PLANT DEVELOPMENT AND YIELD IN THE PINEAPPLE AS AFFECTED BY SIZE AND TYPE OF PLANTING MATERIAL AND TIMES OF PLANTING AND FORCING

By A. R. MITCHELL, B.Agr.Sc.*

SUMMARY

The effects of size and type of planting material, time of planting and time of forcing on plant growth and yield of Smooth Cayenne pineapples were investigated at the Maroochy Horticultural Research Station in south-eastern Queensland.

Heavier planting material resulted in larger plants at the time of forcing, heavier fruit with more fruitlets and multiple tops, and greater slip development, while sucker development was not increased. Harvesting was only slightly delayed by the smaller material.

Slips and tops of equal size resulted in almost identical plant development and yield.

Progressively later autumn plantings caused no significant differences in plant size at the time of forcing or in fruit weight, although there was a downward trend. The latest planting slightly delayed flowering and harvesting irrespective of forcing, and reduced fruitlet numbers. Later planting caused a decided decrease in the number of multiple tops and slips, while early planting reduced sucker development.

Variations in time of forcing for the summer crop had little effect on fruit weight, number of fruitlets or number of multiple tops. However, there was a tendency for May forcing to produce the heaviest fruit. Early forcing resulted in earlier flowering and harvesting, fewer slips from the smaller plants, and a general increase in sucker development.

I. INTRODUCTION

Mitchell and Cannon (1953) stated that the first objective in pineapple plantation management is to ensure a uniform summer plant crop. The best suckers are produced from this crop and a good first ratoon crop should follow. In southern Queensland, production is generally based on these lines. The result is an intensive peak harvest in February/March, which sometimes leads to inefficient handling by growers, canneries and markets.

* Horticulturist, Queensland Department of Agriculture and Stock

This paper deals with possible methods of extending the summer harvest period by means of variations in the planting material used, the date of autumn planting and the date of forcing. At the same time, regard is given to the effects of such variations on the characteristics of plant and fruit.

II. EXPERIMENTAL PROCEDURE

(a) Treatments and Layout

Planting times were: P1, February 26; P2, March 19; and P3, April 9, 1959. Graded summer tops and slips of the Smooth Cayenne variety were used as planting material, the fresh weights being 6 $\pm$ 1 oz and 9 $\pm$ 1 oz. Forcing times with alpha naphthylacetic acid at 10 p.p.m. were: F1, April 26; F2, May 17; and F3, June 7, 1960.

The trial was laid out as a 2 x (3 x 3 x 2 x 2) factorial with split plots, the main plots being various combinations of planting time and forcing time. There were 60 plants per plot, which comprised a double-row 30 ft long.

(b) Cultural Data

Planting was carried out on a slope with a northerly aspect. Plants were fertilized with a 10:2:20 mixture applied in eight side-dressings from late April 1959 to early February 1961. The rate of each application was 25 lb per 1000 plants until flowering, and 50 lb per 1000 plants after flowering.

Losses from top-rot amounted to 3 per cent. of the total planting. Greater losses occurred with the earlier plantings. The gaps were replanted, marked and regarded as missing plants.

Growing conditions were good and plants were generally well-sized at the times of forcing. All forcing was successful in producing a regular summer crop, which was harvested between January 20 and March 13, 1961.

III. RESULTS

(a) Weight of "D-leaf"

The weight of a "D-leaf" (youngest mature leaf) at the time of forcing was suggested by Py (1958) as being a useful indication of vegetative development and subsequent fruit weight. A D-leaf was selected by bunching the leaves together and removing the tallest one. D-leaves were obtained from 16 plants per plot. The mean weights are summarized in Table 1, where the data showing significant second-order interactions have been included.

