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Evaluation of performance and stability of six genotypes of Queen pineapple

(Penilaian terhadap prestasi dan kestabilan enam genotip nanas Queen)

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Key words: *Ananas comosus* L. (Merr.), pineapple, variety, Queen, Moris, Mauritius, genotype x environment, stability

Abstrak

Enam genotip daripada kumpulan nanas Queen iaitu Moris Taiwan, Queen India, Moris Slipping, Moris Sungei Balang, MacGregor dan Tailung dikaji di empat keadaan persekitaran yang berbeza iaitu Pontian (tanah gambut), Kundang (pasir lombong) serta Bukit Tangga dan Serdang (tanah liat).

Hasil daripada ANOVA menunjukkan bahawa kesan genotip, alam sekitar dan interaksi antaranya (GxE) ketara bagi 13 ciri yang dinilai. Bukit Tangga di Zon 1 yang mengalami kemarau selama 2–3 bulan ternyata sebagai lokasi yang paling sesuai untuk pengeluaran nanas Queen yang bermutu. Walau bagaimanapun, tindak balas genotip terhadap pengaruhan pembungaan di lokasi tersebut didapati rendah sedikit.

Genotip Queen yang paling berpotensi dalam kajian ini ialah Moris Taiwan. Genotip ini mempunyai buah yang paling berat (1.3 kg) iaitu purata 20% lebih berat daripada genotip lain. Walau bagaimanapun, tindak balasnya terhadap pengaruhan pembungaan rendah sedikit (92%). Apabila berat buah dan peratus pembungaan digunakan untuk kiraan hasil petak, hasil Moris Taiwan didapati 15% lebih tinggi daripada hasil genotip Queen yang lain.

Interaksi genotip x alam sekitar yang ketara bagi jumlah pepejal larut (JPL), berat buah dan hasil dinilai secara mendalam, dan kestabilan genotip bagi ciri-ciri tersebut dianggarkan dengan kaedah kesusunan tak parametrik.

Bagi JPL, Tailung ialah genotip yang terbaik. Tailung menunjukkan nilai JPL yang tertinggi di keempat-empat lokasi. Oleh yang demikian, anggaran kestabilannya paling rendah (S_i^3 = 0).

Hasil Tailung dan Moris Taiwan didapati tidak stabil (masing-masing S_i^3 = 5.33 dan 3.95). Ketidakstabilan hasil Tailung disebabkan oleh ketidakkekalan berat buahnya di empat lokasi, manakala ketidakstabilan hasil Moris Taiwan diakibatkan oleh tindak balas pembungaan yang tidak menentu di Bukit Tangga.

Abstract

Six genotypes from the Queen group of pineapple, viz. Moris Taiwan, Queen India, Moris Slipping, Moris Sungei Balang, MacGregor and Tailung, were tested over four diverse environments at Pontian (peat), Kundang (sand-tailings), Bukit Tangga and Serdang (clay-loam).

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The ANOVA showed that genotype, environment and GxE effects were mostly significant for the 13 characters evaluated. Bukit Tangga, in the agro-ecological Zone 1 which is characterized by a 2 to 3-month dry spell, appeared to be the most suitable location for producing quality Queen pineapples. However, response to flower induction was found to be slightly poorer.

The most promising Queen genotype in this trial was Moris Taiwan. It had the heaviest mean fruit weight (1.3 kg), which was on the average about 20% heavier than the others. However, its response to flower induction (92%) was slightly poorer, and when fruit weight and flowering percentage were used to compute plot yields, it was found that Moris Taiwan was about 15% higher yielding than the other Queen genotypes.

Significant GxE interactions in total soluble solids (TSS), fruit weight and yield were examined in depth, and the stability of the genotypes in these characters were estimated using a non-parametric ranking method.

For TSS, Tailung was the best genotype, having consistently the highest mean values over all four locations, and this resulted in the lowest possible stability estimate of $S_i^3 = 0$.

Tailung and Moris Taiwan were found to be unstable in yield ($S_i^3 = 5.33$ and 3.95, respectively). The instability of Tailung was a result of inconsistency in fruit weight over the four environments, while the instability in yield of Moris Taiwan was a consequence of erratic response to flower induction at Bukit Tangga.

Introduction

Pineapple is currently the most important fruit crop in Malaysia. The export value of canned pineapple was the highest among fruit exports in 1992 with a value of over RM100 million (Anon. 1993). As a fresh fruit, it is also ranked among the top 10 fruits in the country, both in production volume and priority in research.

