GLOBAL JOURNAL OF BIO-SCIENCE AND BIOTECHNOLOGY

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DEVELOPMENT OF NUTRITIONAL QUALITY AND BIOCHEMICAL CONTENT OF BILIMBI FRUIT BY USING PLANT HORMONE AND BARK STRESS

A.B.M. Sharif Hossain
Biotechnology Program, Department of Biology, Faculty of Science, University of Hail, KSA
*Corresponding Authors email: abm.hossain@uoh.edu.sa

ABSTRACT
Plant hormone keeps a significant role to enlarge the fruit size and quality development. Fruit growers have a lot of interest in making fruit enlargement and shorten maturity to harvest fruit earlier and to make it marketable soon. Gibberellic Acid (GA_3) and bark stress play a significant role in fruit enlargement and development. Bilimbi fruit was used in this experiment. The flower bud were swabbed with the respective chemical (GA_3) and physiological stress (bark stress) at one week interval for 2 weeks. It had been shown that the GA_3 50ppm played major role in developing a bigger sized (length and diameter) fruit as compared to the bark stress, thinning and control. Fruit/bunch was higher as well as lower fruit drop percent compared to other treatments. Fructose content and pH were found higher in the distal end of the fruit than in the middle and proximal end of the fruit. Total soluble solid (TSS) content was higher in the distal end of the fruit than in the middle and proximal end of the fruit in the case of all treatments. However, TSS was higher in the case of GA_3 and bark stress treated fruit than in the thinning and control fruit. The results showed that GA_3 50ppm using swabbed technique was the best and bark stress was more effective for the enlargement of fruit size and improve the better biochemical content in bilimbi fruit.

KEYWORDS: bilimbi fruit, nutrient and biochemical content, GA3, bark stress

INTRODUCTION

Bilimbi fruit (*Averrhoa bilimbi*) native to tropical Asia and grown for edible as well as medicinal fruit value. Bilimbi fruit is used for making a cooling beverage. In Indonesia, it is added in some dishes, for substituting tamarind or tomato. Besides, the fruit can be preserved, which reduces its acidity. It can be replaced by mango in making chutney. In Malaysia, it also used for making jam which is rather sweet. It is used for making pickles[1]. It was reported that the fruit contains high levels of oxalate. Due to tubular necrosis, acute renal failure caused by oxalate has been recorded in several people and made treatment hypercholesterolemia by the concentrated juice[2]. Plant hormones (auxin, Gibeberellic acid and cytokinins) used in order to promotes the growth of fruits[3,4.] GA3 is an important growth regulator that may have many uses to modify the growth and yield contributing of plant[4] GA3 includes a large range of chemicals that are produced naturally within plants. Gibberellin plays a major role in seed germination, affecting enzyme production that mobilizes food production that new cells need for growth. This is done by modulating chromosomal transcription. GA3 causes the remarkable elongation in flower and fruit been reported by several workers[5,6]. Gibberellin promotesthe plants growth. Stimulation of cambial growth in Gibberellin has been reported in shoots[3]. The obvious effect of GA3 had shown the increased in the number of internodes[7]. Maximum number of flowers in a hibiscus flower was obtained by spraying the GA3 at specific concentration [8,9]. Hossain *et al*[10] reported that fruit quality might improve by different stresses like phloem stress in bark, temperature, heat and thinning *etc*. Hoassin *et al*[3] reported that swabbing techniques other than spray was better, environmentally safe and cost effective method. There were a few literatures found in this regard in different fruit, but no literature found for bilimbi fruit. That is why the objectives of this research work were undertaken to study the effect of Gibberelic acid on fruit growth and improve fruit nutritional quality.

MATERIALS & METHODS

This project was carried out in the Institute of Biological Sciences orchard in the University of Malaya, Kuala Lumpur, Malaysia.

Plant material: 10 year-old four *Averrhoa bilimbi* trees were selected in the University of Malaya Botanical garden, Kuala Lumpur. Then, 4 branches of each *Averrhoa bilimbi* tree were selected.

Treatment setting: GA3 50 ppm, thinning of fruit, xylem stress and water control (control) were applied as treatments.

GA3 50ppm application: Four branches were used for each treatment in each trees which are swabbed (once per week until 2 weeks) with GA3 (50ppm) using cotton during the flower bud formation.

