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THE INFLUENCE OF THREE HORMONES ON THE INDUCTION OF FLOWERING AND YIELD OF TWO PINEAPPLE CULTIVARS *(ANANAS COMOSUS)*

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ABSTRACT

Two experiments were conducted on 1st April, 2004 and 5th April, 2005 with pineapple suckers established on 1st July, 2003 at Iwuru to determine the effect of three forcible hormones at different concentrations: (calcium carbide: 25, 30, and 35 g per L napthaleneacetic acid-0.25, 0.5 and 0.75 per L and B-hydroxyethyle hydrazine 0.25, 0.5, 0.25 per L on the flowering and fruiting of two pineapple cultivars. The results showed that plots treated with B-hydroxyethyl hydrazine at 0.5 per L produced flowers within 8 days and were significantly ($P<0.05$) superior to all other treatments. Calcium carbide applied at a concentration of 30 g per L was more outstanding in inducing flowering and fruit production than either 25 or 35 g per L. Increasing the concentration of naphthaleneacetic acid from 0.25 to 0.5 and from 0.5 to 0.75 per L consistently increased the production of flowers in the two cultivars. There was 51.5% drop in flowers production and 34.1% drop in fruit production when B-hydroxyethyl hydrazine was increased from 0.5 to 0.75 per L. These results are discussed in light of application of hormone concentrations in pineapple management.

KEYWORDS: Hormones, flowering and Fruiting of Pineapple

INTRODUCTION

The pineapple (*Ananas comosus*) originated from southern Brazil and Paraguay (Sampson, 1986). It is believed that from here it was spread by Indians through south and Central America to West Indies.

The plants are induced for flowering and fruiting at 15 months using spray of calcium carbide which produces acetylene and naphthalene acetic acid and B-hydroxythyl hydrazine that produce ethylene (Maxwell and Maxwell, 1984). The growth regulator most commonly used for forcing is ethephon, an ethylene-releasing compound that is widely used for field applications in inducing flowering in plants (Collins, 1960; Coppens *et al*, 1997). Ethylene and acetylene are also for fruit forcing. Equally, in commercial agricultural establishments, plants are forced with a solution containing ethephon mixed with urea (Matos, 1995; Leal and Coppens, 1996). Forcing with growth regulators is most effective during cooler weather and hot weather is inconducive to good floral induction (Py *et al*, 1987, Bartholomew *et al*, 2002). The objective of this study is to determine the effect of three fruit forcing hormones at three different concentrations on flowering and fruiting of two pineapple cultivars.

MATERIALS AND METHODS

The trials were conducted on 1 April, 2004 and 5 April, 2005 with suckers established on 1 July, 2003 at Iwuru. Iwuru lies within 8° 14′ N and 8° 20′ E longitude, 5° 14′ N and 5° 18′ N latitude with a rainfall of over 2,000 mm in the rainforest vegetation. The area was previously cropped with cassava followed by a three year fallow in whch guinea grass (*Panicium maximum)* was the dominant fallow species. The area was manually cleared and the debris gathered together and removed.

The trial was planted in a 2 x 3 x 3 split-split-plot in a randomized complete bock design (RCBD) with four replications. The main plot size was 3 m x 48 m, the sub-plot size was 3 m x 12 m sampling area was 3 m x 2 m. The main plot treatment consisted of two pineapple cultivars. The sub-plots were the three hormones and sub-sub-plot consisted of the three hormone concentrations. The total treatment combinations were 18.

Suckers were planted at a spacing of 50 cm between rows and 30 cm within rows. At the beginning of the experiment , the soil was treated with 122.2 P p/ha and 235.0 kg K/ha in the forms of triple super phosphate and muriate of potash, respectively. Furadan was applied to the soil before planting at the rate of 8 kg/ha against ants and other insects.

Ridomil was mixed at the rate of 30.0g g per 2 L of water and was applied to the roots against fungi and nematodes. Weeds were regularly removed and the experimental arrays and boarders were kept clean against neighbour effect. Compound fertilizer N:P:K:Mg 10:10:17:2 was applied in August 2003 and March 2004 at the rates of 68:42:56:35 kg/ha (Ubi *et al* 2005).

At 12 months stage, all the plants had matured with 35 to 40 leaves and were due for forcing. The three forcible hormones used were: calcium carbide, naphthalene acetic acid and B-hydroxyethyle dydrazine which produce ethylene.

