EFFECT OF PLANTING MATERIALS AND SOURCES OF NUTRIENTS ON GROWTH, YIELD AND QUALITY OF BANANA

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CERTIFICATE

This is to certify that the thesis entitled, **‘EFFECT OF PLANTING MATERIALS AND SOURCES OF NUTRIENTS ON GROWTH YIELD AND QUALITY OF BANANA’** submitted to the Department of Horticulture, Faculty of Agriculture, Sher-e-Bangla Agricultural university, Dhaka, in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE IN HORTICULTURE** embodies the results of a piece of bona fide research work carried out by **SIKA MUSTAKI,** bearing Registration No. **14-06134** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma, elsewhere in the country or abroad.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Place: Dhaka, Bangladesh

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This thesis is dedicated

To my parents

Md. Sakandar Ali and Zinnata Zahan Moslima Khatun

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The Author

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ABSTRACT

An experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, during the period from March 2020 to April 2021. The objective of this study was to determine the performance of planting materials and organic and inorganic sources of nutrients on 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. Maximum number of fingers (135.3), yield/plant (18.67 kg), TSS (21.73 %), reducing sugar (15.12 %) were found in P_2 whereas minimum in P_1. Individual fruit weight (150.5 g) was maximum in P_1. Among the sources of nutrients, maximum number of fingers (140.0), yield/plant (21.29 kg), individual fruit weight (152.08 g), TSS (22.09 %), reducing sugar (16.11%) were recorded in M_2. For combined effect, yield/plant (22.45 kg) were maximum in P_2M_2 and minimum (14.73 kg) in P_1M_3. 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.

LIST OF CONTENTS

LIST OF CONTENTS (CONT'D)

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

WAT	Weeks After Transplanting
CD	Cowdung
CWU	Cowdung/Urea
PM	Poultry Manure
CPH	Cocoa Pod Husk
SMC	Spent mushroom compost
TSS	Total soluble solid
Ha	Hectare
µg	Microgram
pH	Hydrogen icon conc.
FYM	Farm yard manure
AEZ	Agro ecological zone
CV	Coefficient of variation
LSD	Least significant difference
et al.	And Others
NPK	Nitrogen, Phosphorus, Potassium
MP	Muriate of potash
TSP	Triple superphosphate
kcal	Kilocalories

CHAPTER I

INTRODUCTION

Banana (*Musa sp.*) is one of the well-known delicious fruits and preferred by people of all ages. It is highly nutritive and also a rich source of energy (89 kcal/100g) (Sidhu and Zafar, 2018). It is one of the cheapest and most nourishing fruits. The origin of banana is considered the southern part of China. In terms of banana production, Bangladesh is ranked 30th among the banana-producing countries of the world (FAOSTAT, 2011; ProMusa, 2017). Banana cultivation is one of the common agricultural practices in Bangladesh all year round. In Bangladesh, banana is mostly cultivated in Narsingdi, Gazipur, Tangail, Rangpur, Bogura, Natore, Pabna, Noakhali, Faridpur, and Khulna districts. Per capita consumption of banana is about 4.7 kg in Bagnladesh (Hossain *et al.*, 2016). In Bangladesh, total banana production in the year 2018-2019, was recorded at 8, 33, 309 metric tons from the cultivated areas of about 48,849 hectares (BBS, 2020). Among different banana cultivars BARI Kola-1, Champa, Amritsagar, Sabri, Kabri, Mehersagar, Dudsagar, Agniswar, Genasundari, Kanaibanshi, Basrai, Binisuta, etc. are commonly available in Bangladesh (Akter, 2017; Mukul and Rahman, 2013).

A major constraint to the expansion of banana cultivation is the scarcity of healthy planting material (Nkendah and Akyeampong, 2003). More than 95% of banana are vegetatively propagated through suckers (Manju and Pushpalatha, 2020). This is usually a very slow process, and produces less planting materials that are likely to be contaminated with soil-borne pathogens, insect pests and nematodes. Also, transplanting of the contaminated material often spreads diseases and shortens the lifespan of plantations (Njukwe *et al.*, 2013). Besides, conventional methods of propagation of banana are unable to supply large quantities of genetically superior individuals required by cultivar development programs, new methods are required to meet the demands. Under the above circumstances, the new technology viz., macro propagation (corm) and tissue culture banana has been advocated as an effective planting materials to produce large numbers of quality banana.

Banana is a heavy feeder of nutrients and requires large quantities for its growth and development (Hazarika *et al.,* 2014). The nutrient requirement of banana was mostly met through inorganic fertilizers. Inorganic fertilizers have deleterious effects on fruit quality besides its adverse effect on soil (Dutta *et al.,* 2010). On the other hand application of both organic and inorganic sources of nutrients have an advantage of consistent and slow release of nutrients, by maintaining ideal C: N ratio, improvement of water holding capacity and microbial biomass of soil profile (Yadav *et al.*, 2010). Fruits harvested from plant receiving organic matter were firmer, have superior TSS and ascorbic acid, lower acidity, attractive color and exacerbate marketable fruit yield up to 58.6% with better quality (Singh *et al.,* 2008). Some studies have suggested that organic manures gave better quality and post-harvest life of fruits when comparing to inorganic sources of nutrients in banana (Patel *et al.*, 2010).

Cowdung, vermicompost and spent mushroom compost are excellent organic fertilizers also commonly used to crop production. Spent mushroom compost is a good source of nutrients, nutrients are released slowly over a longer time, and plants can use them more effectively. It is also improves soil structure by increasing organic matter, water capacity, microbial activity, and soil temperature, and by decreasing soil compaction (Uzun, 2004). Various reports suggested the presence of humic substances in vermicompost. Presence of humic acid fraction in an organic amendment makes it agronomically efficient and ecofriendly (Senesi *et al.,* 2007). Addition of Cowdung increases the organic carbon content of degraded soil which may lead to the increasing activity of beneficial soil microorganisms as well as the fertility status of soil by increasing the availability of nutrients for the plants from soil. Cowdung significantly increased the growth and yield of plants (Gudugi, 2013; Akande *et al.*, 2006; Mehedi *et al.,* 2012). NPK is applied to supply major nutrients needed by plants for optimum growth (Adediran *et al.,* 2004; Naeem *et al.,* 2006). However, where inorganic fertilizers are not available, organic fertilizers can be used as replacement (Naeem *et al.*, 2006) to supply plant nutrients, improvement of soil structure (Dauda *et al.*, 2008) as well as activities of microorganisms in the soil (Suresh *et al.*, 2004).

Little research has been conducted on banana planting materials and fertilizer application in Bangladesh. Hence, keeping the above points in view, present research was undertaken with the following objectives:

- To evaluate the performance of planting materials on growth, yield and quality of banana.
- To study the effect of organic and inorganic sources of nutrients on the growth, yield and quality of banana.

CHAPTER II

REVIEW OF LITERATURE

Banana is the most important fruit in Bangladesh comprising 42 per cent of the total fruit production in Bangladesh (BBS, 2004). Banana is cultivated in a wide range of agro-ecological zones (Wanja, 2010). It occupies an important position among the fruits of the country not only for its wide cultivation all over Bangladesh but also from the standpoint of food value and availability throughout the year. Banana requires large quantity of nutrients for its growth, development and yield. Some of the important and informative literature related to this experimentation have been presented in this chapter.

2.1 Planting material related

Manju and Pushpalatha (2020) performed an experiment on macropropagated plantlets in banana: Performance evaluation with suckers and tissue culture plants in Grand Naine and Nendran. The treatments included plantlets produced by macropropagation (secondary seedlings) (T_1), 3-4 month old pest and disease free sword suckers (T_2), and 2 ½ to 3 months old hardened virus indexed tissue culture plants (T_3). The varieties were V_1 - Grand Naine (AAA) and V_2 - Nendran (AAB), and there were six treatment combinations, viz., Grand Naine (T_1V_1, T_2V_1, T_3V_1), and Nendran (T_1V_2, T_2V_2, T_3V_2). Randomized Block Design (RBD) was adopted with seven replications, and there were 15 plants per replication. The results revealed that macropropagated plantlets performed significantly better than suckers and was on par with tissue culture plants in both Grand Naine and Nendran with respect to bunch weight and yield. In Grand Naine, macropropagated plants recorded the greatest bunch weight of 28.29 kg which was on par with tissue culture plants (26.75 kg). Macropropagated plantlets, tissue culture plants and suckers behaved similarly with respect to TSS, acidity and shelf life, showing that there was no influence on quality parameters by planting material.

Nayak *et al.* (2019) conducted an experiment to study the yield performance of commercial banana cultivars propagated through different methods. They used 4 varieties of banana viz., Champa (AAB), Bantala (ABB), Patkapura (AAB) and Grand Naine (AAA) together constitute 12 treatments using 3 different propagation methods (Macropropagation, Micropropagation and Sucker propagation).The results showed that, micropropagated type, performance of Grand Naine was better as compared to other genotype with regards to the reproductive characters along with the yield and yield attributing traits like number of fingers/bunch (264.72), number of fingers/hand (15.81), number of hands/bunch (16.94), finger weight (136.300g), hand weight (2.155kg), bunch weight (36.082Kg), yield (72.164t/ha).

Parmer *et al.* (2019) reported that plant height, plant girth, leaves per plant and finger length were significantly influenced by planting materials during both the years and in pooled analysis. Whereas, number of hand per bunch and finger girth were influenced due to planting materials during one out of two years. Banana raised through tissue culture recorded higher values of all these traits as compared to that raised through suckers. Banana raised through tissue also produced higher yield as compared to that raised through suckers during both the years and in pooled analysis. The yield of banana was highest in tissue culture plants (80.25 t/ha) and lowest (70.04 t/ha) was for suckers. The highest (211.2 kg/ha) per day productivity was found from tissue culture plants and lowest (178.3) was recorded in suckers. The quality parameters also influenced by planting materials. The maximum pulp: peel ratio (3.17) was obtained from tissue culture bananas and lowest (3.11) was found from suckers.

An experiment was conducted by Parmer and Vinod (2018) on quality of banana influenced by planting materials. Results showed that planting of banana through tissue culture plants significantly increased carbohydrates (22.79 %) and non-reducing sugar (10.20 %) than planting through suckers. In case of TSS and reducing sugar were significantly found unchanged due to different planting materials. Non reducing sugar was noticed significantly the highest (11.47 %) when variety Robusta planting by tissue culture.

Patel and Rath (2018) reported that mass multiplication of banana through macropropagation is a farmer‟s friendly method for disease free planting material generation at field level. The complete process of macropropagation takes 5-7 months (including a hardening period of 45 days) for production of suckers ready for planting. The length of this period varies with the prevailing temperature at the time of planting of the corms for propagation and it is also necessary to produce the suckers as per the proper time of planting in the particular region.

Suryanarayana *et al.* (2018) conducted an experiment on morphological and yield attributing parameters of macropropagated cultivars of banana. In their experiment they found that most all the genotypes produced more height in macropropagated planting in comparison to suckers, maximum plant girth was attained by the macropropagated Grand Naine (63.93 cm) cultivar followed by the macropropagated Bantal (59.25 cm). There was no significant difference on number of fresh leaves between corm and suckers. The number of finger in hand was highest in macropropagated Champa (15.5) followed by Sucker Champa (15.2) and Grand Naine (13.09). They reported that method of propagation appears to have least effect on the bunch yield and other yield attributing characters of banana indicating that it is genetically controlled trait.

Sajith *et al.* (2014) reported that macropropagation offers the cheap alternative with tremendous potential for the production of quality planting material in banana. Pest and disease problems could be overcome in macropropagation method by maintaining a disease-free mother block as the source of healthy and high yielding planting materials at a cheaper cost than tissue culture bananas.

Kasyoka (2013) conducted an experiment regarding the macropropagation of banana. In his experiment, he found that the tissue culture plants had an average height of 44.2 cm while corm propagated plants had average height of 46.1 cm. In the 16th weeks corm propagated plants were tallest followed closely by tissue culture plants. However, the differences were not significantly different. Regarding diameter he found that macro propagated ones had maximum stem diameter than tissue culture plants after 8^{th} week. No significant difference was observed between treatments with regard to days to bunching, days to harvest and crop duration and quality attributes. Macropropagated plantlets, tissue culture plants and suckers behaved similarly with respect to TSS, acidity and shelf life, showing that there was no influence on quality parameters by planting material.

Development of tissue culture technology has been the foundation of high quality, disease free planting material production at a mass scale, particularly in tissue culture propagated crops (Singh, H. P *et al.*, 2011). Overall better quality of fruits was produced by these mother plants. The differences in reducing sugars and non-reducing sugar content of different banana varieties are due to varietal differences and use of different planting materials (Venkata Subbaiah K. *et al.*, 2013).

An experiment was conducted by Roy *et al.* (2010) where he compared between tissue culture plantlets and vegetative suckers. Results showed that micropropagated plants produced 44 leaves/plant whereas vegetative sucker-derived plants of same age i.e., one-year-old formed only 37 leaves/ plant. The average height and girth of the pseudo-stem of micropropagated plants were 243 and 44 cm, while for sucker-derived plants these values were 240 and 39 cm, respectively. Importantly, flowering and harvesting occurred at least one month earlier in micropropagated plants than in conventional ones. Other parameters such as bunch weight, number of fingers, etc. did not vary much between the two plant sources. The percentage of TSS of micropropagated and conventionally propagated banana was 26.88 and 25.6%, respectively. The percentage of reducing sugar of micropropagated and vegetative banana was 7.83 and 6.7%, respectively while the percentage of total sugar was 20.78 and 19.5%, respectively. Total protein was 1.1% in banana fruit derived from micropropagated plants but 0.96% from its vegetative counterpart.

Similarly, carotene content was 0.07 μg/100 g for the former and 0.03 μg/100 g for the latter.

Dhatt *et al.* (2008) reported that genotype and planting material exerted non-significant differences on most of the growth characters during all the years. The growth characteristics (plant height, number of suckers, leaf numbers) of plants raised from mother corm and sword suckers were significantly better than those banana plants raised from tissue culture plants. This could be due to the availability of relatively more stored food material in mother corm than any other planting material. Similar results in respect of plant height and number of suckers have been reported earlier (Singh et al., 2000). Physiological investigations were therefore conducted to compare assimilation potential, dry-mass production and carbohydrate status of tissue culture and corm plants during the first months of development, when greatest differences between the two planting materials could be expected. Management techniques needed to optimize the production potential of tissue culture plants were also suggested from these studies.

Tenkouano *et al.* (2006) reported that macropropagation (corm) derived plantlets are more adaptable to the field conditions because they are photosynthetically active as they are regenerated under in vivo conditions, while tissue cultured plants are partially photosynthetic and hence are very delicate and do not establish easily under field conditions.

Yields in terms of weight and number of marketable fruits per ha were significantly higher when corm and sword suckers were used rather than water suckers were used as planting material. Production of 38.9 t/ha or 135,866 marketable fruits per ha were obtained with corm compared to 33.2 t/ha or 121,132 fruits per ha with water suckers (Berril, 2001).

2.2 Organic fertilizer related

Wang *et al.* (2021) conducted an experiment on yield and quality of cucumber. The experiment was conducted in a completely randomized design with four treatments: control, without the addition of biochar (CK); 15 t ha^{-1} biochar (BC); 15 t ha^{-1} vermicompost (VC); and 7.5 t ha^{-1} biochar + 7.5 t ha^{-1} vermicompost (BV) in plastic shed systems continuously cultivated with cucumber for 0, 5, and 20 years. The application of biochar and vermicompost significantly increased cucumber yields on average by 14.9–29.0%, 21.9–45.6%, and 29.2–56.0%. The increased continuous cropping years had a negative impact on the cucumber fruit quality, which was significantly improved by the application of biochar and vermicompost.

Pawar *et al.* (2020) reported that the maximum plant height (3.40 m), fruit weight (197.47 g), number of fruits (292.12 fruits/tree) and yield (57.69 kg/tree and 15.97 t/ha) were recorded in sweet orange by application of 75% Vermicompost. The quality parameter such as, maximum juice (48.05%), TSS (10.00° Brix), ascorbic acid (55.32 mg/100 ml juice), reducing sugars (4.20%), non-reducing sugars (3.16%), total sugars (7.34%) with minimum acidity (0.46%) were also recorded in treatment by application of 75% Vermicompost.

