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Response of four pineapple hybrids to early flower induction

(Gerak balas empat hibrid nanas terhadap pengaruhan pembungaan awal)

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Key words: *Ananas comosus* L. (Merr.), pineapple, breeding, hybrid, variety, early-fruiting

Abstrak

Empat hibrid nanas iaitu Josapine, A04–16, A12–45 dan C17–33 diaruh untuk berbunga pada peringkat 6, 7 dan 8 bulan selepas ditanam. Pada umumnya, berat buah dan berat pokok segar makin meningkat menurut peringkat pengaruhan yang semakin lewat, tetapi kadar peningkatan berat buah adalah kurang berbanding dengan berat pokok. Ini menyebabkan penurunan nisbah buah:pokok daripada 0.52 pada peringkat pengaruhan 6 bulan kepada 0.45 dan 0.40 masing-masing pada peringkat pengaruhan 7 dan 8 bulan. A04–16 mempunyai purata berat buah yang tertinggi (1.76 kg) tetapi pokok yang paling ringan (2.52 kg). Ini bermakna pembahagian fotosintatnya kepada bahagian ekonomi pokok adalah cekap. Ini dicerminkan oleh nisbah buah:pokoknya 0.74 yang tertinggi berbanding dengan 0.31–0.41 bagi hibrid yang lain. Pada tiga peringkat pengaruhan bunga, A04–16 menunjukkan nisbah buah:pokok yang tinggi (0.6–0.89) dan ini melebihi 1.5–2 kali ganda daripada hibrid lain. Pada peringkat pengaruhan 6 bulan, A04–16 menghasilkan buah bersaiz ekonomi (1.5 kg) tetapi hibrid lain menghasilkan buah kecil (1 kg).

Pembangunan hibrid yang berbuah awal seperti A04–16 adalah berpotensi. Hibrid ini boleh diaruh pada peringkat 6 bulan dan ditambah 5 bulan lagi untuk perkembangan buah. Dengan ini nanas boleh ditimbangkan sebagai tanaman 'annual' tulen pada masa depan. Kelebihan ketara seperti penjimatan kos pengurusan ladang dan pendapatan awal dari modal boleh dicapai dengan menggunakan kultivar yang berbuah awal.

Abstract

Four pineapple hybrids selected for early fruiting i.e. Josapine, A04–16, A12–45 and C17–33 were induced to flower at 6, 7 and 8 months after planting. In general, fruit and plant fresh weights increased with later periods of induction, but the rate of increase in fruit weight was slower than plant weight. This led to a decrease in fruit:plant ratio from 0.52 at 6-month induction to 0.45 and 0.40 at 7 and 8-month induction respectively. A04–16 had the heaviest mean fruit weight (1.76 kg) but the lightest plant weight (2.52 kg) implying its efficient partitioning of photosynthate to the economic part of the plant. This is reflected in its highest fruit:plant ratio of 0.74 compared with 0.31–0.41 for the rest of the hybrids. Over the three periods of flower induction, A04–16 showed a remarkable fruit:plant ratio of 0.6 to 0.89, which were 1.5–2 times higher than the next best hybrid. At 6-month induction, A04–16 developed economic-sized fruits of 1.5 kg while other hybrids yielded only small fruits of around 1 kg.

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There is potential for developing early fruiting hybrids like A04–16 which can be induced at 6 months and adding a further 5 months for fruit development, a pineapple crop in future may be considered a true 'annual'. There are obvious benefits in savings in field management costs and early returns to investment with the use of early fruiting cultivars.

Introduction

One of the greatest advantages in pineapple cultivation is the ability to regulate and accurately time fruit harvest using commercial flower-inducing hormones such as NAA (naphthaleneacetic acid) pills or Ethephon. Flower induction is carried out when the plant reaches a sizeable mass at 10–12 months after planting. Flower and fruit development take another 5–6 months after induction. Therefore, the pineapple production cycle in Malaysia and other tropical countries typically requires 15–18 months from planting to harvesting. Shortening this production cycle would obviously reduce maintenance costs and would bring early returns to investment as well.

