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Role of Ethrel, Polythene Bags and $KMnO_4$ on Storage Life of Banana cv. Grand Naine

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Authors' contributions

This work was carried out in collaboration between both authors. Author MK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AK managed the analyses of the study. Authors MK and AK managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Banana is an important fruit crop with high productivity. "GRAND NAINE' variety of banana has been popularized because of high yield potential with quality fruits. Post harvest life of banana fruit is short for its perishable and climacteric nature. Various physico-chemical changes occur during ripening. A research study was carried out in the laboratory of the Department of Horticulture, Khalsa College, Amritsar during 2016-2017 to study the effect of ethrel, polythene bags and KMnO4 on storage life of banana cv. Grand Naine. The experiment comprised of seven postharvest treatments viz., ethrel 300 ppm, ethrel 400 ppm, ethrel 600 ppm, perforated polythene bags, unperforated polythene bags, unperforated polythene bags with KMnO4 and control. Results revealed that Among all the treatments, KMnO4 treated banana showed minimum (2.3%) total weight loss at 8th day of storage. The highest fruit color (7), pulp to peel ratio (2.41%), fruit taste (9.10), moisture content in pulp (76.60%), total soluble solids (21.97%), total sugars (18.09%) and reducing sugars (12.10%) were observed in the treatment of ethrel 600 ppm.

Keywords: Climacteric; ethrel; unperforated polythene bags; ripening; pulp to peel ratio; grand naine.

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1. INTRODUCTION

Banana (*Musa* sp.) is one of the ancient fruit of the world belonging to the family Musaceae. It is also known as apple of the paradise and is the tallest of the herbaceous plants with pseudostem [1]. It is indigenous to the tropical regions of South –East Asia [2]. It is cultivated on a commercial scale in India, China, Phillipines, Mexico and Columbia. It is equally liked by all age group of people because of its digestibility and palatability. From nutritional point of view, it has high calorific and nutritional values. It contains carbohydrates, crude fiber, proteins, fat, ash, phosphorous, iron, β- carotene, riboflavin, niacin and ascorbic acid [3]. Grand Naine is a popular variety grown mostly in all the export oriented countries of Asia, South America and Africa. This is a superior selection of Giant Cavendish variety Due to several desirable traits like excellent fruit quality and resistance to *Fusarium wilt* it has proved a better variety. This variety has high productivity [4]. Banana is a climacteric fruit showing an increase in respiration rate resulting in development of color, flavor and aroma. Ripening appears to be a co-ordinated process of biochemical differentiation, metabolic reorganization leading to enhanced ethylene, RNA and protein synthesis and increased respiratory activity in climacteric fruits. Banana is harvested mature but in unripe condition and is subsequently allowed to ripen further. In natural conditions, banana ripen slowly, leading to high weight loss, desiccation, uneven ripening and failure to develop good color and aroma. Therefore to reduce the post harvest losses bananas are harvested green and are normally artificially ripened with the use of ripening agents [5]. These include ethylene gas, ethephon, ethrel which helps in early and uniform ripening of banana fruits with good color development and taste. Ethrel treatment of fruits results in high marketable fruit, minimum spoilage percentage and higher peel : pulp ratio [6]. Packaged banana fruits results in more marketable fruits in more number of days as compared to the controlled ones. However, to further boost the production of this crop, adequate ripening technology needs a great attention [7].

2. MATERIALS AND METHODS

The investigation entitled effect of various post harvest treatments on ripening and shelf life of banana cv. Grand Naine was conducted at the laboratory of department of horticulture Khalsa College, Amritsar, during February 2017. The material used for the present experiment were freshly harvested mature banana bunches of cv. Grand Naine. The bananas used in the experiment were collected from the private orchard of Mewa Singh of village Kulaar, Ludhiana. The experiment was conducted in Completely Randomized Design with three replications and 7 treatments viz. T_1 : Ethrel 300 ppm (3 minutes dip), T_2 : Ethrel 400 ppm (3 minutes dip), T_3 : Ethrel 600 ppm (3 minutes dip), T_4 : Perforated plastic cover, T_5 : Unperforated plastic cover, T_6 : Unperforated plastic cover with $KMnO_4$, T_7 : Control. After the application of treatments, the fruits were kept on newspapers on the laboratory table at room temperature. Under control the fruits were simply dipped in distilled water. Each treatment comprised of 20 fingers. Physical and bio-chemical analysis of treated fruits was carried out at two days interval with consideration of the following.