The main cultivar planted for fresh fruit in Malaysia is Moris or Mauritius which comes from the Queen group of pineapple. Over 90% of the pineapple fruit produced for the table come from this cultivar. The rest are produced from two other cultivars, i.e. Sarawak which is closely related to the renowned Smooth Cayenne, and Hybrid 36 which is from the Spanish group.

The typical characteristics of the Queen group of pineapple are the spiny, greyish-purple leaves covered with a whitish bloom; slender, tapering fruit with a large number of small, bulging eyes, and slightly ‘drier’, golden yellow flesh which is crispy and very sweet (Wee 1972). The high total soluble solids content and attractive flesh colour make the Queen pineapple a very desirable parent in hybridization programmes for improvement of pineapple (Chan 1991).

Variations within the group exist, sometimes imperceptible, and at other times, phenotypically evident. These differences arise because of spontaneous mutation in the field, and these changes are genetically fixed by vegetative propagation and perpetuated by preferential selection of the mutant character from generation to generation. The variations due to natural mutation in pineapple populations offer good opportunities for selection and improvement of cultivars. This has led to the selection of sub-varieties in the Queen group, such as the ‘Z’ Queen in South Africa, selected from a single plant variant which had larger fruit and square shoulders (Collins 1962), and MacGregor and Alexandra selected from the Common Rough or Ripley Queen in Australia (Anon. n.d.). In Malaysia, Wee

(1972) described three variants, viz. Mauritius (Moris), Mauritius Slipping and Yankee, that were representatives of the Queen group. While the existence of these Queen genotypes or variants have been known for a long time, systematic evaluation of their performance and their potential as commercial cultivars has yet to be carried out.

This study examines some of the genotypes within the Queen group of pineapple in terms of their performance and stability over diverse environments. The results will be used to identify a high yielding, superior quality and adaptable genotype which could be recommended or released as a new Moris cultivar to local farmers.

Materials and methods

Six genotypes belonging to the Queen group of pineapple were tested over four locations to determine their performance and stability. The genotypes were Moris Taiwan, Queen India, Moris Slipping, Moris Sungei Balang, MacGregor and Tailung. Moris Sungei Balang is currently the most widely cultivated Queen pineapple in Malaysia and was used as a check variety in the trial. The locations covered diverse soil types at Pontian (peat), Kundang (sand-tailings) as well as Bukit Tangga and Serdang (lateritic clay-loam). They also covered two agro-climatic zones, i.e. Zone 3: Pontian in the south-west, and Serdang and Kundang in central-west which do not experience any dry spells; Zone 1: Bukit Tangga in the north-west which experiences a distinct, annual drought of 2–3 months (Nieuwolt et al. 1982).

All the planting materials for this experiment were propagated by quartering techniques described by Lee and Tee (1978) to reduce error in the trial due to propagule age and size as well as variations due to location and season. The source materials were taken from mother plants in the pineapple germplasm collection at MARDI, Pontian. The plants were transplanted in the field when they reached a height of 0.3 m. They were stagger-planted from September 1990 to March 1991 at the various locations. At each location, the plants were planted in a randomized complete block design with four replicates. In each plot, there were 60 plants in three double-row beds of 20 plants each. The spacing was 30 cm x 60 cm between plants and 90 cm between beds.

The agronomic practices at Pontian, Bukit Tangga and Serdang followed the recommendations of Tay (1981), but at Kundang which is situated on sand-tailings, about 1 kg/plant of POME (palm oil mill effluent) was added prior to planting to ameliorate the soil. Flower initiation using 400 ppm ethrel, 4% urea and 0.5% borax was carried out when the plants were 11 months old.

Samples for data entry were drawn from five random plants in the middle bed of each plot. At flower induction, the ‘D’ leaf (tallest leaf) was taken and its weight recorded after drying at 40 ^{o}C for 1 week in the oven. Emergence of the inflorescence was recorded as the number of days taken for emergence of the red heart from the time of flower induction. After 45 days from flower induction, the number of plants that flowered in each plot was counted, and the percentage of flowering computed.