TABLE 1

WEIGHT OF D-LEAF (g)

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	80·5	83·4	80·1	81·3	P1	80·2	82·5	P1	82·2	80·4
P2	73·8	78·4	85·2	79·1	P2	77·3	80·9	P2	81·4	76·8
P3	86·4	76·2	81·0	81·2	P3	77·0	85·4	P3	81·2	81·2
T	80·6	80·6	83·7	81·6	T	79·2	84·1	..	..	..
S	79·8	78·1	80·6	79·5	S	77·2	81·8	..	..	..
6 oz	76·8	78·1	79·7	78·2	..	..	..	..	..	..
9 oz	83·7	80·6	84·6	82·9	..	..	..	..	..	..
Means	80·2	79·3	82·1	80·6	..	..	..	..	..	..

–	T		S		–	T			S		
	6 oz	9 oz	6 oz	9 oz		F1	F2	F3	F1	F2	F3
P1	79·5	85·0	80·8	80·0	P1	79·8	87·8	79·2	81·2	79·0	81·0
P2	82·5	80·3	72·2	81·5	P2	79·0	78·2	87·0	68·5	78·5	83·5
P3	75·5	86·8	78·5	84·0	P3	83·0	75·8	84·8	89·8	76·8	77·2

Significant Factors	Minimum Significant Difference 5%	Minimum Significant Difference 1%	Major Significant Differences
Main effect of Size**	3·0	4·0	9 oz>> 6 oz
Interaction (P x Type x Size)*	7·3	9·8	T > S (with P2 6 oz)
Interaction (P x F x Type)*	8·9	12·0	P1 > P3 (with F2 T)
			P1, P3 > P2 (with F1 S)
			F3 > F1 (with P2 S)
			F1 > F2, F3 (with P3 S)

D-leaf weight was influenced directly by size of planting material only. Smaller planting material resulted in smaller plants at the time of forcing. This was reflected in the lower fruit weight from smaller plants, as seen in Table 5. The correlation between D-leaf weight and fruit weight in this trial is not a close one, as the highly significant (P x F x Size) interaction for fruit weight is completely absent for D-leaf weight. No simple interpretation can be made of the two second-order interactions, and their significance might be disregarded until reproduced in any future work of this nature.

(b) Time of Flowering

After flowering commenced, weekly counts of shilling-sized (approx. 1 in. dia.) inflorescences were made. Mean flowering date was calculated for each plot on the basis of the number of inflorescences reaching the arbitrary size each week. Table 2 contains 2-factor tables summarizing the mean flower emergence dates.

TABLE 2

DATE OF FLOWER EMERGENCE (DAYS AFTER JULY 11, 1960)

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	22·2	35·7	37·2	31·7	P1	32·3	31·1	P1	30·2	33·2
P2	23·9	37·8	38·8	33·5	P2	35·0	32·0	P2	33·1	33·9
P3	31·2	37·9	49·9	39·7	P3	39·4	40·0	P3	39·1	40·3
T	25·1	36·8	40·5	34·1	T	34·4	33·8	. .	. .	. .
S	26·5	37·5	43·4	35·8	S	36·7	34·9	. .	. .	. .
6 oz	24·5	37·8	44·3	35·6	. .	. .	. .	. .	. .	. .
9 oz	27·0	36·5	39·6	34·4	. .	. .	. .	. .	. .	. .
Means	25·8	37·1	42·0	35·0	. .	. .	. .	. .	. .	. .

Significant Factors	Mean Significant Difference		Significant Differences
	5%	1%	
Main effect of P**	3·8	5·6	P1, P2 << P3
Main effect of F**	3·8	5·6	F1 << F2 < F3
Interaction (F x Size)*	3·6	4·9	9 oz < 6 oz (with F3)

The overall effect of latest planting was to delay flowering by approximately one week, independently of the time of forcing. The fact that three weeks' difference in planting time could significantly affect the rate of development from forcing to flowering indicates the possible long-term effects of small variations in planting time. However, in this trial a variation of one week in flowering time was of little practical consequence.

Earlier forcing resulted in earlier flowering, but the rate of flower development was slower. Plants forced in April flowered in 133 days, those forced in May flowered in 123 days, while June-forced plants took only 107 days. This suggests that climatic factors to some extent reduced the effects of variations in forcing time.

