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Effect of post-harvest application of ethylene on ripening and quality of banana

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Abstract:

A post-harvest experiment was undertaken to find out the efficacy of different ethylene doses in ripening and changing the qualities of banana. Two varieties of banana viz., Amritasagar and Sabri were treated separately with six different concentrations of ethylene viz., 25, 50, 75, 100, 125 and 150 ppm along with control. The two-day interval data revealed that faster changes in physico-chemical qualities occurred in ethylene treated bananas than that of untreated ones and an improvement in the quality characters was observed with the increase in concentration. Among the quality characters investigated, pulp to peel ratio (5.79), total sugar (23.79%), reducing sugar (12.66%), non-reducing sugar (11.14%) and TSS (27.94) were

observed to be the highest in Sabri while titratable acidity (0.69%) were found to be the highest in Amritasagar and all were in 150 ppm ethylene. But dry matter content lowered during storage and it was minimum in Amritasagar (25.92%). Whereas in untreated banana dry matter content, pulp to peel ratio, total sugar (%), reducing sugar (%), non-reducing sugar (%), titratable acidity (%) and TSS (%) contents were 30.51 and 35.42, 3.74 and 4.19, 18.47 and 20.30, 9.92 and 10.92, 8.54 and 9.38, 0.62 and 0.58 and 20.95 and 22.09 in Amritasagar and Sabri, respectively at the final day of investigation after 8 days of treatment. Fruits attained full ripe stage within 3.8 and 4.0 days in 150 ppm ethylene treatment in Sabri and Amritasagar, respectively while untreated fruits required at least 10 days to ripen fully. Considering the above findings, it can be concluded that exogenous ethylene brings about rapid ripening with positive changes in the qualities of banana provided that the bananas are in the proper stage of maturity.

Key words: Banana, artificial ripening, ethylene, physico-chemical characters.

INTRODUCTION

Banana (*Musa sapientum* L.) is a crop of major economic importance. It represents the world's largest fruit crop with an annual production of 10.67 million metric tons in 2013 (FAOSTAT, 2015). It constitutes the 4th largest food crop of the world after rice, wheat and maize (Arias *et al.*, 2003). Among the fruit crops grown in Bangladesh, banana ranks first in terms of production comprising nearly 20% of total fruits production with 36% share in area (BBS, 2010). The consumption of banana cuts across every age group from little children to adults as it supplies necessary calories and essential micronutrients (Tran, 2011). Being a climacteric fruit, banana ripens naturally showing changes in skin color, flavor and texture of the flesh during ripening (Botondi *et al.*, 2014). But natural ripening of mature banana may result in softening with

non-uniform, dull, pale yellow and unattractive poor color (Eduardo, 2012). Under natural conditions, it ripens slowly leading to high weight loss, splitting fruit's peel (Subbaiah *et al.*, 2013); hence the marketable quality deteriorates. The small and large scale farmers use ripening agents to overcome these disputes. But most of the ripening agents are toxic and their consumption can cause serious health problems, such as heart disease, skin disease, lung failure and kidney failure (Siddiqui and Dhua, 2010; Hoque, 2012). Now-a-days, ethylene or ethrel is used to improve colour development of fruit (Zhou *et al.*, 2010). It is not a carcinogen and is classified by IARC (International Agency for Research on Cancer) as group D (not carcinogenic to human) and FAO pointed out a maximum allowable daily intake for ethylene at 0.05 mg/kg body weight/day (Bui, 2007). But in Bangladesh, there is hardly any information available pertaining to the use of growth regulating chemicals e.g., ethylene on the ripening of banana. The small-scale farmers have no knowledge of chemicals and its doses safe for human and therefore, use toxic chemicals indiscriminately. Hence, the present study was undertaken to find out a suitable method with effective dose for ripening of banana and to analyze nutritional qualities of the artificially ripened bananas.