At harvest, the fruit and crown weights, core diameter, number of slips and suckers, disease rating of the fruit (marbling, cork spots and leathery pocket), flesh colour, total soluble solids (TSS) and acid contents were recorded from each sample plant. Core diameter was measured from the centre of the longitudinally dissected half of the fruit, and TSS was recorded using a hand refractometer (0–25% Brix). Acid titration followed the method described by Tay (1972). The intensity of flesh colour and disease severity were visually scored from 1 to 10, the higher scores indicating more intense colour or greater disease severity. The plot yield was computed from percent flowering x fruit weight x 60 plants/plot.

The combined ANOVA conducted on all dependent variables assumed that the effects of genotype, environment and their interactions were fixed effects. The data were processed by an IBM 4381–11 using the SAS statistical package.

The analysis of GxE and stability of genotypes in several important characters was done by a non-parametric method proposed by Hühn (1979). The stability statistic S_i^3 was computed based on ranks of genotypes in each environment expressed as $S_i^3 = \Sigma (r_{ij} - \bar{r}_{i.})^2 / \bar{r}_{i.}$
where r_{ij} is the rank of the *i*th genotype in the *j*th environment and $\bar{r}_{i.}$ is the mean of ranks over all environments for *i*th genotype. The genotype with the smallest value was given a rank of 1 and the highest was given a rank of 6.

Results and discussion

The analyses of variance of 13 characters are shown in *Table 1*. Significant differences were found in environment and genotype effects as well as genotype x environment interaction for all the characters with a few exceptions. Disease rating and flowering percentage did not show genotypic differences, while disease rating and 'D' leaf dry weight did not exhibit significant GxE interaction. The non-significance in disease rating between genotypes in the Queen group was to be expected because the group itself is well-known for its resistance or tolerance to a variety of diseases, including leathery pocket and cork spot (Lim 1985) as well as marbled fruit (Chan 1991).

Environment and genotype effects

Comparison of means between environments *(Table 2)* showed that Pontian and Kundang produced the largest fruit (1.23 kg) while Serdang produced the smallest, weighing only 0.89 kg. This concomitantly translates to high yields at Pontian (73.3 kg/plot) and Kundang (71.1 kg/plot) compared with Serdang (53.2 kg/plot). Pontian, located in Zone 3 which has equable rainfall throughout the year and with the friable peat soil and high water table, encouraged high production of vegetative propagules such as slips and suckers. The fruit quality at Pontian was quite good, with fairly high TSS (14.1%) and acid, but fruit at Kundang were poorer in quality with low sugars (12.2%) and pale flesh colour. However, because of the attendant low acids (0.4%), the sugar:acid balance and taste of fruit from Kundang were still acceptable.

Bukit Tangga appears to be the best environment for production of Queen pineapple for quality fresh fruit. The fruit size (as reflected by fruit weight) produced in this location was acceptable (1.08 kg), and perhaps because of the drier environment (Zone 1), the sugar accumulation in the fruit was highest (15.5%). This was also well balanced by high acids to give a good flavour. The flesh colour of fruit produced in this location was also superior. However, the crop may be expected to mature later at this location because the appearance of the inflorescence (red heart) after flower induction took about 9 days longer compared with the other environments *(Table 2).*

Another minor setback at Bukit Tangga was the slightly lower response of plants to flower induction (92.8%), resulting in only moderate yields of 60.5 kg/plot.

With regard to genotype effects, the superiority of Moris Taiwan was very clear-cut *(Table 3).* It had the largest fruit size (1.31 kg) and compared with others, was 17–28% heavier. Fruit size of the Queen genotypes is usually considered small; Nayar et al. (1981) reported a range in fruit weight between 0.32 and 0.83 kg for Queen cultivars in their trial. However, in this trial, the fruit weights were considerably higher, in the range of 1.0–1.3 kg.

Although the fruit weight of Moris Taiwan was about 20 % higher than other genotypes, its flowering response (92%) was slightly lower. Therefore, when translated into yield, Moris Taiwan may be expected to be about 15% higher than the rest. It also had high sugars (14.9% TSS), well-balanced

Table 1. Analyses of variance for 13 characters in six genotypes of Queen pineapple