The fact that the difference in flowering dates between the F3 and F2 treatments was generally less than the difference between F2 and F1 treatments suggests that some plants had already flowered naturally when the F3 forcing was carried out (in June). However, this natural flowering apparently did not occur in the April-planted plots. When plants were forced in June, 9-oz planting material resulted in significantly earlier flowering than 6-oz material. It is therefore apparent that some natural flowering of large plants planted in February or March had occurred by the time the June forcing was carried out.

(c) Time of Harvesting

Mean harvest dates were calculated on the basis of the number of fruit harvested on each day of harvesting. These are shown in the 2-factor tables in Table 3.

TABLE 3

DATE OF HARVEST (DAYS AFTER JANUARY 20, 1961)

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	11·9	21·4	21·0	18·1	P1	18·9	17·3	P1	17·3	19·0
P2	13·9	24·3	21·9	20·0	P2	22·2	17·9	P2	20·0	20·0
P3	18·1	23·4	32·1	24·6	P3	25·0	24·2	P3	24·2	25·0
T	14·8	22·8	24·0	20·5	T	21·4	19·6	..	..	..
S	14·5	23·4	26·0	21·3	S	22·6	20·0	..	..	..
6 oz	14·4	24·3	27·3	22·0	..	..	..	..	..	..
9 oz	14·9	21·8	22·7	19·8	..	..	..	..	..	..
Means	14·6	23·1	25·0	20·9	..	..	..	..	..	..

Significant Factors	Mean Significant Difference 5%	Mean Significant Difference 1%	Major Significant Differences
Main effect of P**	3·3	4·8	P1 << P3 P2 < P3
Main effect of F**	3·3	4·8	F1 << F2, F3
Main effect of Size**	1·3	1·8	9 oz << 6 oz
Interaction (F x Size)*	2·3	3·1	F2 < F3 (with 6 oz)

Six weeks' variation in planting time gave approximately one week's variation in harvesting time. Three weeks' difference in forcing time gave slightly more than one week's difference in harvesting time, but only when forcing was carried out prior to any natural flower initiation.

Comparison between the early planting/early forcing combination and the late planting/late forcing combination shows approximately three weeks' difference in mean harvest dates. The harvest patterns for these two treatment combinations, together with the mean, are shown in Figure 1.

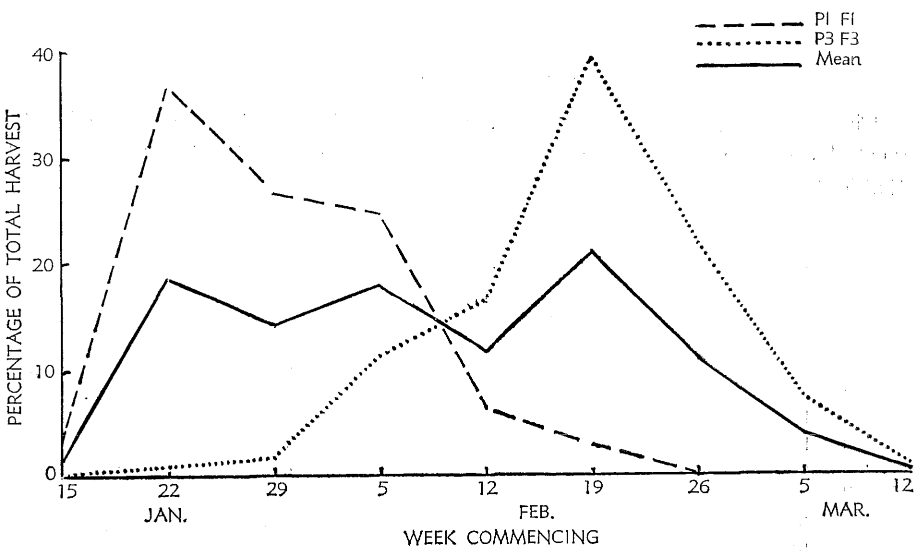

Fig. 1.—Weekly harvests expressed as percentages of total harvests (Treatments P1F1 and P3F3).