MATERIALS AND METHODS

The present research work was conducted in the laboratory of Department of Horticulture, Bangladesh Agricultural University, Mymensingh during the period from October 2015 to January 2015. Mature green bunches of two varieties of banana viz., Sabri and Amritasagar were collected directly from farmer's field and pre-cooled to remove the field heat and thereafter different post harvest treatments viz., six different concentrations of ethylene such as 25, 50, 75, 100, 125 and 150 ppm were applied separately along with control and the treated bananas were kept on the brown paper placed on the table in

the laboratory at ambient conditions for analysis. The experiment was carried out in completely randomized design with five replications. Quality characters such as percent total weight loss, pulp to peel ratio and chemical characters viz., total sugar content, reducing sugar content, non-reducing sugar content, titratable acid content and total soluble solids (TSS) content (% Brix) of banana pulp was determined according to Ranganna (1979) and time taken to ripen and shelf life was estimated according to Mondal (2000). The two-day interval collected data on various parameters were statistically analyzed using MSTAT-C statistical package program and significant differences among the means, if any, were compared by LSD test at 1% and 5% level of probability (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Dry matter content

Total weight loss of both treated and untreated bananas decreased with the advancement of storage which differed significantly. It was observed higher in Sabri than Amritasagar (Fig. 1). Lowest percent dry matter content of banana pulp after 2, 4, 6 and 8 days of treatment was 34.07, 31.92 29.82 and 27.82%, respectively in T_6 (Ethylene; 150 ppm) treatment (Fig. 2). But dry matter content was higher in case of untreated banana. Again, during storage maximum dry matter content was observed in untreated Sabri variety and minimum in Amrisagar treated with Ethylene; 150 ppm (V_1T_6). At 8 days after treatment the highest dry matter content was found 35.42% in untreated Sabri and the lowest was recorded 25.92% in 150 ppm ethylene treated Amritasagar (Table 1). Mondal and Rouf (2011) also similar similar result in their observation with banana.

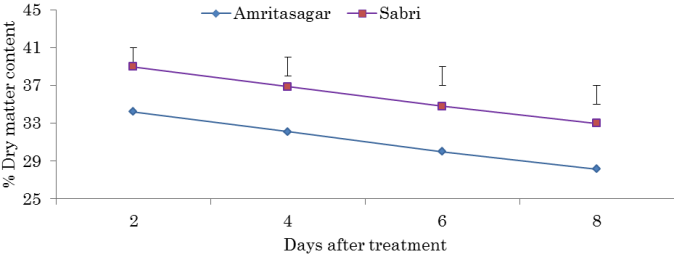

Fig. 1. Main effect of varieties on percent dry matter content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

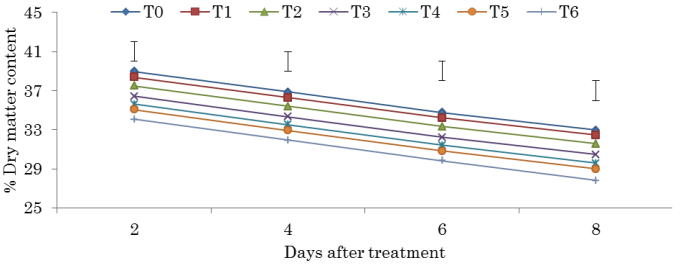

Fig. 2. Main effect of varieties on percent dry matter content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

Pulp to peel ratio

An increase in the pulp to peel ratio in both treated and untreated bananas of each variety was observed with the increase in storage and the variation was found significant being higher in Sabri and lower in Amritasagar (Fig. 3). Following the trend, after 8 days of treatment the maximum pulp to peel ratio (5.25) was found in T_6 (Ethylene; 150 ppm) treatment and minimum in control (3.93) (Fig. 4). Again in interaction, the highest pulp to peel ratio was recorded to be 3.38, 3.95, 4.77 and 5.79 after 2, 4, 6 and 8 days of treatment in V_2T_6 (Sabri with Ethylene; 150 ppm) treatment while the lowest ratios were observed to be 1.40, 1.96, 2.62 and 3.74 after 2, 4, 6 and 8 days of treatment in V_1T_0 (Amritasagar with

control) treatment (Table 1). Increase in pulp to peel ratio is related to water loss from the peel to the pulp and to the atmosphere. These findings derive support of Tripathi *et al.* (1981) and Simmonds (1960).

