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Original Research Article

Plant Age and Rate of Flower Inducer Affects Flower Initiation of 'MD2' Pineapple (*Ananas comosus* L.)

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ABSTRACT

Pineapple plants are induced to flower especially for commercial production to synchronize harvest and save labor costs. This study was conducted to determine the flowering response of 'MD2' pineapple plants of different ages to rates of Ethrel application. The experiment was laid out in Split Plot arrangement in RCBD. The ages of pineapple (9, 10, 11 month-old plants) served as the main plot, whereas the rates of Ethrel (0, 800, 1000, 1200 ppm) as the sub plot.
'MD2' pineapple (10 and 11 months old) exhibited comparable growth characteristics except for D-leaf weight. Plants at 11 months after planting (MAP) were relatively heavier compared to 10 MAP. Growth characteristics of the 9 MAP plantings were generally inferior compared with those of the 10 and 11 months-old. Rate of Ethrel induced 95.56 to 100% apical differentiation of the plants. Although the control showed only 13.33 % apical differentiation at 18 days after treatment, this indicates the readiness of 9 MAP 'MD2' pineapple for flower induction. Apical differentiation of meristems among 'MD2' pineapple have significantly increased and become distinct with the increasing rates of Ethrel. Percent red buds development at 41 days after flower induction increased from plants of 10 to 11 MAP and as the rates of Ethrel application was increased from 800 to 1200 ppm. Likewise there was a significant interaction observed between the age of the plants and the rates of Ethrel in red buds development of 'MD2' pineapple. Highest percentage of red buds development was attained in 11 month-old plants applied with 1200 ppm Ethrel.

Keywords: pineapple flowering, ethylene, plant age, flower initiation

INTRODUCTION

Pineapple, scientifically known as *Ananas comosus* is one of the tropical fruits with greatest demand in the international market due to its high nutritional values and economic uses. In 2004, pineapple has a worldwide production of 16.1 million metric tons. Of this reported productivity, Asia produces 51% (8.2 million mt), with Thailand (12%) and the Philippines (11%) which are the two most productive countries. America and Africa contribute 32% and 16% of the world's production, respectively, with Brazil (9%) and Nigeria (6%) considered also as major producers (FAO, 2006).

Pineapple is generally consumed as fresh fruit. However, with the development of the processing industry, the fruit is now prepared and consumed in various forms such as pineapple chunks, slices, juices, syrups, jams, crushed pineapple, diced pineapple etc. Likewise, the wastes from processing of fruits are further developed into sweets, wines, vinegar, animal feed, etc.

Pineapple plants are induced to flower early especially for commercial

production to synchronize harvest and save labor costs. However, pineapples have erratic response to flower induction treatments resulting in irregular and staggered harvesting. This may be due to variability of plant age, rates of flower inducers applied and other factors. Hence, the study aimed to determine the age of the pineapple plant and rates of Ethrel application best for flower induction.

MATERIALS AND METHODS

The experiment was conducted from November 2011 to March 2012 at Mt. Kitanglad Agricultural Development Corporation (MKADC), Valencia City, Bukidnon. MD2 variety from suckers was used as planting materials. Pineapple suckers were obtained from adjacent fields of MKADC. The planting materials were sprayed with recommended rates of pesticides according to the established standard of MKADC Farm.

As standard farm practice, pineapple plants are grown on staggered basis. From these plantings, fields with existing pineapple plants of different physiological ages: 9, 10 and 11 months after planting were selected. The different age groups were grown on different fields at the same elevation based on optimal management practices.

The experiment was laid out in a Split-Plot arrangement in Randomized Complete Block Design (RCBD). The three ages of pineapple: at 9, 10 and 11 month-old served as Main plot (MP) while the four rates of Ethrel application: 0, 800, 1000 and 1200 ppm as Sub plot (SP).

Each treatment was replicated three times, with a total of 36 experimental plots. Each plot measured 19.5 sq m. with three beds consisting of 150 plants. The inner beds of 50 plants were data rows and the outer two beds with 100 plants served as border rows.