The mean harvest pattern indicates how any pronounced harvest peak can be eliminated by planting two blocks and forcing them at different times. Under the conditions of this trial the combination of P1 F1 and P3 F3 treatments would give a harvest period of six weeks from January 22 to March 5, with 16 $\pm$ 5 per cent. of the total crop being harvested each week and only 6 per cent. remaining to be harvested outside this period.

As neither P1 and P2 treatments nor F1 and F3 treatments have significantly different mean harvest dates, it might be expected that double plantings involving P2F1 and P3F2 treatments would result in a spread of harvest similar to the above. The individual harvest patterns and the mean are shown in Figure 2.

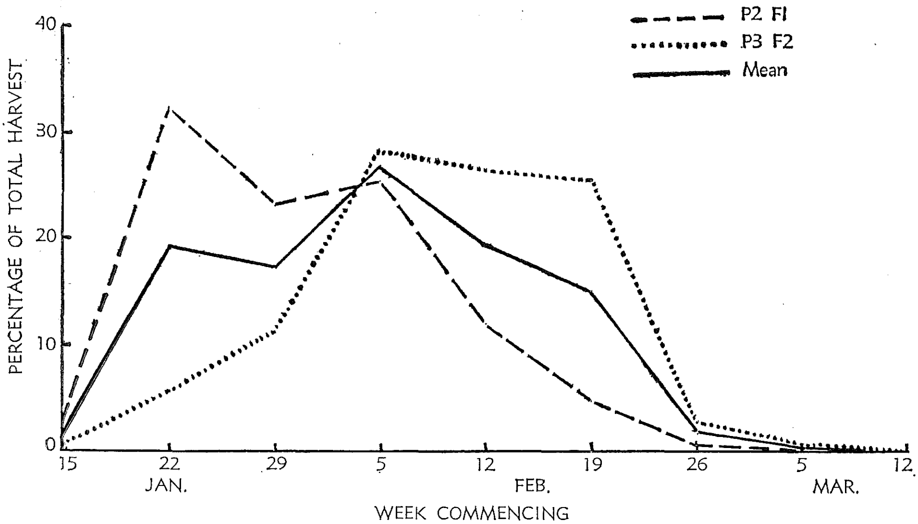

Fig. 2.—Weekly harvests expressed as percentages of total harvests (Treatments P2F1 and P3F2).

The mean shows that a double planting combining the P2F1 and P3F2 treatments would, under the conditions of this trial, give a harvest period of five weeks from January 22 to February 26. Each week, 21 ± 7 per cent. of the total crop would be harvested, with only 3 per cent. remaining to be harvested outside the period.

The reason why harvest patterns for individual treatments do not approximate normal curves is that the northerly aspect of the planting area caused fruit from the lower rows of the double rows to mature approximately 10 days earlier than fruit from the upper rows. The different amounts of sunlight received by upper and lower rows are considered to be important in helping to extend the harvest period.

Comparisons between flowering dates and harvesting dates indicate that treatments had no material effect on the time from flowering to harvesting. However, there was a tendency for later forcing (equivalent to later flowering) to result in faster development of fruit. Progressively later forcing gave average flowering-to-harvesting periods of 151, 148, and 145 days respectively. This suggests that climatic factors slightly reduced the effects of variation in flowering time.

The use of smaller planting material tended to delay harvesting slightly. This effect increased with later forcing times, probably owing to more premature flowering of larger plants before forcing was carried out.

(d) Weight of Fruit

Table 4 contains 2-factor and 3-factor tables showing the average fruit weights.