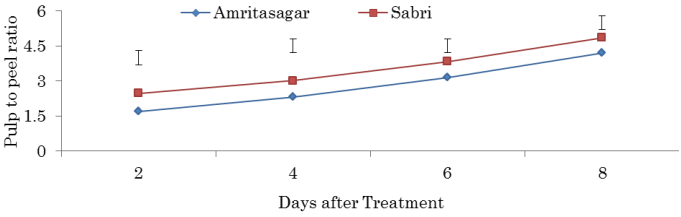

Fig. 3. Main effect of varieties on pulp to peel ratio of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

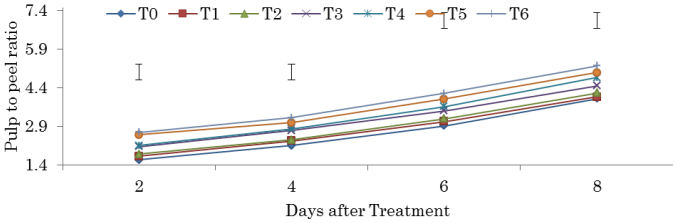

Fig. 4. Main effect of varieties on pulp to peel ratio of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

Total sugar content

Total sugar content was higher in Sabri and lower in Amritasagar during storage and it increased with the increase in concentration and time of storage (Fig. 5). Thus, the maximum level of total sugar contents were recorded to be 11.04, 14.90, 19.51 and 23.50% after 2, 4, 6 and 8 days of treatment, respectively in T_6 (Ethylene; 150 ppm) while the minimum was in T_0 (Control) treatment (Fig. 6). On the other hand, in combination after 2, 4, 6 and 8 days of treatment the maximum total sugar contents was recorded to be 11.06, 15.11, 19.61 and 23.79% in V_2T_6 (Sabri with Ethylene; 150 ppm)

treatment while the minimum total sugar contents were observed to be 7.32, 10.17, 14.52 and 18.47% after 2, 4, 6 and 8 days of treatment in V_1T_0 (Amritasagar with control) treatment (Table 1) which derive support of Tan *et al.* (2014). Chacon *et al.* (1987) also mentioned that sugar content during ripening increased from 13.2 to 19.7%.

Table 1. Combined effect of varieties and treatments on percent total dry matter content, pulp to peel ratio and percent total sugar content of banana at different days after treatment

Variety x Treatment	%Total dry matter content at DAT				Pulp to peel ratio at DAT				%Total sugar content at DAT			
	2	4	6	8	2	4	6	8	2	4	6	8
V_1T_0	36.58	34.48	32.41	30.51	1.40	1.96	2.62	3.74	7.32	10.17	14.52	18.47
V_1T_1	35.76	33.69	31.58	29.78	1.65	2.30	2.98	3.85	8.13	11.80	16.10	20.01
V_1T_2	34.75	32.67	30.56	28.79	1.59	2.15	2.97	3.96	8.46	12.13	16.43	20.40
V_1T_3	33.84	31.73	29.61	27.86	1.80	2.48	3.21	4.13	9.24	12.91	17.21	21.23
V_1T_4	33.06	30.96	28.83	26.97	1.59	2.31	3.25	4.46	8.96	12.63	16.93	21.02
V_1T_5	33.19	31.08	28.95	27.05	1.95	2.51	3.52	4.56	10.68	14.35	18.65	22.80
V_1T_6	32.14	29.99	27.86	25.92	1.95	2.51	3.58	4.70	11.02	14.69	18.99	23.20
V_2T_0	41.36	39.28	37.12	35.42	1.78	2.34	3.21	4.19	7.92	11.77	16.25	20.30
V_2T_1	40.96	38.87	36.82	35.12	1.81	2.37	3.19	4.22	9.16	13.21	17.71	21.67
V_2T_2	40.23	38.14	36.08	34.33	2.05	2.59	3.41	4.44	9.84	13.89	18.39	22.37
V_2T_3	39.04	36.93	34.86	33.09	2.40	2.99	3.78	4.81	10.17	14.22	18.72	22.73
V_2T_4	38.20	36.08	33.99	32.18	2.71	3.30	4.09	5.12	10.57	14.62	19.12	23.18
V_2T_5	36.93	34.78	32.69	30.90	3.17	3.57	4.39	5.42	10.86	14.91	19.41	23.55
V_2T_6	36.01	33.86	31.78	29.73	3.39	3.95	4.77	5.79	11.06	15.11	19.61	23.79
LSD0.05	0.69	0.69	0.69	0.69	0.23	0.21	0.20	0.22	0.17	0.17	0.16	0.17
LSD0.01	0.92	0.92	0.92	0.91	0.30	0.28	0.27	0.29	0.12	0.22	0.22	0.23
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**