Their solution concentrations were:

Calcium carbide solutions: 25g to a L of water
30 g to a L of water
35 g to a L of water,
Naptthalene acetic acid solutions: 0.05 g to a L of water
0.5 g per L.
0.75 g per litre and
B-hydroxyethyl hydrazine solution. 0.025 g per litre
0.05 per litre
0.75 g per litre

The calcium carbide concentration was higher because the active ingredient (a.i) works well within the range used. There was control with no hormones.

The treatments were carried out on the 1 April, 2004 at 1700 h using three different knapsack spraying machines containing the solutions. It was done by 1700 h when the stomata of the leaf was expected to be open and this would enhance the hormones to work effectively. Flower emergence

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interval was recorded by noting the date of first appearance of flower after forcing, and calculating the number of days taken to produce the flower. The numbers of flowers produced was observed by counting the number of flowers produced per treatment after 30 days of flower emergence. The number of days it takes a fruit to mature was observed by counting from the first day of flower emergence after fertilization to when the fruits were ripe for harvest. A fruit was said to be matured when about one third of it turned yellow. Fruit weight was determined by harvesting and weighing all matured fruits in a scale and the average per treatment recorded.

STATISTICAL ANALYSIS

Data was subjected to analysis of variance (ANOVA) and means separated by Fisher's least significant difference at 5% probability level, (Wahua, 1999).

RESULTS

Flower Emergence Interval (days)

The result of the effects of forcible hormones on flower emergence interval (days) on two pineapple cultivars over 15 months is presented in Table 1. During the 2004 planting season, it took B-hydroxyl ethyl hydrazine hormone 9.3 days for flower to emerge on plots where Natal Queen was planted and this was superior to all other treatments during the study period. During the 2005 planting season, B-hydroxyl ethyl hydrazine hormones again took 8.2 (days) for flower to emerge and this was earlier than other hormonal treatments, throughout the study period. The results of the 2004 and 2005 study periods followed a similar trend. Calcium carbide on the average, performed worse than all other hormones throughout the experimental period in that it took about 25 days for flowers to emerge. The control plots in which no hormone was applied recorded more than 4-fold the days it took a flower to emerge when compared with B-hydroxyl ethyl hydrazine and more than two-fold when compared with naphthalene acetic acid. The two cultivars did not differ significantly in their response to treatment (Table 1).

The results of the application of forcible hormones concentration on the flower emergence interval of two pineapple cultivars are presented in Table 1. The use of forcible hormones on the interval on which flowers were produced in the two pineapple cultivars was significant ($P<0.05$). The application of B-hydroxyl ethyl hydrazine at the concentration of 0.5 g per litre ($P<0.05$) produced flowers at an interval of 8 days and this was statistically significant and superior to all other treatments.

The cultivars did not differ significantly in their response to these treatments. The control plots took more days (31 days) on the average to produce flower and this was significantly inferior to all other treatments. The interaction of cultivar x hormones was significant, ($P<0.05$). The application of calcium carbide at the concentration of 30 g per litre of water on the average used 20.5 days to produce flower and this was significantly superior to the application of either 25 g or 35 g per litre for the two cultivars throughout the study period. The application of naphthalene acetic acid at the concentration of 0.75 g per litre took 14.5 days on the average to produce flower in the two cultivars and this was significantly ($P<0.05$) superior to the application of either 0.5 or 1.0 g per litre and the control.

Number of Flowers Produced

The effect of forcible hormones on the number of flowers produced for the two pineapple cultivars is presented in Table 2. The highest number of flowers 153.7 in 2004 and 154.6 in 2005 occurred in plots treated with B-hydroxyl hydrazine and these were significantly ($P<0.05$) higher than all other treatments throughout the study period. The number of flowers produced by B-hydroxyl hydrazine on the average was more than two-fold that of calcium carbide and about five-fold that of the control. The cultivars did not differ significantly in these treatments.

The effect of the application of forcible hormone concentration on the number of flowers produced in two pineapple cultivars is presented in Table 2. The highest number of flowers (214.5) on the average occurred in plots treated with B-hydroxyl ethyl hydrazine concentration and was significantly ($P<0.05$) superior to all other treatments throughout the study period.

