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Shweta Jangam
M.Sc. (Hort.), Department of Fruit Science, Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Agricultural University, Chhattisgarh, India

SP Sharma
Assistant professor, Department of Fruit Science, Pt. K.L.S, College of horticulture and Research Station, Rajnandgaon, Indira Gandhi Agricultural University, Chhattisgarh, India

MS Paikra
Professor, Department of Fruit Science, Pt. K.L.S College of horticulture and Research Station, Rajnandgaon. Indira Gandhi Agricultural University, Chhattisgarh, India

Gunjan Jha
SMS (Hort.), KVK, Rajnandgaon, IGKV, Raipur, Chhattisgarh, India

Dikeshwar Nishad
Assistant Professor, Department of Agricultural Statistics and Social Science L., Pt. S.K.S CARS, Rajnandgaon, Indira Gandhi Agricultural University, Chhattisgarh, India

Corresponding Author:
Shweta Jangam
M.Sc. (Hort.), Department of fruit science, Pt. K.L.S. College of Horticulture and Research Station, Rajnandgaon, Indira Gandhi Agricultural University, Chhattisgarh, India

Effect of different concentrations of ethephon on ripening of banana (*Musa paradisiaca*)

Shweta Jangam, SP Sharma, MS Paikra, Gunjan Jha and Dikeshwar Nishad

Abstract
An experiment entitled "Effect of different concentrations of ethephon on ripening of banana (*Musa paradisiaca*)" was executed in Fruit processing laboratory, Pt. Kishori Lal Shukla College of Horticulture and Research Station, Pendri, Rajnandgaon, IGKV, Raipur (C.G.) in the year 2021-2022. The experimental design applied was completely randomized design (CRD) with a total of eleven treatments which were replicated three times. T_0 (control), T_1 (ethephon @ 100ppm), T_2 (ethephon @ 200ppm), T_3 (ethephon @ 300ppm), T_4 (ethephon @ 400ppm), T_5 (ethephon @ 500ppm), T_6 (ethephon @ 600ppm), T_7 (ethephon @ 700ppm), T_8 (ethephon @800ppm), T_9 (ethephon @900 ppm) and T_{10} (ethephon @ 1000ppm). The experiment concluded that among the treatments T_{10} has performed better in physical and chemical parameters.

Keywords: Banana, ripening, ethephon

Introduction
Banana (*Musa* spp.) is a fruit plant which is large herbaceous, perennial, monocot and monocarpic cultivated in tropical and subtropical regions of the world (Srestha, 2010) [2]. The edible banana is believed to have originated in the hot, tropical regions of South-East Asia (Assam, Burma and Indo-China region).

Banana is the most popular fresh fruit all over the world because of its nutritious value. Its high vitamin B_6 content helps fight infection and is essential for the synthesis of 'heme', the iron containing pigment of haemoglobin. From the nutritional point of view banana has a calorific value ranging from 116 calories/100g and is closely comparable with potatoes but digested more easily (Gopalan *et al*., 2004) [3].

Bananas are generally ripened in the market by calcium carbide and use of this chemical is prohibited due to health reasons (PFA, 2003). It possesses impurities of arsenic and phosphorous hydride which are extremely harmful for health. Therefore, alternative measures need to be investigated for improving the ripening of banana so that uniformly ripened and quality are made available to consumers in domestic and distant markets.

Ethephon (2-chloroethyl phosphonic acid) is ethylene generating commercial chemical. Ethephon is most important and versatile ethylene releasing agent. Ethephon is frequently regarded as superior to other chemical ripening agent. Artificial ripening is the technique by which ripening is regulated to provide desired features aimed at increasing consumer acceptance and sales.

Material and Methods
The present study was conducted in the year 2021–2022, in the Fruit processing laboratory, Pt. Kishori Lal Shukla College of Horticulture and Research Station, Pendri, Rajnandgaon, IGKV, Raipur (C.G.). The experiment was laid out in Completely Randomized Design.