Reduction of pineapple gestation period through manipulation of planting materials, environmental effects as well as genetic factors have been reported. Planting of large slips of Singapore Spanish pineapple resulted in more vigorous growth which enabled earlier induction of flowering and harvests compared with plants grown from small slips (Tan and Wee 1973). In Australia, where there is pronounced seasonal changes in temperatures, the timing in planting and induction is crucial in influencing the period of fruit development from induction to harvest. This varied from 185 days when plants were forced in September or October to 283 days when plants were forced in April or May (Sinclair 1993). Chan and Lee (2000) reported that early fruiting in pineapple might be genetically controlled. Pineapple hybrids selected for early fruiting and induced to flower as early as 7 months after planting, were shown to have the ability to yield economic-sized fruits.

This paper examines the fruiting behaviour of four 'early' hybrid selections when induced to flower at 6–8 months after planting. The periods for flower induction in this experiment are very early compared with the usual 10 months for conventional varieties. The objective of the experiment is to evaluate the response of the new hybrids to very early induction with regard to plant and fruit development. It highlights the inherent characteristics that are required for breeding and selection for early fruiting varieties in pineapple and the possibility of using earliness as a tool for reducing costs in a more efficient production system.

Materials and methods

Four pineapple hybrids i.e. Josapine, A04–16, A12–45 and C17–33 were selected for early bearing from a systematic hybridisation programme started by MARDI in 1984 (Chan 1986). They originated from a F_1 hybrid population consisting of 50 000 seedlings derived from crosses between the Queen, Spanish and Cayenne groups of pineapple. Selections with 'A' prefix were from Spanish x Cayenne crosses while the one with 'C' prefix was from Queen x Spanish cross. Josapine was formerly 'A25–34' but renamed after it was released for commercial cultivation in 1996. To reduce experimental error due to propagule age and size, the quartering technique of Lee and Tee (1978) was used to propagate the plants. The plants were raised to a height of 30 cm before they were planted in the field.

The experiment was conducted on peat at the MARDI research station in Pontian, Johor. The four hybrids were planted on 9 August 1997 in a randomized complete block design with four replicates. In each plot, there were 60 plants grown in three double-row beds of 10 plants in each row. The spacing was 30 cm x 60 cm between plants and 90 cm between beds. Each of the three double-row beds in the plot was separately induced to flower at three different periods i.e. 6, 7 and 8 months after planting. Flower induction (‘forcing’) was carried out with 400 ppm Ethephon, 4% urea and 0.5% borax at a rate of 50 mL to a plant.

Data measurements at harvest included the number of ground suckers, aerial suckers, and slips, and fresh weights of crown, fruit and plant. Fruit analyses were carried out for total soluble solids (TSS) and acid content, core diameter and disease blemishes in the flesh. TSS was recorded using a hand refractometer (0–25% Brix) while acid content was determined by titration following the method described by Tay (1972). Flesh blemishes were visually scored from 1–10 with higher scores indicating greater disease severity.

Results and discussion

The analysis of variance (ANOVA) results are shown in *Table 1* for the 11 agronomic characters. As expected, induction at different months affected primarily plant and fruit weights and its corresponding fruit:plant weight ratio. It also appears to affect aerial sucker development, core size and acid content. Differences between hybrids, however, were found for all characters with the exception of slip development. Interactions between time of induction and hybrids were generally infrequent, found only in fruit:plant ratio, aerial sucker development, acid content and core size *(Table 1).*

The mean values of the four hybrids are presented in *Table 2*. It is interesting to note that A04–16 had the heaviest mean fruit weight (1.76 kg) but the lightest plant mass (2.51 kg), implying its efficient partitioning of photosynthate to the economic part of the plant. This is also reflected in its highest fruit:plant ratio of 0.74 compared with 0.31–0.41 for the rest of

