SAARC J. Agric., 20(1): 157-169 (2022) *DOI*: *https://doi.org/10.3329/sja.v20i1.60609*

EFFECT OF POST-SHOOTING BUNCH SPRAY OF GROWTH HORMONE AND FERTILIZER ON YIELD ATTRIBUTING CHARACTERS OF BANANA

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ABSTRACT

An experiment was conducted at a commercial banana orchard in Chitwan to find out the best chemical to increase the yield and quality of banana during the fruit development stage. The research was laid out in a randomized complete block design (RCBD) with seven treatments and three replications. The treatment included plant growth hormones GA_3 and Naphthalene acetic acid (NAA)@50 ppm and 100 ppm each. Similarly, Sulphate of Potash (SOP) was applied @1.5% and 2%. The first spray was applied soon after the bunch had completely opened, and the second spray was applied 15 days later. The effect of these chemicals on yield and quality parameters was observed. The result revealed that the application of GA_3 @100 ppm increased the length, girth and weight of the bananas. Likewise, the highest weight of the third hand of the banana was also observed in GA_3 @100 ppm, whereas minimum physiological loss in the weight of the finger and maximum pulp to peel ratio was observed in SOP @1.5%. Analyzing all these observed parameters, GA_3 @100ppm was found to be the most suitable growth hormone to increase the overall yield while SOP @1.5% was found suitable to enhance the yield attributing characters of banana.

Keywords: GA_3, Grand Naine, NAA, Perishability, Productivity

INTRODUCTION

Banana (*Musa paradisiaca* L.) is a large herbaceous perennial plant belonging to the Musaceae family in the order Scitamineae (Sawant et al., 2018). Banana originated from the tropical region of South-East Asia and is also known as the "Apple of Paradise." It is one of the major fruit crops grown in tropical and subtropical regions. Modern edible varieties have evolved from two species i.e., *Musa acuminata* and *Musa balbisiana*, and their natural hybrids are originally found in rain forests of South-East Asia (Sawant et al., 2018). Commercial dessert cultivars (species *Musa*

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Received: 03.03.2022 *Accepted: 25.05.2022*

acuminata or the hybrid *Musa* x *paradisiaca*, a cultigen) are imported in great quantities from the tropics; they are most widely eaten in temperate regions. In Nepal, most of the commercial banana plantations are concentrated below 300 m in the Terai region (Ranjitkar et al., 2015). Cavendish gained popularity in the 1950s after the destruction of previously mass-produced cultivar i.e., Gros Michel by Panama disease. This disease is caused by the fungal pathogen *Fusarium sp.* which infects the root region. The productivity is low in Nepal, i.e., only 6.20 mt/ha because of poor management practices (MoALD, 2019). One of the challenges banana growers faces is in yield and quality due to the lack of adequate pre-harvest methods, and farmers are not able to get the size and weight of banana as expected. Among several high yielding varieties, newly introduced varietiey i.e., Grand Naine (G9), a tissue-cultured variety, is popular among commercial farmers in Nepal.

Banana needs the maximum amount of nutrients at the shooting stage, but it might not be able to uptake the required amount of nutrients from the soil due to various soil characteristics and environmental factors (Rajan et al., 2017). The lower productivity in Nepal is due to a lack of proper application of Plant Growth Hormones (PGR) and chemical fertilizers. The primary reason for lower yield is the unavailability of nutrients during shooting and fruit development. Lack of pre-harvest practices is one of the most important factors out of various factors responsible for the low yield and productivity of banana. Growth hormone GA_3 induces elongation of the pseudo stem, abscission of flower parts, increases fruit size, and delays the senescence of fruit (Sathish et al., 2021). Naphthalene acetic acid (NAA) is a plant hormone in the auxin family that plays an important role in fruit formation, abscission, cell elongation, apical dominance, photoperiodism, and geotropism (Hossain et al., 2016). Banana is a potassium-loving plant, and high potassium availability is essential at the fruiting stage. Potassium influences fruit yield in general and fruit quality in particular (Ganeshamurthy et al., 2011). The Sulphate of Potash (SOP) plays an important role in the quality attributes of banana.