TABLE 4

AVERAGE WEIGHT OF FRUIT (OZ, "TOPS OFF")

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	52·8	57·2	55·5	55·2	P1	54·0	56·3	P1	55·3	55·0
P2	51·6	57·4	55·8	54·9	P2	52·9	56·9	P2	55·9	53·9
P3	54·4	53·6	52·5	53·5	P3	51·1	55·9	P3	54·2	52·8
T	53·2	56·4	55·8	55·1	T	53·4	56·9	..	..	..
S	52·6	55·8	53·4	53·9	S	51·9	55·9	..	..	..
6 oz	50·3	54·5	53·2	52·7	..	..	..	..	..	..
9 oz	55·5	57·7	56·0	56·4	..	..	..	..	..	..
Means	52·9	56·1	54·6	54·5	..	..	..	..	..	..

–	6 oz			9 oz		
	F1	F2	F3	F1	F2	F3
P1	50·0	56·2	55·8	55·5	58·2	55·2
P2	51·5	53·2	54·0	51·8	61·5	57·5
P3	49·5	54·0	49·8	59·2	53·2	55·2

Significant Factors	Mean Significant Difference		Major Significant Differences
	5%	1%	
Main effect of Size**	1·6	2·1	9 oz >> 6 oz
Interaction (P x F x Size)**	4·7	6·4	F2 >> F1 (with P2—9 oz) P3 >> P2 (with F1—9 oz) P2 >> P3 (with F2—9 oz)

The effect of increasing the size of planting material from 6 oz to 9 oz was significantly to increase average fruit weight by 7 per cent. Based on the planting system used in this trial, the increase was equivalent to 1½ tons per acre.

Trends indicate that small planting material may have to be planted early to obtain optimum fruit size, whereas the time of planting with large plants is less critical. Tops tended to produce heavier fruit than slips. There was a tendency also for forcing in mid-May to produce heavier fruit than forcing carried out three weeks earlier or later.

No interpretation can be given for the second-order interaction, as significant differences appear to be anomalous. Such differences must be disregarded until their reality can be verified in further work along these lines.

(e) Number of Fruitlets

An approximate index of the total number of fruitlets in the fruit was obtained by counting the number of fully developed fruitlets arranged in a long spiral around the fruit. There are almost invariably eight rows of fruitlets arranged in long spirals, and the approximate total number is obtained by multiplying the number arranged in a long spiral by eight. The results are presented in Table 5.

TABLE 5

NUMBER OF FRUITLETS ARRANGED IN LONG SPIRAL

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	14·59	13·99	13·79	14·12	P1	13·83	14·41	P1	14·10	14·14
P2	14·09	13·89	13·95	13·98	P2	13·68	14·28	P2	14·01	13·94
P3	13·65	13·44	13·02	13·37	P3	12·94	13·80	P3	13·48	13·26
T	14·05	13·82	13·72	13·86	T	13·53	14·20	..	..	..
S	14·17	13·72	13·46	13·78	S	13·44	14·12	..	..	..
6 oz	13·55	13·58	13·32	13·48	..	..	..	..	..	..
9 oz	14·67	13·96	13·86	14·16	..	..	..	..	..	..
Means	14·11	13·77	13·59	13·82	..	..	..	..	..	..

Significant Factors	Mean Significant Difference 5%	Mean Significant Difference 1%	Significant Differences
Main effect of P*	0·56	0·81	P1, P2 > P3
Main effect of Size**	0·23	0·32	9 oz >> 6 oz
Interaction (F x Size)*	0·41	0·55	F1 > F2 (with 9 oz)

Late planting and the use of small planting material independently lowered the number of fruitlets. These factors reduced the extent of differentiation of fruitlets during the formation of the inflorescence, probably as the result of reduced plant vigour. The advantage of using large planting material was most obvious when early forcing was carried out.

Following early forcing (in April), the consequent formation of the inflorescence would occur prior to midwinter, during a period when conditions for growth processes would be more favourable. An increase in fruitlet number would therefore be expected with early forcing, and was in fact obtained with large plants. As no such increase was observed for small plants, it is obvious that fruitlet number was limited largely by plant size. Fruit weight may be partly limited by fruitlet number, as comparison between Tables 4 and 5 tends to indicate.

