompost on growth of brinjal plant (*Solanum melongena*) under field conditions". *Journal on New Biological Reports* 1.1 (2012): 25-28.

32. Patil RB and Borse CD. "Effect of planting material and transplanting of seedlings of different age on the yield of turmeric". *Indian Cocoa, Arecanut and Spices Journal* 4.1 (1980): 3-5.

33. El-Bassiony AM., *et al*. "Growth, yield, and fruit quality of sweet pepper plants (Capsicum annuum L.) as affected by potassium fertilization". *American Journal of Science* 6.12 (2010): 722-729.

34. Moraditochaee M., *et al*. "Effects of vermicompost application and nitrogen fertilizer rates on fruit yield and several attributes of eggplant (*Solanum melongena* L.) in Iran". *World Applied Sciences Journal* 15.2 (2011): 174-178.

35. Khan TH., *et al*. "Effect of vermicompost on growth, yield, and quality of chili (*Capsicum annum* L.) under the agro-climatic condition of Peshawar, Pakistan". *Pure and Applied Biology* 8.1 (2019): 856-865.

36. Kumar B and Gill BS. "Growth, yield and quality of turmeric (*Curcuma longa* L.) as influenced by different planting method, plant density and planting material". *Journal of Spices and Aromatic Crops* 19.1-2 (2010): 42-49.

37. Athani SI and Hulamani NC. "Effect of vermicompost on fruit yield and quality of banana cv. Rajapuri (Musa AAB)". *Karnataka Journal of Agricultural Sciences* 13 (2000): 942-946.

38. Wang X-X., *et al*. "Vermicompost Improves Tomato Yield and Quality and the Biochemical Properties of Soils with Different Tomato Planting History in a Greenhouse Study". *Frontiers in Plant Science* 8 (2017): 1978.

39. Parmar HC., *et al*. "Yield, Per Day Productivity and Quality of Banana (*Musa paradisica* L.) Influenced by Different Varieties and Planting Materials under Middle Gujarat Climatic Condition". *International Journal of Current Microbiology and Applied Sciences* 8.01 (2019): 213-217.

40. Pandey SD., *et al*. "Studies in nutritional requirement of tissue cultured banana cv. Robusta. Annual Report, NRCB, Trichy (2010): 8-19.

41. Venkata Subbaiah K., *et al*. "Effect of varieties and pretreatments on physico-chemical and sensory quality of banana". *Karnataka Journal of Agricultural Sciences* 26.1 (2013): 115-118.

42. Dey P., *et al*. "Effect of biofertilizer on physico-chemical characteristics of guava (*Psidium guajava* L.) fruit". *The Indian Journal of Agricultural Sciences* 75 (2005): 95-96.