Post-shooting spray as pre-harvest practice can help to increase the size and quality of banana. A better comprehension of these pre-harvest practices can help to define the most appropriate cultural practices. The experiment was proposed on the application of GA_3, NAA, and SOP to monitor the production and quality of banana fruit. Our general objective was to assess the effect of post-shooting bunch spray of different chemicals on the size, weight, and quality of banana. We intended to monitor the change in fruit yield and the beneficial effects of PGR and fertilizers on plant growth. This study will help to attain knowledge on pre-harvest hormone and nutrient management practices which will ultimately allow farmers to get better prices in the market with an increase in yield and quality. This study will also help farmers to increase perishability to make locally produced banana more acceptable to consumers.

MATERIALS AND METHODS

The research was carried out from March 2021 to June 2021. The research was conducted in an already established commercial banana orchard located at Kalika Municipality in the Chitwan district of Nepal. Geographically, the research site is located at 27°42’05"N latitude and 84°31’41"E longitude 259 meters above sea level (Fig. 1).

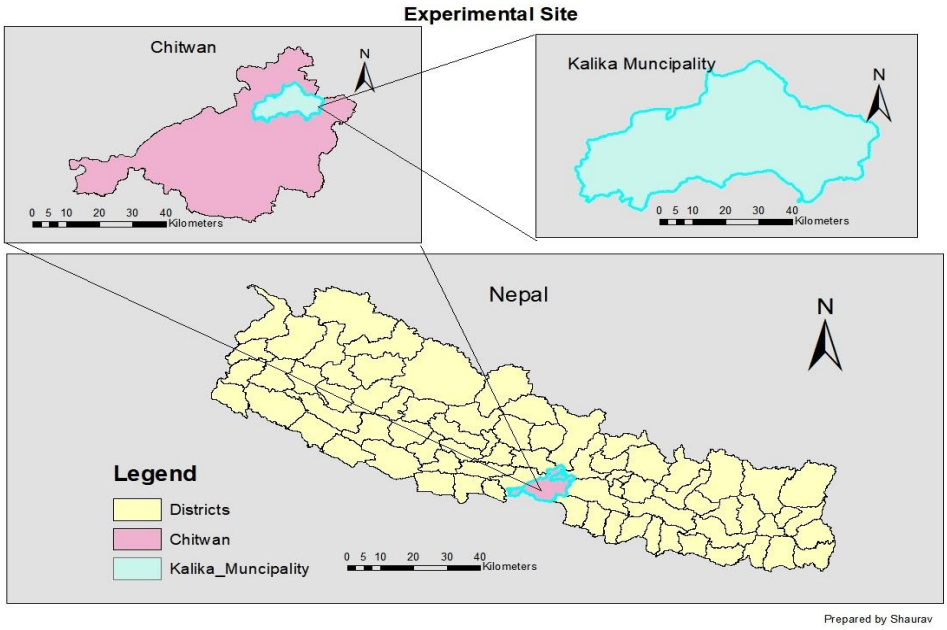

Figure 1. Map of Nepal showing Experimental Site

Climatic Condition of the site

The experimental site falls within the sub-tropical climate zone ie., the inner terai of Nepal. This place has three distinct seasons i.e., Rainy Monsoon (June-October), cool winter (November-February), and hot summer (March-May). The maximum temperature during the research occurred in April (37.87°C), while the lowest temperature occurred in March (18.74°C). Monsoon rainfall started after May and June received the highest rainfall during the research period. Relative humidity (RH) was only 24.95% in March, and it started rising after April reaching 82.33% in June.

Design of Experiment

The experiment was laid out in Randomized Complete Block Design (RCBD) with seven treatments, and each treatment was replicated thrice.

T_1 = Control
T_2 = GA_3 @50 ppm
T_3 = GA_3 @100 ppm
T_4 = NAA @50 ppm
T_5 = NAA @100 ppm
T_6 = SOP @1.5%
T_7 = SOP @2%

Variety: Grand Naine (G_9) Number of sprays: Two;
First spray: After the complete opening of bunch
Second spray: 15 days after the first spray

The variety selected for the experiment was the Grand Naine (G9) because of its better fruit quality and productivity. The banana orchard was prepared by deep ploughing, harrowing and, field levelling. At the time of planting, 60×60×60 cm^3 pits were dug out at a spacing of 2 x 1.8 m^2, and 15 kg of well decomposed Farm Yard Manure (FYM) was applied in each pit along with 350 g Urea, 240 g DAP, and 420 g MOP.