Thinning: Thinning was done using 5 fruits left (removing 50% of fruits from the selected bunches of bilimbi fruit).

Bark or phloem stress: Bark stress was employed at the base of the branches by removing bark except leaving I-Shape bark (2 cm of length remaining 3mm connecting strips) junction with lower to upper level of shoot.

Each selected branches were then marked for the identification. Before harvested, the fruit diameter, fruit length, number of fruits drop and set finally were

measured during the harvesting. After six weeks, the fruits were harvested.

Measurement the fruit: The fruit length and diameter was measured using the Vernear scale.

Juice collection: Fruit juice was collected manually using hand immediately after harvest using hand threaser and also cheesecloth and preserve in the freezer to determine the TSS and pH. Fruit juices were collected according to each portion of the fruits like proximal end, middle portion and distal end (Figure 1). Then, it was kept in the vials and then stored in the refrigerator.

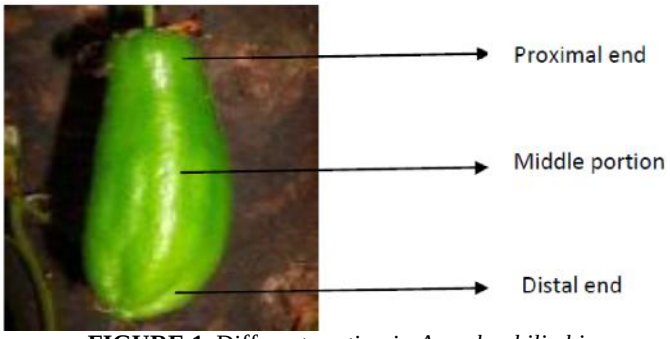

FIGURE 1. Different portion in *Averrhoabilimbi*

(a) Water control (b) GA3 50ppm (c) Bark or phloem stress (d) Thinning

FIGURE 2.Fruit growth at different treatments.

Total soluble solids (TSS) determination: The Total Soluble Solid (TSS) content in the *Averrhoa bilimbi* was determined by using an Atagorefrectometer (Japan) by placing a drop of fruit juice on its prism. The percentage of TSS was obtained from direct reading of the refractometer. In order to obtain the accurate result, the experiment was repeated and the average reading was recorded.

pH measurement: pH was measured using the pH meter. One drop of sample was homogenized in 1 ml of boiled distilled water and 1 ml of de-ionized water of pH 7.0. The pH of *Averrhoa bilimbi* juice was recorded by using an electronic pH meter. The pH meter was standardizing with the help of buffer solution.

RESULTS

Physiological data analysis

It has been shown from the table 1, fruit per bunch and fruit drop percent were higher in the treated trees than the control tree. The highest fruit per bunch was found in the GA3 treated fruit and drop percent was the lowest in the GA3 treated fruit and the highest was found in the water control (Table 1). Fruit length, diameter and juice content were higher in the GA3, bark stress and thinning treated tree than the water control tree (Table 1).

TABLE 1. Effects of different treatments on fruit growth and juice content

Treatment	Fruit/bunch (Starting)	Fruit/bunch (during harvest)	% drop	Fruit length (cm)	Fruit Diameter (cm)	Juice content (ml)
Control	10.0	8.0±0.7	20±1.0	4.7±0.05	1.3±0.01	8.5±0.4
Thinning	5.0	4.4±0.1	12±0.9	5.3±0.04	1.5±0.01	10±0.5
Bark stress	10.0	9.1±0.6	9.0±0.6	5.5±0.06	2.6±0.02	12±0.4
GA3	10.0	9.2±0.7	8.0±0.6	5.8±0.03	2.9±0.01	14±0.3

Biochemical parameter analysis

pH and fructose content were determined from the proximal, middle and distal end of the bilimbi fruit shown in Table 2. The pH content was found higher in treated fruit than the water control fruit in the case of proximal, middle and distal end. It was the highest in the distal end (Table 2). Accordingly, fructose content was found higher in the treated (thinning, bark stress and GA3) fruit than the water control fruit in the case of proximal, middle and distal end. It was the highest in the distal end (Table 2).