Table 1. ANOVA: Mean square values

	df	Frt:Plt	Plant wt.	Crown	G-sucker	A-sucker	Slip	Frt wt.	Acid	TSS	Blemish	Core
Month (M)	2	0.0651**	10.6909**	542 ns	0.7658 ns	0.9858**	0.0408 ns	0.5411**	0.0176**	0.7014 ns	2.1058 ns	22.4233**
Rep	3	0.0029 ns	1.6472**	1 730 ns	0.6667 ns	0.0200 ns	0.0816 ns	0.1603**	0.0021 ns	0.8419 ns	0.3142 ns	2.4141 ns
Hybrid (H)	3	0.4393**	5.3274**	56 813**	25.3933**	1.2378**	0.0408 ns	0.9480**	0.0454**	28.1151**	69.4031**	182.6719**
M x H	6	0.0136**	0.4284 ns	3 667 ns	0.3933 ns	0.2002**	0.0408 ns	0.0240 ns	0.0069**	0.4962 ns	0.7281 ns	8.6944*
Error	33	0.0024	0.2081	1 576	0.3873	0.0351	0.0186	0.0238	0.0013	0.2530	0.6542	3.1790
Total	47											

Table 2. Mean values of 4 hybrids

	Plt:Frt ratio	Plt. wt. (kg)	Crown (g)	G-sucker (no.)	A-sucker (no.)	Slip (no.)	Frt. wt. (kg)	Acid	TSS	Blemish	Core (mm)
A04–16	0.74a	2.51c	328.9a	0.81c	0.00b	0.00a	1.76a	0.69b	12.38bc	6.35a	32.38a
C17–33	0.41b	3.30b	182.2c	1.83b	0.68a	0.00a	1.30b	0.71b	11.99c	1.61bc	23.63c
A12–45	0.38b	3.19b	270.7b	3.43a	0.20b	0.11a	1.14b	0.83b	12.84b	2.16bc	24.95bc
Josapine	0.31c	4.13a	194.3c	3.98a	0.58a	0.00a	1.20b	0.71b	15.38a	1.08c	25.75b

Column means with the same letter are not significantly different at $p = 0.01$ according to DMRT

Table 3. Mean values at 3 induction periods

Month @ Induction	Plt:Frt ratio	Plt. wt. (kg)	Crown (g)	G-sucker (no.)	A-sucker (no.)	Slip (no.)	Frt. wt. (kg)	Acid	TSS	Blemish	Core (mm)
6	0.52a	2.40c	237.7a	2.51a	0.15b	0.09a	1.13b	0.71b	13.2a	3.2a	25.3b
7	0.45b	3.41b	245.4a	2.74a	0.31b	0.00a	1.45a	0.74ab	12.9a	2.7a	27.4a
8	0.40c	4.02a	249.1a	2.30a	0.64a	0.00a	1.46a	0.77a	13.3a	2.5a	27.3a

Column means with the same letter are not significantly different at $p = 0.01$ according to DMRT

the hybrids. The shortcomings of A04–16 however, lie in its susceptibility to spotting in the fruit flesh and its large core size. These defects were also revealed earlier by Chan and Lee (1999).

The mean values at the three induction periods are presented in *Table 3*. In general, the fruit and plant weights increased with the time of induction but the increase rate of fruit weight was slower than that of plant weight. This led to a decrease in the fruit:plant weight ratio from 0.52 at 6-month induction to 0.45 and 0.40 at 7 and 8-month induction respectively *(Table 3)*. This correlation of increased fruit weight with increase in plant mass is, however, not