An experiment by Narayan *et al.* (2017) on response of organic manures on quality of peach fruit, in their experiment the treatments were T_1 - control (200 : 150 : 200g, N : P : K as inorganic fertilizer), T_2 - FYM 30 kg per plant, T_3 - FYM 40 kg per plant, T_4 - FYM 50 kg per plant T_5 - Vermicompost 10 kg per plant T_6 - Vermicompost 15 kg per plant, T_7 - Vermicompost 20 kg per plant, T_8 - Poultry manures 2.5 kg per plant, T_9 - Poultry manures 5 kg per lant, T_{10} - Poultry manures 7.5 kg per plant, T_{11} - Neem cake 3 kg plant, T_{12} -Neem cake 5 kg per plant, T_{13}- Neem cake 7 kg per plant, T_{14} -FYM 30 kg + Vermicompost 10 kg + Poultry manures 2.5 kg + Neem cake 3 kg. They found maximum TSS, ascorbic acid, reducing sugar, total sugar of fruits was observed with application of FYM 30 kg + Vermicompost 10 kg +Poultry manures 2.5 kg + Neem cake 3 kg per plant while minimum TSS, ascorbic acid, reducing sugar, total sugar was observed with control (inorganic fertilizer). Titratable acidity showed that plants fertilized with inorganic fertilizer (control) gave maximum titratable acidity although minimum titratable acidity was observed with application of FYM 30 kg+ Vermicompost 10 Kg + Poultry manures 2.5 kg + Neem cake 3 kg per plant.

Hema *et al.* (2016) conducted an experiment on Effect of Organic Manures and Bio-fertilizers on Yield and Fruit Quality of Banana cv. Grand Naine (AAA). They found maximum fruit yield (89.22 t ha^{-1}), bunch weight (36.13), hands $bunch^{-1}$ (9.39), fruit length (21.42) and fruit girth (12.91) from FYM (15 kg)+NC (1.875 kg)+VC (7.5 kg)+Ash (9.94 kg) treatment and plants in the treatment N_0 +P_0 +K_0 have recorded lowest yield characters. Reducing and nonreducing sugars content in fruits was higher (9.40 and 9.00) in FYM (15 kg) +NC (1.875 kg) +VC (7.5 kg) +Ash (9.94 kg) which make the fruits sweeter and acceptable.

Vanilarasu and Balakrishnamurthy (2014) conducted an experiment on effect of organic manures on quality of banana. Results revealed that the fruit quality parameters like TSS (23.23%), total sugars and non-reducing sugars (14.92% and 6.06) and ascorbic acid (12.92 mg/100 g) contents were registered highest values in plants treated with vermicompost as compared to the inorganic treatments.

Bahrampour and ziveh (2013) determined the effect of vermicompost on growth, yield and fruit quality of tomato (*Lycopersicum esculentum*) var. Super Beta) in a field condition. The experiment was a randomized complete block design with four replications. The different rates of vermicompost (0, 5, 10 and 15 t ha-1) were incorporated in to the top 15 cm of soil. During experiment period, fruits were harvested twice in a week and total yield were recorded for two months. At the end of experiment, growth characteristics such as leaf number, leaf area and shoot dry weights were determined. The results revealed that addition of vermicompost with rate of 15 t ha^{-1} significantly increased Ec of fruit juice and percentage of fruit dry matter up to 30 and 24%, respectively. The content of K, P, Fe and Zn in the plant tissue increased 55%, 73%, 32% and 36% compared to untreated plots respectively.

The effect of vermicompost and other fertilizers on growth, yield and nutritional status of tomato was studied by Meenakumari and Shehkar (2012).

Joshi and Vig (2010) conducted an experiment on tomato growth, yield and quality influenced by vermicompost. Four treatments were used Soil (Control), VC15 (Soil + 15%VC), VC30 (Soil + 30% VC), VC45 (Soil + 45% VC). Mean plant height (cm) in treatments VC15, VC30 and VC45 were found to be 63cm, 63.4cm and 63.5, m respectively, which were significantly greater than mean plant height of 38cm reported in soil (control). Similarly, mean stem diameter was also observed to be significantly higher in three treatments (0.89, 0.88 and 0.88cm) than control (0.47cm). It was observed that number of fruits/plant in three treatments (10.9, 15.0 and 15.6) was also increased significantly than those in control (5.9). Total yield/plant (kg) of tomatoes in soil came out to be 0.36kg, while it came out to be 0.61, 0.79 and 0.85 in treatments VC15, VC30 and VC45 respectively. Mean soluble solids (%) in all the three treatments (5.48, 5.89 and 5.93) showed a significant increase as compared with control (4.57). Titratable acidity (mg citric acid/100g) in treatments VC15, VC30 and VC45 came out to be 0.0061, 0.0063 and 0.0059 which were lower than control (0.0069).

Uma and Malathi (2009) found that plants of Amaranthus sp. in plots receiving vermicompost had higher values of growth, yield and quality parameters as compared to plants in plots receiving chemical fertilizers.

Suthar (2009) reported that garlic (Allium sativum) plants with vermicompost treatment (at 20 t/ha) had higher values of various growth and yield parameters as compared to values of these parameters in chemical fertilizer treatment.

Plants receiving vermicompost might have received nutrition in a balanced and sustained way than those receiving inorganic fertilizers only (Arancon et al. 2004; Singh et al. 2008) and it might have helped the plants in producing albino and malformed fruits in lesser number. Increases have been reported in number of fruits/plant of strawberry (Fragaria 9 ananassa) (Singh et al. 2008), number of fruit/plant of two cultivars (sultan and storm) of Cucumber (*Cucumis sativus*) (Azarmi *et al.*, 2009), number of fruits/plant and fruit length of eggplant

(*Solanum melongena* L.) (Moraditochaee *et al.,* 2011). Better growth of plants under different doses of vermicompost might have favoured the production of firmer, better coloured and quality fruit. Number of pods/plant and seeds/plant of groundnut (*Arachis hypogaea*) increased by vermicompost applications (Mycin *et al.,* 2010).

Peyvast et al. (2008) applied vermicompost prepared from cattle dung in greenhouse as four different treatments i.e. 0, 10, 20 and 30 % to investigate its effect on spinach (*Spinacia oleracea*). Treatment with 0 % vermicontrol served as control. Highest plant height (14.56 cm) was observed in treatment with 10 % vermicompost while lowest plant height was observed in control (13.70 cm). Plant heights of 14.30 and 14.16 cm were recorded in treatments with 20 and 30 % vermicompost respectively. Although all the treatments with vermicompost increased plant height significantly as compared to control, no significant difference was observed between three vermicompost treatments.

Paul and Bhattacharya (2012) applied vermicompost at the rate of 5 and 2.5 t/ha on African marigold (Tagetes). Other treatments included cattle dung manure and cattle dung manure plus 50 % NPK. Maximum plant fresh weight and dry weight were observed in treatment of vermicompost at the rate of 5 t/ha.

Moghadam *et al.* (2012) observed early flowering and increased number of flower of Lilium plant on application of vermicompost. There was an increase in protein content of Andrographis paniculata, TSS of spinach, average caretenoid content, total sugar content, reducing sugars content and non-reducing sugars content of Amaranthus species, protein (%) and fat (%) of okra (Abelmoschus esculentus), total soluble protein(%) and carbohydrates of A. esculentus as reported by Vijaya *et al.* (2008), Peyvast *et al.* (2008), Uma and Malathi (2009), Ansari and Kumar Sukhraj (2010) and Vijaya and Seethalakshmi (2011) respectively. Better plant growth in different vermicompost amendments may be the reason for a better quality of fruits (Singh *et al.*, 2008; Azarmi *et al.*, 2009).

Fresh weight and dry weight of lettuce (*Lactuca sativa*) plants significantly increased in 50:50 and 20:80 mixtures of feed stock compost and vermicompost mixtures as compared to feedstock derived compost alone (Ali *et al.,* 2007).

Spent mushroom compost is used as a fertilizer, nutrients are released slowly over a longer time, and plants can use them more effectively. Previous studies have also revealed several advantages of spent mushroom compost on using it as organic manure, which includes its use as manure for nutritionally poor soil, neutralizing acidic soils and in some cases for improving the polluted sites (Ahlawat and Sagar, 2003). Its availability is also not a problem; the production of 1 kg fresh mushroom generates about 5 kg SMC (Lau *et al.,* 2003), thereby results in generation of million tonnes of SMC per annum. Therefore, after giving some suitable treatments, it can completely or partially substitute the growing medium for cultivation of different horticultural crops (Ahlawat *et al.,* 2006). It also improves soil structure by increasing organic matter, water capacity, microbial activity, and soil temperature, and by decreasing soil compaction. The benefits of SMC in orchards are modest in the first year, but increase considerably in subsequent years (Polat *et al.,* 2009). It is a good source of phosphorus and potassium, but not of nitrogen.

Pathak *et al.* (2020) conducted an experiment on Biochar, Leaf Compost, and Spent Mushroom Compost for Tomato Growth in Alternative to Chemical Fertilizer. The treatment of the experiments were T_1- 100% Soil (control), T_2- 30% Activated Biochar (30% Activated Biochar and 70% Soil), T_3- 30% Leaf compost (30% Leaf compost and 70% Soil), T_4- 30% SMC (30% SMC and 70% Soil). Number of leaves was highest in the treatment of T_2 (30% Biochar) initially from 3rd to 5th week followed by the treatment T_4 (30% SMC) and then by treatment T_3 (30% leaf compost) as compared to control, soil amended with the 30% SMC (T_4) showed the highest growth in plant height. The appearance of the first flowers was noticed in T_4 and T_2 treatments on the 9th week of cultivation, meanwhile the numbers of flowers were highest in T_4 compared to control followed by T_2 treatment while the first flowers appear in T_1 treatments and T_3 in the 11th week.

Rahman *et al.* (2016) conducted an experiment on Effect of Spent Mushroom Substrate and Cowdung on Growth, Yield and Proximate Composition of Brinjal. The treatments were T_1: Chemical fertilizer + Cowdung (10 t/ha), T_2: Chemical fertilizer + SMS (10 t/ha), T_3: Chemical fertilizer + Cowdung (5 t/ha) + SMS (5 t/ha), T_4: Chemical fertilizer, T_5: Cowdung (10 t/ha) + SMS (10 t/ha). Maximum plant height of BARI Begun-6 (80.11 cm) and BARI Begun-8 (75.56 cm) were measured from T_3 where both SMS and cowdung were used with chemical fertilizer and minimum plant heights for both varieties were measured in T_5. The plant with treatment T_3 produced early flowering BARI Begun-6 (70.47 days) and BARI Begun-8 (70.20 days) and delayed flowering was occurred in the treatment T_5. The maximum number of fruit per plant of BARI Begun-6 (7.4) and BARI Begun-8 (20.47) were measured from T_3 and the minimum from the treatment T_5. The other treatments T_1 and T_2 were statistically similar with T_3 in BARI Begun-6. The highest weight of individual fruit of BARI Begun-6 (262.3 g) and BARI Begun-8 (70.99 g) were measured from T_3 and the minimum from the treatment T_5.

An experiment was conducted by Asrafi *et al.* (2015) on Effect of spent mushroom compost on yield and fruit quality of tomato. Treatments were defined according to the different levels of inorganic fertilizer and SMS compost as basal application. The treatments were as follows: T_1= No fertilizer and compost application (control) T_2= Recommended dose of fertilizers (RFD) T_3=25% SMC-N+ 75% fertilizer-N T_4= RFD + 2.5 t ha^{-1} SMC T_5= 50% SMC-N + 50% fertilizer-N T_6= 100% SMC-N T_7= 100% SMC-N + 50% fertilizer-N. The result revealed that the highest fruit number per plant in treatment T_3 (68), treatment T_4 (SMC at 2.5 t ha^{-1} along with RFD) recorded significantly higher fruit yield (46.0 t ha^{-1}) and lowest yield was recorded in treatment (T_1) (20.5 t ha^{-1}). Total sugar and reducing sugar were found highest in treatment T_3 (4.08%) and T_5 (0.540%), respectively with statistically similar result of treatment T_4

(3.96%) for total sugar and T_2 (0.503%), T_3 (0.487%), T_4 (0.533%) and T_6 (0.492%) for reducing sugar.

Jonathan *et al.* (2015) reported that spent mushroom compost mixed with depleted garden soil generally enhanced all the variables of growth considered when compared with control and significantly promoted height, stem girth, number of leaves, flowers and fruit production in all the vegetables investigated.

Orluchukwu and Adedokun (2014) reported that the plant height of pineapple did not show any significance difference on the application of poultry manure and spent mushroom compost. The highest fruit weight of 13.52kg/plot was obtained with the application of poultry manure compared to 12.42kg/plot with spent mushroom compost.

Spent mushroom compost mixed with loamy soil produced significantly greater plant height, stem girth, number of leaves and total leaf area for tomato (Kadiri and Mustapha, 2010).

The lowest yield and earliness in cucumber growth were obtained in cultures with soil. Effects of SMC on total yield (kg m^{-2}), first quality fruit amount in total yield (%), total soluble solids (%), fruit width (cm) and length (cm) of cucumber were statistically significant during entire growth (Polat *et al.,* 2009).

Cultivation of tomato in soil mixed with anaerobically or aerobically recomposted mushroom compost significantly enhanced the fruit yield and quality over FYM and control treatments. Soil amended with anaerobically recomposted spent mushroom compost, reduced the incidence of different pathogens and insect-pests (Ahlawat *et al.*, 2009).

Ahlawat and Sagor (2007) reported that total protein, vitamin C, total sugar and reducing sugar contents of tomato fruit and potato tuber were found the highest in spent mushroom compost treatment. Spent composted mushroom improved the firmness and ascorbic acid content. They also reported that mixing of soil with recomposted SMC enhanced the tomato quality with respect to higher fruit weight, ascorbic acid content, dry matter, total soluble solids and acidity.

Polat *et al.* (2004) reported that there were statistically significant differences among different levels of spent mushroom compost applications in terms of total yield in lettuce growing as two and four tons/da spent mushroom compost applications gave the best result in terms of total and marketable yield.

Soil treated with decomposed cowdung were found to contain enough soluble phosphoric acid, potash and lime (Pal *et al.,* 2001). The long term use of cowdung increased aggregate stability, macro pores. Addition of cowdung to soil lower bulk density (Olaniyan *et al.,* 2006). Cowdung has been used as a soil conditioner since ancient times and its benefits have not been fully harnessed due to large quantity required in order to satisfy the nutritional needs of crop (Makinde *et al.,* 2007). Cowdung releases nutrient slowly and steadily and activates soil microbial biomass (Baley *et al.,* 2001). Eghball (2009) noted that K and P deficiencies were reduced when cowdung was applied with rising pH values. The application of animal manure, which contains both mineral and organic N, is useful for maintaining and improving soil fertility (Takahashi *et al.,* 2004).

Hossain (2020) conducted an experiment on yield and quality of cherry tomato. Results revealed that maximum amount of TSS% (6.60) and vitamin C content (15.27 mg 100 g^{-1}) were recorded when cowdung was applied at 5 t ha^{-1}. Minimum vitamin C content (12.77 mg 100 g^{-1}) was found in control plot. The number of fruits per plant was significantly influenced by the application of different levels of fertilizer. The maximum number of fruit per plant (146.83) was recorded in poultry litter at 5 t ha^{-1} and the minimum number of fruits per plant (59.33) was observed under control treatment. The maximum fruit yield per plant (846.33g) was recorded in poultry litter at 5 t ha^{-1} treatment and the minimum yield per plant (398.83g) was observed in control treatment.

Zaman *et al.* (2017) reported that the application of CD influenced plant height and it was increased with the advanced doses of CD. The shortest plants were recorded with control. However, the tallest plant (98cm in acid soil and 94cm in non-calcareous soil) was found in the pots receiving higher CD dose @ 10 t/ha.

The highest number of branches plant^{-1} at 60 DAP was counted from the plant receiving 10 t CD ha^{-1} and lowest branch number was counted from control. Maximum number of leaves (159.0 in acid soil and 170.0 in non-calcareous soil) at harvest was recorded with CD10 (10 t/ha) which was significantly higher than all other levels of CD in both soils.

Usman (2015) reported that there were no significant differences in plant height of tomato treated with three different organic manures (20t/ha each of cowdung, goat and poultry manure). However, between 4 and 8 WAT, there was significant differences observed in plant heights among the treatments. 20t/ha of poultry manure used showed its superiority over others in plant height with a plant height of 38.02. The result also revealed that tomato treated with 20t/ha of cowdung and goat manure at 8 WAT readings taken of the plant heights had the maximum of 27.36 and 28. 92 respectively.

Nweke and Nsoanya (2015) conducted an experiment on Cowdung and Urea Fertilization on Growth, and Yield of Cucumber. The treatment of the experiments were CO = O kg per plot (control that received no treatment application). CW = 12 kg Cowdung per plot. U = 391 g urea per plot equivalent to 150 kgNha^{-1} CWU = 6 kg Cowdung + 196 g urea equivalent to 75 kgNha^{-1}. Results revealed that maximum number of leaves (23.43), maximum number of fruits (7.01), maximum weights of fruits (8.29 kh/plot) in cucumber was obtained from treatment CWU (cowdung/urea).