Mature and fully developed fruits of uniform size and free from injuries were purchased from farm jangleshwar, Rajnandgaon. Ethephon is available in liquid form and is water soluble. To prepare 5 litres of stock solution,10 ml of ethephon was measured and dissolved under distilled water and made it up to 5 litres. Solutions for various treatments *viz*., 100, 200, 300, 400, 500, 600, 700, 800, 900 and 1000 ppm. Uniform size fruits were randomly selected for each treatment and fruits were dipped in the respective solution for 5 minutes and then dried for 30 minutes under fan. Fruits dipped in distilled water (5 minutes) were treated as control. Detailed observations were recorded at 3rd, 6th, 9th, 12th and 15th days of storage. They were physiological loss in weight, Days taken for ripening, Pulp to peel ratio, Total sugar, Reducing sugar and Total soluble salts.

Result and Discussion

Physical parameters

Table 1 shows the significant effect of ethephon on physiological weight loss of banana and it was recorded that the maximum physiological weight loss was under treatment T_{10} with 3.15%, 5.58%, 10.06%, 17.98% and 27.14% at 3rd, 6th, 9th, 12th and 15th days of storage. The minimum physiological weight loss was under treatment T_0 (control) with 1.21%, 2.53%, 3.02%, 7.28% and 15.60% at 3rd, 6th, 9th, 12th and 15th days of storage. Physiological weight loss in untreated fruits might be due to the low respiration rate. Whereas, maximum weight loss in fruit was with ethephon 1000 ppm due to the increase in respiration rate and other related physiological process for ripening of fruits. This result is in agreement with the findings of Kohli and Reddy (1983) [5] and Arumugam *et al.* (2002) [1].

Table 2 revealed that the maximum number of days taken for ripening was recorded in T_0 (13.00 days), followed by T_1 (11.67 days) and T_2 (11.33 days) and the minimum days were recorded for T_{10} (5.67 days). The significant acceleration of ripening caused by the ethephon treatments as seen in this study lend support to the idea that exogenous ethylene supplementation may have raised the minimum exogenous threshold level. Such ripening stimulating changes are directly correlated with the concentration of applied ethephon. These results were confirmed by Srinivasan (1971) [4] and Kohli and Reddy (1983) [5].

Table 3 illustrates that ethephon showed significant effect on pulp to peel ratio of banana. Treatment T_{10} showed the significantly highest value of pulp to peel ratio at 3rd, 6th, 9th, 12th, and 15th days of storage (i.e., 2.37, 3.85, 3.93, 4.08, 4.70 respectively). However, the least value of pulp to peel ratio was scored by T_0 at 3rd, 6th, 9th, 12th, and 15th days of storage and the values are (1.48, 1.85, 2.60, 2.70 and 2.85 respectively). The rise in pulp to peel ratio of banana may be because of the reason that the change in the concentration of pulp and peel. Sugar synthesis is comparatively faster in pulp with respect to peel and thus due to change in the osmotic pressure, water is withdrawn from the pulp and the pulp to peel ratio increased accordingly (Shrestha, 2010) [2].

Chemical parameters

Table 4 depicted that the ethephon showed significant effect on TSS with maximum ˚Brix of 17.30, 22.44, 22.63, 22.77, and 22.80 under T_{10} at 3rd, 6th, 9th, 12th, and 15th days of storage respectively. While the minimum TSS was recorded under T_0 (5.57, 15.40, 16.21, 16.44, and 16.47 ˚Brix at 3rd, 6th, 9th, 12th, and 15th days of storage respectively). This increase in TSS was due to the accumulation of sugars. The increase in the sugar content is the characteristics biochemical process of the fruits during the ripening period due to the hydrolysis of starch to simpler sugars, such as glucose, fructose and sucrose. Similar findings were reported by Kohli and Reddy (1983) [5].

