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ORIGINAL RESEARCH ARTICLE

Preharvest application of ethephon improved growth, maturity and quality of banana

Bishal Shrestha[1] and Nirajan Bhandari[2*]

[1]Agriculture and Forestry University, Rampur, Chitwan, NEPAL
[2]Agriculture and Forestry University, College of Natural Resource Management, Pakhribas, Dhankuta, NEPAL
[*]Corresponding author's E-mail: iaasnirajan@gmail.com

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ABSTRACT

Poor yield, non-uniform ripening, and delay in maturity are some serious issues faced by commercial banana growers in the country. This research was conducted in a commercial banana orchard of Chitwan from December 2021 to April 2022 in order to study the effect of different doses of ethephon on growth, maturity, and quality of banana. Five different doses of ethephon (200, 400, 600, 800, 1000 ppm) were sprayed on a banana bunch at 15th days after shooting which were compared with the control (no ethephon treatment) in RCBD design. The maturity of the bunch was significantly hastened at a higher concentration of ethephon (above 600 ppm). Fruit length and fruit weight were also observed higher at 600 ppm (10.21 cm and 62.68 g) and 800 ppm (10.67 cm and 63.26 g) ethephon spray. The bunch treated with 600 ppm ethephon had the highest TSS (10.78^{o}B and 23.27^{o}B at 0 and 5 days of storage, respectively) and PPR (1.65). Considering quantitative and qualitative parameters, preharvest ethephon spray @600 ppm significantly improved growth, maturity, and quality of banana fruits.

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INTRODUCTION

Banana is a fruit crop of great significance in Nepal, both in terms of area and production. It is commercially cultivated in tropical and subtropical regions of Nepal. Banana is one of the leading fruit crops, sharing about 35% of summer fruit production and 24% of total fruit production in the country (MOALD, 2023). Banana, whether eaten raw or cooked, green, half-ripe, or ripe, is one of the significant sources of calories for the worldwide human diet (Arvanitoyannis & Mavromatis, 2009). Owing to its potential expansion in the production area, productivity, high demand condition, and a sustainable crop in terms of food security, may greatly contribute to improving livelihood of people (Ranjitkar *et al*., 2015; Alemu, 2017). However, a huge quantum (5300 tons) of fresh or dried bananas has been imported into Nepal from different countries annually (DOC, 2023). This situation primarily occurs due to lower production and productivity of banana in the country. Among different strategies, the productivity of banana can be increased with the application of plant growth regulators in the existing commercial banana orchard. The exogenous application of plant growth regulators has been shown to play a role in fruit development and quality (Kumar *et al*., 2014). Ethephon (2-chlorethylphosphonic acid), a plant growth regulator, has been shown to accelerate the growth and development of fruits and vegetables, ultimately enhancing the maturity and quality of harvested commodities (Shafiq *et al*., 2014; Jalili Marandi *et al*., 2014 and Cocco *et al*., 2022). Ethylene is popularly known for its ripening action, though, it regulates various aspects of plant life cycle including flowering, fruiting, fruit growth, and fruit development (Lin *et al*., 2009). However, the application of ethephon as a preharvest spray has not been practiced so far in the commercial production of banana in the country. Studies have shown that the preharvest application of ethephon has a positive impact on various aspects of fruit production, including flowering, fruiting, uniform maturation, ripening, and overall

fruit quality (Gill & Bal, 2010 and Duyvelshoff & Cline, 2013). The application of ethephon effectively enhances the production of endogenous ethylene, which in turn promotes early maturity and facilitates the timely harvesting of fruits (Kassem *et al*., 2011 and Marzouk & Kassem, 2011). Upon application, ethephon breaks down into ethylene, which is rapidly absorbed by plant tissues, thereby stimulating the plant to produce even more ethylene through a positive feedback loop (Petri *et al*., 2016). Orchards that employ effective management techniques, such as the use of ethephon spraying, are able to achieve early harvesting of high-quality fruits (Marzouk and Kassem, 2011; Mohammed-Al-Saif *et al*., 2017 and Cocco *et al*., 2022). Therefore, the purpose of this research was to assess the effectiveness of different concentrations of ethephon on the growth, maturity, and quality of banana fruits.

MATERIALS AND METHODS

Location and site of research

Field research was carried out at the commercial farm of Ratnanagar-13, Chitwan which is located at 27°38'38"N latitude and 84°30'36"E longitude with an altitude of 200 meters above sea level. This site was 13 km east of Bharatpur, Chitwan. The field experiment was carried out from December 2021 to April 2022.

Selection of the cultivar and the orchard

A banana variety 'Jhapali Malbhog' was selected for the research which is one of the popular varieties in the locality. A healthy commercial orchard was selected based on the previous history of production volume and sale. Sword suckers were used as planting material in the orchard.

Tagging of plants

Tagging was done on the standing crops based on the research design. A total of 120 selected plants in the field were divided into four parts lengthwise for blocking with 30 plants per block and 5 plants per plot.

