

Original Research Article

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Response of 1-MCP on Physiological and Physical Characteristics in Banana (*Musa paradisiaca* L.) cv. Tella Chakkerakeli during Storage

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ABSTRACT

Keywords

1-MCP, Banana, Storage, 1-methyl cyclopropane, Fruit firmness retention

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In order to extend the shelf life of banana cultivar Tella Chakkerakeli was fumigated with 1-methylcyclopropane (1-MCP) at four different concentrations (100, 200, 300 and 400 ppb) @ 24h exposed time and stored at ambient conditions. Among all the treatments, 400 ppb was found to be an effective in extending shelf-life with recorded minimum ethylene evolution rate ($0.440 \mu\text{l kg}^{-1} \text{hr}^{-1}$), physiological loss in weight (4.739%), pulp to peel ratio and maximum fruit firmness retention (9.665 kg cm^{-2}). The entire 1-MCP treated banana showed better results over control (kept at open air @ 24h).

Introduction

Banana (*Musa paradisiaca* L.) is one of the major commercial fruit crop grown in tropics and subtropics. It plays a key role in the economy of developing countries. India has vast prospective to cultivate and produce the high quality banana fruits and are exported to the local markets instead of the international markets. Approximately 25 to 30% of the harvested fresh produce is deteriorated in every year due to high perishable nature of the fruits, pitiable handling practices and inadequate storage facilities. The causes for

postharvest losses of fresh produce are an increase in respiration rate, ethylene production, physiological disorders and general senescence. Generally banana is classified as climacteric fruit which is characterized by a low rates of ethylene production and respiration during the pre-climacteric phase, followed by a sudden burst in ethylene production and respiration rate during ripening (Burg and Burg, 1965). The sudden rises in respiration rate and ethylene production during ripening stage are responsible for major postharvest losses in bananas. Ethylene is a gaseous hormone, it

accelerates the ripening in climacteric fruits. The ripening is mainly triggered through the action of ethylene binding to its receptor sites located on cell membrane (Sisler and Serek, 1997).

A novel gaseous anti-ethylene compound 1-Methylcyclopropene (1-MCP) has been reported to have inhibitory effects on ethylene action (Serek *et al.*, 1994; Sisler *et al.*, 1995). It is a stable powder and easily released the ethylene gas when dissolved in water. It acts by binding irreversibly to ethylene-receptors hence, subsequent signal transduction and translation responses are not elicited, causes fruits to be ripen and soften more slowly, thereby maintaining the quality of produce for longer period. 1-MCP treatment extended the green life and/or inhibited the ripening of tomato, banana and plum fruits (Serek *et al.*, 1995, Sisler *et al.*, 1995, Macnish *et al.*, 1997, Abdi *et al.*, 1998, Golding *et al.*, 1998).

In this present paper, we have investigated the effects of 1-MCP on banana fruit ripening by measuring ethylene evolution rate ($\mu\text{l kg}^{-1}\text{hr}^{-1}$), physiological loss in weight ($\text{g kg}^{-1}\text{hr}^{-1}$), pulp to peel ratio and fruit firmness.

Materials and Methods

Plant material and treatments

The current research work was carried out in the in the Department of Fruit Science, College of Horticulture, V.R.Gudem, Dr.YSRHU during the year 2015-18. Mature green (80-85% Maturity) Tella Chakkerakeli banana bunches were harvested from the experimental farm field of HRS, Kovvur, Dr.YSRHU. Later harvested bunches are dehanded carefully and second hand from each bunch brought to the laboratory. Then the hands were cleaned in tap water, dipped in 0.1% Bavistin for a while and air dried under fan for 10-15 minutes. Later the banana hands

were placed in known volume carton boxes (CFB) for imposing 1-MCP. The required quantity of 1-MCP Ansp-F tablets for known volume carton boxes for yielding 100 ppb, 200 ppb, 300 ppb and 400 ppb were calculated (1.1g of tablet in 40L carton box gives 900 ppb concentration) and crushed into powder with mortar and pestle.