Gudugi (2013) concluded that CD @ 20 t ha^{-1} was responsible for getting the tallest plant.

Sultana and Rashid (2012) conducted an experiment on effect of cowdung and potassium on growth and yield of Kohlrabi. The experiment consisted of 3 levels of cowdung manure (0, 20 and 40 t ha^{-1}) and 4 levels of potassium (0, 20, 50, 80 kg K ha^{-1}). The highest plant height (40.38 cm) was obtained from the C_2 (40 t cowdung ha^{-1}) treatment while the lowest plant height (37.05 cm) was obtained from C_0 (0 t cowdung ha^{-1}) treatment. Cowdung showed highly significant effect on the number of leaves per plant. The maximum number of leaves per plant

(10.59) was obtained from C_2 (40 t cowdung ha^{-1}) treatment while the minimum number of leaves (9.55) was found from the treatment of C_0 (0 t cowdung ha^{-1}) at harvest. The highest marketable yield per plot (6.52 kg) and per hectare (34.14 t ha^{-1}) were found from C_2 (40 t cowdung ha^{-1}) treatment while the minimum marketable yield per plot (4.60 kg) and per hectare (24.00 t ha^{-1}) were obtained from control (0 t cowdung ha^{-1}).

Cowdung produced 3.50t/ha of tomato fruits while the least yield of 1.20t/ha of tomato were recorded in the control treatment. The observed behavior of tomato fruit yield in the experiment was also in line with the report of Dantata *et al.* (2011).

Saidu *et al.* (2011) reported that the maximum plant height was observed at 3, 6, and 9 WAT when cowdung was applied at 17.5t/ha, cowdung at 22.5 t/ha recorded highest number of branches while the lowest number of branches was recorded where cowdung was not applied. There was significant difference in the number of fruits and this was recorded when 17.5 t/ha of cowdung was applied. The maximum fruit weight was recorded when 17.5 t/ha of cowdung was applied and lowest fruit weight recorded in the control.

The fruit count showed positive and significant response to cowdung application. The result from this study indicated that increase in cowdung application generally enhanced fruit production of tomato and that tomato grown without cowdung produced fruits which were smaller and fewer in number. This is in line with the findings of (El-Tantawy, 2009).

The application of cowdung at 22.5 t/ha recorded highest number of branches while the lowest number of branches was recorded where cowdung was not applied in tomato. The increase in manure rate significantly increased plant height (Dauda, 2003).

The significant difference observed in the number of leaves also conformed to the work of Reddy and Reddi (2002) who reported that high quality cowdung manure increased leaf length.

2.3 Inorganic fertilizer related

Mohammed *et al.* (2021) conducted an experiment on effect of NPK on the growth, yield and quality of cucumber. The treatments of the experiment were T_1: No fertilizer (control), T_2: (100:60:60 NPK $kgha^{-1}$), T_3: (100:60:120 NPK $kgha^{-1}$), T_4: (100:120:60 NPK $kgha^{-1}$), T_5: (100:120:120 NPK $kgha^{-1}$), T_6: (150:60:60 NPK $kgha^{-1}$), T_7: (150:60:120 NPK $kgha^{-1}$), T_8: (150:120:60 NPK $kgha^{-1}$), T_9: (150:120:120 NPK $kgha^{-1}$). Results exposed that maximum plant height (256.67 cm), maximum number of fruits per plant, maximum fruit weight (179.67 gm), maximum fruit yield (56.76 t ha^{-1}) was recorded in T_9.

Afolabi *et al.* (2021) reported that organic fertilizer and, to a lesser extent, inorganic fertilizer (NPK 15: 15:15 and urea) could be conveniently used to increase lettuce yield. Organic fertilizer was seen to have the highest growth parameters followed by inorganic fertilizer during this experiment. Inorganic fertilizer showed the highest nutrient content for the proximate analysis of lettuce.

Yadav *et al.* (2020) reported that maximum plant height (24.65 cm), maximum number of leaves was recorded in the plants treated with Vermicompost 2.5 kg/plot + NPK 15:8:6 gm/plot in strawberry. The maximum yield per plant (109 gm) was recorded in the plant treated with FYM 10kg/plot + NPK 15:8:6 gm/plot closely followed by Vermicompost 2.5 kg/plot +NPK 15:8:6 gm/plot and minimum yield per plant (75 gm) was recorded under control strawberry plants.

An experiment was conducted by Altaf *et al.* (2019) on effect of NPK and organic manure and their combination on growth, yield and nutrient uptake of chilli. Results exposed that application of NPK in combination with FYM recorded maximum plant height at harvesting (64.51 cm) which was found significantly different from control treatment (36.55 cm). The higher number of branches (23.60) was noted in chili with application of NPK100%+FYM. The number of fruit $plant^{-1}$, fruit width, fruit length, and fruit weight were statistically maximum with the application of NPK100%+FYM (24.56, 6.91 cm, 4.88 cm and 69.34 g/hill respectively) as compared to control treatment.

Dubey *et al.* (2017) conducted an experiment on effect of NPK on Plant Growth, Yield and Quality of Capsicum (Capsicum annum L.) c.v. Swarna Under Shade Net Condition. Results showed that maximum plant height at 30, 60, 90, 120 and 150 days after planting was recorded in T_7: NPK@ 175:55:45 kg/ha with (35.76cm, 50.10cm, 66.73cm, 89.10cm and 116.70cm respectively), maximum stem girth (mm) at 30, 60, 90, 120 and 150 days after planting was record in T_7: NPK@ 175:55:45 kg/ha with (13.37mm, 23.49 mm, 35.70 mm, 47.07 mm and 54.32 mm). The maximum fruit yield per plant (kg) was recorded in T_5: NPK@ 155:55:45 kg/ha. The maximum total soluble solids (^{0}Brix) was recorded in T_6: 155:55:55 kg/ha. They concluded that application of NPK@ 155:55:45 kg/ha proved to be the most suitable combination of nitrogen, phosphorus and potassium in relation to growth yield and quality of capsicum.

In banana Mintah *et al.* (2017) reported that largest stem girth was recorded on the NPK+PM treatments at Mpobi (37.33 cm) and Kenyasi (31.67 cm), higher number of functional leaves were produced by the plantain when it was treated with PM, NPK+CPH and NPK+PM than the control. The organic fertilizers as well as their combinations with NPK also gave shorter planting to flowering time, comparative to plots treated with only NPK. The NPK+PM and NPK+CPH treatments produced the heaviest bunches of 10.85 and 10.97 kg respectively, the longest plantain fingers measuring 28.00 cm and 27.67 cm for Mpobi and Kenyasi respectively were obtained under NPK+PM treatments, The highest yield (18,529.00 kg) was obtained when the plantain was treated with NPK+CPH.

Shafeek *et al.* (2015) reported that the highest level of NPK fertilizers (100%) significantly improved the chemical characters of cantaloupe fruits compared to the intermediate and the lowest levels of NPK (75 and 50%). The highest significant values of nitrogen, protein and vitamin C were recorded with the highest level of NPK fertilizers. While, no significant differences were detected among the levels of NPK fertilizers on the percentages of total sugars, moisture and TSS.

The plants treated with $N_{300}P_{125}K_{225}$ g/plant/year produced the highest number of fruits/plant (Nasreen *et al.,* 2013).

Harthi and Al-Yahyai (2009) conducted an experiment on growth and yield of banana with the application of NPK. The treatments were T_1 = no fertilizer applied; T_2 = 300-50-250 g/mat/yr, T_3 = 600-100-500 g/mat/yr, and T_4 = 900-150-750 g/mat/yr. Results revealed that largest bunch weight, total fruit weight was obtained in T_3 treatment as compared to the control (T_1). Mean middle-hand weight was the lowest with T_1 in comparison with T_3 and T_4 treatments, but T_1 was not significantly different from T_2. There was a significant difference between T_3 and T_4, in which middle-hand weight in T_3 approached 1.37 kg whereas it was 1.12 kg with T_4 where the rate of fertilizer was double than that of T_3. Similarly, the number of fingers per middle hand was largest (16 fingers) in case of T_3 treatment followed by T_4 compared to the control (T_1) which had the lowest number of fingers (13 fingers).

Nalima and Kumar (2007) under silty clay loam soil condition recorded the number of functional leaves at shooting stage (17.13), higher leaf area (12.34 m^2) in tissue culture banana with the application of N@ 165g, P @ 52.5 g and K @ 495g per plant.

In banana maximum pseudo-stem height, stem circumference, number of hands and fingers, bunch weight, fruit yield, pulp: peel ratio and fruit quality such as TSS, total sugars, reducing sugars were recorded due to 75% recommended dose of fertilizer + application schedule (N: P: K in the ratio of 3:2:1, 1:3:2 and 2:1:3 at vegetative growth, at flowering stage and fruit development to maturity stage). Earliest flowering and fruit maturity was also recorded in same treatment (Kumar and Pandey, 2008).

CHAPTER III

MATERIALS AND METHODS

This chapter illustrates information concerning methodology that was used in execution of the experiment. It comprises a short portrayal of location of experimental site, climatic condition, materials used for the experiment, treatments of the experiment, data collection procedure and statistical analysis etc.

3.1 Experimental site

The experiment was conducted at the Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka 1207 during the period from March 2020 to April 2021. The location of the experimental site is situated in $23^{0}74^{/}$ N latitude and $90^{0}35^{/}$ E longitude with an elevation of 8 meter from sea level (Anon, 1989) in Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP-FAO, 1988) under AEZ No. 28. The selected plot was high land and the soil series was Tejgaon. The soil texture of the experimental soil was sandy loam (Appendix I).

3.3 Climatic condition of the experimental site

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October.

3.4 Planting materials

The corm and tissue culture plantlet of variety BARI kola-1 was collected from Bangladesh Agricultural Research Institute (BARI), Joydepur, Gazipur.

3.5 Treatments of the experiment

The experiment comprised of two factors.

Factor A: Planting materials

Two different planting materials were used. These were –

i. Tissue culture plantlet (P_1)

ii. Corm (P_2)

Factor B: Organic and inorganic fertilizers

i. Cowdung (M_1) @ 60 kg per plant

ii. Vermicompost (M_2) @ 20 kg per plant

iii. Spent mushroom compost (M_3) @ 30 kg per plant

iv. Inorganic fertilizers (M_4) @ 780 g Urea: 720 g TSP: 1000 g MP per plant

Treatment combination: P_1M_1, P_1M_2, P_1M_3, P_1M_4, P_2M_1, P_2M_2, P_2M_3, P_2M_4.

Fertilizers were collected from Jannat Nursery, Agargaon, Dhaka except Spent mushroom compost. Spent mushroom compost was collected from National Mushroom Development and Extension center, Savar, Dhaka.

3.6 Design of the experiment

The experiment was set in a Randomized Complete Block design with 3 replications.

3.7 Production methodology

3.7.1 Land Preparation

The experimental field was thoroughly ploughed and levelled properly. The Pits of 60 cm x 60 cm x 60 cm size were dug at a spacing of 2 m x 2 m and were allowed to expose to the sunlight for one week before planting of corm and tissue culture saplings.

3.7.2 Nutrient analysis of soil

To determine pH, organic matter content and macro and micro nutrients of soil; composite soil samples were collected from the experimental field and were analyzed in soil testing laboratory, SRDI, Dhaka. Chemical properties of soil collected from the experimental site presented in Appendix I.

3.7.3 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 1 and were applied as per the treatments.

Table 1. Nutrient composition of organic manures

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

Source: Soil Resource Development Institute (SRDI)

3.7.4 Time and method of fertilizer application

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.

3.7.5 Planting of corm and tissue culture plantlets

Corm and tissue culture plantlets were planted in the pits during the months of March after application of manures and TSP.

3.7.6 Inter cultural operations

Weeding

The field was properly hoed and weeds were removed. Weeding was done at monthly interval.

Desuckering

The suckers arising from the base of the plants were removed and only main plant was allowed to grow.

Plant protection measure

Plant protection measures against sigatoka leaf spot disease of banana was taken at 15 days interval by spraying tilt 250 EC @ 0.5 ml/L of water.

3.8 Parameters

Data were collected in respect of following parameters:

Growth related parameters

- Pseudo-stem height (cm)
- Number of leaves
- Pseudo-stem diameter (cm)

Physiological parameter

- SPAD value

Yield related parameters

- Number of days to inflorescence initiation
- Number of days to maturation
- Length of inflorescence (cm)
- First hand to last hand length (cm)
- Total number of hands

- Total number of fingers
- Individual fruit weight (g)
- Yield/plant (kg)

Quality related parameters

- TSS%
- pH
- Titratable acidity %
- Ascorbic acid content (mg/100g)
- Total sugar %
- Reducing sugar %
- Color

3.9 Data collection

3.9.1 Pseudo-stem height (cm)

Pseudo-stem height was measured during harvesting stage from the base of the pseudo-stem to the base of the peduncle and expressed in centimeter (cm).

3.9.2 Number of leaves

Number of leaves per plant were counted at harvesting stage of banana.

3.9.3 Pseudo-stem diameter (cm)

Pseudo-stem diameter was measured at 30 cm above the ground level and expressed in centimeter (cm) through the measuring tape and data were taken at harvesting stage of banana.

3.9.4 SPAD value

Before measurement SPAD-502 meter was calibrated using the reading checker supplied by the manufacturer. Each leaf SPAD value obtained was the average of 10 readings (5 on each side of leaf midrib), and then for each extract, two chlorophyll determinations were performed (Leon *et al.*, 2007).

3.9.5 Days to inflorescence initiation and maturation

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.

3.9.6 First hand to last hand length (cm)

First hand to last hand length was measured from the first hand at the top upto last hand through measuring tape and expressed in centimeter.

3.9.7 Total number of fingers

The number of total fingers were recorded by counting all the fingers in each bunch and the average number of fingers per bunch were calculated and expressed in number.

3.9.8 Individual fruit weight (g)

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.

3.9.9 Yield/plant (kg)

Yield per plant was calculated by multiplying total number of fingers per plant with individual fruit weight and expressed in kilogram.

3.9.10 Total soluble solid (TSS %)

At room temperature, the total soluble solids of banana fruit pulp were directly measured using a hand refractometer (Model BS Eclipse 3-45) as suggested by Ranganna (1986). A drop of fruit pulp was placed on the refractometer's prism, and the reading was taken. The percentage soluble solids (°Brix) was used to express the results.

3.9.11 pH

pH was measured using a phs-25 pH meter. An electrolytic cell comprise of two electrodes (calomel electrode and glass electrode) was standardized with buffer solution of pH 7.00 and 4.01. Then the electrodes were dipped into the test sample. A voltage corresponding to pH of the solution was identified by the instrument.

Extraction of sample

In a 100 ml beaker, ten grams of fresh banana pulp was placed and homogenized with distilled water in a blender. The combined components were then filtered and transferred to a 100 ml volumetric flask, which was then filled with distilled water to the desired volume and pH determined by inserting the electrodes into the sample solution and stabilized readings were recorded.

3.9.12 Titratable acidity of pulp

The acidity of fruit was estimated by titrating the fruit pulp extract with 0.1 N sodium hydroxide using phenolphthalein as indicator (Ranganna, 2004).

Extraction of sample

In a 100 ml beaker, ten grams of fresh banana pulp was placed and homogenized with distilled water in a blender. The combined components were then filtered and transferred to a 100 ml volumetric flask, which was then filled with distilled water to the desired volume.

Procedure

In a conical flask, ten ml of pulp solution were taken. After adding two to three drops of phenolphthalein indicator, the conical flask was violently shaken. It was then promptly filtered through a burette with 0.1 N NaOH solution until a persistent pink color developed. Burette readings were used to calculate the amount of NaOH solution needed for titration. The acid content of the banana sample was calculated using the following formula:

$$TA\% = \frac{(\text{Titrate} \times \text{Normality of alkali} \times \text{volume made up} \times \text{equivalent wt.of acid} \times 100)}{(\text{volume of sample taken for estimation} \times \text{wt.of sample taken} \times 1000)}$$

.3.9.13 Ascorbic acid content:

Ascorbic acid content (ascorbic acid) was estimated by using 2, 6-Dichlorophenol indophenol (DCPIP) visual titration method (Ranganna, 2004). In a 100 ml beaker, ten grams of fresh banana pulp was placed and homogenized with oxalic acid in a blender. The combined components were then filtered and transferred to a 100 ml volumetric flask, which was then filled with oxalic acid to the desired volume. Then, 10 ml from solution was taken in conical flask and titrated against DCPIP (Standard dye) to a pink end point which should persist for at least 15 seconds. Ascorbic acid content in terms of mg/100 g pulp weight was calculated.

5% Oxalic acid solution preparation:

It was prepared by dissolving 50g oxalic acid powder in 1000 ml distilled water.