TABLE 2. The acidity (pH) and fructose of *Averrhoa bilimbi* at different treatments

Treatment	Proximal end		Middle portion		Distal end	
	pH	Fructose	pH	Fructose	pH	Fructose
Control	3.1±0.3	5.0±0.4	3.0±0.2	5.3±0.3	2.9±0.1	5.5±0.3
Thinning	3.3±0.2	5.9±0.5	3.1±0.1	6.4±0.2	3.1±0.05	6.6±0.3
Bark stress	3.8±0.3	6.2±0.3	3.9±0.05	6.5±0.3	4.1±0.1	6.9±0.2
GA3	3.6±0.2	7.0±0.4	3.9±0.2	7.3±0.4	4.8±0.2	7.7±0.2

It has been shown in Figure 3, total soluble solid (TSS) was higher in the GA3 50ppm, thinning and bark or phloem stress than in water control in the case of proximal, middle and distal ending. In GA3 50ppm, it was the highest in the distal end than middle and proximal end. However, in the case of water control, thinning and bark stress, TSS was found different sequence in the proximal, middle and distal end compared to the GA3 50 ppm (Figure 3).

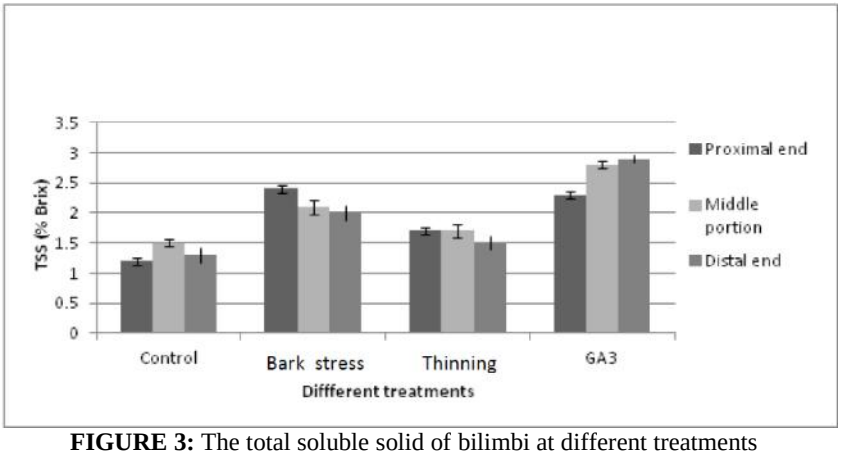

FIGURE 3: The total soluble solid of bilimbi at different treatments

Correlation between the pH and fructose content was shown in the Figure 4. It was found positive correlation between pH and fructose. Fructose content was found increasing trend while increasing pH content exhibited. Here log correlation was found appropriate rather than linear (Figure 4).