Experimental design and treatment details

The research was laid out in a single factorial randomized complete block design (RCBD). The treatment of the experiment consisted of six different doses of ethephon which were replicated four times (Table 1). The plant itself was considered as a single experimental unit. There were 30 plants selected for one treatment and a total of 120 plants for the whole experiment.

Table 1. Treatment details.

Treatments	Treatment details
T1	Control
T2	200 ppm
T3	400 ppm
T4	600 ppm
T5	800 ppm
T6	1000 ppm

ppm is parts per million

Preparation and application of ethephon

Ethephon was commercially available in liquid form. Commercially available Kripon (39% SL) was used as a source of ethephon. The stock solution of 200 ppm of ethephon was prepared by dissolving 0.51 ml of ethephon in 1 L of distilled water. A similar procedure was followed to prepare the respective concentrations of ethephon. The different concentration of ethephon was applied 15 days after shooting. The ethephon was sprayed to all plants of the plot.

Intercultural operations

Various intercultural operations, such as earthing up, propping, weeding, denavelling, removal of floral remnants, and spraying of plant protection measures, were conducted. Earthing up was performed four months after planting by raising the soil level around the base of the plant by 25-30cm. Manual weeding was carried out at intervals of 25 days. Propping was done during the bunching stage as needed. The male bud was removed after the last hand of the bunch emerged. The withered floral remnants at the top of the fruits were removed after 10-15 days of bunch emergence. Plant protection measures were also practiced as necessary.

Harvesting

The harvesting time was determined based on the observation of maturity indices like the fullness of the finger and the disappearance of angle in the fingers. Based on such maturity indices, harvesting of the bunch was done on three different dates. The harvesting process involved cutting the mother plant from the middle portion when the upper part of the plant began to topple down. The bunch was handled with great care using the hand and cut out, leaving a 15 cm stalk above the first hand.

Data collection

The data collection commenced subsequent to the application of various concentrations of ethephon on banana bunches, with the primary data being recorded after harvest. Throughout the entirety of the research period, the climatic data, including temperature and relative humidity, was consistently recorded. Different parameters like days to harvest, fruit length, fruit weight, total soluble solid (TSS), and pulp to peel ratio (PPR) were measured. For simple measurements, such as fruit length and weight, a measuring scale and digital weighing balance were used. TSS was determined using a Handheld Refractometer at room temperature (20°C), with the readings expressed in degree Brix (°Brix). The TSS was measured in two stages namely, TSS (0 DAS): immediately after harvesting and TSS (5 DAS): after full ripening of fruits (5 days of storage at ambient room temperature i.e. 20 °C). The PPR was calculated by dividing the weight of pulp by the weight of peel (Mohapatra *et al*., 2016).

Statistical analysis

The collected data were compiled and entered into the MS Excel program. Analysis of variance for all parameters was carried out using the R-Studio version 4.2.3. Mean separation was carried

out using the least significant difference (LDS) at 0.05 level of significance (P < 0.05).

RESULTS AND DISCUSSION

Effect of different concentrations of ethephon on days to harvesting, fruit length, and fruit weight of banana

Ethephon is widely recognized as a potent plant growth regulator in agriculture, owing to its exceptional biological and physiological properties (Yang *et al*., 2021). It has the ability to release ethylene, which is then assimilated by fruits, resulting in enhanced growth and development (Singh and Dwivedi, 2008 and Korsak and Park, 2010). Analysis of variance showed that the different concentrations of ethephon significantly affect the number of days to harvesting, fruit length, and fruit weight of banana. Fruits treated with higher concentrations of ethephon were found to be harvested earlier. The fruits treated with ethephon 600 ppm (102.61 days), 800 ppm (100.27), and 1000 ppm (100.23 days) were statistically similar for days to harvesting. In contrast, fruits that did not receive any ethephon treatment (control) had a delayed harvesting time of 116.00 days. Furthermore, the fruits treated with ethephon at a concentration of 400 ppm exhibited the highest fruit length of 10.93 cm, which was statistically at par with ethephon 600 ppm (10.21 cm) and ethephon 800 ppm (10.67 cm). The control fruits had the lowest fruit length of 8.18 cm. The highest fruit weight was observed in the fruits treated with ethephon 800 ppm (63.26 g) which was statistically similar to ethephon 600 ppm (62.68 g). The lowest fruit weight was observed in the fruits without ethephon treatment (40.26 g) (Table 2).