Dye solution preparation:

It was prepared by dissolving 260 mg of the sodium salt of 2, 6-dichlorophenol indophenol in approximately 1000 ml of hot distilled water containing 210 mg of sodium bicarbonate.

3.9.14 Total sugar content

The Phenol-sulfuric acid method was used to determine the total sugar content of banana pulp (Dubois *et al.*, 1956). To determine total sugar, the following reagents were used:

i. Phenol 5%
ii. H_2SO_4 96%
iii. Ethanol 80%
iv. Standard glucose

Procedure

Homogenized fresh 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 80ºC. 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 25-30ºC 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.

Calculation

Absorbance corresponds to 0.2 ml of test = x mg of glucose

% total sugar = (x ÷ 0.2) × 100

3.9.15 Reducing sugar content

The dinitrosalicylic acid technique was used to measure the reducing sugar content of banana pulp (Miller, 1972).

Reagents:

i. **Dinitrosalicylic acid (DNS) reagent:** It was prepared by adding 1 gm of DNS, 200 mg of crystalline Phenol and 50 mg of sodium sulphite in a beaker and mixed with 100 ml of 1% NaOH.

ii. **40% solution of Rochelle salt:** It was prepared by dissolving 40 g of sodium potassium tartarate with 100 ml of distilled water in a 100 volumetric flask.

Procedure

Homogenized fresh ripened 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 80ºC. 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. A blank solution (distilled water) was prepared in the same way as above.

Calculation

% Reducing sugar = (Optical density from graph ÷ volume of sample) ×100

3.9.16 Color

The changes of external color of banana was determined by Hunter Lab Colorimeter and data reported as L*, a* and b* values of Cielab scale (McGuire, 1992). Skin color was measured with six readings near the peduncle, the center and the apex on opposite sides of the fruit.

3.10 Statistical analysis

The collected data were statistically analyzed by STATISTIX 10 software. The significance of difference between the pairs of means was compared by least significant difference (LSD) test at the 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULTS AND DISCUSSION

The research work was accomplished for the evaluation of the performance of planting materials of banana against different organic and inorganic fertilizers. In this chapter, findings of executed research work have been put forwarded and discussed. Some of the data have been presented in table and others in figure for ease of discussion, comprehension and understanding. A summary of the analysis of variances in respect of all parameters have been shown in appendices. Results have been presented, discussed and possible interpretations are given under the following heads.

4.1 Pseudo-stem height (cm)

Pseudo-stem height was significantly affected by the planting materials (Appendix II). Maximum pseudo-stem height was recorded in P_2 (174.3 cm) and minimum was found in P_1 (163.9 cm) (Figure 1). This result obtained from this study was similar with the result of Dhatt *et al.* (2008) who reported that the growth characteristics (plant height) raised from mother corm were significantly better than those banana plants raised from tissue culture plants.

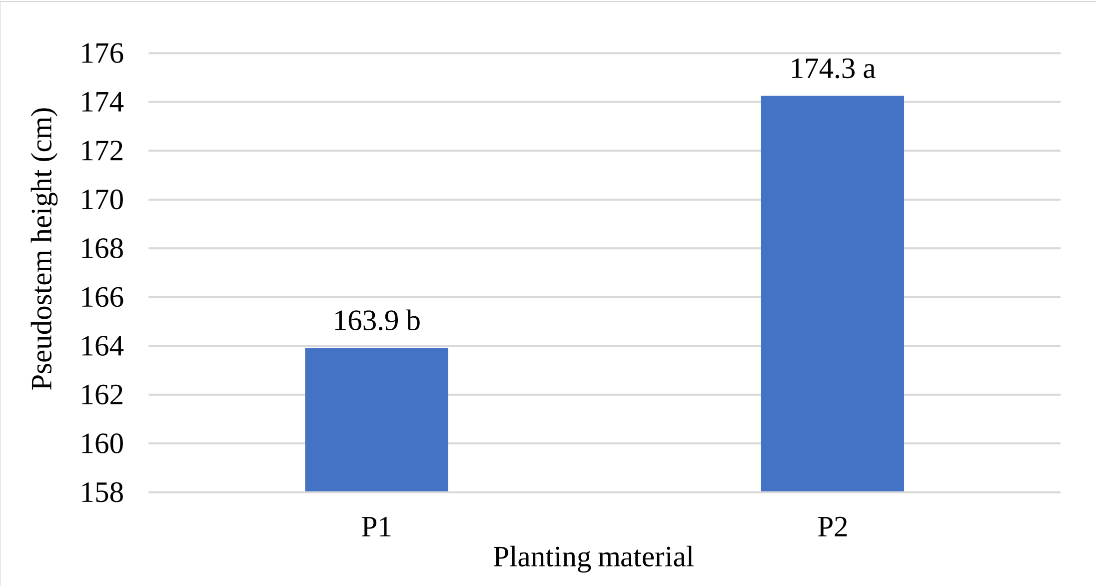

Figure 1. Effect of planting materials on pseudo-stem height of banana at harvest ($LSD_{0.05}$ = 0.527)

P_1 = Tissue culture plantlet, P_2 = Corm

Pseudo-stem height of banana significantly affected by the fertilizers treatment during harvesting stage (Appendix II). Maximum height was found in vermicompost (M_2; 176.5 cm) treated plants and minimum was found in cowdung treated plants (M_1; 158.7 cm) (Figure 2). 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 (Meenakumari and Shehkar, 2012).

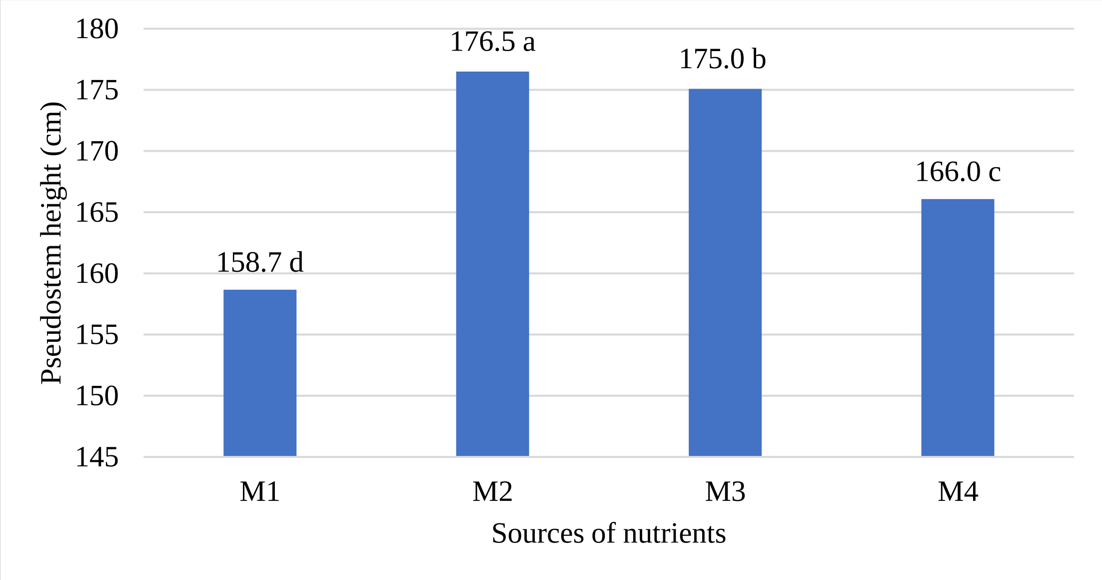

Figure 2. Effect of organic and inorganic sources of nutrients on pseudo-stem height of banana at harvest ($LSD_{0.05}$ = 0.745)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

Considering the combined effect of planting material and fertilizers, exposed significant variation regarding pseudo-stem height (Appendix II). It was found that maximum pseudo-stem height (185.2 cm) was found in P_2M_2 treatment combination which was significantly superior from all other treatments and minimum (155.2 cm) was found in P_1M_1 treatment combination (Table 2).

Table 2. Combined effect of planting materials and sources of nutrients on pseudo-stem height of banana at harvest

Treatments	Pseudo-stem height (cm)
P_1M_1	155.2 f
P_1M_2	167.8 d
P_1M_3	170.8 c
P_1M_4	161.8 e
P_2M_1	162.2 e
P_2M_2	185.2 a
P_2M_3	179.3 b
P_2M_4	170.3 c
CV%	0.36
$LSD_{0.05}$	1.05

Means with different letters significantly differ at 5% level of LSD.

P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.2 Number of leaves

The number of leaves was counted during harvesting stage of banana. Number of leaves was found statistically significant by planting materials of banana (Table 3 and Appendix III). Maximum number of leaves was counted in P_2 (11.67) this could be due to the availability of relatively more stored food material in corm than in tissue culture plantlets. Similar results in respect of number of leaves have been reported earlier by Singh *et al.* (2000). Minimum number of leaves was counted in P_1 (10.67) (Table 3).

The maximum number of leaves was recorded on M_2 (12.50) during harvesting stage and minimum (10.00) was found in M_4 (Table 3). M_2 significantly increased number of leaves. The number of leaves were increased in M_2 due to the presence of plant growth regulating substance in vermicompost. Moreover, it improves soil biological function which increase nutrient availability, thereafter enhanced plant growth (Christina and Jorge, 2011).

Considering combined effects, number of leaves (13.00) was counted the highest in P_2M_2 and the lowest (9.33) in P_1M_4 treatment. P_2M_2 was significantly different from all other treatment combination.

Table 3. Effect of Planting materials and sources of nutrients and their combined effect on number of leaves of banana

Treatments	Number of leaves
Planting materials	
P_1	10.67 b
P_2	11.67 a
CV%	3.97
$LSD_{0.05}$	0.388
Fertilizers	
M_1	11.00 b
M_2	12.50 a
M_3	11.17 b
M_4	10.00 c
CV%	3.97
$LSD_{0.05}$	0.549
Combined effect of planting materials and fertilizers	
P_1M_1	10.33 e
P_1M_2	12.00 b
P_1M_3	11.00 cde
P_1M_4	9.33 f
P_2M_1	11.67 bc
P_2M_2	13.00 a
P_2M_3	11.33 bcd
P_2M_4	10.67 de
CV%	3.97
$LSD_{0.05}$	0.776

Means with different letters significantly differ at 5% level of LSD.

P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.3 SPAD value

Significant variation was detected between corm and tissue culture plantlets regarding SPAD value of leaves (Appendix IV). P_2 (47.14) was recorded highest SPAD value during harvesting stage and lowest was found in P_1 (45.33) (Table 4). P_2 had the highest SPAD value this could be due to corm propagated bananas captured more sunlight and have maximum reserved food than tissue culture saplings. These findings confirm the results of Uddin *et al*. (2002) and Sharma and Gupta (2003) in gladiolus.

Maximum SPAD value was observed in vermicompost treated plants (M_2; 48.07) whereas minimum in NPK (M_4; 45.20) treated plants (Table 4). Vermicompost application increase of the mineral uptake, such as, nitrogen and phosphorus (Arancon *et al.,* 2005; Zaller, 2007). N is the chief constituent of chlorophyll, proteins and amino acids, the synthesis of which is accelerated through increased supply of N (Jahanshah *et al.,* 2014). Vermicompost contains both major and micro nutrients and contributed to the higher level of chlorophyll. Increase in SPAD value on account of vermicompost application is in accordance with the previous observations of (Anwar *et al.,* 2005).

Combined effect of planting materials and fertilizers, maximum SPAD value was found in P_2M_2 (49.15) treatment and minimum was found in P_1M_4 (43.60) treatment combination (Table 4).

Table 4. Effect of Planting materials and sources of nutrients and their combined effect on SPAD value of banana

Treatments	SPAD value
Planting materials	
P_1	45.33 b
P_2	47.14 a
CV%	4.54
$LSD_{0.05}$	1.84
Fertilizers	
M_1	46.43 ab
M_2	48.07 a
M_3	45.23 b
M_4	45.20 b
CV%	4.54
$LSD_{0.05}$	2.59
Combined effect of planting materials and fertilizers	
P_1M_1	46.56 ab
P_1M_2	47.00 ab
P_1M_3	44. 17 b
P_1M_4	43.60 b
P_2M_1	46.30 ab
P_2M_2	49.15 a
P_2M_3	46.30 ab
P_2M_4	46.80 ab
CV%	4.54
$LSD_{0.05}$	3.67

Means with different letters significantly differ at 5% level of LSD.

P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.4 Pseudo-stem diameter (cm)

Pseudo-stem diameter was measured during harvesting stage of banana. The maximum pseudo-stem diameter was found in P_2 (64.00cm) treatment and minimum was found in P_1 (59.87cm) treatment (Figure 3). Corm propagated plants had significantly the highest pseudo-stem diameter (Appendix V). This might be due to increased availability of photosynthates due to enhanced growth rate of vegetative plant parts under the treatments of corm. These results are in accordance with those obtained by Sharma and Gupta (2003).

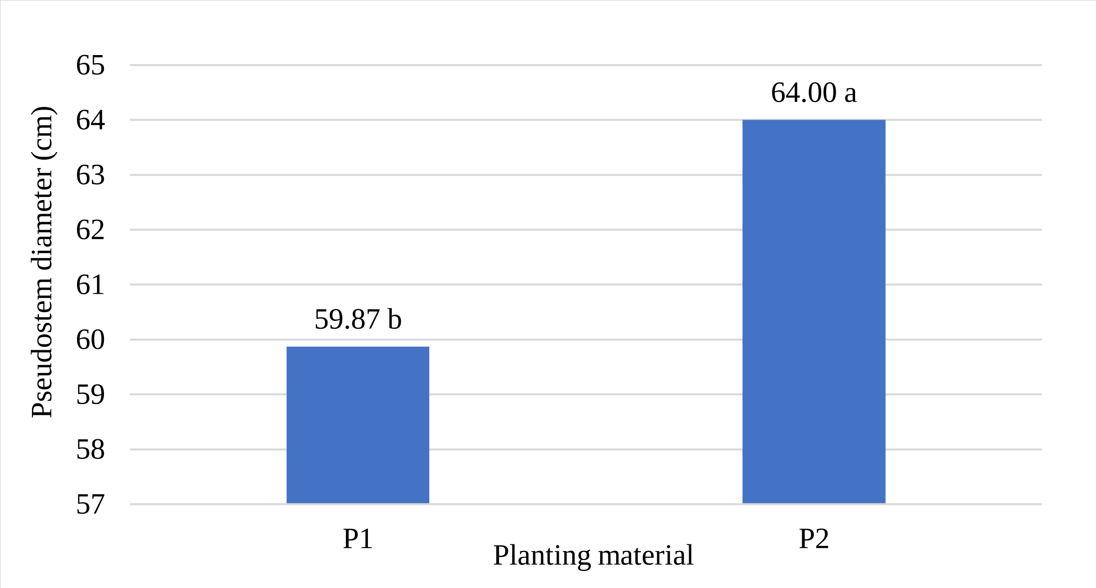

Figure 3. Effect of planting materials on pseudo-stem diameter of banana ($LSD_{0.05}$ = 1.90)

P_1 = Tissue culture plantlet, P_2 = Corm

Vermicompost treated plants had the highest pseudo-stem diameter (M_2; 68.16 cm) whereas lowest was found in NPK treated plants (M_4; 56.00 cm) (Figure 4). In this research, pseudo-stem diameter was measured during harvesting stage and vermicompost treated plants had the statistically superior pseudo-stem diameter among all other treatments. The increase in girth of pseudo-stem by the treatment with vermicompost might be due to the improvement of physical properties of soil, higher nutrients uptake and increased activity of micro-organisms which were manifested in the form of enhanced growth and higher carbohydrates production as explained by Kumar *et al.* (2008) and Hassan *et al.* (2001) in banana.