ns Not-significant (p>0.05), * p<0.05, ** p<0.01; V_1= Amritasagar, V_2 = Sabri; T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

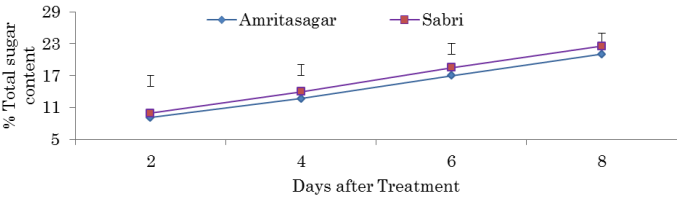

Fig. 5. Main effect of varieties on percent total sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

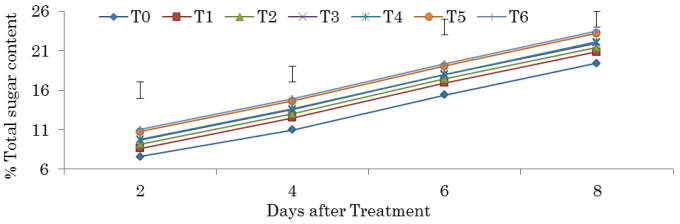

Fig. 5. Main effect of treatments on percent total sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

Reducing sugar content

An increasing trend in the reducing sugar content was found in both the varieties during ripening period. It increased gradually from 2 to 8 days after treatment and it was found maximum in T_6 (Ethylene; 150 ppm) treatment (Fig. 8) and minimum in T_0 (Control) treatment. Following the similar trend, the maximum reducing sugar contents were recorded to be 7.38, 9.48, 10.78 and 12.89% after 2, 4, 6 and 8 days of treatment in V_1T_6 (Amritasagar with Ethylene; 150 ppm) treatment while the minimum reducing sugar contents were observed to be 4.36, 6.62, 7.82 and 9.93% after 2, 4, 6 and 8 days of treatment in V_1T_0 (Amritasagar with control) treatment (Table 2). Chacon *et al.* (1987) had the same opinion.

Non-reducing sugar content

Non-reducing sugar content of bananas followed the similar trend as per reducing sugar content and a significant variation observed during the ripening period where the highest non-reducing sugar contents after 2, 4, 6 and 8 days of treatment were recorded to be 3.90, 5.85, 9.11 and 11.14% in V_2T_6 (Sabri with Ethylene; 150 ppm) treatment while the lowest in V_1T_0 (Amritasagar with control) (Table 2). The results have got support of Muthuswamy *et al.* **(**1971**)** who found very less non-

reducing sugar at the initial stage and with the advanced of fruit maturity non-reducing sugar increased.