It is well understood that the ethephon has crucial role in regulating maturity, yield, and quality of fruits (Whale *et al*., 2008; Mahajan *et al*., 2010 and Shafiq *et al*., 2014). The application of ethephon spray before harvest increases the ethylene content in the fruit, thereby accelerating maturation and ripening and facilitating early harvesting (Amiri *et al*., 2010; Marzouk & Kassem, 2011 and Hussain *et al*., 2015). Our study also yielded similar results, as higher doses of ethephon shortened the maturity and harvesting time, likely due to its impact on internal ethylene production and other physiological processes (Lieberman, 1979 and El-Kereamy *et al*., 2000). This finding aligns with the findings of Marzouk & Kassem (2011), who reported harvesting 15-17 days earlier than the control group. Our study demonstrated that the application of ethephon within specific concentrations (400 to 800 ppm) improved the growth of banana fingers, but at 1000 ppm, both fruit length and weight were significantly reduced. The increase in yield observed at specific concentrations of ethephon application was attributed to an increase in finger and bunch weight in our study. Ethephon treatment regulates the transition of fruit from cell division to cell expansion, resulting in increased size and weight (Atta-Aly *et al*., 1999). A similar result was reported by Mohammed-Al-Saif *et al*. (2017) at high concentrations of ethephon.

Effect of different concentrations of ethephon on total soluble solid content and pulp to peel ratio

The results indicated that the effect of varying concentrations of ethephon on the total soluble solid content and pulp to peel ratio was found to be significant (Table 3). The fruits treated with ethephon 600 ppm exhibited the highest total soluble solid content, measuring 10.78°B at day 0 and 23.27°B at day 5 of storage. Conversely, the fruits treated with ethephon 200 ppm and the control group displayed the lowest total soluble solid content, measuring 7.78°B and 16.41°B at day 0 and day 5 of storage, respectively. The highest total soluble solid content observed at 600 ppm may be attributed to an increase in sugar content during ripening, which depends on the hydrolysis of starch into sugar or ripening initiated by an optimal dose of ethylene application. Hussain *et al*. (2015) and Whale *et al*. (2008) also reported maximum TSS content with the application of an optimum dose of ethephon. Additionally, the fruits treated with ethephon 600 ppm demonstrated the highest pulp to peel ratio, measuring 1.65, which was statistically similar to the ratios observed in the fruits treated with ethephon 200 ppm (1.64) and ethephon 400 ppm (1.63). The highest pulp to peel ratio observed in the fruits treated with ethephon 600 ppm might be correlated with the sugar content in the fruits. A rise in sugar content within the pulp may facilitate osmotic transfer from pulp to peel, enabling water to shift from the peel to the pulp (Mohapatra *et al*., 2016).

Table 2. Effect of different concentrations of ethephon on days to harvesting, fruit length, and fruit weight of banana.

Treatments	Days to harvesting	Fruit length (cm)	Fruit weight (g)
Control (No Ethephon)	116.00^{a}	8.18^{c}	40.26^{d}
Ethephon (200 ppm)	111.54^{b}	10.10^{ab}	49.87^{c}
Ethephon (400 ppm)	106.92^{c}	10.93^{a}	57.90^{b}
Ethephon (600 ppm)	102.61^{d}	10.21^{a}	62.68^{a}
Ethephon (800 ppm)	100.27^{d}	10.67^{a}	63.26^{a}
Ethephon (1000 ppm)	100.23^{d}	9.36^{b}	57.46^{b}
LSD	4.01**	0.80**	3.71**
CV (%)	2.50	5.37	4.46

Means separation in column followed by the same letters are not significantly different at p=0.05, **= highly significant, LSD = Least Significant Difference, CV = Coefficient of Variation, ppm = parts per million.

Table 3. Effect of different concentrations of ethephon on total soluble solid content and pulp to peel ratio.

Treatments	TSS (0 DAS) (°B)	TSS (5 DAS) (°B)	PPR
Control (No Ethephon)	8.65^{bc}	16.41^{b}	1.49^{b}
Ethephon (200 ppm)	7.78^{c}	18.75^{b}	1.64^{a}
Ethephon (400 ppm)	9.77^{ab}	20.03^{ab}	1.63^{a}
Ethephon (600 ppm)	10.78^{a}	23.27^{a}	1.65^{a}
Ethephon (800 ppm)	8.83^{bc}	19.62^{b}	1.45^{b}
Ethephon (1000 ppm)	8.47^{bc}	17.66^{b}	1.43^{b}
LSD	1.62*	3.37*	0.06**
CV (%)	11.93	11.60	2.89

Means separation in column followed by the same letters are not significantly different at p=0.05, *= significant, **= highly significant, DAS = Days after storage, LSD = Least Significant Difference, CV = Coefficient of Variation, ppm = parts per million.

Conclusion

In conclusion, preharvest application of ethephon at an early stage of bunch initiation significantly enhanced the growth, maturity, and quality of banana fruits. Ethephon spray could be a prime option for early and uniform harvest of banana to meet the demand of fresh banana in the market. Considering harvesting time, weight of finger, and other qualitative parameters, ethephon @600 ppm could be suggested for commercial banana producing farmers.

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Authors contribution

Conceptualization, BS and NB; Methodology, BS and NB; Investigation, BS; Data analysis, BS; Writing-original draft preparation, NB; Writing-review and editing, BS and NB. All authors have read and agreed to the published version of the manuscript.

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