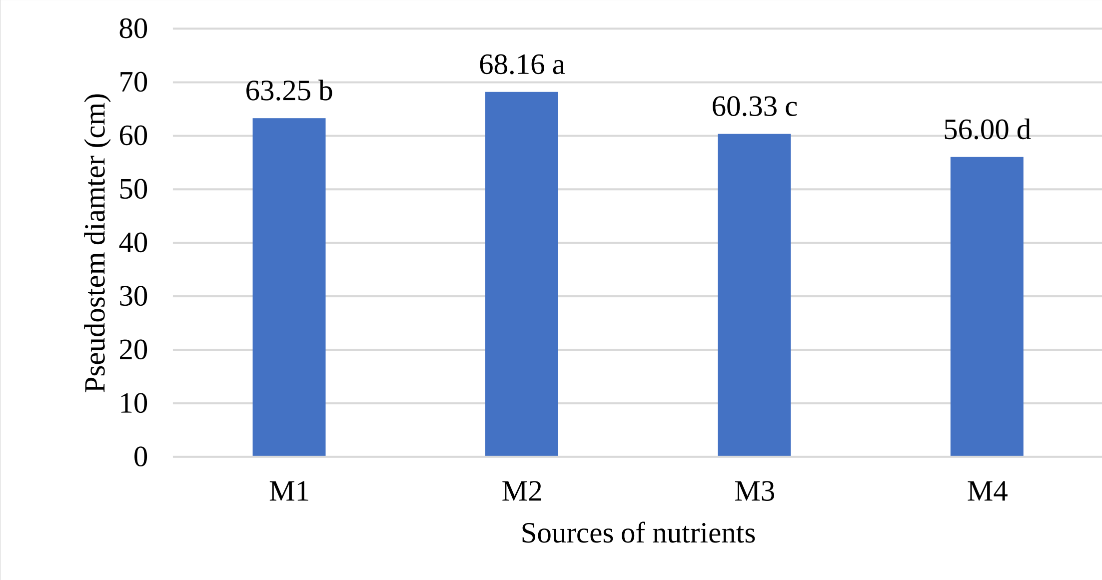

Figure 4. Effect of organic and inorganic sources of nutrients on pseudo-stem diameter of banana ($LSD_{0.05}$ = 2.69)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

Pseudo-stem diameter was varied significantly due to combined effect of planting materials and fertilizers (Appendix V). The treatment combination of P_2M_2 (71.00cm) significantly increased the pseudo-stem diameter of banana and statistically different from all other treatment combinations. The lowest was measured in P_1M_4 (55.00cm) (Table 5).

Table 5. Combined effect of planting materials and sources of nutrients on pseudo-stem diameter of banana

Treatments	Pseudo-stem diameter (cm)
P_1M_1	60.00 cd
P_1M_2	65.33 b
P_1M_3	59.16 cd
P_1M_4	55.00 e
P_2M_1	66.50 b
P_2M_2	71.00 a
P_2M_3	61.50 c
P_2M_4	57.00 de
CV%	3.51
$LSD_{0.05}$	3.80

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.5 Days to inflorescence initiation

Significant variation in respect of days taken for inflorescence initiation (visual observation) was observed between the planting materials of banana. Longest period was required for P_2 (231.0 days) whereas shortest period for P_1 (210.9 days) (Table 6). The earlier inflorescence initiation in tissue culture plants might be due to the faster development of the tissue culture plants compared with corm propagated plants reported by (Manju and Pushpalatha, 2020), would have contributed to the shorter crop cycles reported with Tissue culture plants.

Days to inflorescence initiation was significantly affected by different fertilizers (Appendix VI). Inflorescence initiation was earliest in cowdung (M_1; 216.9 days) treated plants and maximum days required for vermicompost (M_2; 226.8 days) treated plants (Table 6). Findings of Dauda (2003) who observed that each increase in cowdung manure rate significantly increased plant growth. This might be reason for taken less days for cowdung to inflorescence initiation.

Considering the combined effect of planting materials and fertilizers, it was found that minimum days were required in P_1M_1 (204.9 days) treatment combination and maximum days were required in P_2M_2 (234.9 days) treatment combination (Table 6).

4.6 Days to maturation

The maturity period, measured in number of days, from planting to physiological maturity followed the same pattern as the time of inflorescence initiation. The plants that matured earliest were those that had the shortest number of days to flowering and vice versa. Days to maturation of banana was counted from the days to inflorescence initiation of banana. Significant variation in respect of days taken for maturation was observed between the planting materials of banana (Appendix VI). Longest period was required for P_2 (154.8 days) whereas shortest period for P_1 (134.4 days) (Table 6). Shortest days required for maturation of banana for tissue culture plants due to root system, originating from juvenile rhizome tissue, and the large initial leaf area, enabled tissue culture plants to reach full assimilation potential at an earlier stage of development, with a doubling of both mean functional leaf area and total dry-mass production compared with corm propagated plants (Mulugo *et al.*, 2020)

Maturation of banana was taken minimum days in spent mushroom compost (M_3; 138.3 days) treated plants which was statistically same with M_1 (142.8 days) and M_2 (144.9 days) treatments and maximum days was required in NPK treated plants (M_4; 152.7 days) (Table 6). The rapid growth of banana on organic fertilizer treated plants resulted in early flowering and maturity. This means adequate fertilization of the soil leads to shorter growing and reproductive cycle culminating in more frequent harvesting (Mintah *et al.*, 2017).

Number of days required for maturation of banana was significantly affected by the combined effect of planting materials and fertilizers (Appendix VI). The treatment combination of P_1M_3 (117.0 days) significantly lowest the days to maturation of banana and statistically different from all other treatment combinations. The maximum days required in P_2M_4 (162.9 days) treatment (Table 6).

4.7 Length of inflorescence (cm)

The maximum inflorescence length was found in P_2 (136.8 cm) treatment whereas minimum length was found in P_1 (124.1 cm) treatment (Table 6). P_2 was significantly different from P1 treatment (Table 6). This indicates the rate of growth is more in corm propagated bananas than tissue culture plants. This agrees with the findings of Joab (2014) and Ogero (2012).

Vermicompost treated plants had the highest inflorescence length of banana (M_2; 143.2 cm) followed by M_1 (140.5 cm) treatment. The minimum length was found in M_3 (116.0 cm) treatment (Table 6). Inflorescence length might be related to the positive effect of vermicompost and microorganisms in increasing the root surface per unit of soil volume, water-use efficiency and photosynthetic activity, which directly affects the physiological processes and utilization of carbohydrates (Rahman *et al.*, 2012).

The treatment combination significantly affected the inflorescence length. 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 was significantly different from each other (Table 6).

Table 6. Effect of Planting materials and sources of nutrients and their combined effect on yield contributing parameters of banana

Treatments	Yield contributing parameters		
	Days to inflorescence initiation	Days to maturation	Length of inflorescence (cm)
Planting materials			
P_1	210.9 b	134.4 b	124.1 b
P_2	231.0 a	154.8 a	136.8 a
CV%	3.31	7.05	4.76
$LSD_{0.05}$	0.213	0.298	5.43
Fertilizers			
M_1	216.9 b	142.8 ab	140.5 a
M_2	226.8 a	144.9 ab	143.2 a
M_3	219.3ab	138.3 b	116.0 b
M_4	220.8 ab	152.7 c	122.0 b
CV%	3.31	7.05	4.76
$LSD_{0.05}$	0.302	0.421	7.68
Combined effect of planting materials and fertilizers			
P_1M_1	204.9d	141 c	137.3 bc
P_1M_2	219.0 bc	138 c	132.3 c
P_1M_3	208.8 cd	117 d	110.8 f
P_1M_4	210.9 cd	142.5 c	116.0 ef
P_2M_1	225.0 ab	144.9 bc	143.8 ab
P_2M_2	234.9 a	151.8 abc	154.0 a
P_2M_3	234.0 a	159.9 ab	121.3 de
P_2M_4	231.0 ab	162.9 a	128.1 cd
CV%	3.31	7.05	4.76
$LSD_{0.05}$	0.427	0.596	10.86

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.8 First hand to last hand length (cm)

Corm propagated banana plants had the highest length from first hand to last hand (P_2; 72.75 cm) comparing with tissue culture plants (P_1; 62.75 cm) during the experimentation (Figure 5). P_2 was significantly different from P_1 treatment. Teaolia *et al.* (2014) observed that banana bunch yield was strongly correlated with plant girth and its contribution to variation in yield. Plant girth was maximum in corm propagated plants (64.00 cm) which may be the reason for corm propagated plants had maximum length form first hand to last hand, ultimately increased yield.

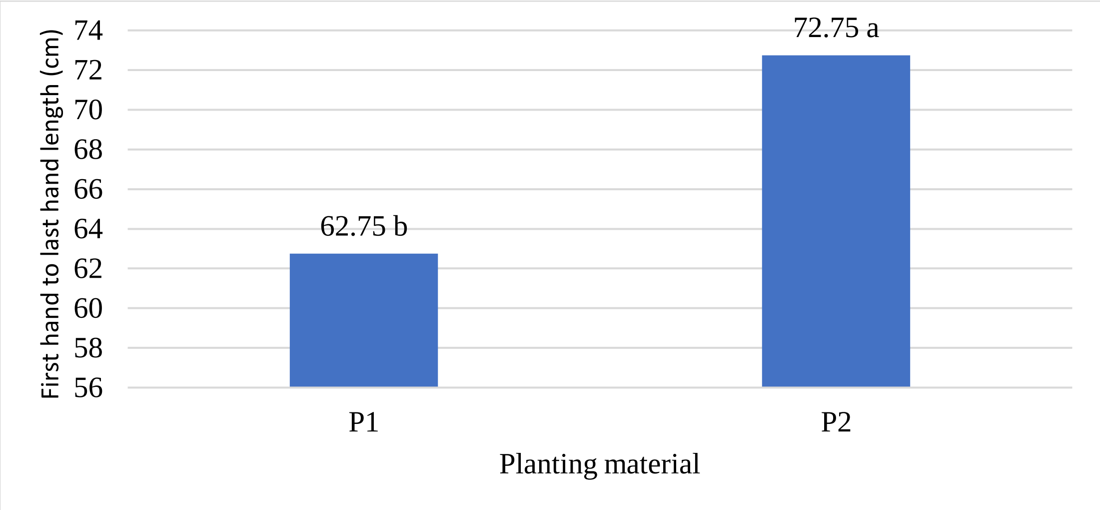

Figure 5. Effect of planting materials on first hand to last hand length (cm) of banana ($LSD_{0.05}$ = 3.63)

P_1 = Tissue culture plantlet, P_2 = Corm

Length from first hand to last hand of banana significantly affected by the fertilizers. The maximum length was found in M_2 (80.00 cm) treatment and minimum was found in M_3 (59.25 cm) treatment (Figure 6). Vermicompost is the rich source of humic acids and micro and macronutrients (Fernndez-Luqueno *et al.*, 2010). Plant-available form of nitrogen (nitrate) is greater in vermicompost. Increase in N levels, microbial activity on adding vermicompost leads to greater root expansion, which in turn leads to greater uptake of nutrients, water and rate of photosynthesis, ultimately leading to high yield (Taleshi *et al.*, 2011). Vermicompost affected positively on the length from first hand to last hand of banana.

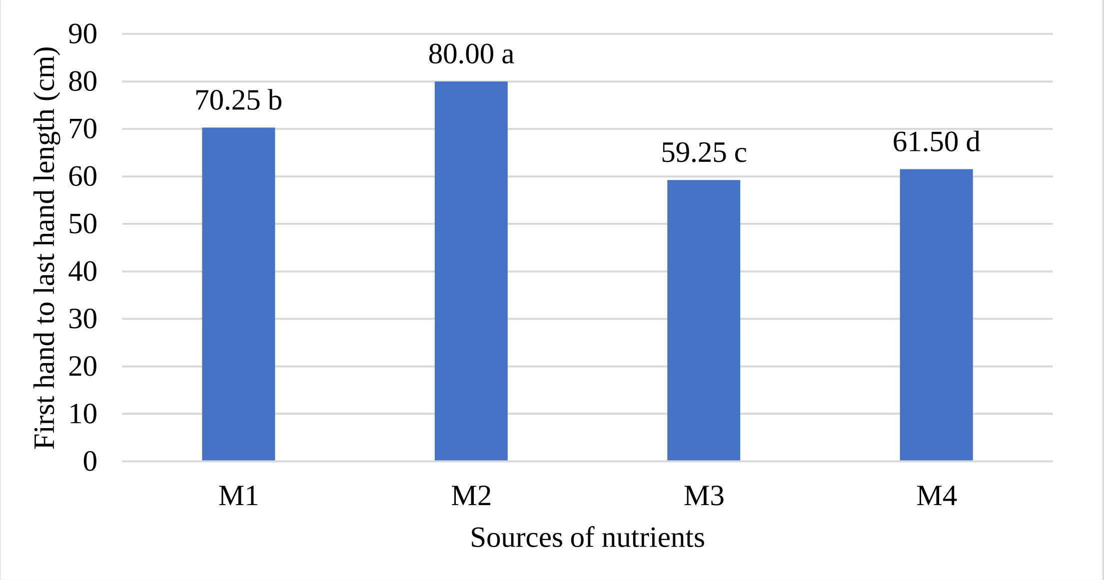

Figure 6. Effect of organic and inorganic sources of nutrients on first hand to last hand length (cm) ($LSD_{0.05}$ = 4.88)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

Combined effect of planting materials and fertilizers also exposed significant variation (Appendix VII). The highest length of first hand to last hand was measured in P_2M_2 (89.00 cm) treatment combination which was significantly superior from all other treatment combination. The minimum length from first hand to last hand was found in P_1M_3 (57.00) treatment combination (Table 7).

Table 7. Combined effect of planting materials and sources of nutrients on First hand to last hand length (cm) banana

Treatments	First hand to last hand length (cm)
P_1M_1	65.00 cd
P_1M_2	71.00 bc
P_1M_3	57.00 e
P_1M_4	58.00 e
P_2M_1	75.50 b
P_2M_2	89.00 a
P_2M_3	61.50 de
P_2M_4	65.00 cd
CV%	5.40
$LSD_{0.05}$	6.51

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.9 Total no. of hands

Maximum number of hands recorded by the treatment P_2 (8.58) which was significantly higher than P_1 (6.53) (Table 8). This might be due to corm propagated plants are more adaptable to the field conditions because they are photosynthetically active hence produce more bunch and number of hands, while tissue cultured plants are partially photosynthetic and hence are very delicate and do not establish easily under field conditions (Tenkouano *et al.*, 2006).

Among the fertilizers, vermicompost treated plants had the highest number of hands (M_2; 8.83). M_2 was significantly different from all other treatments. Lowest number of hands was counted in M_3 (6.67) treatment although it was statistically same with M_1 (7.00) (Table 8). The increase in hands number in vermicompost treatment may be attributed to increase in level of readily converted available form of essential micro & macro nutrient in the presence of either dead or live worms and offered growth mechanism in plants, resulting in increased yield parameters. Vermicompost has also beneficial effects on physical and chemical soil structure and water up take, resulting in improving plant growth and productivity. The present findings are supported with the results reported by Bohane and Tiwari (2014) in ber, Shukla *et al*. (2014) in guava, Hussain *et al*. (2015) in banana and Kundu *et al.* (2015) in Ber.

Total number of hands was significantly affected by the treatment combination. 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 (Table 8).

4.10 Total no. of fingers

Highest number of fingers was recorded by the treatment P_2 (135.3) and lowest number of fingers was found in P_1 (119.4). P_2 treatment was significantly increased total number of fingers in banana (Table 8). Undeniably the leaves produce photosynthates which are utilized to develop the reproductive parts as a site of storage for future perpetuation. In banana plant the number of leaves decides the bunch size, bunch weight and the finger characteristics (Suryanarayana *et al.,* 2018). The data revealed that corm propagated bananas had the highest number of leaves during harvesting stage hence produce more photosynthates thus increased finger number.

Among the fertilizers, vermicompost treated plants had the highest number of fingers (M_2; 140.0). M_2 was significantly different from all other treatments. The Lowest (112.8) number of fingers was counted in M_3 treatment (Table 8). The effect of vermicompost on number of fingers could be attributed to increase in N levels, microbial activity on adding vermicompost leads to greater root expansion, which in turn leads to greater uptake of nutrients, water and rate of photosynthesis, ultimately leading to increase total number of fingers (Taleshi *et al.,* 2011).

Total number of fingers varied significantly due to the combined effect of planting materials and fertilizers (Appendix VIII). The treatment combination P_2M_2 (150.7) significantly increased the total no of fingers whereas minimum hand numbers was counted in P_1M_3 (109.0) (Table 8).

4.11 Individual fruit weight (g)

It was observed from the results of the present experiment that planting material significantly differed by means of the individual fruit weight (Appendix VIII). Maximum fruit weight of banana per plant was recorded in P_1 (150.5 g) and minimum individual fruit weight was found in P_2 (140.7) (Table 8). Tissue culture plants have several leaves already present at the time of planting. Theoretically therefore, tissue culture plants have more leaf area, resulting in active photosynthetic rate and dry matter accumulation rate, ultimately increased fruit weight of bananas (Patel and Rath, 2018).

Individual fruit weight significantly affected by the fertilizers treatment (Appendix VIII). Maximum fruit weight was recorded in M_2 (152.08 g) and minimum fruit weight value was found in M_3 (130.8 g) (Table 8). Vermicompost has rich nutrient content and leading to increase uptake of NPK nutrients (Mamta *et al.,* 2012) which help the plant to get adequate food and nutrients thus may help to enhance the fruit weight.

The combined effect of planting materials and fertilizers significantly affected the individual fruit weight of banana. The treatment combination P_1M_2 (161.2 g) significantly increased weight of individual fruit whereas minimum was found in P_2M_3 (126.5 g) (Table 8).