The 1-MCP powder was placed inside the flask containing a rubber septum. Then warm distilled water (at 40-50⁰C) was added to the flask for dissolving the 1-MCP powder. The flask was then placed inside the container through the top opening and the flask lid is removed immediately before the carton box was completely sealed. This modified method was described by Wongmetha and Lih-Shang Ke (2012) and Alves *et al.*, (2005). After exposure to 24 hrs at room temperature the carton boxes were opened and the banana hands were kept for storage studies at ambient room temperature (32±2°C and 78±2% RH). The banana fruits were sampled for enzyme analysis at 3 day interval. The treatments attempted in this experiment were 1-Methylcyclopropene (100 ppb), 1-Methylcyclopropene (200 ppb), 1-Methylcyclopropene (300 ppb) and 1-Methylcyclopropene (400 ppb) along with control (kept at open air @24h).

Observations recorded

Ethylene evolution rate ($\mu\text{l kg}^{-1}\text{hr}^{-1}$)

The ethylene concentration in the head space of zip bag was measured by piercing the probe of ethylene analyzer (Bioconservicon) into the wall of zip bag. The production of C₂H₄ was calculated in $\mu\text{l kg}^{-1}\text{h}^{-1}$ by using formula:

Ethylene ($\mu\text{l kg}^{-1}\text{h}^{-1}$) =

$$\frac{\text{C}_2\text{H}_4 \text{ ppm} \times (\text{container vol.} - \text{fruit vol.}) \times 60 \text{ min}}{[\text{Fruit weight (kg)}] \times [\text{Enclosing time (min)}] \times 1000}$$

Physiological loss in weight (%)

The weight of the individual banana hand was recorded using electronic balance (Cal-One-6TC15) before storage. Thereafter, the weights were recorded specified intervals during storage and the cumulative PLW was calculated with the following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Pulp to peel ratio

The pulp to peel ratio was calculated in selected five fruits per replication, weighing the pulp and peel of the fruits separately and expressing the ratio between them.

Fruit firmness (kgcm⁻²)

A table top Penetrometer (Model-FT-327, EFFEGI, Made in Italy) with a spherical 1.1cm diameter plunger was used to record the firmness of the fruits. The plunger was inserted upto a depth of 5mm without peel and the force required was recorded directly in kgcm⁻².

Shelf life (d)

The shelf life of fruits was determined by recording the number of days the fruits remained in good condition during storage. The stage at which more than 50 per cent of the stored fruits became unfit for consumption was considered as end of shelf life in that particular treatment and expressed as mean number of days (Padmalatha, 1993).

Statistics

The experiment was designed in a factorial completely randomized design (FCRD) with

three replications. The data was analyzed as per the design and the results were compared from the CD value obtained through ANOVA (Panse and Sukhatme, 1984).

Results and Discussion

Ethylene evolution rate

The ethylene produced internally, regulates the major changes during ripening of climacteric fruits, such as peel and pulp colour, firmness, soluble solid content, acidity and respiratory rate. Ethylene evolution rate followed an increasing trend in all treatment combinations from 1st day to the 10th day of storage but in open air treated fruits (untreated with 1-MCP) ethylene evolution rate increased much rapidly, which achieved its peak (2.030 $\mu\text{l kg}^{-1} \text{hr}^{-1}$) on 7th day of storage and slowly declined to 10th day of storage period (1.110 $\mu\text{l kg}^{-1} \text{hr}^{-1}$) (Table 1 and Fig. 1). Maximum ethylene production (1.145 $\mu\text{l kg}^{-1} \text{hr}^{-1}$) was observed in untreated banana. While the lowest climacteric peak of ethylene (0.440 $\mu\text{l kg}^{-1} \text{hr}^{-1}$) was observed in the banana fruits treated with 1-MCP @ 400 ppb, followed by 1-MCP @ 300 ppb treated banana (0.605 $\mu\text{l kg}^{-1} \text{hr}^{-1}$). The greater delay in the ethylene production by 1-MCP treatment might be due to interference of 1-MCP with the autocatalytic production of ethylene, as all ethylene binding sites might have been irreversibly blocked by 1-MCP. Similar results were reported by Feng *et al.*, (2000), Martinez-Romero *et al.*, (2003), Hershkovitz *et al.*, (2005), Penchaiya *et al.*, (2006) and Manenoi *et al.*, (2007).