All plants used in the experiment were induced at the same time to prevent variation in weather conditions, which can influence the flower induction treatment. Flower induction treatments were applied at 7-8 am using a knapsack sprayer calibrated to discharge 2,500 liters solution per hectare or 33.33 ml per plant.

Data Gathered

Data gathered were the initial characteristics of test crops (plant height, plant weight, number of leaves, D- leaf weight, color rating of apical leaves and Carbon: Nitrogen ratio), percent apical differentiation, percent red bud development, and plant height after flower induction treatment.

RESULTS AND DISCUSSION

Initial Characteristics of Test Crops

Height of 'MD2' pineapple at different ages vary with an average of 108.09 cm at 9 months after planting (MAP), 116.73 cm for 10 MAP and 117.37 for 11 MAP respectively. Results indicate that the 10 and 11 MAP ages of pineapple plants have more or less similar heights with an average difference of about 0.64 cm. On the other hand, the 9 MAP had the least height of 108.09 cm with a difference of 9.25 cm in comparison with the 11 MAP.

The weight of 'MD2' pineapple plants differed with ages or stages of growth. However, plants at 10 and 11 month- old had similar weights of 3.19 and 3.04 kg respectively but relatively higher compared to the 9- month old plants with 2.1 kg only.

'MD2' pineapple showed an increasing 'D' leaf weight as the plant developed. Based on age, the D-leaf weights at 9, 10 and 11thmonths were 112.84, 119.17 and 127.09 grams, respectively. A D-leaf is the youngest among the adult leaves of pineapple as well as the most physiologically active. Its weight is reflective of the readiness of pineapple for flower forcing and bases for forecasting weight of fruits. According to Fornier et al (2006), in pineapple "Flhoran 41", a D-leaf of 70 g is sufficient to get exportable fruits, whereas 80 g is the standard for "MD2" and "Smooth Cayenne". In "Perola", it was recommended that the plant can be induced

to flower when D-leaves have a minimum fresh weight of 80 g and a minimum length of 1.0 m in order to get fruits weighing more than 1.5 kg (Reinhardt et al, 1987).

Leaves of 'MD2' pineapple plants at 9, 10 and 11 months were 31.33, 32.67, and 34.33, respectively with only one leaf difference per month. According to Cunha and Cabral (1999) the leaves represent about 90 % of the total fresh weight. Pineapple varieties have different number of leaves as basis for their maturity which may be equated with their ages.

The color rating of 'MD2' pineapple plants increased with age (Table 1). Those 'MD2' pineapple plants at 9 months old had an apical color rating of 1 described as green while those at 10 and 11 month-old had distinct green and dark green leaf apices respectively.

The average C/N ratio of 'MD2' pineapple vary with age of plants. This data reflect the amount of carbohydrate accumulated by plants in relation to their nitrogen content during the plant growth and development. Results indicate that the carbohydrate to nitrogen ratio of 'MD2' pineapple plant increased as the plants aged, the least 39.47 in 9 months old while in the 10 and 11 MAP they have more or less similar C/N ratio of 52.49 and 52.61 respectively.

Table 1. Initial characteristics of the test crops used in this study

CHARACTERISTICS	AGES OF PLANTS		
	9MAP	10 MAP	11 MAP
Average Plant Height (cm)	108.09	116.73	117.37
Average Plant Weight (kg)	2.10	3.04	3.19
D-Leaf Weight (grams)	112.84	119.17	127.09
Average Number of Leaves	31.33	32.67	34.33
Color Rating of Apical Leaves*	2.07	3.27	3.53
Average C/N Ratio	39.47	52.49	52.61

*Apical Leaf Color Rating

Color Rating	Description
5	The apex shows a distinct 7 cm above wide dark green color while leaves surrounding the apex have dark green color
3	The apex shows a distinct green color of about 4-6 cm wide
1	The apex has distinct light green color about 2.5 to 3.0 cm diameter

Apical Differentiation

Table 2 presents the percentage apical differentiation of 'MD2' pineapple plants at various ages applied with different rates of ethrel. Results revealed that apex differentiation was not significantly affected by the ages of plant. However, the rates of ethrel application significantly influenced this parameter. But no significant interaction effects were observed between these two factors.