4.12 Yield/plant (kg)

Significant variation was found on yield per plant of banana due to planting materials of banana (Table 8 and Appendix VIII). Maximum yield per plant (19.04 kg) was found from treatment P_2 and minimum yield per plant (17.97 kg) was found from P_1 (Table 8).

Yield per plant of banana significantly affected by the fertilizers treatment (Appendix VIII). Among the fertilizers, vermicompost (M_2) treated plants had maximum yield per plant (21.29 kg) whereas minimum yield per plant (16.74 kg) was found from M_3 treatment (Table 8).

Yield per plant of banana was varied significantly due to combined effect of planting materials and fertilizers (Table 8 and Appendix VIII). 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. 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.

Table 8. Effect of Planting materials and sources of nutrients and their combined effect on yield parameters of banana

Treatments	Yield parameters			
	Total number of hands	Total number of fingers	Individual fruit weight (g)	Yield/plant (kg)
Planting materials				
P_1	6.53 b	119.4 b	150.5 a	17.97 b
P_2	8.58 a	135.3 a	140.7 b	19.04 a
CV%	4.88	1.39	0.92	1.46
$LSD_{0.05}$	0.32	1.55	1.17	0.24
Fertilizers				
M_1	7.00 c	122.8 c	145.8 c	17.90 c
M_2	8.83 a	140.0 a	152.08 a	21.29 a
M_3	6.67 c	112.8 d	130.8 d	16.74 d
M_4	7.83 b	134.5 b	148.3 b	19.95 b
CV%	4.88	1.39	0.92	1.46
$LSD_{0.05}$	0.46	2.19	1.65	0.34
Combined effect of planting materials and fertilizers				
P_1M_1	6.33 de	113.7 f	149.5 c	16.99 e
P_1M_2	7.33 c	129.3 c	161.2 a	20.84 b
P_1M_3	6.00 e	109.0 f	135.2 f	14.73 f
P_1M_4	6.67 d	125.7 d	156.3 b	19.65 c
P_2M_1	7.67 c	130.7 c	142.2 de	18.58 d
P_2M_2	10.33 a	150.7 a	149.0 d	22.45 a
P_2M_3	7.33 c	116.7 e	126.5 g	14.76 f
P_2M_4	9.00 b	143.3 b	145.0 e	20.78 b
CV%	4.88	1.39	0.92	1.46
$LSD_{0.05}$	0.64	3.10	2.33	0.48

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.13 Total soluble solid (TSS %)

Total soluble solid content in fruits was higher (21.73 %) in P_2 treatment which make the fruits sweeter and more acceptable. P_2 (21.73 %) is significantly different from P_1 (20.65 %) (Figure 7). Total soluble solid was higher in corm propagated plants due to translocation and mobilization of assimilates are more in corm thereby making fruits sweeter (Kumar and Gill, 2010).

Organic and inorganic fertilizer significantly affected total soluble solid content of banana fruit. The maximum TSS content was recorded in M_2 (22.09 %). The minimum TSS was found in M_4 (19.08 %) (Figure 8). NPK was significantly different from the organic manures. The increased total soluble solid were due to the addition of different organic manures to the soil and in turn to plants, which might had enhanced the biosynthesis and translocation of carbohydrates into fruits (Athani and Hulamni, 2000).

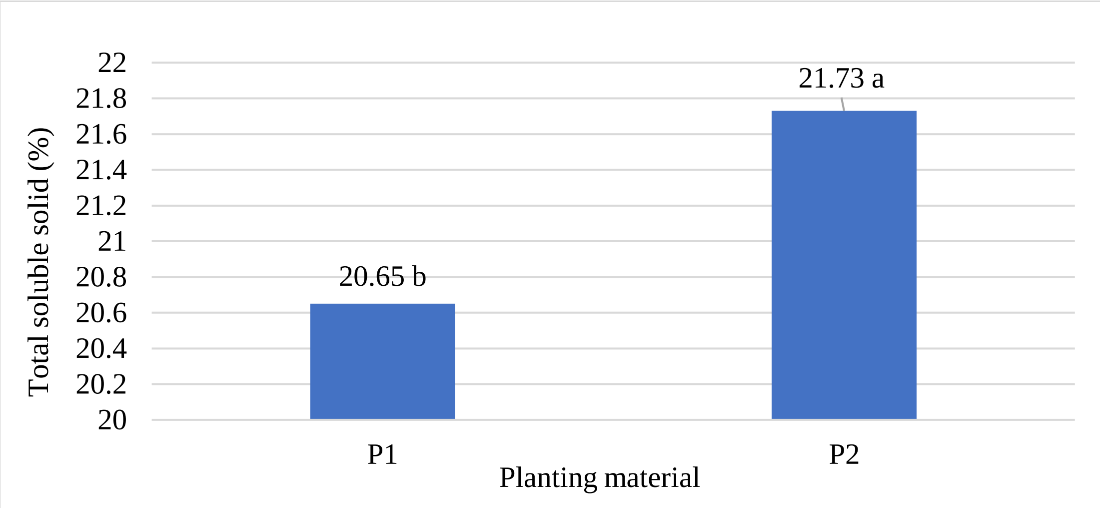

Figure 7. Effect of planting materials on total soluble solid content of banana ($LSD_{0.05}$ = 0.388)

P_1 = Tissue culture plantlet, P_2 = Corm

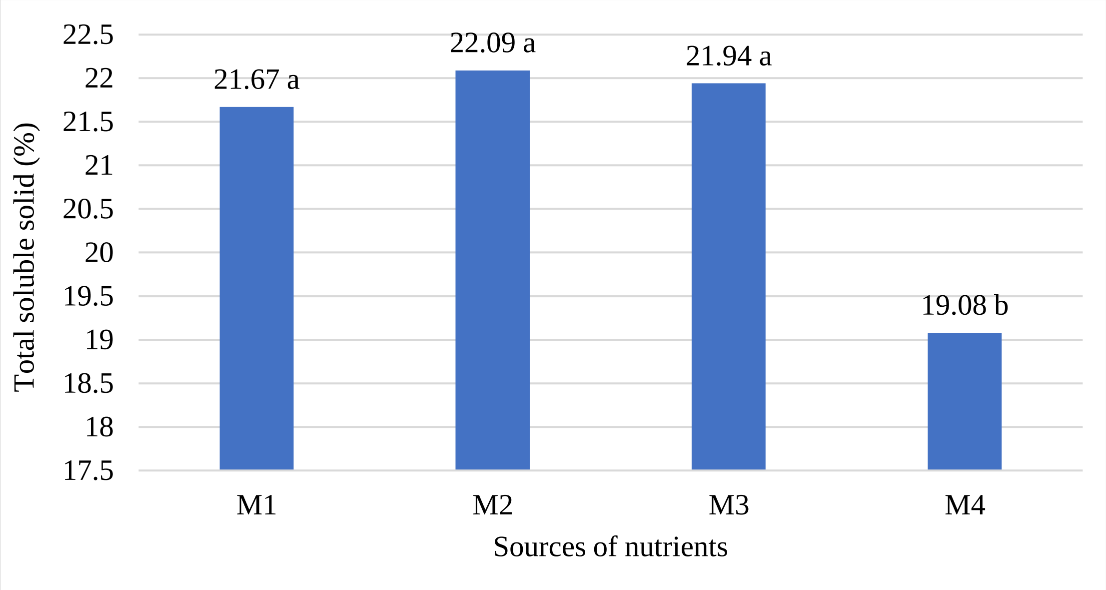

Figure 8. Effect of organic and inorganic sources of nutrients on total soluble solid content of banana ($LSD_{0.05}$ = 0.561)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

The combination of treatments in respect of TSS content of banana had significant variation (Appendix IX). 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 %) (Table 9).

Table 9. Combined effect of planting materials and sources of nutrients on total soluble solid content of banana

Treatments	Total soluble solid content (%)
P_1M_1	20.22 d
P_1M_2	21.55 c
P_1M_3	22.86 ab
P_1M_4	18.00 e
P_2M_1	22.33 b
P_2M_2	23.11 a
P_2M_3	21.33 c
P_2M_4	20.16 d
CV%	2.14
$LSD_{0.05}$	0.794

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.14 pH

Variations in pH of banana under different planting materials were observed during quality analysis of banana. The pH values under planting materials showed significant variation (Appendix IX). The highest (5.04) pH value was recorded in P_2 and lowest value was recorded in P_1 (4.82) (Figure 9). The pH has been correlated to planting material in banana (Lebrum, 2008; Hakkim *et al.*, 2012) and strawberry (ElMasry *et al.*, 2007). The high pH in corm propagated plants probably was a result of an increase in the organic acid contents in the fruits (Arvanitoyannis and Mavromatis, 2009).

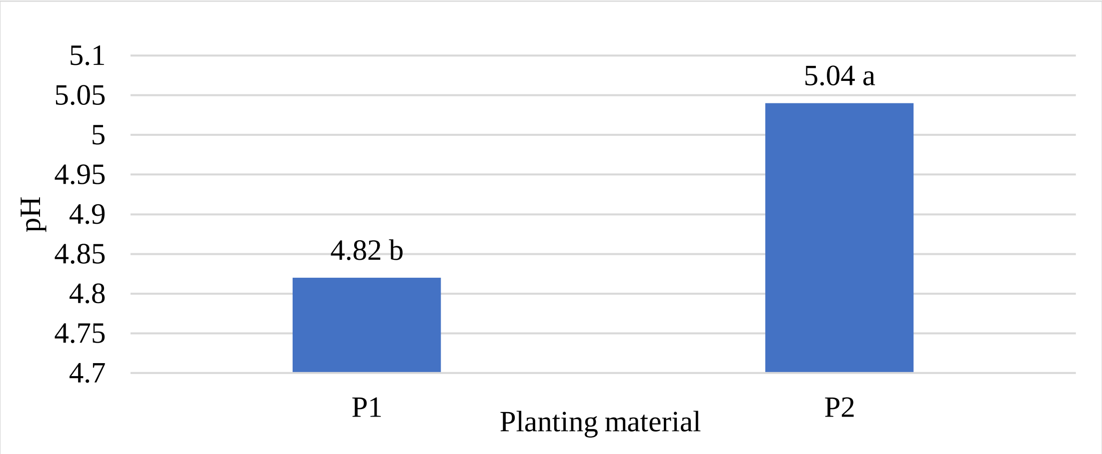

Figure 9. Effect of planting materials on pH of banana pulp ($LSD_{0.05}$ = 0.075)

P_1 = Tissue culture plantlet, P_2 = Corm

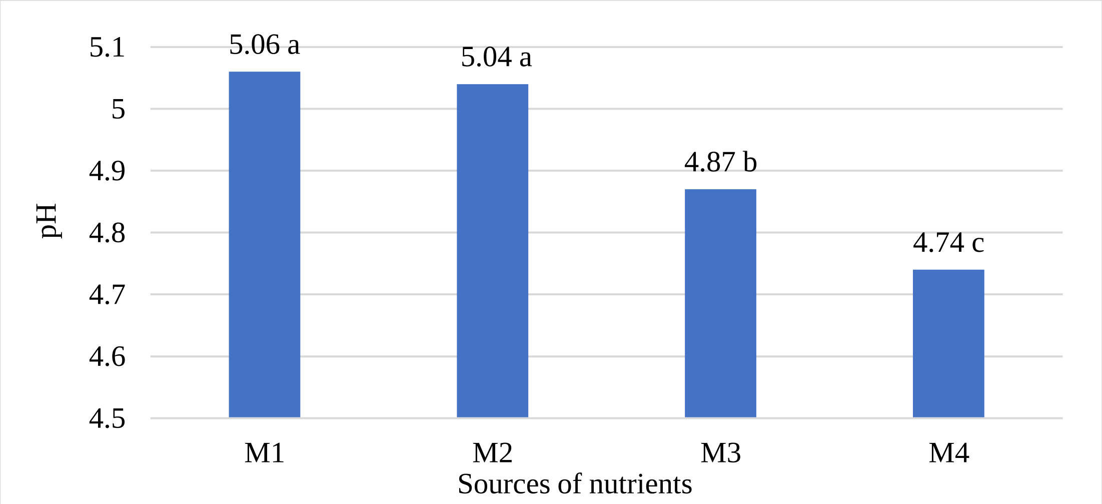

Figure 10. Effect of organic and inorganic sources of nutrients on pH of banana pulp ($LSD_{0.05}$ = 0.106)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

Among the fertilizers, cowdung treated plants had the highest pH value (M_1; 5.06) followed by M_2 (5.04) and they were statistically same. The lowest value was found in M_4 (4.74) (Figure 10). Water-soluble organic carbon was enhanced by the addition of cowdung. Qualities such as the vitamin C, pH, soluble sugar contents in fruit were significantly positively correlated with water-soluble organic carbon, indicating that banana fruit quality could be improved by adding vermicompost and cowdung (Wang *et al.*, 2017).

The treatment combination P_2M_1 (5.32) increased the pH values whereas minimum was recorded in P_1M_4 (4.62) (Table 10). P_2M_1 significantly different from the all other treatment combination.

Table 10. Combined effect of planting materials and sources of nutrients on pH of banana

Treatments	pH
P_1M_1	4.80 d
P_1M_2	5.08 b
P_1M_3	4.77 de
P_1M_4	4.62 e
P_2M_1	5.32 a
P_2M_2	5.00 bc
P_2M_3	4.98 bc
P_2M_4	4.87 cd
CV%	1.74
$LSD_{0.05}$	0.149

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.15 Titratable acidity (%)

The maximum titratable acidity was recorded in P_1 (0.62 %) and minimum was recorded for P_2 (0.52 %) (Table 11). The effect of planting materials on titratable acidity of banana fruit pulp had significant variation (Appendix IX). The reduction in acidity in corm propagated plants might be due to more accumulation of sugar in fruits. The similar results were reported by Keshavan *et al.* (2006) and Tripathi *et al.* (2014) in banana.

Organic manures had no significant variation towards titratable acidity of banana fruit pulp. However, maximum titratable acidity was recorded in NPK treated plants (M_4; 0.68 %). M_4 significantly different from organic fertilizers (Table 11). These results are in agreement with those of Hamman *et al.* (2003) as they found that plants received organic source of nutrients had lower titratable acidity compared with using NPK mineral source alone.

The combined effect of P_1M_4 (0.74 %) had the highest titratable acidity which is significantly different from all other treatments whereas minimum was recorded in P_2M_2 (0.42 %) (Table 11).

Table 11. Effect of Planting materials and sources of nutrients and their combined effect on titratable acidity of banana

Treatments	Titratable acidity (%)
Planting materials	
P_1	0.62 a
P_2	0.52 b
CV%	9.04
$LSD_{0.05}$	0.045
Fertilizers	
M_1	0.53 b
M_2	0.52 b
M_3	0.56 b
M_4	0.68 a
CV%	9.04
$LSD_{0.05}$	0.064
Combined effect of planting materials and fertilizers	
P_1M_1	0.64 b
P_1M_2	0.53 cd
P_1M_3	0.58 bcd
P_1M_4	0.74 a
P_2M_1	0.51de
P_2M_2	0.42 e
P_2M_3	0.55 cd
P_2M_4	0.62 bc
CV%	9.04
$LSD_{0.05}$	0.091

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.16 Ascorbic acid content (mg/100g)

The effect of planting materials on ascorbic acid content of banana fruit pulp had significant variation (Appendix X). The maximum ascorbic acid was recorded in P_1 (11.87 mg/100g) and minimum was recorded in P_2 (10.24 mg/100g) (Table 12). The decrease in ascorbic acid in corm propagated bananas may be due to increase in accumulation of more assimilate or total soluble solids in corm propagated bananas compared to tissue culture (Seema *et al.,* 2018).

Ascorbic acid content varied significantly among the fertilizers treatment (Appendix X). The maximum ascorbic acid content was recorded in NPK treated plants (M_4; 14.08 mg/100g) whereas minimum was recorded in M_2 (8.00 mg/100g) (Table 12). The improvement in ascorbic acid content by application of optimum dose of NPK may be explained by the fact that increase the availability of N, P and K in the soil solution. Consequently absorption would be higher and nutrient accumulation in fruits tissue increased (Shafeek *et al.,* 2015).

The combined effect of P_1M_4 (15.36 mg/100g) had the highest ascorbic acid content which was significantly different from all other treatments whereas minimum was recorded in P_2M_2 (7.68 mg/100g). P_1M_4 and P_2M_2 statistically different from each other (Table 12).