Physiological loss in weight

The physiological loss in weight occurs mainly through the respiration and transpiration losses along with some other metabolic processes. Less loss of moisture from the produce indicates the maintenance of turgidity which in turn justifies the freshness

of the produce. Here, the physiological loss in weight (PLW) of the banana fruits increased with the advancement of storage period, rather slowly in the beginning but at a faster pace as the storage period advanced (Table 2 and Fig. 2).

Furthermore, 1-MCP treatments have significantly lowered physiological weight loss of banana fruits during storage. The PLW was minimum (4.739%) in the banana fruits treated with 1-MCP (400 ppb) followed significantly (5.063%) by 1-MCP (3000 ppb) treatment and maximum PLW (11.823%) was observed in the untreated banana fruits. Also, the interaction effect between treatment and storage period (T x S) was highly significant as the highest PLW (24.177%) was observed in untreated banana fruits on 10th day while the lowest PLW (2.56%) was recorded in banana fruits treated with 1-MCP (400 ppb) on 4th day of storage (Table 1).

The reduced weight loss in treated fruits can be attributed to low levels of respiration and ethylene evolution rate and delayed ripening of such fruits which maintained rigidity of the fruit tissue and thereby reduced the transpiration losses. Similar favourable effects of 1-MCP in reducing the PLW of banana fruits has also been reported by (Siriboon and Banluisilp (2004), Dharmasenal and Kumari

(2005) and Krishna Kumar and Thirupathi, (2014).

Pulp to peel ratio

An increasing trend in the pulp to peel ratio was observed during storage starting from the 1st day to the 10th day. However, the rate of increase was significantly high in the untreated banana compared to the treated ones (Table 3 and Fig. 3). Maximum (3.048) pulp to peel ratio was noticed in untreated banana and minimum in fruits fumigated with 1-MCP @ 400 ppb (2.060), followed by 1-MCP @ 300 ppb (2.323).

The pulp to peel ratio increased gradually from 1st day to 10th day of storage as the ripening advances. It could be due to slow conversion of starch into sugars and slow increase in the loss of moisture from the peel through transpiration. The pulp to peel ratio was lowest in 1-MCP treated fruits which might be due to delay in the moisture loss from the peel and also due to delay in the conversion of starch into sugars since 1-MCP inhibits ripening by blocking ethylene receptor sites thus preventing ethylene action. The results are in conformity with earlier reports of Ramana *et al.*, (1971) and Desai and Deshpande (1975) in banana.

Table.1 Effect of postharvest fumigation of 1-MCP ethylene evolution rate ($\mu\text{l kg}^{-1} \text{ hr}^{-1}$) in Tella Chakkerakeli banana stored at ambient conditions ($32\pm 2^\circ\text{C}$ and $78\pm 2\%$ RH)

Treatments (T)	Storage Period(S)				
	1 st Day	4 th Day	7 th Day	10 th Day	Mean
1-MCP @ 100 ppb	0.440	0.810	1.280	1.860	1.098
1-MCP @ 200 ppb	0.370	0.500	1.000	1.380	0.813
1-MCP @ 300 ppb	0.260	0.420	0.720	1.020	0.605
1-MCP @ 400 ppb	0.170	0.220	0.450	0.920	0.440
Control (open air)	0.560	0.880	2.030	1.110	1.145
Mean	0.360	0.566	1.096	1.258	
	SE(m)		C.D.@5%		
Treatment	0.004		0.012		
Storage Period	0.004		0.011		
T×S	0.008		0.024		

Table.2 Influence of postharvest fumigation of 1-MCP on physiological loss in weight (%) in Tella Chakkerakeli banana stored at ambient conditions (32±2°C and 78±2% RH)

Treatments (T)	Storage Period(S)				
	1 st Day	4 th Day	7 th Day	10 th Day	Mean
1-MCP @ 100 ppb	0.000	6.040	12.817	18.497	9.338
1-MCP @ 200 ppb	0.000	3.380	6.270	14.207	5.964
1-MCP @ 300 ppb	0.000	2.900	5.090	12.260	5.063
1-MCP @ 400 ppb	0.000	2.560	4.580	11.817	4.739
Control (open air)	0.000	7.120	15.997	24.177	11.823
Mean	0.000	4.400	8.951	16.191	
	SE(m)		C.D.@5%		
Treatment	0.042		0.119		
Storage Period	0.037		0.107		
T×S	0.083		0.238		