2.1 Fruit Firmness

Pulp firmness of banana was determined by cutting the cross section of fruits [8]. The fruits were prepared by cutting reversely at the midpoint consisting 1 cm of fruit tissue and the force was applied using penetrometer to penetrate the tissue with constant depth .The penetrometer reading was noted in terms of kg/cm^2.

2.2 Physiological Loss in Weight

The weight of the fruits under study was taken with an analytical balance and kept for storage. Per cent total weight was again calculated after two days of storage. The loss in weight was calculated as:

Physiological loss in weight (PLW) = (Initial weight- Final weight / Initial weight) x 100

2.3 Fruit Taste

The panel of five judges from the Department of Food Science and Technology, Khalsa College, Amritsar scored the quality characteristics of each sample on nine point Hedonic scale. The product with an overall score of 5 or above was considered acceptable [9]. The scale is as follows:

Score	Acceptability
9	Extremely digestible
8	Very much digestible

7	Moderately digestible
6	Slightly digestible
5	Neither digestible
4	nor digestible
3	Slightly undigestible
2	Moderately undigestible
1	Very much undigestible
0	Extremely undigestible

2.4 Pulp to Peel Ratio

The fruits were peeled at intervals of 2,4,6 and 8 days of storage. After separation of peel from pulp, the peel and pulp were weighed separately with an electric balance and pulp to peel ratio was calculated.

2.5 Fruit Color

Changes in the skin colour of the fruits were recorded during storage by matching pericarp colors with standard Munsell's color chart.

2.6 Total Soluble Solids (%)

The pulp of ripened fruits under study was strained through a muslin cloth. Total soluble solids of strained pulp extract were determined with the help of Bausch and Lomb hand refractrometer with subsequent corrections made with the help of temperature correction chart at 20°C room temperature [10].

2.7 Moisture Content of Pulp (%)

Five fingers of banana pulp were weighed and placed in a petridish which was placed in an electric oven at 80°C for 72 hours until the weight became constant. It was then cooled and weighed again. Finally, the per cent moisture content of banana pulp was calculated using the following formula:

Percent moisture = (IW-FW / IW) x 100

IW= Initial weight of pulp
FW= Final weight of the pulp

2.8 Titratable Acidity (%)

Titratable acidity was estimated by titrating a known volume of fruit juice against N/10 NaOH solution using 0.1 per cent phenolphthalein solution as an indicator and the end point was determined by the appearance of permanent pink color [10]. The following formula was applied for calculating the acidity and the results were expressed as percentage of malic acid.

Acidity (%) = [0.0067×0.1N NaOH used (ml) / Juice taken (ml) x 100]

2.9 Total Sugars (%)

The total sugars were determined by the method given by [10]. To the 10 ml of juice, 1 g of lead acetate was added and kept for half an hour. Then 1 g of potassium oxalate was added and the volume was made to 100 ml. The solution was then filtered and this filtrate was taken in a burette. 25 ml of filtrate was taken in to 100 ml measuring flask and 25 ml of distilled water and then 5 ml of HCL (60% by volume) was added to it. It was left overnight for 24 hours at room temperature for acid hydrolysis followed by neutralization of excess acid with 10 per cent NaOH in the initial stage and with 0.1 N NaOH near the neutralization point. Subsequently the solution titrated against boiling standard Fehling solution by using methylene blue as an indicator. The results were expressed in percentage of sugars.