(f) Number of Multiple Tops

The number of fruit with two or more tops are given for each plot of 60 plants in Table 6.

TABLE 6

NUMBER OF MULTIPLE TOPS PER PLOT

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	14·0	16·6	21·9	17·5	P1	16·3	18·7	P1	18·5	16·5
P2	10·2	14·8	15·2	13·4	P2	9·8	17·1	P2	14·5	12·3
P3	8·8	7·8	6·6	7·7	P3	4·8	10·7	P3	8·7	6·8
T	12·2	13·9	15·6	13·9	T	11·9	15·8	..	..	..
S	9·8	12·2	13·6	11·9	S	8·6	15·1	..	..	..
6 oz	8·2	10·7	12·0	10·3	..	..	..	..	..	..
9 oz	13·8	15·4	17·2	15·5	..	..	..	..	..	..
Means	11·0	13·0	14·6	12·9	..	..	..	..	..	..

Significant Factors	Mean Significant Difference		Significant Differences
	5%	1%	
Main effect of P**	3·8	5·5	P1 > P2 >> P3
Main effect of Type*	1·7	2·3	T > S
Main effect of Size**	1·7	2·3	9 oz >> 6 oz

The results show that the occurrence of multiple tops was largely governed by time of planting and size of planting material. The fact that early planting of large planting material resulted in more multiple tops suggests that plant development at the time of forcing is involved. These two factors would result in improved establishment prior to the onset of winter, and such advantage would be carried through until forcing. Type of planting material was for once a significant factor, the tops giving slightly more multiple tops than the slips.

(g) Number of Slips

The average number of slips per plant is shown in 2-factor and 3-factor tables in Table 7.

TABLE 7

NUMBER OF SLIPS PER PLANT

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	1·85	2·16	2·38	2·13	P1	1·89	2·37	P1	2·02	2·24
P2	1·08	1·37	2·08	1·51	P2	1·09	1·93	P2	1·48	1·54
P3	1·02	0·68	1·00	0·90	P3	0·49	1·31	P3	0·81	1·00
T	1·26	1·26	1·78	1·43	T	1·10	1·77	..	..	..
S	1·37	1·55	1·86	1·59	S	1·22	1·97	..	..	..
6 oz	0·70	1·20	1·58	1·16	..	..	..	..	..	..
9 oz	1·94	1·61	2·06	1·87	..	..	..	..	..	..
Means	1·32	1·40	1·82	1·51	..	..	..	..	..	..

–	6 oz			9 oz		
	F1	F2	F3	F1	F2	F3
P1	1·22	2·25	2·20	2·49	2·06	2·56
P2	0·70	0·84	1·74	1·46	1·90	2·42
P3	0·18	0·50	0·78	1·87	0·86	1·21

Significant Factors	Mean Significant Difference		Major Significant Differences
	5%	1%	
Main effect of P**	0·52	0·75	P1 > P2 > P3
			P1 >> P3
Main effect of Size**	0·20	0·27	9 oz >> 6 oz
Interaction (F x Sixe)**	0·35	0·47	F3 > F2 >> F1 (with 6 oz)
			F3 > F2 (with 9 oz)
Interaction (P x F x Size)*	0·60	0·82	F1 > F2, F3 (with P3 . 9 oz)

Early planting and the use of large planting material were independently responsible for a significant increase in the number of slips, as was the case with multiple tops. The occurrence of slips and the occurrence of multiple tops are considered to be expressions of plant vigour, which would be improved by earlier planting and larger planting material.

There was a trend for slip numbers to increase with later forcing, but the F1-9 oz combination was out of line with this trend, particularly when late planting was carried out. No simple interpretations of the second-order interaction can be suggested.

(h) Number of Suckers

Suckers which were large enough to be forced for the ratoon crop were counted at the time of forcing, which was May 1961 for all plots. Only suckers which were longer than 8 in. were counted. Table 8 shows the average number of suckers per plant.