Source	df	MS Fruit wt.	Core	Slip	Sucker	Crown wt.	Disease	Flesh colour	TSS	Acid	'D' leaf	Flower %	Days to red heart	Yield/ plot
Environment	3	0.6143**	76.14**	12.74**	49.26**	13 101**	0.1078**	7.6911**	46.20**	0.3783**	142 142**	247.83**	455.45**	2 121.3*
Rep (environ)	12	0.0210ns	1.27ns	0.48ns	3.49*	617ns	0.0273ns	0.1056ns	0.83ns	0.0030ns	5 933**	13.23ns	0.97ns	64.6ns
Genotype	5	0.1720**	50.56**	35.62**	53.65**	41 370**	0.0287ns	0.8530**	9.89**	0.0453*	35 223**	121.12ns	247.34**	426.6*
GxE	15	0.0547**	6.69**	3.78*	4.08**	2 153**	0.0271ns	0.2454**	1.43**	0.0146**	1 583ns	115.27**	37.67**	366.8**
Error	60	0.0190	1.84	1.67	1.50	348	0.0192	0.0875	0.55	0.0015	2 221	18.46	2.80	75.8

* = significant at $p = 0.05$ ns = not significant
** = significant at $p = 0.01$

Table 2. Comparison of means of 12 characters of Queen pineapple at four environments

Environ	Fruit wt. (kg)	Core (mm)	Slip	Sucker	Crown wt. (g)	Flesh colour	TSS (%)	Acid (%)	'D'leaf (g)	Flower (%)	Red heart (days)	Yield (kg/plot)
Pontian	1.23a*	27.7a	2.6a	4.6a	153.7a	6.2b	14.1b	0.65a	377c	99.5a	30.0b	73.3a
Kundang	1.23a	24.0c	1.9b	1.4b	116.1b	5.9c	12.2c	0.40b	375c	95.7a	30.2b	71.1a
Bkt. Tangga	1.08b	23.8c	2.0b	1.3b	158.6a	7.1a	15.5a	0.64a	539a	92.8b	39.0a	60.5b
Serdang	0.89c	25.6b	0.9b	1.7b	115.6b	6.0c	14.2b	0.66a	441b	99.3a	30.9b	53.2c

*values within a column with the same letter are not significantly different at $p = 0.01$ according to DMRT

Table 3. Comparison of means of six genotypes of Queen pineapple

Genotype	Fruit wt. (kg)	Core (mm)	Slip	Sucker	Crown wt. (g)	Flesh colour	TSS (%)	Acid (%)	'D' leaf (g)	Flower (%)	Red heart (days)	Yield (kg/plot)
Taiwan	1.31a*	27.3a	0.7de	1.1c	91b	6.0d	14.9b	0.54c	385b	92.1b	38.8a	72.4a
Q India	1.12b	23.7b	2.9ab	1.1c	172a	6.3bc	13.7b	0.63a	471a	99.4a	32.0c	66.8ab
Slipping	1.09b	23.9b	4.0a	1.8c	173a	6.3bc	13.6b	0.62ab	468a	99.4a	27.8e	65.0ab
Balang	1.07b	24.3b	0.0e	3.0b	156a	6.5ab	13.6b	0.63a	452a	97.8a	29.6d	62.8b
MacGregor	1.06b	24.6b	2.2bc	2.1bc	167a	6.6a	13.4b	0.59b	457a	96.4ab	31.7c	61.3b
Tailung	1.02b	27.7a	1.4dc	5.9a	53c	6.1cd	15.5a	0.50d	361b	95.6a	35.0b	58.5b

*values within a column with the same letter are not significantly different at $p = 0.01$ according to DMRT with high acid (0.54%) for good flavour. However, it did not produce much slips and suckers, and therefore its propagation and regeneration of the ratoon crop may be a problem. The maturation of the crop may be 7–11 days later than the others, judging from the delayed emergence of the inflorescence *(Table 3).*

Another genotype that deserved special mention was Tailung. It had the highest sugar content (15.5%) and very good eating quality, but it bore small fruit (1.02 kg) and tended to produce excessive suckers (about 6/plant). It was also prone to a condition known as split-peduncle which causes fruit malformation.

Analysis of GxE interaction and stability

The occurrence of genotype x environment interaction in most of the characters implied that the genotypes' performance over the environments did not follow a predictable trend. An analysis of the nature of the interaction using Hühn's non-parametric ranking method was carried out for TSS, fruit weight and yield. The results are shown in *Table 4.*

With regard to TSS, Tailung was the most superior. It had the highest mean and this was maintained without exception, over all four environments. This resulted in the lowest stability estimate possible (S_i^3 = 0). Moris Taiwan was second, but only at two locations. It could not maintain its position at Pontian and faltered more severely at Serdang *(Table 4),* resulting in a moderate instability value (S_i^3 = 1.50). Queen Slipping and MacGregor were relatively stable, but their TSS means were not very high.