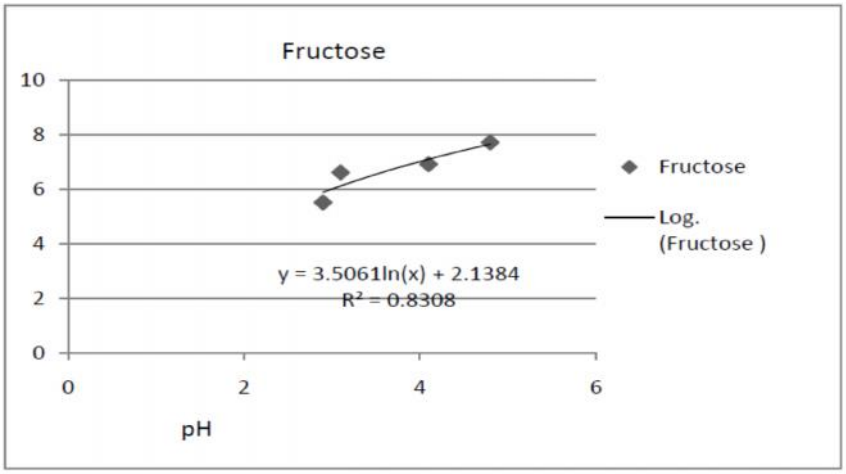

FIGURE 4. Correlation between pH and fructose content of bilimbi fruit

DISCUSSION

Fruit length and diameter were found higher in the GA3 50ppm and bark stress. This was due to the effects of bark or phloem stress and GA3. Xylem tissue is responsible for the transportation of water and soluble mineral nutrients from the roots throughout the plant and phloem tissue is responsible to transport carbohydrate (glucose, sucrose) from leaf to shoot and the final to the root[10,11]. By doing the bark stress or phloem stress treatment to the fruits, the carbohydrate that was not transported from upper part to lower part of the shoot where the treatment was set[5]. Consequently the fruit size become higher compared with the control. For the biological treatment GA3 (one type of plant hormone) was used. It was reported that GA3 influenced the fruit growth and development [6,8]. Fruit growth is characterized by cell division followed by cell differentiations which were influenced by cytokinins, gibberellins and auxins[12,13]. Gibberellins can promote cell

division and elongation respectively. The increase of fruit weight was attributed to the effect of (GA3), acting synergistically increasing fruit diameter and size[14]. Localized application of (GA3) to bilimbi is known to increase the sink strength enabling them to attract photo assimilates from the foliage and to develop fully formed fruits[15]. In this experiment, 50 PPM concentration of GA3 was used. The 50 PPM was chosen because of the previous research, the result showed that 50 PPM concentration had the better effect in terms of other fruits growth and developments. The spraying of GA3 on the bilimbi fruits probably satistified the initial requirement for fruit. While, for the GA3 treatment, it just promoted the fruit elongation in terms of cell division and cell differentiation[14.] The plants, which are rich in gibberellin, have long internodes. Gibberellins are less sensitive to light compared to auxins and they show less depressive effect in high-dose applications. The Gibberellins encourage germination by breaking the dormancy of the seeds within the botanical organs is proportional to the amount of increase in gibberellin. Gibberellins are known to increase the parthenocarpic fruit production like auxins and even they are sometimes more efficient [4,16,17,18]. In the results, it has been found that thinning increased the fruit size also. Fruit size was generally increased by the chemical thinners because thinning of fruits causes increase in fruit size[16]. Thinning fruits increases the leaf to fruit ratio because removing some of the fruits causes the remaining ones to become larger in size but not in direct proportion to the increase in the number of leaves per fruit[16]. Yield is a function of thinning factors as flower bud number per bud, fruit number and fruit size[16]. It has been assumed that these factors contribute equally to yield. The findings of the present study agree with the findings of Wismer[14] who obtained increased yield from thinning. Fruit shape is affected by chemical thinners differently, *e.g.* Gibberellins and some cytokinins increase fruit length and kinetin and Auxin do not affect fruit shape[16]. Phloem stress also made response to fruit size. Jose[19] found that girdling treatments cause lower vegetative growth in relation to control in mango trees.Arakawa et al. Arakawa [20] reported that trunk growth of apple trees was significantly increased above the girdling point and reduced below it. Onguso *et al* [21] reported that the increase of trunk circumference above the girdle might be caused by swelling of the trunk due to the accumulation of carbohydrates. They also stated that girdling blocks the translocation of sucrose from leaf to root through the phloem bundles. The block decreases the starch content in the root and accumulates sucrose in the leaf. Total Soluble Solid (TSS) and pH were found higher in middle and distal end than proximal end of the fruit. It is done because every portion in the fruits would have different carbohydrate contents, sugar content as well as different taste. It is due to the different exposure to sunlight. Normally, the middle portion and the distal end exposed more to sunlight compared to the proximal end. Thus, photosynthesis rate occurred rapidly at these portions which led to the higher levels of carbohydrate in the fruits. Brix are a measure of TSS in a given weight of fruit juice. It is often expressed as the percentage of sucrose. However, the sucrose here is actually the sucrose, fructose, vitamins, amino acids, proteins, hormones and other solids. The higher the Brix, the better its quality[3,10 .22,23,24,25,26].

CONCLUSION

From the result it can be concluded that GA3 50ppm is the best treatment compared to others showing the biggest size (length and diameter) and highest TSS and fructose content of bilimbifruit. Then the bark stress and thinning treatments showed the second highest compared to the control.

ACKNOWLEDGEMENT

I am thankful to the University of Malaya, Malaysia and University of Hail, Saudi Arabia for providing support to complete this research work.

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