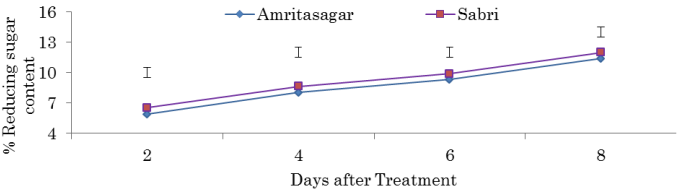

Fig. 7. Main effect of treatments on percent reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

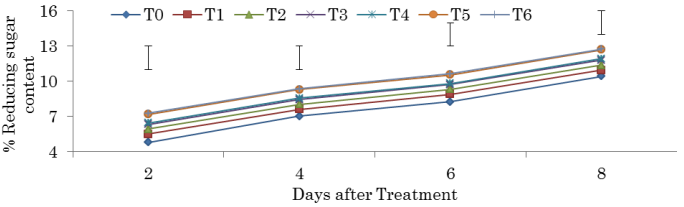

Fig. 8. Main effect of treatments on percent reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

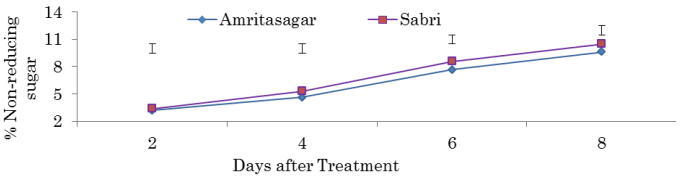

Fig. 9. Main effect of treatments on percent non-reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

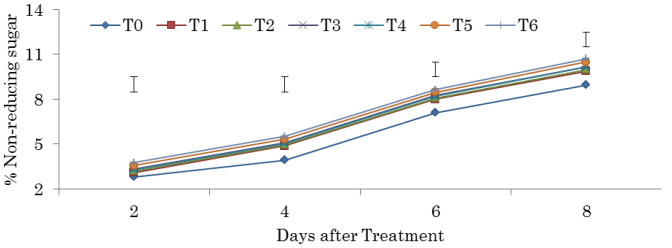

Fig. 10. Main effect of treatments on percent non-reducing sugar content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

Table 2. Combined effect of varieties and treatments on percent reducing sugar, non-reducing sugar, titratable acid and total soluble solids content of banana at different days after treatment

Variety x Treatment	% Reducing sugar content at DAT				% Non-reducing sugar content at DAT				% Titratable acid content at DAT				% Total soluble solids content at DAT			
	2	4	6	8	2	4	6	8	2	4	6	8	2	4	6	8
V_1T_0	4.36	6.62	7.82	9.93	2.9	3.55	6.70	8.54	0.32	0.42	0.51	0.62	12.26	16.46	18.85	20.95
V_1T_1	5.15	7.25	8.55	10.60	2.9	4.54	7.54	9.40	0.33	0.43	0.52	0.61	16.41	20.61	22.69	24.77
V_1T_2	5.68	7.78	9.08	11.13	2.7	4.35	7.35	9.27	0.35	0.46	0.55	0.66	17.47	21.67	23.75	25.83
V_1T_3	5.94	8.04	9.34	11.41	3.3	4.87	7.87	9.82	0.34	0.48	0.59	0.68	17.70	21.75	23.56	25.91
V_1T_4	5.84	7.94	9.24	11.32	3.1	4.69	7.69	9.70	0.38	0.49	0.61	0.68	18.96	23.01	24.41	27.17
V_1T_5	7.00	9.10	10.4	12.51	3.6	5.25	8.24	10.29	0.40	0.51	0.65	0.69	19.40	23.45	24.85	27.61
V_1T_6	7.38	9.48	10.8	12.89	3.6	5.20	8.20	10.31	0.42	0.55	0.69	0.68	19.77	23.77	25.17	27.93
V_2T_0	5.27	7.47	8.72	10.92	2.6	4.30	7.53	9.38	0.30	0.39	0.48	0.58	13.69	17.59	19.99	22.09
V_2T_1	5.89	7.99	9.24	11.31	3.2	5.22	8.48	10.37	0.32	0.42	0.52	0.59	16.49	20.64	22.96	25.20
V_2T_2	6.22	8.32	9.56	11.65	3.6	5.57	8.83	10.72	0.35	0.44	0.52	0.62	17.15	21.30	23.62	25.86
V_2T_3	6.76	8.86	10.1	12.21	3.4	5.36	8.62	10.52	0.34	0.45	0.53	0.63	17.50	21.56	23.72	26.12
V_2T_4	7.07	9.17	10.4	12.52	3.5	5.44	8.70	10.66	0.35	0.46	0.55	0.64	18.18	22.24	24.16	26.80
V_2T_5	7.38	9.48	10.7	12.86	3.5	5.43	8.69	10.69	0.36	0.48	0.59	0.64	18.93	22.88	24.66	27.36
V_2T_6	7.17	9.27	10.5	12.66	3.9	5.85	9.11	11.14	0.37	0.49	0.62	0.67	19.91	23.86	25.60	27.94
LSD0.05	0.09	0.08	0.08	0.08	0.2	0.19	0.19	0.19	0.02	0.02	0.03	0.02	0.30	0.30	0.30	0.30
LSD0.01	0.12	0.11	0.11	0.11	0.3	0.25	0.25	0.26	0.03	0.03	0.03	0.03	0.40	0.40	0.40	0.40
Level of significance	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**	**