The cultivar x hormones concentration interaction in terms of number of flowers produced was significant ($P<0.05$). There was 81.7% increase in number of flowers produced when calcium carbide was increased from 25 g per litre and 11.9% drop in flower production when the concentration was further increased from 30 g to 35 g per litre in the two cultivars throughout the experimental period. Equally, there was 103.3% increased in flower production on the average, when B-hydroxyl ethyl hydrazine was increased from 0.025 to 0.5 g per litre and 51.5% drop in flower production when the concentration was further increased from 0.5 g to 0.75 g per L. Increasing the concentration of naphthalene acetic acid from 0.25 g to 1.0g and from 0.75 g to 0.5 g per L consistently increased the production of flowers compared with nil. The cultivars did not differ significantly in their response to this treatment (Table 2).

Fruit Maturity (days)

The effect of forcible hormones on the number of days it takes a fruit to mature in two pineapple cultivars over 18 months is presented on Table 3. The application of B-hydroxyl ethyl hydrazine took an average of 45.4 (days) in 2004 and (45.1 days) in 2005 and these values are significant ($P<0.05$) higher than all other values during the study period. The effect of calcium carbide on fruit maturity compared with the control was not statistically significant ($P<0.05$) throughout the study period. The two cultivars did not differ significantly in their reaction to these treatments.

Data on fruits maturity as influenced by treatment combinations is presented in Table 3. Fruits maturity was faster with the application of B-hydroxyl ethyl hydrazine at concentration of either 0.75 g or 0.5g per liter and this was significantly superior to all other treatments.

The interaction of cultivars x hormones concentration was for fruit mururity was significant ($P<0.05$). The cultivars produced their earliest matured fruits at similar concentration levels throughout the study period.

Fruit Yield (t/ha)

Although data was not provided, the effect of the forcible hormone on the fruit yield of pineapple was greater in plots that had B-hydroxyl ethyl hydrazine than in either calcium carbide or naphthalene acetic acid.

The results of fruit yield as influenced by forcible hormones concentration treatment combinations of two cultivars of pineapple are presented in Table 4. The application of B-hydroxyl ethyl hydrazine with a concentration of 0.5 g per liter gave the highest fruit yield (4.3 t/ha), on the average and this was significantly ($P<0.05$) higher than all other treatments in the two cultivars during the study period. The application of B-hydroxyl ethyl hydrazine concentration at either 0.25 g or 0.75 g per liter was not statistically significantly higher than the 1.7 t/ha and 2.2 t/ha obtained from the concentrations of 25 g and 35 g per liters of water respectively. The fruit yields obtained by applying naphthalene acetic acid at the concentration levels of 0.25 g, 0.5 g and 0.75 g per L were very close to those obtained from the three concentration levels of calcium carbide (25, 30 and 35 g per L) throughout the growing season.

The interaction of cultivar x hormones concentration on fruit yield showed that the cultivars produced their maximum yields at the first increment from 25 g to 30 g per liter for calcium carbide concentrations, 0.25 g to 0.5 g per liter for naphthalene acetic acid and 0.5 g per liter for B-hydroxyl

ethyl hydrazine concentration and then dropped later in the two cultivars. Thus, there was 36.4% drop in fruit yield when calcium carbide concentration was increase from 30 g to 35 g per liter 25.9% drop in fruit yield when naphthalene acetic acid concentration was increased from 0.5 g to 0.75 g per liter and 26.4% drop when B-hydroxyl ethyl hydrazine concentration was increased from 0.5 g to 0.75 g per liter in the two cultivars during the study period

DISCUSSION

In this study. B-hydroxyl ethyl hydrazine was outstanding in inducing flowering, increased flower production, and early fruit maturity as was earlier reported (Sampson, 1986; Morton, 1987, Leal and Coppens, 1996, Camha and Augusto, 2005). The values recorded for calcium carbide for flower emergence interval, flower production and fruit maturity were inferior to those of either Naphthalene acetic acid or B-hydroxyl ethyl hydrazine. This may be attributed to weather effect, as hot weather is inconducive to good floral induction (Bartholomew *et al*, 2002, Chinnasri *et al* 2006). From the statistical analysis, it has been found that there were significant differences in the fruit yield among the different hormone concentrations and on the average the control in which no hormone was applied performed the least (Haung, 2004, Moyle, *et al* 2006).

The highest number of flowers (214.5) on the average, recorded by the two cultivars where B-hydroxyl ethyl hydrazine was applied at concentration of 0.5g per L is an indication that the treatment promotes flower initiation at shorter interval as evidenced in this study. This might have equally led to the highest fruit yield (4.3 t/ha) recorded from this treatment.