$$\text{Total sugars (\%)} = \text{Fehling factor} \times \frac{\text{Stock Solution}}{\text{Weight of Sample}} \times \frac{\text{Second Stock Solution}}{\text{Vol. of filtrate taken x Vol. of filtrate used}} \times 100$$

$$= 0.05 \times \frac{100}{10} \times \frac{100}{25 \times A} \times 100$$

2.10 Reducing Sugars (%)

The reducing sugars were determined by the method given by [10]. To the 10 ml of juice, 1 g of lead acetate was added and kept for half an hour. Then 1 g potassium oxalate was added and volume was made 100 ml. The solution was then filtered and this filtrate was taken in a burette. 5 ml of each Fehling's solution A and B was pipette out in a flask and kept on hot plate and was titrated with the

filtrate. 3-4 drops of methylene blue indicator were added to a solution in a flask before titrating. Titration was then started and continued till appearance of permanent brick red color and volume of the filtrate was noted as A. Reducing sugars were calculated by using the following formula.

$$\text{Reducing Sugar (\%)} = \text{Fehling factor} \times \frac{\text{Stock Solution}}{\text{Weight of Sample x Vol. of filtrate used}} \times 100$$

$$= 0.05 \times \frac{100}{10 \times A} \times 100$$

2.11 Non-reducing Sugars (%)

Non-reducing sugars were calculated by subtracting reducing sugars from total sugars and multiplied with 0.5 [10].

2.12 Starch Content (%)

Starch content was determined according to the method of [11].

Reagents

1) 1 N Acetic acid: it was prepared by adding 30 ml of glacial acetic acid to 500 ml of water.
2) 1 N $CaCL_2$: it was prepared by dissolving 27.5 g of anhydrous $CaCL_2$ in water and diluting to 500 ml.
3) 1% Silver nitrate: it was prepared by dissolving 1 g of $AgNO_3$ in 100 ml of water.

Procedure

(a) Preparation of sample: About 50 g of blended sample was taken into a 1000 ml beaker, with 400 ml of 0.05 N HCL. Then it is placed in water bath at 80-90°C for 2 hours replacing the water lost by evaporation. It was then cooled and transferred to 500 ml volumetric flask and the volume made up with water and filtered.

(b) Estimation: To 50 ml of the filtrate, 50 ml of distilled water and 5 ml of 1N NaOH was added and kept overnight. Next day, 25 ml of acetic acid and 12.5 ml 1N calcium chloride solution were added with stirring. After an hour it was boiled for a minute and filtered through oven dried, previously weighed whatman filter paper no. 41. The precipitates were washed with distilled water until they were free from chloride, (tested with 1 per cent silver nitrate solution). The precipitates were then dried at 100°C overnight, cooled in a desiccator, weighed and per cent calcium pectate was calculated.

Calculation

% calcium pectate = (Wt. of calcium pectate × Vol. made up / Vol. of filtrate taken × Wt. of sample taken) x 100

3. RESULTS AND DISCUSSION

A significant variation was observed in the firmness of banana fruits that received different post harvest treatments (Table 1). The results showed reduction in fruit firmness steadily over a period of 8 days. After 6 days of storage fruits treated with ethrel 600 ppm were the least firm (6.53 kg/cm^2). Inclusion of $KMnO_4$ in the bags showed improvement in fruit firmness. Maximum firmness (7.48 kg/cm^2) was obtained in the fruits treated with $KMnO_4$ stored in poly bags. The effects of $KMnO_4$ coincides with the results obtained by [12]. The delay in firmness of fruits stored in polythene bags with ethylene absorber $KMnO_4$ as compared to the other treatments could be due to reaction of $KMnO_4$ with ethylene to produce carbon dioxide and water, thus limiting the role of ethylene on ripening. Softening of fruits is related to a change in cell wall components and starch degradation. With the advance in ripening there may be breakdown of the cell walls, reduction in the cohesion of middle lamella due to solubilization of the pectic substances and movement of water from the skin to the flesh as a result of osmosis, all of which result in softening of the fruits [12].

The different post harvest treatments exhibited a pronounced effect on weight loss of banana during storage (Table 1). The highest physiological loss in weight was observed with ethrel 600 ppm (5.9 %) on the 8th day of storage which resulted in shrivelling, softening and over-ripening of fruits. Minimum loss in weight (2.3%) was recorded in unperforated bags with $KMnO_4$ treated fruits and these were hard in texture. The results corresponds with the weight loss values reported by [13] for fruits stored under open ambient condition for the same period. The lower weight loss obtained from fruits placed in

polythene bags with perforation compared to those in non-perforated ones could be due to the removal of ethylene which has a catalytic role in increasing respiration, and maintaining RH in the package thus reducing water loss [14]. Increase in the membrane permeability following the respiration might resulted in the loss of moisture through the peel as evidenced in this study by the shrinkage of peel. Loss in weight by various treatments also has been reported by [7] in banana cv. Grand Naine. The findings of [15] in three banana cultivars are also in line with the present study.