Table 4. Changes in Fruit:Plant ratio of 4 hybrids over 3 induction periods

Hybrid	6-month			7-month			8-month		
	Frt. wt. (kg)	Plt. wt. (kg)	Frt:Plt ratio	Frt. wt. (kg)	Plt. wt. (kg)	Frt:Plt. ratio	Frt. wt. (kg)	Plt. wt. (kg)	Frt:Plt. ratio
A04–16	1.55	1.80	0.89	1.97	2.71	0.73	1.76	3.01	0.60
C17–33	1.07	2.35	0.46	1.37	3.65	0.38	1.46	3.89	0.38
A12–45	0.91	2.47	0.40	1.23	3.31	0.38	1.28	3.79	0.36
Josapine	1.02	3.01	0.35	1.23	3.98	0.32	1.34	5.41	0.26

always true. Sinclair (1993) reported that there was no relationship between fruit mass and plant mass at induction when Smooth Cayenne variety was induced at 13–17 months from planting. These very late stages of induction had resulted in the development of overly large plants, some reaching 4.8 kg. Earlier studies by Chan and Lee (1999) also showed that A04–16 did not show correlation between fruit and plant mass when the hybrid was induced late at 10 months. The absence of correlation was explained by the possibility that the fruit mass was influenced by plant mass only within a certain limit. Plant weight increase after a certain point appeared to be ineffective in increasing fruit weight further and in fact, may be detrimental to fruit development. Sinclair (1993) showed this point when smaller plants in his experiment yielded larger fruits compared with those from overly large plants.

The changes in fruit:plant ratio and its components fruit weight and plant weight for the 4 hybrids over the 3 periods of induction are shown in *Table 4*. The most outstanding performer was A04–16 which showed a remarkable fruit:plant ratio of 0.6–0.89 at various periods of induction. These values are about 1.5–2 times better than the next best hybrid. A04–16 developed economic-sized fruits (1.55 kg) even when ‘forced’ as early as 6 months after planting. It is interesting to note that the fruit:plant ratio of all hybrids decreased when plants were induced later, indicating a disproportionate rate of change in fruit versus plant mass. All hybrids showed more rapid increase in plant weight compared with fruit weight, leading to a decrease in the ratio over time *(Table 4)*. This is in agreement with Malézieux (1993) who found similar relationship between fruit and plant dry matter accumulation when Smooth Cayenne was induced at 1–10 months after planting.

The potential for early induction at 6 months is demonstrated by hybrid A04–16, which yielded economic-sized fruits of 1.5 kg on relatively small plants weighing 1.8 kg. Chan and Lee (1999) reported that for a similar fruit weight of 1.5 kg to be obtained, plant masses of 3.2 kg and 4.2 kg for Gandul and Moris respectively have to be achieved. In the case of Smooth Cayenne, the linear regression of plant and fruit mass reported by Malézieux (1993) would suggest a plant mass of 2.8 kg or more to achieve this same fruit weight.

The current commercial pineapple cultivars require a fairly long period of growth to attain a certain minimum plant mass before flower induction. This does not seem necessary at least for one hybrid A04–16 in this trial. For this hybrid, the growing period for plant development can be telescoped into 6 months before induction and it has therefore, the potential to be grown as an annual crop compared with 15–18 months for conventional varieties. Translated to economic benefits, this hybrid could save at least 20–35% of field management costs on top of allowing convenience in crop scheduling that goes with annual cropping. However, due to several shortcomings such as flesh blemishes and large core size, A04–16 may only be currently recommended as a parent for improving earliness in fruiting of conventional cultivars.

Conclusion

Based on the findings from this experiment, there is potential for developing varieties which can be induced at 6 months and adding on 5 months for fruit development, a pineapple crop in future may take less than 12 months from planting to harvest. This will then make pineapple a truly 'annual' crop. The greatest benefit would be the savings that can amount to 20–35% of the maintenance cost of the normal crop cycle of 15–18 months. The shorter crop cycle will also bring earlier returns to investment and the 12-month cycle will be more convenient for planning and scheduling of activities in a calendar year.

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