Apex differentiation signals the transformation of the plants from vegetative to reproductive stage. However, it was found that the apical differentiation among plants of different ages was not significant. Likewise, those 'MD2' pineapple plants at 10 MAP had relatively higher (81.67 %) apical differentiation but not significantly different from those plants at 9 and 11 MAP.

For 9 months old 'MD2' pineapple plant, unsprayed with ethrel (control) did not show apical differentiation whereas application of 800 ppm of ethrel increased the percentage of plants (93.33 %) with apical differentiation. Increasing the rates of ethrel application to 1000 and 1200 ppm, gave 100 % of plants exhibiting apical differentiation respectively (Table 2).These results indicate that at 9 MAP, 'MD2' pineapple plants are responsive to ethrel application which is evident in its apical differentiation at 18 days after treatment with 93.3 to 100 % of plants attaining such morphological changes.

Table 2. Percent apical differentiation of 'MD2' pineapple plants at different ages in response to rates of Ethrel, 18 days after application

Ages Of Plants (months)	RATES OF ETHREL (ppm)				MEAN
	0	800	1000	1200	
9	0.00	93.99	100	100	73.33
10	26.67	100	100	100	81.67
11	13.33	93.33	100	100	76.67
MEAN	13.33[b]	95.56[a]	100[a]	100[a]	

CV (MP) = 8.99 %; CV (SP) = 8.63 %

Means within the same row followed by a common letter are not significantly different at 5 % level based on DMRT.

According to Augustus and da Cunha (2005) floral differentiation of pineapple can be triggered by chemical substances and whose susceptibility to

environmental or chemical factors can be related to age or size of the plants. The involvement of hormones synthesized by plants like auxins and ethylene as the real inducing factor (Burg and Burg, 1966) and ethrel or ethephon which is ethylene in liquid form can trigger flower induction as evidenced in its apical meristem differentiation. In fact it was reported by De Poel and De Croylaan (2009) that 'MD2' pineapples at 3 months after planting have reached physiological maturity and is susceptible to ethylene treatments even though they are not yet large enough to produce marketable fruit.

In general, regardless of ages 'MD2' pineapple plants without Ethrel application had very low or did not at all show apical differentiation. However at 10 MAP, all plants sprayed with increasing rates of ethrel at 800, 1000 and 1200 ppm exhibited 100 % apical differentiation (Table 3). Likewise, at 11 MAP, the same trend was observed on 'MD2' pineapple plants applied with different rates of ethrel treatments which significantly differed with the control in Table 3.

Table 3. Transformed data on percent red buds developed in 'MD2' pineapple at different ages in response to rates of Ethrel application

TREATMENTS	PERCENT RED BUDS DEVELOPED
Plant Ages (Factor A)	
9 MAP A_1	0.71^b
10 MAP A_2	4.32^a
11 MAP A_3	4.93^a
F-Test A	**
Rates of Ethrel (Factor B)	
0 B_1	0.71^d
800 ppm B_2	3.22^c
1000 ppm B_3	4.20^b
ppm B_4	4.71^a
F-Test B	**
Plate Age (A) x Rates of Ethrel (B)	
A_1B_1	0.71^d
A_1B_2	0.71^d
A_1B_3	0.71^d
A_1B_4	0.71^d
A_2B_1	0.71^d
A_2B_2	4.43^c
A_2B_3	5.80^c
A_2B_4	6.33^b
A_3B_1	0.71^d
A_3B_2	4.53^c
A_3B_3	6.08^b
A_3B_4	8.40^a

Means within the same column followed by a common letter are not significantly different at 5 % level based on DMRT.
**- highly significant

Based on the result, the rates of 1000 and 1200 ppm of Ethrel applied on 9 months old 'MD2' pineapple plants which induced 100 % apical differentiation, suggested an optimum rates of 1000 ppm on 9 MAP. However, on 10 MAP the rates of 800, 1000 and 1200 ppm Ethrel attained 100 % apical differentiation among 'MD2' pineapple plants suggested that 800 ppm ethrel could be an optimum rate for 10 MAP for commercial flower induction.