Figure 2. Grand Naine (G9) Variety in the experimental area

Planting was carried out in the second week of April 2020. Selectively, well hardened, healthy tissue culture plants of G9 variety banana plant having 5 to 6 leaves were used for planting.

Preparation of solutions

The required quantity of powder of Gibberellic acid (GA_3) and Naphthalene Acetic Acid (NAA) was weighed and added in alcohol just sufficient to dissolve the powder, and then the final volume of the stock solution was made up with distilled water. The

required quantity of sulphate of potash powder was weighed and directly dissolved in distilled water, and then the final volume of one litre was made up to get the required sulphate of potash solution. The 200 ml volume of the solution was sufficient enough for thorough wetting of the bunch (Fig. 2). The first spray was given after the complete opening of the last hand, and the second spray was applied 15 days after the first spray. Spraying was done on a bunch from all sides with the help of a hand sprayer.

Observations recorded

The finger weight was measured by weighing four fingers from the 3rd hand in grams with the help of a weighing scale and then the average was worked out. The length of the same fingers from the third hand was measured with a thread, and then the thread was measured on a scale, and finally, the average size of the fingers was expressed in centimetres. The girth of the same fingers from the third hand was measured similarly with the help of thread and the average size of the finger was expressed in centimetres. The fruits, which were used for recording the weight loss during ripening, were used to calculate peel weight as well as pulp weight. The bunches were harvested when the fruit colour changed from dark green to light green, and the ridges on the fruits disappeared. The third hand was separated from the bunch and weighed using a weighing scale. Loss in weight of fruit from the third hand was calculated based on the difference in fresh weight of the fruit at the time of harvesting and the weight of fruit at the time of ripening. The weight loss was then averaged per fruit and expressed in percentage. The fruits, used for recording the weight loss during ripening, were also used to calculate the pulp to peel ratio. It was calculated by dividing the respective pulp weight by the respective peel weight.

$$\text{Physiological loss in weight (PLW)} = \frac{\text{Weight at harvesting stage} - \text{weight at eating stage}}{\text{Weight at harvesting stage}} \times 100\%$$

Statistical analysis

The collected data was systematically arranged, compiled, and entered in MS Excel. Statistical software such as R studio v.3.6.3 and MS Excel 2016 were used for data analysis. Analysis of variance (ANOVA) and mean comparison by Duncan's Multiple Range Test (DMRT) were performed using R-studio. Mean values were considered significantly different at a 5% level of significance.

RESULTS AND DISCUSSION

The results obtained from the field experiment were undertaken to assess the effectiveness of post-shooting bunch spray of chemicals on yield attributing characters and quality of banana are presented with the help of tables and figures wherever necessary. The results were assessed and discussed with supporting evidence from past literature.

Weight of finger (g)

The analysis of variance (ANOVA) revealed that the different bunch spray of chemicals had a significant effect ($P<0.001$) on the weight of the finger (Fig. 3). In our research, the highest weight of the finger was obtained in the bunches sprayed with GA_3 @100 ppm (122.79 g) which was statistically at par with GA_3 @50 ppm (117.30g). Likewise, the weight of the finger in treatment NAA @100 ppm was 114.66 g which was at par with treatments SOP @1.5% (112.11 g), NAA @50 ppm (109.25), and SOP @2% (108.80 g). However, the lowest finger weight was obtained in the control plot (101.66 g). The bunches sprayed twice with SOP (1.5%) and sleeved with 18 blue polythene were the most profitable, having the highest gross income and net return and the best benefit-to-cost ratio (Gamit and Prajapati, 2018). GA_3, through exogenous application in the present investigation, might have kept the protein synthesis in an active state, allowing the fruit to continue growth for a longer period (Patel et al., 2011). Similar effects in bananas and Ebeed et al. (2008) in grapes and significant increase in the average weight of bananas when 1-2 month-old bunches were sprayed with GA_3.