For fruit weight, the superiority of Moris Taiwan was outstanding. It had the heaviest fruit and appeared to be the most stable (S_i^3 = 0.13), with the ability to maintain its top rank over all environments

Table 4. Performance ranking and stability of six genotypes over four environments for TSS, fruit weight and yield

Genotype	Mean	Mean of ranks	Pontian	Kundang	Bkt. Tangga	Serdang	S_i^3
TSS (%)							
Tailung	15.6	6.00	6*	6	6	6	0.00
Taiwan	14.0	4.00	4	5	5	2	1.50
Q India	13.7	3.50	5	4	4	1	2.57
Slipping	13.6	2.75	2	3	2	4	1.00
Balang	13.6	2.50	3	1	1	5	4.40
MacGregor	13.4	2.25	1	2	3	3	1.22
Fruit weight (kg)							
Taiwan	1.31	5.75	6	6	5	6	0.13
Q India	1.12	4.25	3	5	6	3	1.59
Slipping	1.09	3.50	5	3	4	2	1.43
Balang	1.07	2.25	2	4	2	1	2.11
MacGregor	1.06	2.75	4	2	1	4	2.45
Tailung	1.02	2.50	1	1	3	5	4.40
Plot yield (kg)							
Taiwan	72.4	4.75	6	6	1	6	3.95
Q India	66.8	4.00	2	5	6	3	2.50
Slipping	65.0	3.75	5	4	4	2	1.27
Balang	62.8	2.50	3	3	3	1	1.20
MacGregor	61.3	3.00	4	2	2	4	1.33
Tailung	58.2	3.00	1	1	5	5	5.33

*lowest mean value = rank 1
highest mean value = rank 6

except Bukit Tangga, where it slipped to second place. The genotype that showed the strongest GxE interaction and therefore was the least stable for this character, was Tailung (S_i^3 = 4.40).

For yield, it was evident that the inconsistent rankings of the genotypes over the four locations had caused a significant genotype x environment interaction. The round-about turn in rankings of Moris Taiwan and Tailung were glaring examples *(Table 4).* Moris Taiwan was the best yielder over three environments, but at Bukit Tangga, it turned out to be the least productive of the genotypes. The same applied for Tailung which was the poorest yielder at Pontian and Kundang, but came in second at Bukit Tangga and Serdang. These two showed the highest S_i^3 values (Tailung = 5.33 and Moris Taiwan = 3.95), indicating their relative instability for yields over the set of environments.

The expression of stability (or the lack of it) can be explained by examining, at the four locations, the inter-play of two factors, i.e. flowering percentage and fruit weight, that were used to compute yield *(Table 5).* It was clear that the inconsistency in yield of Tailung was related to its instability in fruit weight as discussed earlier because its flowering response was consistently around 83–100% at all the environments. On the other hand, Moris Taiwan which showed consistent high values for fruit weight over the four locations, was unstable for yield because of inconsistency in the second factor, i.e. response to flower induction *(Table 5).* Its flowering response was very good at three of the environments (93.8–100%), but at Bukit Tangga, it dipped to 77.8%, resulting in the sharp yield decline and the bottom ranking for yield.

Figure 1 illustrates the yield behaviour of the genotypes at the four locations. It was evident that the six genotypes can be clustered into two groups. The first was a group of genotypes made up of MacGregor, Balang, Slipping and Queen India. They have more or less similar yields at any one

Table 5. Flowering, fruit weight and plot yield of six genotypes of Queen pineapple over four environments

Genotype	Pontian			Kundang			Bukit Tangga			Serdang		
	Flower (%)	Fruit wt. (kg)	Yield (kg)	Flower (%)	Fruit wt. (kg)	Yield (kg)	Flower (%)	Fruit wt. (kg)	Yield (kg)	Flower (%)	Fruit wt. (kg)	Yield (kg)
Taiwan	100.0	1.70	102.3	93.8	1.43	80.8	77.8	1.11	51.7	97.2	0.99	57.7
Q India	99.2	1.15	67.4	100.0	1.28	76.9	99.2	1.18	70.5	99.2	0.87	52.0
Slipping	100.0	1.19	71.7	100.0	1.24	74.4	98.5	1.08	64.2	99.2	0.86	51.1
Balang	100.0	1.13	68.1	98.0	1.25	73.5	93.5	1.04	58.9	100.0	0.83	49.6
MacGregor	98.0	1.19	70.3	99.2	1.16	69.1	88.5	0.99	53.3	100.0	0.88	52.5
Tailung	100.0	1.00	60.0	83.2	1.04	52.1	99.2	1.08	64.3	100.0	0.94	56.4