ns Not-significant ($p>0.05$), * $p<0.05$, ** $p<0.01$; V_1= Amritasagar, V_2= Sabri; T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

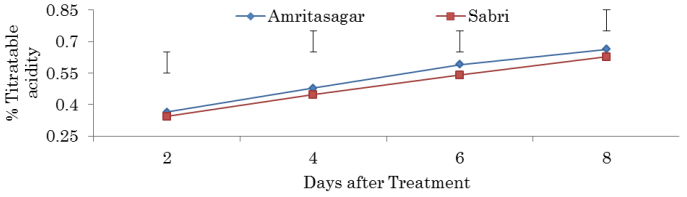

Fig. 11. Main effect of treatments on percent titratable acid content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

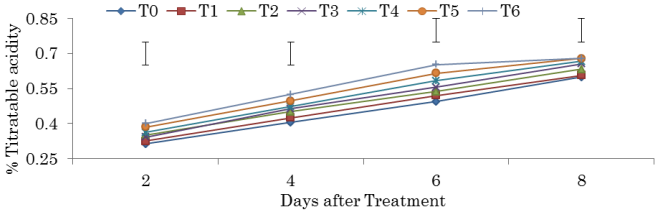

Fig. 12. Main effect of treatments on percent acid content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

Titratable acid (TA) content

Titratable acidity (TA) was observed higher in Amritasagar than Sabri (Fig. 11). The maximum titratable acid content of banana was found in T_6 (Ethylene; 150 ppm) treatment followed by T_5 (Ethylene; 125 ppm) treatment and minimum in T_0 (Control) treatment (Fig. 12). Again, the highest titratable acidities were found to be 0.42, 0.55 and 0.69% in V_1T_6 (Amritasagar with Ethylene; 150 ppm) treatment after 2, 4 and 6 days of treatment, respectively and after 8 days of treatment it was observed 0.69% in V_1T_5 (Amritasagar with Ethylene; 125 ppm) (Table 2) whereas minimum values were found in V_2T_0 (Sabri with Control). TA in V_1T_6 had reached its peak after 6 days of treatment but then it declined gradually. The results agree with the report of Tapre and Jain (2012) who reported that TA increased to its peak as ripening progressed.

Total soluble solids (TSS) content

TSS contents increased with the progress of ripening and it reaches maximum after 8 days of treatment which was found higher in Sabri than in of Amritasagar (Fig. 13). T_6 (Ethylene; 150 ppm) treatment resulted in maximum TSS but lowest in control. Again, after 2, 4, 6 and 8 days of treatment, the highest values were observed to be 19.91, 23.86, 25.60 and 27.94% in V_2T_6 (Sabri with Ethylene; 150 ppm) treatment and the lowest were 12.26, 16.46, 18.85 and 20.95% in V_1T_0 (Amritasagar with control) (Table 2). The present results have got support of Sandipkumar and Shanmugasundaram (2015 and Mondal and Rakib (2014).