Maximum score of fruit taste was observed in the treatment of ethrel 600 ppm on 6th day of storage. Unperforated bags with $KMnO_4$ resulted in minimum fruit taste scores which might be due to the fact that the fruits under $KMnO_4$ were not ripened and their texture was hard. Also, $KMnO_4$ seems to be ethylene absorber. The increase in taste in all the treatments might be due to the reason that during ripening starch hydrolysis occurred due to enzymes and converted into glucose and fructose [16]. The findings of [17] in banana cv. Robusta, [7] in cv. Grand Naine are in support with the present results.

The post harvest treatments showed a noticeable effect on pulp to peel ratio and variation among the treatments which was statistically significant at different days of storage (Table 1). Highest pulp to peel ratio (2.41) was recorded in the treatment of ethrel 600 ppm followed by ethrel 400 ppm (2.23). Lowest pulp to peel ratio was observed with the treatment of unperforated bags with $KMnO_4$ (1.49). The increase in the pulp to peel ratio might be due to the change in sugar concentration in the pulp compared to the peel thus contributing to different change in osmotic pressure. Water might be lost from the peel of banana both by transpiration and osmosis due to which the peel weight was reduced and pulp to peel ratio increased. The increase in pulp to peel ratio during ripening was also observed by [18]. [15] also reported the same in banana cvs. Amritsagar, Mehersagar and Genasundori.

The fastest color change was observed in ethrel 600 ppm treatment and reached at full yellow color with brown spots over it on 8th day with scoring of (7.00). Unperforated polythene bags and unperforated bags with $KMnO_4$ and showed least score in terms of fruit color (3.66) The conversion of green color of the peel into yellow might be as a result of chlorophyll degradation which acted as an indicator of senescence that was enhanced by high rate of respiration which in turn was regulated by temperature, ethylene, O_2, CO_2 gases [19].

Maximum TSS (21.68%) was recorded in the treatment of ethrel 600 ppm followed by ethrel 400 (21.58%) TSS after 8 days of storage while ethrel 300 ppm showed TSS of (21.25%) and cold water + ethrel 200 ppm (21.18%). Minimum TSS was obtained in the fruits treated with unperforated bags with $KMnO_4$ (19.92%) which was due to the ethylene absorbing capacity of $KMnO_4$ which delayed the ripening of fruits [12]. The observed increment in TSS content during ripening of fruits followed the natural ripening and senescence processes that have also been also exhibited in related traits including color change, firmness and fruit marketability which are typical of post harvest change in climacteric fruits [19]. The present results are in agreement with the report of [13] and [20] in banana.

The data on moisture content in pulp presented in (Table 2) demonstrated that during the whole storage period moisture content in pulp of banana increased. The highest moisture content (76.60%) was recorded in ethrel 600 ppm. Lowest moisture content in pulp (57.12%) was observed in the fruits treated with un perforated bags with $KMnO_4$. The increase in pulp moisture content during ripening might be due to the carbohydrate breakdown and osmotic transfer from peel to pulp. These results are also in agreement with the findings of [20] and [15] in banana cultivars. The findings of [17] in banana cv. Robusta are in accordance with the present results.

The maximum titratable acidity (0.56%, 0.50%, 0.47% and 0.39%) was observed at 2nd, 4th, 6th and 8th days of storage in polythene bags containing $KMnO_4$ followed by (0.55%, 0.48 %, 0.45% and 0.36%) at 2nd, 4th, 6^{th,} 8th day with treatment of un perforated polythene bags while minimum acidity (0.36%, 0.29%, 0.23% and 0.18%) was observed in ethrel 600 ppm. The decrease in titratable acidity during storage might be due to the utilization of organic acids in respiration process and other bio-degradable reactions, glycolytic pathways or might have been used in respiration or both. Earlier findings of [7] in banana cv. Grand Naine, [17] in Robusta banana and [21] in Grand Naine banana also obtained the similar results. The present studies are also in line with the findings of [6] in banana cv. Grand Naine and [15] in banana cultivars.