Table 5 shows the data of total sugar of banana recorded at 3rd, 6th, 9th, 12th and 15th days of storage. maximum total sugar was recorded in T_{10} (1000ppm) with (10.95, 16.45, 18.24, 18.48, 18.75%) at 3rd, 6th, 9th, 12th, and 15th days of storage respectively. However, the minimum total sugar was recorded in T_0 (control) with (6.07, 9.03, 9.41, 10.65 and 11.05%). The increase in the sugar content was the characteristics biochemical process of the fruits during the ripening period due to the hydrolysis of starch to simple sugars, such as glucose, fructose and the sucrose. Similar findings were reported by Galal *et al.* (2001) [6] in banana.

Table 6 shows the data of reducing sugar of banana at 3rd, 6th, 9th, 12th and 15th days of storage. Highest value of reducing sugar at 3rd, 6th, 9th, 12th, and 15th days of storage (i.e., 8.07, 9.09, 12.55, 12.75, 17.32% respectively) However, the least value of reducing sugar was scored by T_0 at 3rd, 6th, 9th, 12th, and 15th day of storage and the values are (2.11, 5.77, 7.60, 8.93, and 10.27% respectively). The reason behind increasing pattern of reducing sugar may be because of increased hydrolysis of starch to simple sugar. Similar findings were obtained by Galal *et al.* (2001) [6], Rao *et al.* (1971) in banana, Kulkarni *et al.* (2004) [7], Mann (1985) [8] in mango.

Table 1: Effect of different concentrations of ethephon on physiological loss in weight of banana

Notation	Treatments	3rd Day	6th Day	9th Day	12th Day	15th Day
T_0	Control	1.21	2.53	3.02	7.28	15.61
T_1	100ppm	1.22	3.05	3.24	9.21	16.42
T_2	200ppm	1.43	3.11	3.59	8.59	17.05
T_3	300ppm	1.46	3.61	4.81	10.09	17.14
T_4	400ppm	1.71	3.88	5.02	12.74	17.81
T_5	500ppm	2.25	4.32	6.25	15.08	18.26
T_6	600ppm	2.34	4.55	6.49	15.26	19.10
T_7	700ppm	2.37	4.54	7.07	16.27	20.80
T_8	800ppm	2.44	4.79	8.62	16.99	21.55
T_9	900ppm	2.83	4.83	8.75	17.37	25.71
T_{10}	1000ppm	3.15	5.58	10.06	17.98	27.14
CD at 5%		0.17	0.31	0.17	0.31	0.24
SE(m)		0.06	0.11	0.06	0.11	0.08
CV		4.79	4.51	4.79	4.51	2.29

Table 2: Effect of different concentrations of ethephon on days taken for ripening of banana

S. No.	Notation	Treatments	Days taken for ripening (0-15 days)
1.	T_0	Control	13.00
2.	T_1	100ppm	11.67
3.	T_2	200ppm	11.33
4.	T_3	300ppm	11.00
5.	T_4	400ppm	9.67
6.	T_5	500ppm	9.33
7.	T_6	600ppm	8.67

8.	T_7	700ppm	7.33
9.	T_8	800ppm	7.00
10.	T_9	900ppm	6.33
11.	T_{10}	1000ppm	5.67
CD at 5%			1.11
SE(m)			0.38
CV			7.09

Table 3: Effect of different concentrations of ethephon on pulp to peel ratio of banana

Notation	Treatments	3rd Day	6th Day	9th Day	12th Day	15th Day
T_0	Control	1.48	1.85	2.60	2.70	2.85
T_1	100ppm	1.53	2.03	2.74	2.85	2.95
T_2	200ppm	1.58	2.26	3.18	3.35	3.51
T_3	300ppm	1.63	2.35	3.21	3.38	3.61
T_4	400ppm	1.68	2.46	3.36	3.45	3.75
T_5	500ppm	1.73	2.55	3.50	3.58	3.86
T_6	600ppm	1.78	2.73	3.56	3.64	3.92
T_7	700ppm	1.95	2.92	3.61	3.72	4.06
T_8	800ppm	2.05	3.33	3.71	3.81	4.38
T_9	900ppm	2.16	3.67	3.75	3.92	4.58
T_{10}	1000ppm	2.37	3.85	3.93	4.08	4.70
CD at 5%		0.14	0.09	0.33	0.10	0.09
SE(m)		0.05	0.03	0.11	0.04	0.03
CV		4.59	1.84	5.81	1.73	1.41