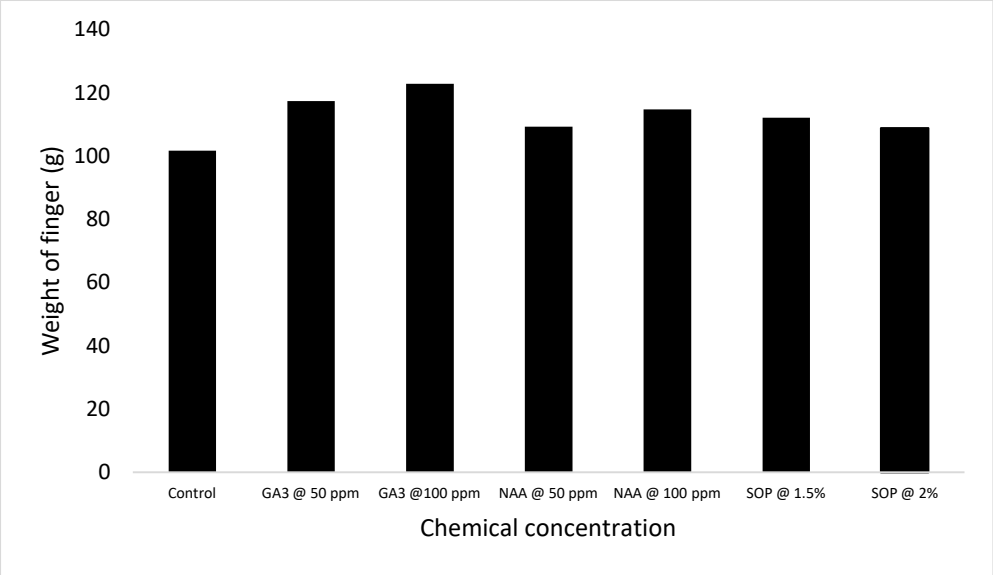

Figure 3. Weight of finger of banana as influenced by different bunch spray of chemicals

Length and girth of fingers (cm)

The banana bunches which were sprayed with different chemicals showed a highly significant difference ($P<0.01$) in the length of the finger of the banana (Table 1). The longest finger of banana was obtained in a banana bunch sprayed with GA_3 @100 ppm (22.36 cm), whereas the shortest length of the finger was obtained in

control (18.78 cm) which was statistically at par with NAA @50 ppm (18.78 cm). However, GA_3 @100 ppm treatment was statistically similar with GA_3 @50 ppm (21.56 cm), NAA @100 ppm (21.18 cm), SOP @1.5% (21.11 cm), SOP @2% (20.91 cm).

The bunches sprayed with different chemicals also showed a significant difference ($P<0.05$) in the girth of fruits. The highest girth, i.e., 12.27 cm was observed in fingers of the bunch sprayed with GA_3 @100 ppm which was statistically similar to GA_3 @50 ppm (12.27 cm). The lowest girth of the finger was observed in the control (10.13 cm) which was at par with NAA @50 ppm (10.74 cm) and NAA @100 ppm (10.86 cm) (Table 1).

Rajan et al. (2017) concluded the existence of a significant increase in berry size in all GA_3 treatments (25, 50 and, 100 ppm) in terms of girth. Fratoni et al. (2017) and Kumar et al. (2008) reported a significant increase in banana bunch treated with 1.5% SOP as it induced faster growth of fingers, length, and the girth of fingers, ultimately increasing the girth of the bunch. The shallow rooting characteristic of plant necessitates vigorous manuring at the soil surface (Senthilkumar et al., 2017). Kumar et al. (2011) observed that fruit length had been increased significantly in the treatments involving 200 ppm GA_3 spray starting from 60 days after shooting till harvest. He reported a significant increase in length, diameter, weight, and fruit yield per panicle when 15 ppm GA_3 and 6% Urea were applied in a commercial variety of mango i.e, *Kesar*.

Table 1. Length and girth of fingers of banana as influenced by different bunch spray of chemicals

Treatment	Length of finger (cm)	Girth of finger (cm)
Control	18.78^{c}	10.13^{d}
GA_3 @50 ppm	21.56^{a}	12.27^{ab}
GA_3 @100 ppm	22.36^{a}	12.40^{a}
NAA @50 ppm	19.88^{bc}	10.74^{cd}
NAA @100 ppm	21.18^{ab}	10.86^{bcd}
SOP @1.5%	21.11^{ab}	11.84^{abc}
SOP @2%	20.91^{ab}	11.57^{abc}
LSD (0.05)	1.46	1.34
SE_m (±)	0.18	0.16
F-probability	<0.01**	<0.05*
CV (%)	3.93	6.60
Grand Mean	20.83	11.40