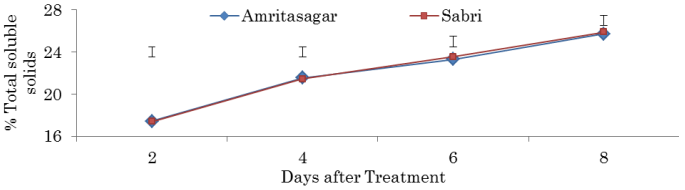

Fig. 13. Main effect of varieties on percent total soluble solids content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

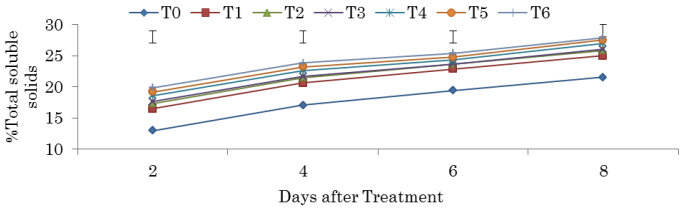

Fig. 14. Main effect of treatments on percent total soluble solids content of banana at different DAT. Vertical bars represent LSD at 1% level of significance.

T_0= Control, T_1= Ethylene; 25 ppm, T_2= Ethylene; 50 ppm, T_3= Ethylene; 75 ppm, T_4= Ethylene; 100 ppm, T_5= Ethylene; 125 ppm, T_6= Ethylene; 150 ppm

Time taken to ripen banana

Ripening is a biochemical process which involves a series of physiological changes in colour, aroma, flavor and texture (Sogo-Temi *et al.*, 2014). It took higher time to ripen in Amritasagar than in Sabri (Fig. 15). Under V_2T_6 (Sabri with Ethylene; 150 ppm) treatment banana ripened in 3.8 days while in V_1T_0 (Amritasagar with control) treatment it took maximum 8.4 days (Table 2). Exogenous application of ethylene accelerated the ripening process (Robinson and Sauco, 2010) and enhanced the physico-chemical changes shortening the time to reach fully ripe stage.

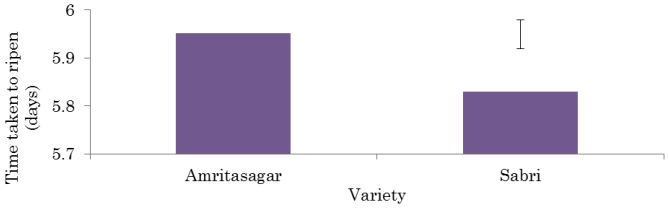

Fig. 15. Main effect of varieties on time taken to ripen banana. Vertical bar represent LSD at 1% level of significance.

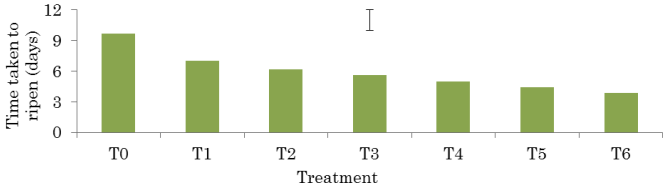

Fig. 16. Main effect of treatments on time taken to ripen banana. Vertical bar represent LSD at 1% level of significance.

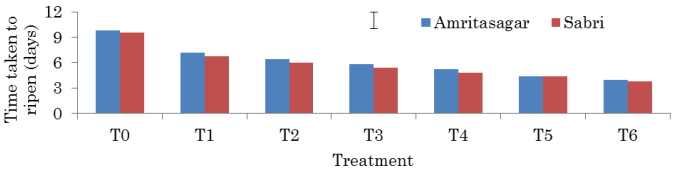

Fig. 17. Combined effect of variety and treatment on time taken to ripen banana. Vertical bar represent LSD at 1% level of significance.

CONCLUSION

Now, from the results of this study it can be concluded that exogenous ethylene application brought about rapid ripening of banana with no deterioration in the quality characters rather improvement of those qualities provided that bananas are treated at proper stage of maturity.

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