Table 1. Effect of various post harvest treatments on physical properties of banana cv. Grand Naine

Treatments	Fruit firmness				Physiological loss in weight				Pulp to peel ratio				Fruit taste				Fruit Color			
	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day
T_1 : Ethrel 300 ppm	8.38	8.04	7.53	6.84	1.32	2.40	3.00	3.50	1.33	1.62	1.83	2.17	0.00	6.90	8.83	8.99	1.33	3.66	4.00	6.00
T_2 : Ethrel 400 ppm	8.24	7.82	7.20	6.21	1.60	2.80	3.50	3.90	1.38	1.63	1.86	2.23	0.00	7.32	9.00	9.10	1.66	3.33	4.33	6.33
T_3 : Ethrel 600 ppm	7.79	7.25	6.53	6.00	1.80	3.10	4.30	5.90	1.43	1.84	1.98	2.41	0.00	7.82	9.36	9.20	2.00	4.00	5.00	7.00
T_4 : Perforated plastic cover	8.50	8.29	7.78	7.21	1.20	1.91	2.20	2.60	1.21	1.35	1.49	1.61	0.00	6.61	8.62	8.58	1.00	2.00	3.00	4.00
T_5 : Unperforated plastic cover	8.62	8.35	7.87	7.42	1.19	1.88	2.20	2.40	1.20	1.32	1.45	1.56	0.00	6.21	8.41	8.72	1.00	2.00	2.66	3.66
T_6 : Unperforated plastic cover with $KMnO_4$	9.20	8.94	7.92	7.48	0.90	1.10	2.00	2.30	1.20	1.30	1.40	1.49	0.00	4.60	7.79	8.31	1.00	1.33	2.33	3.33
T_7 : Control	8.49	8.21	7.73	7.10	1.21	1.96	2.40	2.90	1.24	1.38	1.52	1.64	0.00	6.72	8.75	8.83	1.00	2.00	2.67	4.33
CD (P=0.05 %)	0.02	0.02	0.23	0.25	0.24	0.22	0.02	0.25	0.12	0.21	0.15	0.15	0.04	0.07	0.04	0.02	0.53	0.68	0.75	0.77

Note: fruit taste score was zero on the second day because fruits were unripe.

Table 2. Effect of various post harvest treatments on bio-chemical properties of banana cv. Grand Naine

Treatments	Total soluble solids				Moisture content of pulp (%)				Titratable acidity				Total sugars				Reducing sugars				Non Reducing Sugars				Starch content			
	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day
T_1 : Ethrel 300 ppm	13.94	19.57	21.65	21.25	73.10	73.40	74.20	74.50	0.42	0.33	0.27	0.22	5.21	9.35	10.72	17.79	4.91	6.84	8.39	11.35	0.30	2.51	2.33	6.44	16.26	12.73	9.43	6.01
T_2 : Ethrel 400 ppm	14.17	20.78	21.97	21.58	73.70	73.90	74.30	74.60	0.39	0.31	0.26	0.21	6.14	10.10	10.93	17.82	5.25	7.39	8.45	11.45	0.89	1.96	2.48	6.37	15.03	11.43	8.21	5.07
T_3 : Ethrel 600 ppm	14.93	21.15	22.80	21.68	74.20	74.70	75.10	76.60	0.36	0.29	0.23	0.18	6.25	10.69	11.12	18.09	5.96	7.82	9.15	12.10	0.29	2.28	1.97	5.99	14.56	10.03	6.99	3.01
T_4 : Perforted plastic cover	11.69	18.02	20.45	20.72	64.51	67.20	69.42	71.20	0.53	0.46	0.42	0.34	4.22	7.75	10.26	16.02	4.16	6.29	8.04	9.70	0.06	1.58	2.22	6.32	17.57	13.74	11.16	6.97
T_5 : Unperforated plastic cover	10.93	17.97	19.82	20.04	52.40	55.21	60.15	61.24	0.55	0.48	0.45	0.36	4.21	7.10	10.05	14.89	4.02	6.17	7.02	9.13	0.19	0.93	3.03	5.76	18.06	14.12	11.24	7.00
T_6 : Unperforated plastic cover with $KMnO_4$	9.92	15.00	16.82	19.92	49.94	51.68	56.12	57.12	0.56	0.50	0.47	0.39	3.86	6.81	9.98	10.99	2.06	5.84	6.56	7.89	1.18	0.97	3.22	3.10	21.12	16.49	11.34	7.01
T_7 : Control	11.98	18.64	20.55	20.61	70.06	72.30	72.60	72.90	0.50	0.42	0.39	0.30	4.52	7.99	10.29	16.78	4.33	6.38	8.17	10.30	0.19	1.61	2.12	6.48	17.42	13.26	11.03	6.95
CD (P=0.05 %)	0.04	0.07	0.05	0.05	0.02	0.01	0.03	0.03	0.04	0.06	0.06	0.05	0.02	0.025	0.02	0.04	0.02	0.02	0.025	0.025	0.25	0.2	0.21	0.15	0.17	0.19	0.18	0.18