TABLE 8

NUMBER OF SUCKERS PER PLANT

–	F1	F2	F3	Means	–	6 oz	9 oz	–	T	S
P1	0·91	0·68	0·68	0·76	P1	0·79	0·72	P1	0·74	0·77
P2	1·07	0·86	0·89	0·94	P2	0·94	0·94	P2	0·93	0·95
P3	1·08	0·99	0·81	0·96	P3	0·98	0·94	P3	0·96	0·96
T	0·97	0·87	0·80	0·88	T	0·88	0·87	..	..	..
S	1·07	0·82	0·79	0·89	S	0·93	0·86	..	..	..
6 oz	1·06	0·88	0·78	0·91	..	..	..	..	..	..
9 oz	0·98	0·81	0·81	0·87	..	..	..	..	..	..
Means	1·02	0·84	0·80	0·89	..	..	..	..	..	..

Significant Factors	Mean Significant Difference		Significant Differences
	5%	1%	
Main effect of P**	0·07	0·10	P2, P3 >> P1
Main effect of F**	0·07	0·10	F1 >> F2, F3
Interaction (F x Type)*	0·07	0·10	S > T (with F1)

The earliest planting reduced the development of suckers, while early forcing increased it. This is a reversal of the trend for slip production, probably due to a repressive effect of slip growth on sucker development. However, this reasoning does not explain why slips produced significantly more suckers than did tops when forcing was carried out in April.

It is of note that sucker number appeared to be unaffected by size of planting material, whereas most of the foregoing data showed highly significant responses to this factor. However, differences in size of suckers have not been taken into account.

IV. CONCLUSIONS

The date of planting (in autumn), the date of forcing (for a summer crop), and the size of original planting material were all important factors in pineapple plant development. Type of planting material was not important.

Time of planting had no significant effect on the size of plant and fruit, but had a marked effect on the expression of other morphological characters. Three successive plantings in late February, mid-March and early April gave progressively fewer slips and multiple tops. Planting later than mid-March significantly delayed flowering and harvesting by a few days, and slightly reduced the number of fruitlets in each fruit. Planting prior to mid-March reduced sucker development by 20 per cent.

Time of forcing, whether in late April, mid-May or early June, had no significant effect on subsequent fruit weight or the number of multiple tops. However, mid-May forcing tended to produce the heaviest fruit. Forcing prior to mid-May significantly advanced flowering and harvesting by more than a week, slightly increased the fruitlet number when large planting material was used, and increased sucker development by approximately 24 per cent. With small planting material, successive forcings from late April till early June progressively increased the number of slips.

Larger planting material resulted in larger plants at the time of forcing, as indicated by D-leaf measurements. The 9-oz planting material gave a 7 per cent. increase in fruit weight compared with 6-oz material. Flowering and harvesting tended to be slightly advanced by using the larger material, particularly when late forcing was carried out. Large planting material significantly increased the number of multiple tops, fruitlets and slips. Increases in fruitlets and slips occurred mainly with April forcing. No effect of size on sucker development was observed.

Tops and slips gave similar results. Exceptions were that tops gave slightly more multiple tops than did slips, and slightly fewer suckers when April forcing was carried out.

Harvest patterns show that a pronounced harvest peak can be eliminated by planting and forcing two areas each at different times. By planting one block no later than mid-March and forcing it in late April the following year, and planting another in early April and forcing it no earlier than mid-May, the harvest may be fairly evenly spread over five weeks or more.

Maximum slip number was obtained by planting large slips or tops in February. Planting no earlier than mid-March and forcing no later than late April the next year gave the maximum sucker development.

V. ACKNOWLEDGEMENTS

Acknowledgement is made to Mr. R. C. Cannon (now Assistant Director of Horticulture), under whose direction this trial was carried out, and to Mr. P. B. McGovern (Chief Biometrician), who carried out the statistical analyses.

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(Received for publication July 20, 1962)