Weight of third hand (kg)

The analysis of variance (Table 2) showed that the different bunch spray of chemicals had a significant effect on the weight of the third hand. The superiority in weight of the third hand was found in GA_3 @100 ppm (1.95 kg). The third hand's lowest weight was found in control, i.e., 1.46 kg. GA_3 brings about certain metabolic changes, which are reflected by more accumulation of food constituents in the fruit and thereby, through the increased weight of an individual berry, ultimately increased weight of the third hand. A similar effect was observed by Biswas and Lemtur (2014) when they studied the effect of GA_3 50 mg/l on a bunch of characters of banana. They observed an increase in bunch weight, bunch length as well as weight of hands in GA_3 as compared to control.

Table 2. Weight of finger of banana as influenced by different bunch spray of chemicals

Treatment	Weight of third hand (kg)
Control	1.46^{e}
GA_3 @50 ppm	1.77^{b}
GA_3 @100 ppm	1.95^{a}
NAA @50 ppm	1.55^{de}
NAA @100 ppm	1.59^{cde}
SOP @1.5%	1.71^{bc}
SOP @2%	1.66^{bcd}
LSD (0.05)	0.13
SE_m (±)	0.02
F-probability	<0.001***
CV (%)	4.29
Grand Mean	1.67

Note: SE_m, standard error of the mean; LSD, least significance difference; CV, coefficient of variation. Treatment means followed by the same letter(s) are non-significance differences on the Duncan multiple range test at 0.05 level of significance.

Pulp and peel ratio of finger

Bunch spray by different chemicals was found to be significant ($P<0.05$) in peel weight of finger (Table 3). Maximum peel weight was found in NAA @100 ppm (25.72 g), and it was statistically at par with all the treatments except control (21.41g) and SOP @1.5% (22.75 g), which has minimum peel weight. Similarly, pulp weight was also found significant ($P<0.001$) when bunches were sprayed with different chemicals (Table 4). Maximum pulp weight was obtained in GA_3 @100 ppm (70.51

g), and it was statistically at par with GA_3 @50 ppm and SOP @1.5%. However, minimum peel weight i.e., 54.28 g was obtained in control.

Table 3. ANOVA of peel and pulp weight of banana as influenced by different bunch spray of chemicals.

Peel Weight of Banana					
Source of Variation	df	Sum of Square	Mean Square	F value	Pr(>F)
Replication	2	12.394	6.1969	2.8095	0.09981
Treatments	6	45.682	7.6137	3.4519	0.03221*
Residual/Error	12	26.468	2.2057		
Pulp Weight of Banana					
Replication	2	0.22	0.112	0.0189	0.9813
Treatments	6	616.03	102.671	17.2958	2.883e-05***
Residual/Error	12	71.23	5.936		

df - Degree of freedom; "*" Significant at 0.05 level of significance; "**" Significant at 0.01level of significance; "***" Significant at 0.001 level of significance.

A highly significant difference ($P<0.01$) was found in the pulp: peel ratio when banana bunches were sprayed with different chemicals (Table 4). The highest pulp: peel ratio, i.e., 2.98, was noted in SOP 1.5%, which was at par with GA_3 @50 ppm and GA_3 @100 ppm, whereas the lowest pulp: peel ratio was noted in NAA @50 ppm (2.30), which was statistically similar to NAA @100 ppm (2.39).

Kumar and Kumar, (2007) observed similar significant effects with foliar spray of SOP @1.5% twice, initially after the opening of the last hand and 30 days later on pulp: peel ratio of banana. The high availability of potash at the finger development stage had an impact on yield and quality that supports the fruit development until harvesting. The assurance of the nutrients at this stage positively affects quality parameters. Retention of these nutrients at the fruit developing stage helps fruit bunch accumulate photosynthesis, thus contributing to fruit size, and ultimately to quality such as pulp: peel ratio. Potassium is a metabolic activator that boosts the rate of respiration and photosynthesis (Davies, 2003).