Table 12. Effect of Planting materials and sources of nutrients and their combined effect on Ascorbic acid content (mg/100g) of banana

Treatments	Ascorbic acid content (mg/100g)
Planting materials	
P_1	11.87 a
P_2	10.24 b
CV%	6.20
$LSD_{0.05}$	0.794
Fertilizers	
M_1	11.36 b
M_2	8.00 c
M_3	10.79 b
M_4	14.08 a
CV%	6.20
$LSD_{0.05}$	1.12
Combined effect of planting materials and fertilizers	
P_1M_1	12.48 b
P_1M_2	8.32 d
P_1M_3	11.34 bc
P_1M_4	15.36 a
P_2M_1	10.24 c
P_2M_2	7.68 d
P_2M_3	10.24 c
P_2M_4	12.80 b
CV%	6.20
$LSD_{0.05}$	1.58

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.17 Total sugar (%)

Total sugar content in fruits was higher (25.10 %) in P_2 treatment which make the fruits sweeter and acceptable and lower content was recorded in P_1 (22.97 %) treatment (Figure 11). There was significant variation between corm and tissue culture plants. Total sugar was significantly found changed due to different planting materials (Parmar and Vinod, 2018).

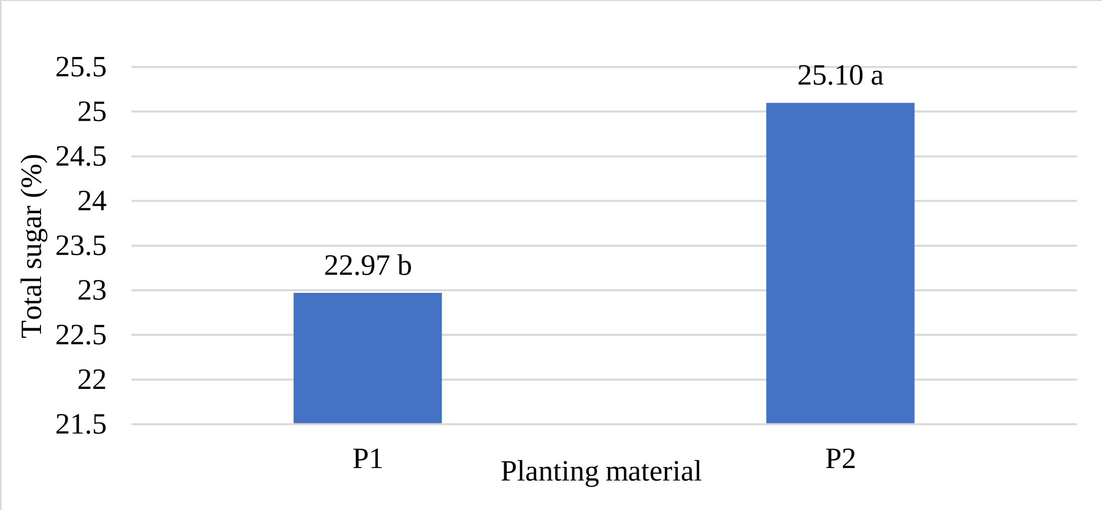

Figure 11. Effect of planting materials on total sugar (%) of banana pulp ($LSD_{0.05}$ = 0.829)

P_1 = Tissue culture plantlet, P_2 = Corm

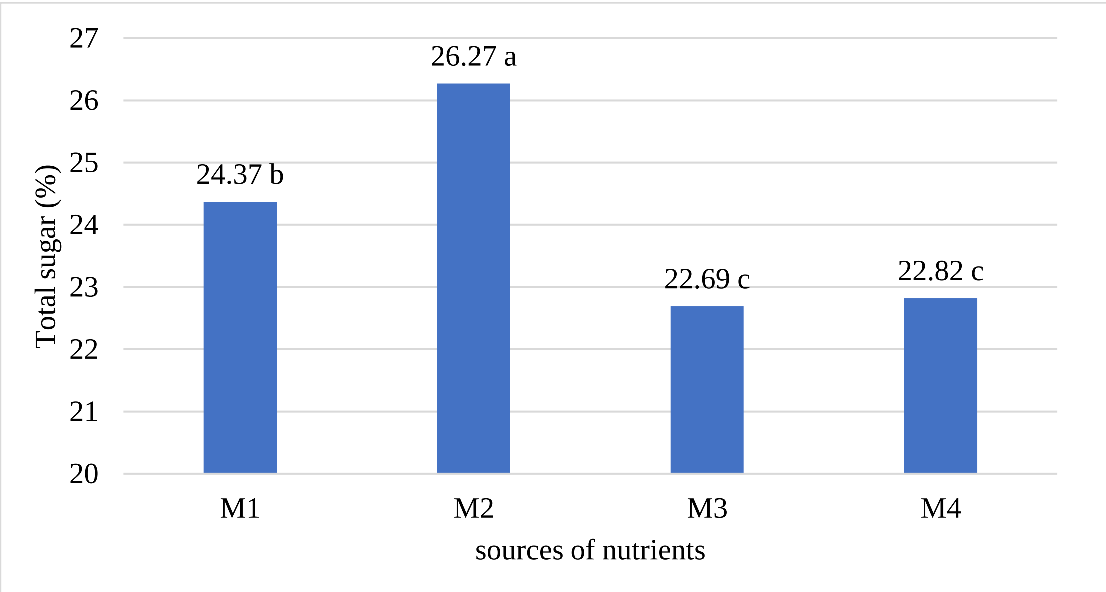

Figure 12. Effect of organic and inorganic sources of nutrients on total sugar (%) of banana pulp ($LSD_{0.05}$ = 1.17)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

Vermicompost significantly increased the total sugar content (M_2; 26.27 %). The minimum total sugar content was recorded in M_4 (22.82 %) (Figure 12). Higher fruit quality with higher sugar content could be explained due to the better role of the nutrients especially exchangeable potassium available more through vermicompost. The potassium was a major factor in the carbohydrate synthesis, break down and translocation of starch and synthesis of protein and neutralization of physiologically important organic acids (Pandey *et al.,* 2001).

The combination of treatment P_2M_2 (26.96 %) had the highest content of total sugar followed by P_1M_2 (25.58 %) and lowest total sugar content was recorded in P_1M_4 (21.24 %) (Table 13).

Table 13. Combined effect of planting materials and sources of nutrients on total sugar content of banana

Treatments	Total sugar (%)
P_1M_1	23.44 d
P_1M_2	25.58 ab
P_1M_3	21.62 e
P_1M_4	21.24 e
P_2M_1	25.30 bc
P_2M_2	26.96 a
P_2M_3	23.76 cd
P_2M_4	24.39 bcd
CV%	3.94
$LSD_{0.05}$	1.65

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.18 Reducing sugar (%)

It was observed from the results of the present experiment that reducing sugar significantly differed by means of different planting materials of banana (Appendix X). Highest reducing sugar was recorded in P_2 (15.12 %) and lowest was recorded in P_1 (13.67) (Figure 13). The differences in reducing sugars and non-reducing sugar content of banana were due to varietal differences and use of different planting materials (Venkata Subbaiah K. *et al.,* 2013).

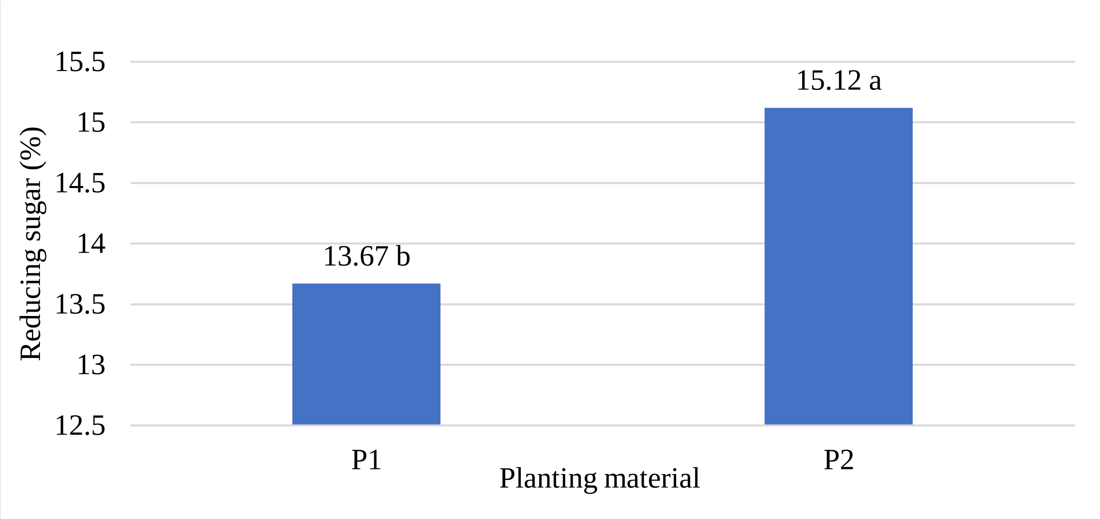

Figure 13. Effect of planting materials on reducing sugar (%) of banana pulp ($LSD_{0.05}$ = 0.305)

P_1 = Tissue culture plantlet, P_2 = Corm

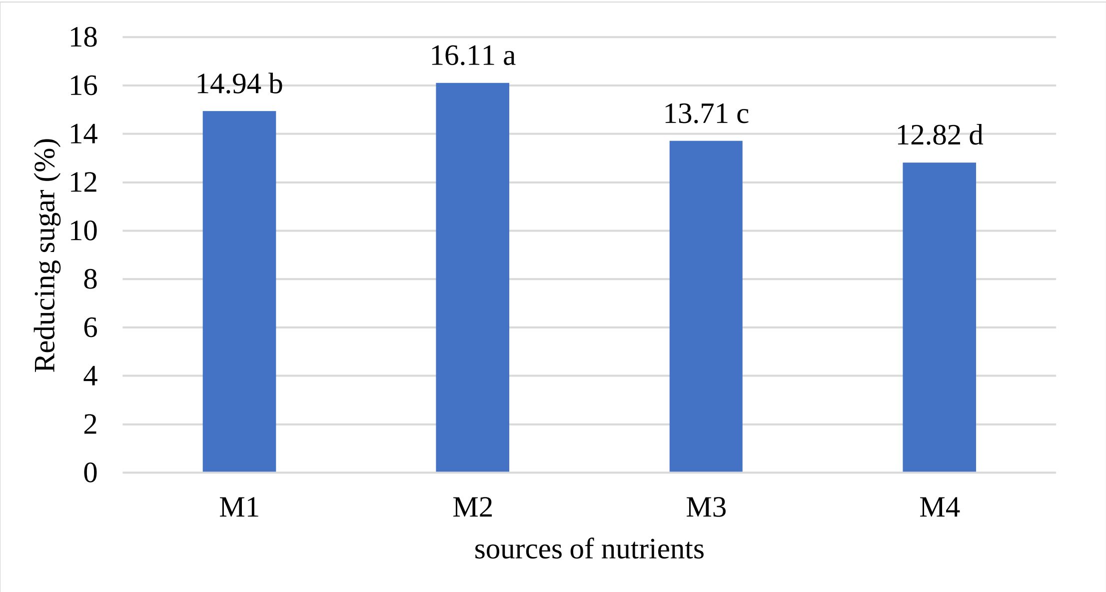

Figure 14. Effect of organic and inorganic sources of nutrients on reducing sugar (%) of banana pulp ($LSD_{0.05}$ = 0.431)

M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

Fertilizers exposed significant variation regarding the reducing sugar content of banana (Appendix X). The highest reducing sugar content was found in vermicompost treated plants (M_2; 16.11 %) and lowest was measured in NPK treated plants (M_4; 12.81 %) (Figure 14). The availability of nitrogen from vermicompost might have increased leaf area with higher synthesis of assimilates which in turn enhanced rate of photosynthesis. Such effects have been attributed to increase rate of translocation of photosynthetic products from leaves to developing fruits and thereby increasing reducing sugars in banana. These findings are in agreement with (Dey *et al.,* 2005).

The combined effect of planting materials and fertilizers had the significant effect (Appendix X). The treatment combination P_2M_2 (17.38 %) had highest reducing sugar content whereas minimum reducing sugar content was found in P_1M_4 (11.88 %) treatment combination (Table 14).

Table 14. Combined effect of planting materials and sources of nutrients on reducing sugar (%) content of banana

Treatments	Reducing sugar (%)
P_1M_1	14.85 bc
P_1M_2	14.84 bc
P_1M_3	13.10 e
P_1M_4	11.88 f
P_2M_1	15.03 b
P_2M2	17.38 a
P_2M_3	14.32 c
P_2M_4	13.74 d
CV%	2.42
$LSD_{0.05}$	0.609

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

4.19 Color measurement

Distinct variation was noted in the fruit color of banana, influenced by the planting materials and fertilizers. The higher L* value indicates the lighter color which was found in the P_1 (60.25) treatment, which was statistically different to the treatment of P_2 (55.67) (Table 15). External appearance of the fruit is strongly influenced by the color, which under a normal ripening process is mainly given by chlorophyll degradation and the appropriate carotenoid synthesis major lutein, α-carotene, and βcarotene (Wall, 2006).

The highest lightness (L) color was noted from the fruit which had been fertilized with the NPK (M_4; 64.83) fertilizer. On the other hand, the lowest external lightness was found with organic fertilizer (M_1; 50.50) treatment (Table 15). In a previous study by Crecente-Campo (2012), similar results were noted where they compared the external color brightness value of the banana fruits and reported low L values for organic and high L values for chemical fertilizer. However, in this study, the highest lightness values were obtained while chemical (NPK) fertilizer treatment.

The treatment combination had a significant effect in respect of L* values (Appendix XI). The highest L* value was found in P_1M_4 (69.00) and the lowest L* value was recorded in P_2M_1 (48.67).

The redness value a* was highest in the treatment of P_2 (10.83), whereas the lowest a* value was found in the treatment of P_1 (8.42) (Table 15).

The highest a* value was found in M_1 (10.50) although it was statistically same with M_2 and M_3. The lowest a value was found in M_4 (7.67) (Table 15).

The treatment combination P_2M_2 (12.00) had the highest a* value and P_1M_4 had the lowest a* value (6.33). P_2M_2 and P_1M_4 significantly different from each other (Table 15).

The higher b* value indicates yellow color and was found in P_1 (45.08) and the lower b* value was found in the treatment of P_2 (39.96) (Table 15).

Vermicompost treated plants had the highest b* values (M_2; 45.22) followed by M_1 (42.17) and lowest value was found in M_4 (41.04). Similar to a* values, the highest b* values were noted from the organic fertilizer treatment. Gulbag and

Ilgin (2016) similarly investigated the effects of organic and inorganic nutrients on strawberry cultivars. In that study, researchers found that the highest b* value was obtained from the 'Elsanta' cultivar treated with vermicompost, the lowest b* value was obtained from the inorganic treatments.

The treatment combination P_1M_2 (50.33) had the highest b* value followed by P_1M_1 (46.00) and P_2M_4 had the lowest b* value (38.33) (Table 14). P_1M_2 and P_2M_4 significantly different from each other.

There was a significant variation in chroma values of planting materials (Appendix XI). The higher Chroma value was found in P_1 (46.25) and the lower value was found in the treatment of P_2 (40.25) (Table 15).

Vermicompost treated plants had the highest chroma values (M_2; 45.46) indicated that vermicompost treated bananas had more brighter appearance followed by M_1 (43.83) and lowest value was found in M_4 (41.98) (Table 15).

There was significant variation among the treatment combination regarding the chroma value of banana (Appendix XI). The highest chroma value was observed in P_1M_2 (50.67) and lowest was found in P_2M_4 (40.25) (Table 15).

Table 15. Effect of Planting materials and sources of nutrients and their combined effect on peel color of banana

Treatments	Peel color			
	L	a	b	c
Planting materials				
P_1	60.25 a	8.42 b	45.08 a	46.25a
P_2	55.67 b	10.83 a	39.96 b	40.55b
CV%	3.36	7.30	6.21	5.60
$LSD_{0.05}$	1.71	0.616	2.31	2.12
Fertilizers				
M_1	50.50 d	10.50 a	42.17 ab	43.83 ab
M_2	54.50 c	10.00a	45.22 a	45.46 a
M_3	62.00 b	10.33a	41.67 b	42.33b
M_4	64.83 a	7.67 b	41.04 b	41.98b
CV%	3.36	7.30	6.21	5.60
$LSD_{0.05}$	2.41	0.87	3.26	3.01
Combined effect of planting materials and fertilizers				
P_1M_1	52.33 de	9.67 b	46.00 ab	47.33 ab
P_1M_2	58.67c	8.00 c	50.33 a	50.67 a
P_1M_3	61.00 bc	9.67b	41.33 c	43.33bc
P_1M_4	69.00 a	6.33d	42.67 bc	43.67 bc
P_2M_1	48.67 e	12.00 a	39.42 c	40.33c
P_2M_2	50.33 de	11.33 a	40.10 c	41.33c
P_2M_3	63.00 b	11.00 a	42.00 bc	43.33c
P_2M_4	60.67bc	9.00 bc	38.33 c	40.25c
CV%	3.36	7.30	6.21	5.60
$LSD_{0.05}$	3.41	1.23	4.62	4.25

Means with different letters significantly differ at 5% level of LSD.
P_1 = Tissue culture plantlet, P_2 = Corm
M_1 = Cowdung, M_2 = Vermicompost, M_3 = Spent mushroom compost, M_4 = NPK

CHAPTER V
SUMMARY AND CONCLUSIONS

5.1 Summary

An experiment was conducted at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka to study the growth, yield and quality of banana under different planting materials and organic and inorganic sources of nutrients during period from March 2020 to April 2021. Treatments of the experiment included planting materials viz. Tissue culture plantlet (P_1), Corm (P_2) and sources of nutrients viz. Cowdung (M_1), Vermicompost (M_2), Spent mushroom compost (M_3), inorganic fertilizers (M_4). The experiment was set in a Randomized Complete Block Design with 3 replications. There were 8 combinations of treatments.