Table.3 Effect of postharvest fumigation of 1-MCP on pulp to peel ratio in Tella Chakkerakeli banana stored at ambient conditions (32±2°C and 78±2% RH)

Treatments (T)	Storage Period(S)				
	1 st Day	4 th Day	7 th Day	10 th Day	Mean
1-MCP @ 100 ppb	2.220	2.480	2.800	3.480	2.745
1-MCP @ 200 ppb	2.100	2.350	2.650	3.040	2.535
1-MCP @ 300 ppb	1.880	2.060	2.490	2.860	2.323
1-MCP @ 400 ppb	1.640	1.920	2.200	2.480	2.060
Control (open air)	2.310	2.730	3.250	3.900	3.048
Mean	2.030	2.308	2.678	3.152	
	SE(m)		C.D.@5%		
Treatment	0.011		0.032		
Storage Period	0.010		0.028		
T×S	0.022		0.063		

Table.4 Influence of postharvest fumigation of 1-MCP on fruit firmness (kgcm-2) in Tella Chakkerakeli banana stored at ambient conditions (32±2°C and 78±2% RH)

Treatments (T)	Storage Period(S)				
	1 st Day	4 th Day	7 th Day	10 th Day	Mean
1-MCP @ 100 ppb	10.027	8.147	5.840	1.070	6.271
1-MCP @ 200 ppb	10.967	8.760	6.930	3.550	7.552
1-MCP @ 300 ppb	12.737	10.607	8.467	5.670	9.370
1-MCP @ 400 ppb	13.457	11.017	8.137	6.050	9.665
Control (open air)	8.617	5.370	1.250	0.820	4.014
Mean	11.161	8.780	6.125	3.432	
	SE(m)		C.D.@5%		
Treatment	0.034		0.097		
Storage Period	0.030		0.087		
T×S	0.068		0.195		

Table.5 Influence of postharvest fumigation of 1-MCP on shelf life (d) in Tella Chakkerakeli banana stored at ambient conditions (32±2°C and 78±2% RH)

Treatments (T)	Shelf life (d)
1-MCP @ 100 ppb	8.25
1-MCP @ 200 ppb	10.5
1-MCP @ 300 ppb	13.75
1-MCP @ 400 ppb	16.5
Control (open air)	5.5
SE(m)	0.329
C.D.@5%	1.001

Fig.1 Effect of postharvest fumigation of 1-MCP ethylene evolution rate ($\mu\text{l kg}^{-1} \text{hr}^{-1}$) in Tella Chakkerakeli banana stored at ambient conditions (32±2°C and 78±2% RH)

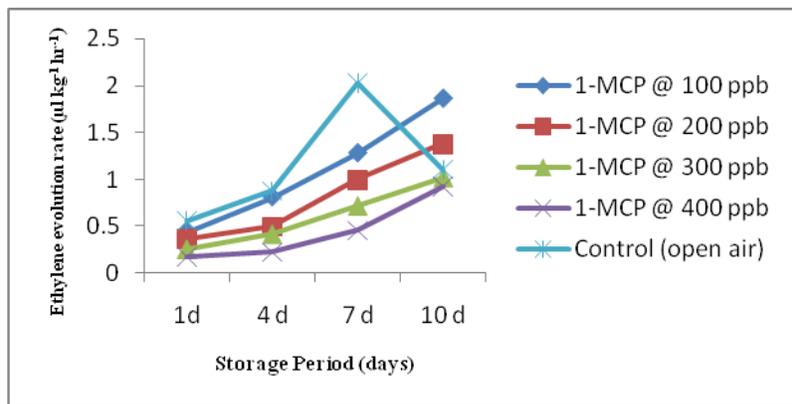


Fig.2 Influence of postharvest fumigation of 1-MCP on physiological loss in weight (%) in Tella Chakkerakeli banana stored at ambient conditions (32±2°C and 78±2% RH)