The data on the effect of post harvest application of ethrel and polythene bag treatments on total sugars of banana cv. Grand Naine presented in (Table 2) depicted that significantly higher total sugars (18.09%) were analysed from the fruits treated with ethrel 600 ppm. Unperforated polythene bags with $KMnO_4$ registered the lowest (10.99%) total sugar. The observed increment in the amount of total sugars might be due to the conversion of starch into sugars due to respiratory metabolic pathways in starch hydrolysis. Similar observations were recorded by [17] and [12] in banana fruits. The increase in sugars in ethrel 600 ppm might be due to the faster ripening process which converted starch into sugar while the slower rate in the treatments of polythene bags could be due to the effects of them in delaying the ripening process. The delay in the increase of the sugars by inclusion of $KMnO_4$ in polythene bags might be attributed to the ethylene removal effect of $KMnO_4$ [14]. The research findings of [7] and [6] in banana cv. Grand Naine are in line with the present findings.

From the perusal of the data it is clear that ethrel and polythene bags exerted a significant effect on the reducing sugars depicting the highest percentage of reducing sugars in the fruits treated with ethrel 600 ppm (12.10%). Minimum reducing sugars were recorded in the fruits treated with $KMnO_4$ because fruits were unripe even after 8 days and it was due to ripening inhibiting effect of $KMnO_4$. The observed lesser amount of reducing sugars at the early period of ripeness followed by an increment as ripening progresses could be due to the higher amount of sugars at later stage of ripeness which were in agreement with the report of [12]. Significantly higher non reducing sugars (6.48%) were analysed from the control fruits. Lowest non reducing sugars were recorded in the treatment of unperforated bags with $KMnO_4$ (3.1%) after 8 days of storage. The better sugar content might be due to the synergistic effect of various ripening agents. It might also be due to the production of total sugars and reducing sugars which led to the non reducing sugar levels accordingly. Similar increase in sugars during ripening has been reported by [22] in purple passion fruit and [23] in banana. Starch level decreased in all the treatments as ripening advanced. However decrease was more rapid with ethrel 600 ppm. The maximum starch content (7.01%) was found with the treatment of unperforated bags with $KMnO_4$. In this study starch levels decreased in all the treatments as the ripening advanced. Ripening resulted in decline of starch content which could be attributed to the increased activity of amylase and other enzymes resulting in gluconeogenesis [23,24] The findings of [21] in banana cv. Grand Naine are in line with the present results.

4. CONCLUSION

It is concluded from the present study that ethrel 600 ppm proved to be the most effective treatment in enhancing TSS, reducing sugars, total sugars, physiological loss in weight, pulp to peel ratio, fruit taste, fruit color and moisture content in pulp as compared to other treatments. Minimum acidity was also observed under the fruits treated with ethrel 600 ppm. By going through the results of the present study it may be concluded that ethrel 600 ppm can be successfully used for adequate ripening of banana fruits cv. Grand Naine.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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