There are 'MD2' pineapple plants however whose apical meristem have differentiated (13.33 %) without Ethrel application. This may suggest that some plants are ready for flowering which may be triggered by other factors like climatic factors, cultural practices, as supported by the high C/N ratio in 10 and 11 months old pineapple plants.

Percent Red Buds

The average red buds developed at 41 days after flower induction from'MD2' pineapple plants of various ages is presented on Table 3. Results revealed that the development of red buds was highly affected by the ages of 'MD2' pineapple plants and the rates of ethrel application as well as the interaction of these factors.

It was found that 'MD2' pineapple plants of 11 MAP significantly developed higher red buds (31.67 %) but statistically comparable to those at 10 MAP which formed 23.33 % red buds at 41 days after treatment. In comparison, 'MD2' pineapple plants at 9 MAP (Control) did not develop red buds at all. Likewise, regardless of age, 'MD2' pineapple plants without ethrel application (Control) did not form red buds in their apex.

A significant interaction effects between these two factors revealed that the development of red buds increased as the plants become older and as the rates of ethrel application on these plants increased as evidenced in the highly significant appearance of red buds reaching an average of 70 % among 11 MAP plants sprayed with 1200 ppm of ethrel at 41 days after the

application of treatment. These are best supported by the data on apical differentiation of 'MD2' pineapple plants (Table 3) showing higher percentage of plants among those older plants applied with higher rates of ethrel treatments.

Although those at 9 MAP applied with 800 ppm of ethrel significantly exhibited apical differentiation, there was no development of red buds. This delay may be attributed to some other plant factors like lower C/N ratio, lesser plant weight, lesser number of leaves which are essential in the flower induction of pineapple as what had been pointed out in the earlier discussion of results.

Plant Height After Flower Induction Treatment

Plant height was highly influenced by the independent effects of plant age and rates of ethrel application (Table 4). However no significant effects were observed between these two factors.

Results revealed that height of older plant i.e. 11 MAP was relatively higher (122.97 cm) than those in 10 MAP but their difference was not significant. However, height of these two ages of 'MD2' pineapple plants differed from those at 9 MAP (114.37 cm) at 41 days after ethrel treatment. It was found however, that the change in plant height (6 cm based on initial height prior to application of treatment) of 9 MAP plants was higher among all ages of plants. This result indicated that after flower induction treatment, all plants especially those at 9 MAP still increased in their height. This may suggest that the formation of leaves may still compete with the carbohydrates utilized for the formation of fruits. It may also indicate that the plants require the formation and development of leaves which may contribute to the photosynthetic activity of the plant necessary to support for the development of fruits.

Table 4. Average plant height (cm) of 'MD2' pineapple at different ages in response to rates of Ethrel application

Age Of Plant (months)	RATES OF ETHREL (ppm)				MEAN
	0	800	1000	1200	
9	121.83	116.37	110.70	108.57	114.37^{b}
10	126.07	120.20	116.87	114.77	119.48^{a}
11	129.77	123.77	120.60	117.73	122.97^{a}
MEAN	125.89^{a}	120.11^{b}	116.06^{c}	113.69^{c}	

CV (MP) = 3.36 %; CV (SP) = 2.86 %

**Means within a row and a column followed by a common letter are not significantly different at 5 % level based on DMRT.

CONCLUSIONS

Eleven (11) months old 'MD2' pineapple is the best age of plants being the most responsive to flower induction treatments.

Application of Ethrel at the rate of 1200 ppm induced the highest percentage of floral initiation as evidenced by the apical meristem differentiation, and development of red buds on 'MD2' pineapple plants.

Application of Ethrel at the rate of 1200 ppm on eleven (11) months old 'MD2' pineapple plants is the best combination of treatments that will give the highest percentage flower initiation and red buds development.

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