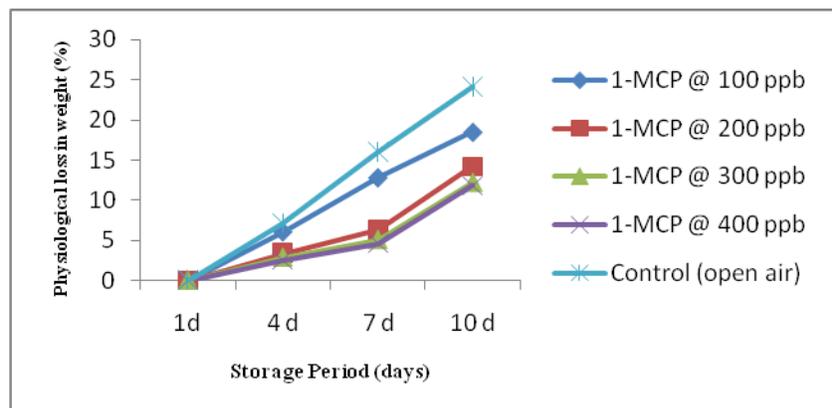


Fig.3 Effect of postharvest fumigation of 1-MCP on pulp to peel ratio in Tella Chakkerakeli banana stored at ambient conditions ($32\pm 2^{\circ}\text{C}$ and $78\pm 2\%$ RH)

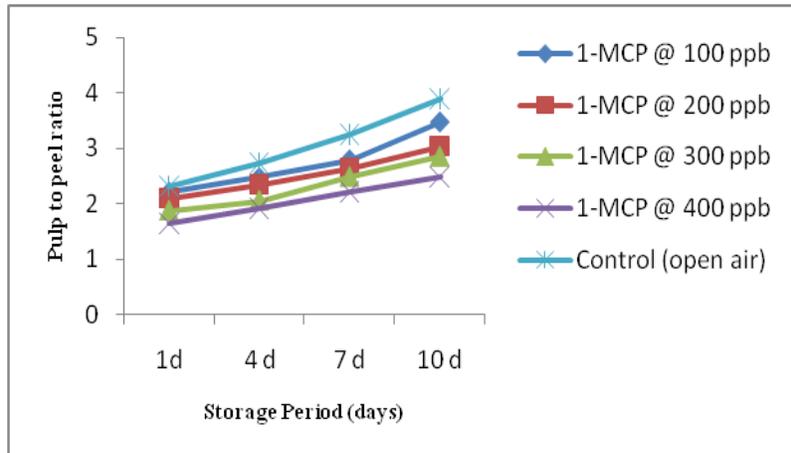


Fig.4 Influence of postharvest fumigation of 1-MCP on fruit firmness (kgcm^{-2}) in Tella Chakkerakeli banana stored at ambient conditions ($32\pm 2^{\circ}\text{C}$ and $78\pm 2\%$ RH)

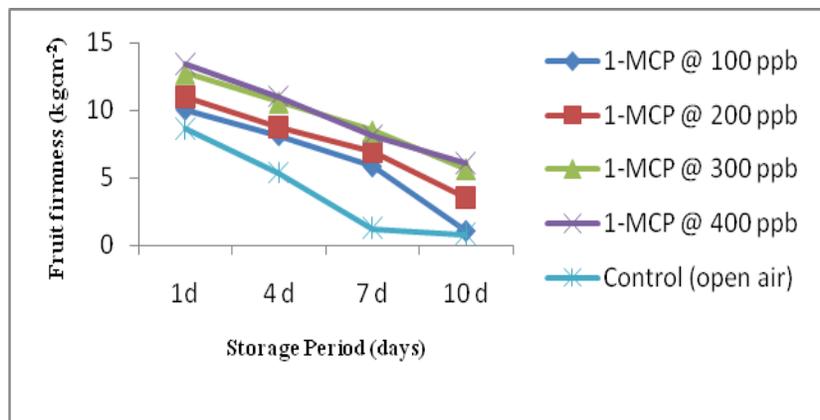
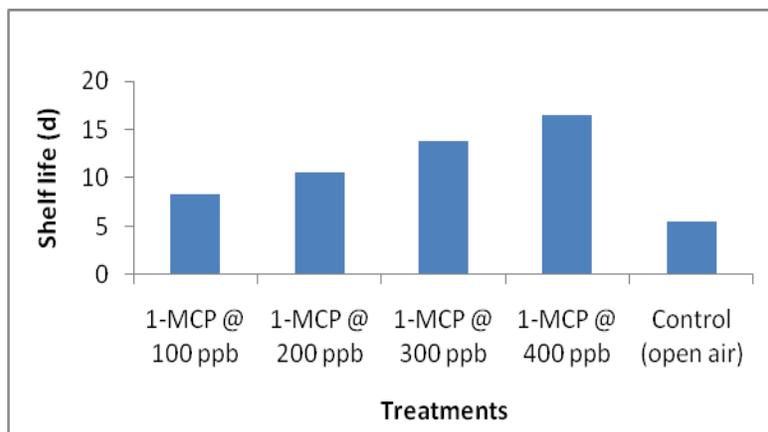