Table 4: Effect of different concentrations of ethephon on total soluble solid of banana (˚Brix)

Notation	Treatments	3rd Day	6th Day	9th Day	12th Day	15th Day
T_0	Control	5.57	15.40	16.21	16.44	16.47
T_1	100ppm	4.67	15.69	16.61	16.74	17.10
T_2	200ppm	5.68	16.44	16.92	16.99	16.99
T_3	300ppm	8.45	17.54	17.61	18.04	18.08
T_4	400ppm	9.20	18.63	19.10	19.21	19.24
T_5	500ppm	13.77	20.83	20.91	21.32	21.35
T_6	600ppm	14.00	21.12	21.56	21.86	21.89
T_7	700ppm	14.99	21.42	21.76	22.21	22.25
T_8	800ppm	15.46	21.65	21.99	22.44	22.48
T_9	900ppm	16.45	22.23	22.45	22.65	22.68
T_{10}	1000ppm	17.30	22.44	22.63	22.77	22.80
CD at 5%		0.90	1.10	0.35	1.18	0.42
SE(m)		0.31	0.37	0.12	0.40	0.59
CV		4.64	3.34	1.04	3.44	3.58

Table 5: Effect of different concentrations of ethephon on total sugar of banana (%)

Notation	Treatments	3rd Day	6th Day	9th Day	12th Day	15th Day
T_0	Control	6.07	9.03	9.41	10.65	11.05
T_1	100ppm	6.12	10.40	11.79	11.91	13.25
T_2	200ppm	6.78	13.39	15.21	15.55	15.65
T_3	300ppm	7.25	14.63	15.26	15.75	15.97
T_4	400ppm	7.61	15.09	15.65	15.95	16.14
T_5	500ppm	8.30	15.65	16.35	16.45	16.65
T_6	600ppm	9.78	15.67	16.79	16.95	17.10
T_7	700ppm	9.96	15.90	17.20	17.35	17.45
T_8	800ppm	10.40	16.18	17.24	17.48	17.65
T_9	900ppm	10.78	16.39	18.08	18.32	18.55
T_{10}	1000ppm	10.95	16.45	18.24	18.48	18.75
CD at 5%		0.15	0.59	0.94	0.58	0.51
SE(m)		0.05	0.20	0.32	0.20	0.17
CV		1.01	2.38	3.53	2.13	1.85

Table 6: Effect of different concentrations of ethephon on reducing sugar of banana (%)

Notation	Treatments	3rd Day	6th Day	9th Day	12th Day	15th Day
T_0	Control	2.11	5.77	7.60	8.93	10.27
T_1	100ppm	2.13	5.85	7.69	8.96	10.73
T_2	200ppm	2.94	6.31	7.94	9.06	10.87
T_3	300ppm	3.04	7.01	8.09	9.27	11.28

T_4	400ppm	3.48	7.37	8.72	9.75	11.83
T_5	500ppm	5.26	7.37	10.31	10.74	12.67
T_6	600ppm	5.51	8.24	10.79	11.29	12.93
T_7	700ppm	6.15	8.43	11.07	11.62	13.26
T_8	800ppm	6.36	8.78	11.34	12.03	14.87
T_9	900ppm	7.25	9.08	11.68	12.05	15.42
T_{10}	1000ppm	8.07	9.09	12.55	12.75	17.32
CD at 5%		0.11	0.44	0.17	0.21	0.28
SE(m)		0.04	0.15	0.06	0.07	0.10
CV		1.35	3.37	1.02	1.15	1.28

Conclusion

On the basis of present investigation on "Effect of different concentrations of ethephon on ripening of banana (*Musa paradisiaca*)" the following conclusions can be made:

- In the physical parameter treatment T_{10} showed the highest value of all the observation except days taken for ripening that decreased with increase in concentrations.
- In chemical parameter T_{10} showed the highest value of all the observation

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