Table 1: The effect of forcible hormones on flower emergence interval on two pineapple cultivars over 15 months

Cultivar	Control (no hormone)	Calcium carbide	Naphthalene acetic acid	B-hydroxyl ethyl hydrozine	Mean
		2004			
Smooth Canyenne	47.0	26.6	17.0	12	25.6
Natal queen	46.0	23.0	17.3	9.3	23.8
Mean	46.5	24.8	17.1	10.6	
		2005			
Smooth Canyenne	48.0	25.5	16.6	11.4	25.3
Natal queen	47.0	24.2	16.4	8.2	24.0
Mean	47.5	24.8	16.5	9.8	

LSD (0.05) between treatment means

	2004	2005
Cultivar	NS	NS
Hormone	5.0	5.2
Cultivar x hormone	6.4	6.4

Table 2: The effect of forcible hormones on the number of flower produced in two pineapple cultivars over 15 months

Cultivar	Control (no hormone)	Calcium carbide	Naphthalene acetic acid	B-hydroxyl ethyl hydrozine	Mean
		2004			
Smooth Canyenne	31.0	68.6	84.0	154.0	84.3
Natal queen	30.0	69.0	83.3	153.4	83.9
Mean	30.5	68.8	83.6	153.7	
		2005			
Smooth Canyenne	32.0	66.4	85.6	55.0	84.7
Natal queen	31.0	67.5	84.2	154.2	84.2
Mean	31.5	66.9	84.9	154.6	

LSD (0.05) between treatment means

	2004	2005
Cultivar	NS	NS
Hormone	14.5	16.2
Cultivar x hormone	17.2	18.4

Table 3: The effect of forcible hormones on the number of days it takes a fruit to mature in two pineapple cultivers over 18 months

Cultivar	Control (no hormone)	Calcium carbide	Naphthalene acetic acid	B-hydroxyl ethyl hydrozine	Mean
		2004			
Smooth Canyenne	77.0	71.3	53.0	40.6	60.4
Natal queen	78.0	70.3	53.6	50.3	62.9
Mean	77.5	70.8	53.3	45.4	
		2005			
Smooth Canyenne	76.0	70.4	52.4	40.2	59.7
Natal queen	77.0	70.0	53.2	50.0	62.5
Mean	76.5	70.2	52.8	54.1	

LSD (0.05) between treatment means

	2004	2005
Cultivar	NS	NS
Hormone	7.9	12.0
Cultivar x hormone	8.5	14.2

Similar results were recorded by other researchers (Maxwell and Maxwell, 1984, Sampson, 1987 and Ubi *et al*, 2005).

Compared with the control, the three forcible hormone concentrations showed a positive effect on flower emergence interval, number of flowers produced, period of fruit growth to maturity and fruit yield of the two pineapple cultivars. The results showed that maximum pineapple fruits could be produced using B-hydroxyl ethyl hydrazine as forcible hormone and at a concentration 0.5g per L. Thus the ranking: B-hydroxyl ethyl hydrazine > naphthalene acetic acid> calcium carbide: for high yielding of smooth canyenne and Natal queen pineapple cultivars.

CONCLUSION

Those results would suggest that the use of B-hydroxyl ethyl hydrazine hormone and at a concentration of 0.5g per L rather than 0.75g would enhanced maximum production of fruits of both smooth canyenne and natal queen pineapple cultivars. This system of pineapple management would be cost effective with greater turnover for economic benefits to the farmer.

Table 4: The effect of forcible hormones concentration on flower emergence interval (days) of two pineapple cultivars over 15 months

	Control	Calcium carbide			Naphthalene acetic acid g/L			B-hydroxyl ethyl hydrazine g/L			
	0	25	30	35	0.25g	0.5g	0.75g	0.25g	0.5g	0.75g	Mean
					2004						
Smooth Cayenne	48.0	32.0	20.0	28.0	21.0	16.0	14.0	10.0	8.0	9.0	20.6
Natal queen	47.0	31.0	21.0	20.0	20.0	17.0	15.0	11.0	8.0	9.0	20.8
Mean	47.5	31.5	20.5	20.5	20.5	16.6	14.5	10.5	8.0	9.0	-
					2005						
Smooth Cayenne	46.0	31.3	20.2	27.4	22.1	15.5	15.0	11.1	9.0	8.2	20.4
Natal queen	45.8	30.5	20.0	21.0	20.4	16.5	14.4	10.0	7.5	9.2	21.0
Mean	45.9	30.9	20.1	24.2	21.2	16.0	14.7	10.5	8.2	8.7	-