Fig.5 Influence of postharvest fumigation of 1-MCP on shelf life (d) in Tella Chakkerakeli banana stored at ambient conditions ($32\pm 2^{\circ}\text{C}$ and $78\pm 2\%$ RH)



Fruit firmness

The firmness of fruit tissues is mainly due to the physical properties of the individual cell walls and the middle lamella that contains the pectic-substances which act as cementing material. During ripening, the fruit tissues become soft due to the degradation of cell wall and intercellular adhesive substances. Hence, firmer fruits stay long in the market than those exhibiting less firmness. In the current study, firmness of Tella Chakkerakeli banana fruits has decreased gradually with simultaneous softening of fruits with increase in storage period. Banana fruits exposed to 1-MCP treatment (400 ppb) were firm, exhibiting significantly higher firmness (9.665 kgcm^{-2}) than other concentrations of 1-MCP or untreated fruits (4.014 kgcm^{-2}) (Table.4 and Fig. 4). The remarkable influence of 1-MCP treatment on fruit softening might be due to reduction in ethylene in such fruits as ethylene is extensively involved in postharvest fruit softening and acceleration of overall ripening of fruits. Hence, 1-MCP induced ethylene inhibition would have caused a delay in fruit softening during storage. The retardation of fruit softening in response to 1-MCP treatment has also been reported in banana (Pelayo *et al.*, 2003; Moradinezhad *et al.*, 2010; Zhu *et al.*, 2015), mango (Liu *et al.*, 2010; Nghiem and Shiesh, 2010; Burondkar *et al.*, 2013; Ngamchuachit *et al.*, 2014), guava (Bassetto *et al.*, 2005), plum (Abdi *et al.*, 1998; Martinez-Romero *et al.*, 2003), avocado (Pesis *et al.*, 2002; Hershkovitz *et al.*, 2005) and papaya (Manenoi *et al.*, 2007).

Shelf life

Maximum shelf life (16.5 d) was recorded in Tella Chakkerakeli banana treated with 1-MCP @ 400 ppb (d) and lowest shelf life (5.5 d) was recorded in untreated banana (Table 5 and Fig. 5). All the 1-MCP treated banana

fruits showed improved shelf life compared to control. The reason for high concentration of 1-MCP was effective in order to suppress the more ethylene binding sites developed in the banana fruit tissues during ripening. These findings are in conformity with, Jiang *et al.*, (1999), Jansasithorn and kanlayanarat, (2006), Moradinezhad *et al.*, (2006, 2010) and Krishna kumar and Thirupathi, (2014) in banana.

It was concluded that exposure of Tella Chakkerakeli banana fruits to 1-methylcyclopropane extended the economic shelf life at ambient conditions ($32 \pm 2^\circ\text{C}$ and $78 \pm 2\%$ RH) compared to the untreated control fruits. 1-MCP (400 ppb) retained minimum ethylene evolution rate, physiological loss in weight, pulp to peel ratio and maximum fruit firmness retention. All 1-MCP concentrations showed better results over control (kept at open air @ 24h).

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