Table 4. Peel weight, Pulp weight and Pulp: Peel ratio of fingers of banana as influenced by different bunch spray of chemicals

Treatment	Peel weight (g)	Pulp weight (g)	Pulp: Peel
Control	21.41^{c}	54.28^{e}	2.53^{bc}
GA_3 @50 ppm	23.88^{abc}	68.42^{a}	2.71^{ab}
GA_3 @100 ppm	25.22^{ab}	70.51^{a}	2.82^{ab}
NAA @50 ppm	25.34^{ab}	57.96^{de}	2.30^{c}
NAA @100 ppm	25.72^{a}	61.41^{cd}	2.39^{c}
SOP @1.5%	22.75^{bc}	67.00^{ab}	2.98^{a}
SOP @2%	23.16^{abc}	63.14^{bc}	2.83^{ab}
LSD (0.05)	2.64	4.33	0.31
SE_m (±)	0.32	0.53	0.04
F-probability	<0.05*	<0.001***	<0.01**
CV (%)	6.21	3.85	6.52
Grand Mean	23.93	63.24	2.65

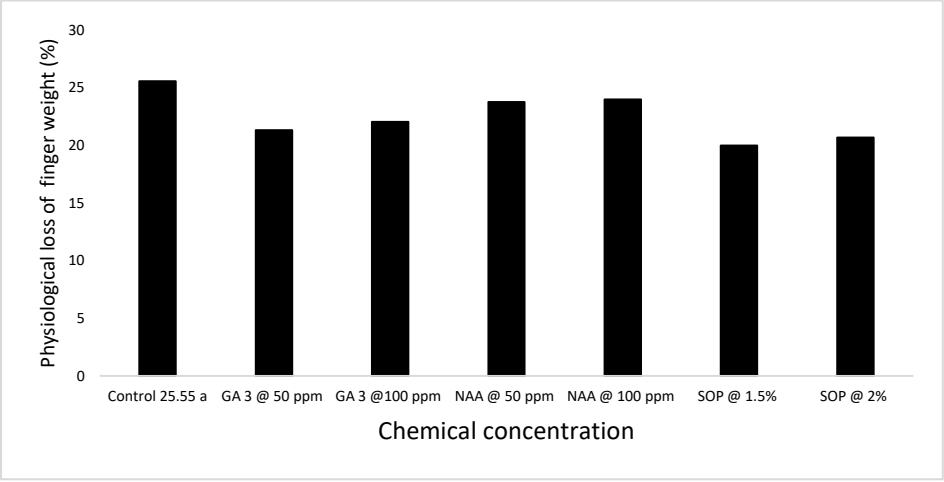

Figure 4. Physiological loss in weight of banana as influenced by different bunch spray of chemicals

Physiological loss in weight (PLW)

Different chemicals sprayed in bunches of banana show a highly significant difference ($P<0.01$) in the physiological loss in weight (Fig. 4). The minimum physiological loss in weight was recorded in SOP @1.5% (19.97%) and it was statistically at par with SOP @2%, GA_3 @100 ppm and GA_3 @50 ppm. However, the minimum physiological loss in weight was noted in Control (25.55%), which was statistically at par with NAA @100 ppm and NAA @50 ppm. The improvement regarding PLW could be possible by the synergistic relationship between Sulphur and Potassium and resulted in increased uptake of nutrients such as N, P, K and, S which enhanced dry matter content (Magray et al., 2017). Kumar and Kumar, (2008) observed that potassium application at the 1.5% level as sulphate of potash had a higher total dry matter production resulting in a lesser loss in weight during storage.

CONCLUSION

Post-shooting bunch spray significantly increased the yield and quality of banana. The use of GA_3 @100 ppm and SOP @1.5% can increase banana's overall yield and quality respectively. A significant difference in girth of the banana, the weight of the finger, finger length of banana, and pulp: peel ratio of banana was observed due to bunch spraying. Application of GA_3 @100 ppm as a bunch spray in banana was the most effective chemical to increase the yield and yield attributing characteristics of banana. Since NAA @50 ppm increased peel weight and led to minimum pulp: peel ratio, spraying of NAA was not found economically feasible.. Similarly, SOP application @1.5% was most effective to increase the quality parameters such as pulp: peel ratio and physiological loss in weight. Similarly, cultivars, starting soil fertility, production method, and agroclimatic conditions influence nutrient selection and dosage, as well as time, mode, and frequency of administration. Further investigation is needed to find out more effective chemicals to enhance the quality of banana.

ACKNOWLEDGEMENT

The research was funded by Prime Minister Agriculture Modernization Project (PMAMP). Authors are thankful Local Farmer for providing the commercial banana orchard to conduct the study.

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