LSD (0.05) between treatment means

	2004	2005
Cultivar	NS	NS
Hormone	4.8	4.7
Cultivar x hormone concentration	6.1	5.8

Table 5: The effect of forcible hormones concentration on the number of flower produced in two pineapple cultivars over 15 months

	Control	Calcium carbide			Naphthalene acetic acid g/L			B-hydroxyl ethyl hydrazine g/L			
	0	25	30	35	0.25	0.5	0.75	0.25	0.5	0.75	Mean
					2004						
Smooth Cayenne	31.0	46.0	85.0	75.0	69.0	85.0	98.0	105.0	215.0	142.0	95.0
Natal queen	30.0	47.0	84.0	76.0	68.0	85.0	97.0	106.0	214.0	141.0	102.0
Mean	30.5	46.5	84.5	75.5	68.5	85.5	97.5	105.5	214.5	-	-
					2005						
Smooth Cayenne	30.0	44.4	78.3	76.0	68.4	83.9	97.1	104.0	213.0	141.0	936.1
Natal queen	30.0	46.5	83.1	75.2	67.5	84.0	96.2	105.0	213.1	142.0	942.6
Mean	30.0	45.4	80.0	75.6	67.9	84.0	96.6	104.5	213.0	141.5	942.6

LSD (0.05) between treatment means

	2004	2005
Cultivar	NS	NS
Hormone concentration	8.5	7.6
Cultivar x hormone concentration	12.1	11.8

Table 6: The effect of forcible hormones concentration on the number of days it take fruit to mature in two pineapple cultivars over 18 months

	Control	Calcium carbide			Naphthalene acetic acid g/L			B-hydroxyl ethyl hydrazine g/L			
	0	25	30	35	0.25	0.5	0.75	0.25	0.5	0.75	Mean
					2004						
Smooth Cayenne	77.0	75.0	64.0	75.0	65.0	48.0	46.0	62.0	45.0	45.0	62.2
Natal queen	78.0	74.0	64.0	73.0	66.0	49.0	46.0	63.0	44.0	45.0	62.2
Mean	77.5	74.5	64.5	74.5	65.5	48.5	46.0	62.5	44.5	45.0	-
					2005						
Smooth Cayenne	78.0	76.0	63.0	75.0	65.0	48.0	46.0	63.0	45.0	45.0	60.4
Natal queen	79.0	75.0	63.0	74.0	66.0	48.0	46.0	63.0	44.0	43.0	60.1
Mean	78.5	75.5	63.0	74.5	65.5	48.0	46.0	63.0	44.5	44.0	

LSD (0.05) between treatment means

		2004	2005
Cultivar		NS	NS
Hormone concentration		10.2	10.3
Cultivar x hormone	concentration	11.4	12.0

Table 7: The effect of forcible hormones concentration on the fruit yield (t/ha) of two pineapple cultivars over 15 months.

Cultivar	Control	Calcium carbide			Naphthalene acetic acid g/L			B-hydroxyl ethyl hydrazine g/L			
	0	25	30	35	0.25	0.5	0.75	0.25	0.5	0.75	Mean
					2004						
Smooth Cayenne	1.40	1.6	2.8	2.01	1.8	3.2	2.6	3.2	4.1	3.4	2.6
Natal queen	1.6	1.7	3.2	2.4	1.9	3.5	2.7	3.3	4.3	3.3	2.8
Mean	1.5	1.7	3.0	2.2	1.9	3.4	2.7	3.3	4.3	3.4	-
					2005						
Smooth Cayenne	1.3	1.5	2.7	2.0	1.7	3.1	2.5	3.1	4.1	3.3	25.3
Natal queen	1.5	1.6	3.1	2.3	1.8	3.4	2.6	3.2	4.2	3.2	26.9
Mean	1.4	1.6	2.9	2.1	1.8	3.3	2.6	3.2	4.2	3.3	

LSD (0.05) between treatment means

	2004	2005
Cultivar	NS	NS
Hormone concentration	0.3	0.3
Cultivar x hormone concentration	0.4	0.4

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