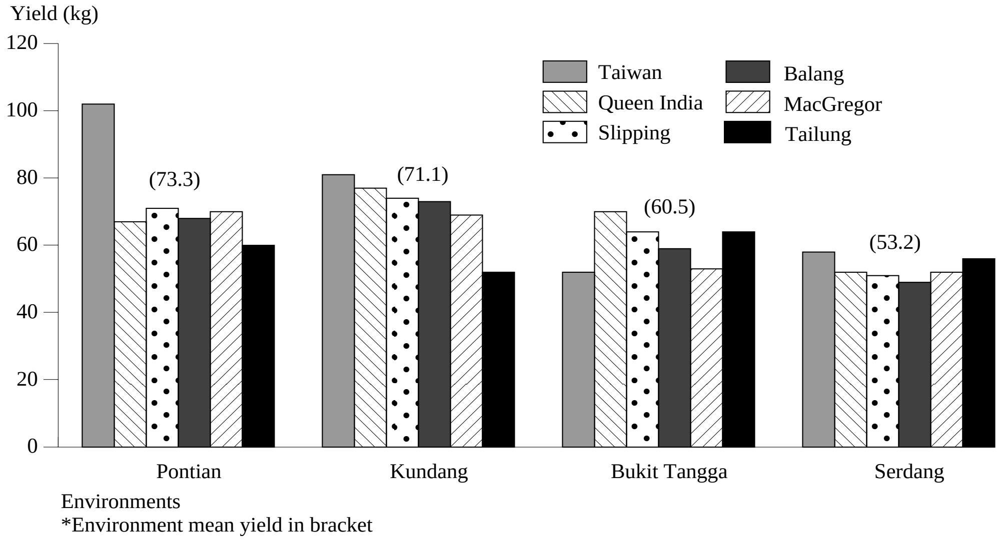

Figure 1. Yield of six Queen genotypes at four environments

location and followed the same trends in yield changes when environments were changed. In general, they performed poorly at the least productive environment (Serdang) but picked up well at the other three more productive environments. This was the group that showed good yield stability in the earlier discussions. In contrast, the second group made up of Tailung and Moris Taiwan had rather unpredictable trends and were, therefore, more unstable. Tailung did not change its yield very much even with increasing productivity of environments (Kundang and Pontian) except for an inexplicably sharp increase at Bukit Tangga. Moris Taiwan performed poorly at less productive environments but truly stamped its mark in more productive environments, particularly at Pontian, where its yield was at least 30% better than the others *(Figure 1).*

Selection and recommendations

Moris Balang is the standard cultivar of Queen planted in Malaysia, and is especially widespread in the west coast of Johor. Results from this trial indicated that there may be one or two in the Queen group that have the potential to replace the present cultivar.

Moris Taiwan appeared to have the best prospects. It has good fruit qualities, consistent fruit size and high yields. Its performance was tarnished somewhat by the late maturation of the crop, poor suckering and slip development, and the relatively unstable yield. However, some of these shortcomings appear to have a remedy.

Poor suckering and slip development may not allow good crop ratooning in Moris Taiwan. Thus, farmers may have to resort to one plant crop per cycle. This may not be difficult to accept because it is already the standard practice in well-managed estates cultivating canning pineapple. The practice has also caught on well with smallholders because work schedules can be more accurately timed, and production in terms of fruit size and quality is very uniform.

The relatively unstable yield estimate for Moris Taiwan should not be unduly alarming. It arose solely because of the relatively poor response to flower induction at Bukit Tangga. Research to improve flowering using chemical inductants will vastly improve the yield and performance of the cultivar there.

In conclusion, Moris Taiwan appears to be the ‘King of the Queen’, at least in this set of variants. Combined with a suitable location for cultivation such as Bukit Tangga, and with removal of minor setbacks, excellent quality fresh pineapples may be produced from this cultivar.

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