Collected data were statistically analyzed for the evaluation of treatments for the detection of the best planting materials for banana, the best fertilizers and best combination regarding growth, yield and quality of banana. Summary of the results and conclusion have been described in this chapter.

Different growth characteristics of banana, maximum pseudo-stem height (174.3 cm), number of leaves (11.67), SPAD value (47.14), pseudo-stem diameter (64.00 cm) were recorded from P_2 (corm). Conversely, the minimum pseudo-stem height (163.9 cm), number of leaves (10.67), SPAD value (45.33), pseudo-stem diameter (59.87 cm) were recorded from P_1 (Tissue culture) treatment. On the other hand, observing the fertilizers treated plants, M_2 (Vermicompost) generated maximum pseudo-stem height (176.5 cm), number of leaves (12.50), SPAD value (48.07), pseudo-stem diameter (68.16cm) at harvesting stage while minimum pseudo-stem height (158.7 cm) in M_1 (Cowdung) but number of leaves (10.00), SPAD value (45.20), pseudo-stem diameter (56.00 cm) were recorded from M_4 (NPK) treatment. In combined effect of planting materials and fertilizers, P_2M_2 treatment combination generated utmost pseudo-stem height (185.2 cm), number of leaves (13.00), SPAD value (49.15), pseudo-stem diameter (71.00cm).

In banana planting materials P_1 (Tissue culture) had taken shortest days to inflorescence initiation (210.9 days) and maturation (134.4 days) while P_2 (Corm) taken longest days to inflorescence initiation (231.0) and maturation (154.8 days). Regarding fertilizers M_1 (Cowdung) had taken less time to inflorescence initiation (216.9 days) and M_3 (Spent mushroom compost) for maturation (138.4 days) while longest period from M_2 for inflorescence initiation (226.8 days) and M_4 for maturation (152.7 days). Considering combined effect P_1M_1 required minimum time for inflorescence initiation (204.9 days) and P_1M_3 for maturation (117 days) and maximum time required for P_2M_2 (234.9 days) for inflorescence initiation and P_2M_4 (162.9 days) for maturation respectively.

Maximum inflorescence length (136.8 cm), first hand to last hand length (72.75 cm), total number of hands (8.58), total number of fingers (135.3), yield/plant (19.04 kg) was found from P_2 (corm) but maximum individual fruit weight (150.5 g) was found from P_1 (Tissue culture). Minimum inflorescence length (124.1 cm), first hand to last hand length (62.75 cm), total number of hands (6.53), total number of fingers (119.4), yield/plant (17.97 kg) was found from P_1 (Tissue culture) but minimum individual fruit weight (140.7 g) was recorded in P_2 (Corm) bananas.

Considering fertilizer treatments, maximum inflorescence length (143.2 cm), first hand to last hand length (80.00 cm), total number of hands (8.83), total number of fingers (140.0), individual fruit weight (152.08 g), yield/plant (21.29 kg) was found from M_2 (vermicompost) and minimum inflorescence length (116.0 cm), first hand to last hand (59.25 cm), total number of hands (6.67), total number of finger (112.8), individual fruit weight (130.8 g), yield/plant (16.74) was found in M_3.

Regarding Combined effect of planting materials and fertilizers, maximum inflorescence length (154.0 cm), first hand to last hand length (89.00 cm), total number of hands (10.33), total number of fingers (150.7), yield/plant (22.45 kg) was found in P_2M_2 treatment combination but individual fruit weight (161.2 g) was found maximum in P_1M_2 treatment combination. Minimum inflorescence length (110.7cm), first hand to last hand length (57.00), total number of hands

(6.00), total number of fingers (109.0), yield/plant (14.73 kg) was found in P_1M_3 treatment combination and minimum individual weight (126.5 g) was found in P_2M_3 treatment combination.

Regarding planting materials on quality parameters of banana, maximum TSS (21.73 %), pH (5.04), total sugar (25.10 %), reducing sugar (15.12 %) were found in P_2 (Corm); maximum titratable acidity (0.62 %), ascorbic acid content (11.87 mg/100g) were found in P_1 (Tissue culture). Minimum TSS (20.65 %), pH (4.82), total sugar (22.97 %), reducing sugar (13.67 %) were found in P_1 (Corm); minimum titratable acidity (0.52 %), ascorbic acid content (10.24 mg/100g) were found in P_2.

Regarding fertilizers treatments, maximum TSS (22.09 %), total sugar (26.27 %), reducing sugar (16.11 %) was found in M_2 (Vermicompost) treatment and minimum TSS (19.08 %), total sugar (22.82 %), reducing sugar (12.81%) was found in M_4 (NPK). Combined effect of planting materials and fertilizers, it was found that maximum TSS (23.11%) total sugar (26.96 %), reducing sugar (17.38 %) were found in P_2M_2 while minimum TSS (18.00 %), total sugar (21.24 %), reducing sugar (11.88 %) were found in P_1M_4 treatment combinations. .

Maximum pH (5.06) was found in M_1 (cowdung) while minimum was found in M_4 (4.74). Maximum titratable acidity (0.68 %) and ascorbic acid content (14.08 mg/100g) were recorded in M_4 and minimum titatable acidity (0.52 %) and ascorbic acid content (8.00 mg/100g) was recorded in M_2 treatment.

Combined effect of planting materials and fertilizers, it was found that maximum pH (5.32) was found in P_2M_1 and minimum (4.62) in P_1M_4 treatment combination. Maximum titratable acidity (0.74 %) and ascorbic acid content (15.36 mg/100g) was recorded in P_1M_4 whereas minimum titratable acidity (0.42 %) and ascorbic acid (7.68 mg/100g) content was found in P_2M_2 treatment combination.

Effect of planting materials on color of banana, maximum L* value (60.25), b* value (45.08) and c* value (46.25) were observed in P_1 and minimum L* (55.67), b* (39.96), c* (40.55) were observed in P_2 treatment.

Fertilizers effect on color of banana, maximum L* (64.83) in M_4, b* value (45.22) and c* value (45.46) were observed in M_2 and minimum L* (50.50) in M_1 and b* value (41.04) and c* (41.98) were observed in M_4.

Combined effect of planting materials and fertilizers maximum L* (69.00) in P_1M_4, b* (50.33) and c* (50.67) in P_1M_2 were found and minimum L* (48.67) in P_2M_1, b* value (38.33) and c* value (40.25) in P_2M_4 were found.

5.2 Conclusion

Regard as the above results, it can be concluded that corm as a planting material and vermicompost as organic sources of nutrient offered the best performance for yield and quality of banana.

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APPENDICES

Appendix I: Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka

A. Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Horticulture Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairy leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not applicable

Source: Soil Resource Development Institute (SRDI)

B. Chemical properties of soil collected from the experimental site

pH	Organic Matter	N	P		S	K	Ca	Mg	Be	Cu	Fe	Zn	Mn
			Bray	Olsen									
	%		µg/g soil			mEq/100g soil			µg/g soil				
6.0	2.10	0.13	13.58	-	92.87	0.10	17.8	2.20	0.64	2.42	51.52	6.69	8.47

Source: Soil Resource Development Institute (SRDI)

Appendix II: Mean square of effect of planting materials and organic and inorganic sources of nutrients on pseudo-stem height of banana

Mean square	Degrees of freedom	Mean square of pseudo-stem height (cm)
Replication	2	0.135
Factor A	1	640.667*
Factor B	3	417.028*
AB	3	33.417*
ERROR	14	0.362

*Significant at 5 % level of significance

Appendix III: Mean square of effect of planting materials and organic and inorganic sources of nutrients on number of fresh leaves of banana

Mean square	Degrees of freedom	Mean square of number of fresh leaves
Replication	2	0.292
Factor A	1	6.000*
Factor B	3	6.333*
AB	3	0.333*
ERROR	14	0.196

*Significant at 5 % level of significance

Appendix IV: Mean square of effect of planting materials and organic and inorganic sources of nutrients on SPAD value of banana

Mean square	Degrees of freedom	Mean square of SPAD value
Replication	2	1.268
Factor A	1	19.530*
Factor B	3	10.999*
AB	3	3.232*
ERROR	14	4.397

*Significant at 5 % level of significance

Appendix V: Mean square of effect of planting materials and organic and inorganic sources of nutrients on pseudo-stem diameter of banana

Mean square	Degrees of freedom	Mean square of pseudo-stem diameter (cm)
Replication	2	2.906
Factor A	1	102.094*
Factor B	3	156.705*
AB	3	7.872*
ERROR	14	4.716

*Significant at 5 % level of significance

Appendix VI: Mean square of effect of planting materials and organic and inorganic sources of nutrients on yield contributing parameters of banana

Sources of variation	Degree of freedom	Mean square of yield contributing parameters		
		Days to inflorescence initiation	Days to maturation	Length of inflorescence (cm)
Replication	2	0.018	0.090	20.70
Factor A	1	2.734*	2.768*	964.48*
Factor B	3	0.120*	0.236*	1082.86*
AB	3	0.063*	0.456*	62.81*
Error	14	0.059	0.116	38.47

*Significant at 5 % level of significance

Appendix VII: Mean square of effect of planting materials and organic and inorganic sources of nutrients on first hand to last hand length of banana

Mean square	Degrees of freedom	Mean square of first hand to last hand length (cm)
Replication	2	2.619
Factor A	1	400.925*
Factor B	3	407.468*
AB	3	40.910*
ERROR	14	15.532

*Significant at 5 % level of significance

Appendix VIII: Mean square of effect of planting materials and organic and inorganic sources of nutrients on yield parameters of banana

Sources of variation	Degree of freedom	Mean square of yield parameters			
		Total number of hands	Total number of fingers	Individual fruit weight (g)	Yield/plant (kg)
Replication	2	2.04	26.37	7.51	2.55
Factor A	1	24.0*	1520.04*	943.76*	9.26*
Factor B	3	5.61*	897.49*	521.09*	72.23*
AB	3	1.0*	50.82*	42.87*	0.909*
Error	14	0.14	3.14	1.77	0.076

*Significant at 5 % level of significance

Appendix IX: Mean square of effect of planting materials and organic and inorganic sources of nutrients on quality parameters of banana

Sources of variation	Degree of freedom	Mean square of quality parameters		
		Total soluble solid (%)	pH	Titratable acidity (%)
Replication	2	0.172	0.019	0.002
Factor A	1	6.923*	0.295*	0.06*
Factor B	3	12.124*	0.133*	0.032*
AB	3	17.042*	0.089*	0.011*
Error	14	2.875	0.007	0.003

*Significant at 5 % level of significance

Appendix X: Mean square of effect of planting materials and organic and inorganic sources of nutrients on quality parameters of banana

Sources of variation	Degree of freedom	Mean square of quality parameters		
		Vitamin C content (mg/100g)	Total sugar (%)	Reducing sugar (%)
Replication	2	0.176	1.063	0.046
Factor A	1	16.072*	27.319*	12.486*
Factor B	3	37.290*	16.749*	12.591*
AB	3	1.245*	0.841*	1.482*
Error	14	0.822	0.898	0.121

*Significant at 5 % level of significance

Appendix XI: Mean square of effect of planting materials and organic and inorganic sources of nutrients on peel color of banana

Sources of variation	Degree of freedom	Mean square of color measurement			
		L	a	b	c
Replication	2	8.042	0.8750	3.749	3.762
Factor A	1	126.042*	35.0417*	157.278*	194.881*
Factor B	3	262.375*	10.4861*	20.612*	15.155*
AB	3	36.153*	2.1528*	34.813*	21.527*
Error	14	3.804	0.4940	6.971	5.911

*Significant at 5 % level of significance

A. Tissue culture banana

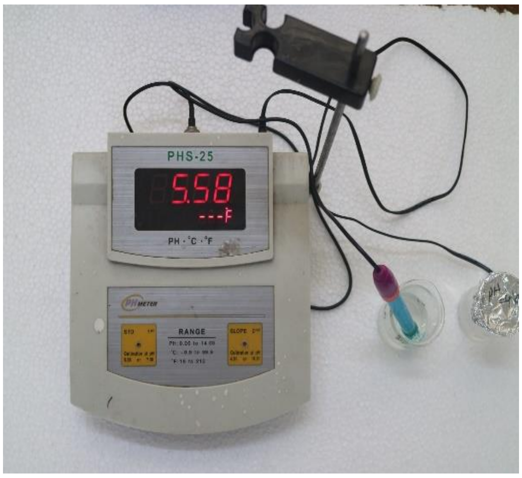
B. Corm of banana

Plate 1. Planting materials of banana (BARI kola-1)

a. Test tubes in water bath for the estimation of reducing sugar

b. Micro beakers in water bath for the estimation of total sugar

c. Spectrophotometer reading



d. Determination of pH

Plate 2. Apparatus used for chemical analysis of banana

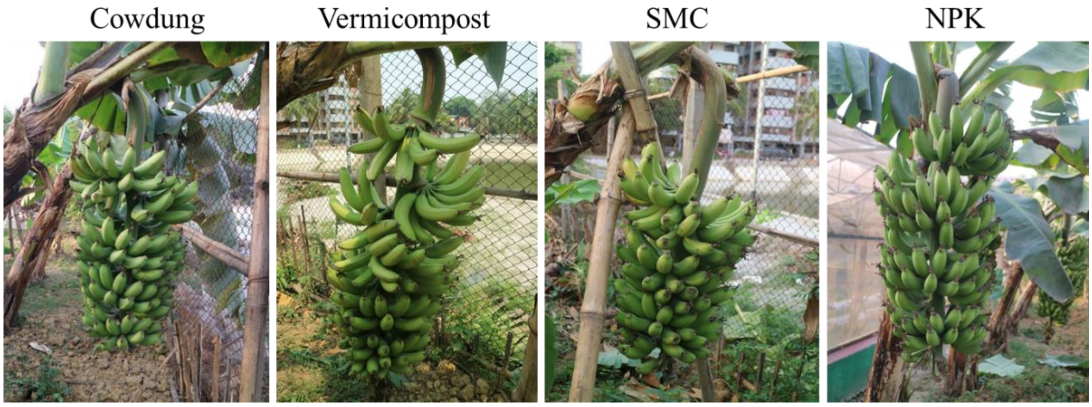


Plate 3. Banana fruits grown with corm and different fertilizers

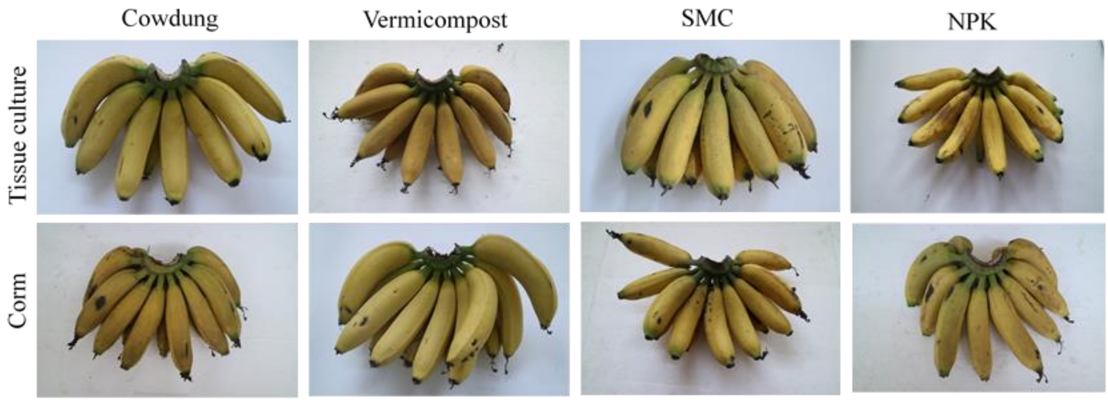


Plate 4. Skin color of banana at edible stage