

QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

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**SCREENING OF MANGO VARIETIES AT BOWEN,
QUEENSLAND**

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SUMMARY

Nine mango accessions with acceptable fruit quality and maturing between 2 weeks earlier and 4 weeks later than commercial Kensington Pride were selected for commercial testing from 43 accessions at the Bowen Horticultural Research Station.

Selections in the continuing programme were made after evaluation during 4 years based on time of maturity, palatability, skin colour, endocarp fibre, presence of turpentine flavours and average fruit weight. Time of maturity was assessed as the weekly interval when 50% of fruits were soft ripe. This was 23 to 30 December for Kensington Pride. Palmer, Smith and Banana-1 matured 1 to 2 weeks earlier than Kensington Pride while Carrie and Irwin matured 1 week later and Kent and Keitt matured 3 and 4 weeks later. Haden and Zill matured at the same time as Kensington Pride.

I. INTRODUCTION

Commercial mango growing in the dry tropics of Queensland is based on a single variety, Kensington Pride. The industry is characterized by a short cropping period of about 6 to 8 weeks from late November and irregular annual production (Anon 1975). Anthracnose (*Collectotrichum gloeosporioides* Penz) is a limiting factor in fruit production in all countries where mangoes are grown and high humidities prevail (Singh 1968). It is the most common disease problem in Queensland (Simmonds 1965, Muirhead 1976, and Grattidge 1978). Also, bacterial black spot (*Pseudomonas mangiferaeindicae*), which is a severe problem in South Africa (Meulen 1971), was recorded for the first time in the Bowen district in 1976 and first confirmed in 1977 by Moffett, Peterson and Wood (1979).

The short cropping season at Bowen contrasts with 4-month cropping in Florida where more than 10 varieties are used (Malo 1977). The advantage of using several varieties which mature at different times to extend the cropping season in mango has been previously described by Lynch and Mustard (1955) and Campbell and Malo (1967) in Florida and Meulen (1971) in South Africa. Also, a greater range of varieties including regular bearing types as mentioned by Meulen (1971) and by Singh (1968) could help even out annual yield fluctuations.

Flower induction techniques such as smudging (Valmayor 1968) and applications of ethrel (Dutcher, personal communication) and potassium nitrate (Mendoza and Cuevas 1974) have been used in the Philippines to promote early fruit production. However, only inconsistent results have been obtained from ethrel and potassium nitrate applications to Kensington variety in the Bowen district (Wright, personal communication).

Latitude and altitude of the mango growing locality have long been regarded as important influences on time of cropping (Singh 1968). Kensington Pride reaches peak maturity at Weipa (about 13°S) in early to mid November, about 6 weeks earlier than in Bowen at 20°S latitude (Watson, personal communication). Also, the author has observed that Kensington variety matures about 1 week later for each degree of latitude from Bowen to Brisbane (28°S). However, peak maturity at Mareeba (17°S) occurs in mid to late January about 3 weeks later than in Bowen, indicating how higher altitude (350 m) can offset the effect of lower latitude.

Campbell and Malo (1967) described Florida varieties which were anthracnose-resistant. These varieties could be useful in overcoming this disease under Queensland conditions. Varieties with resistance to bacterial black spot are known in South Africa (Wood, personal communication), and such varieties may ultimately be needed in Queensland.

A mango variety introduction and evaluation programme was initiated in Queensland in the early 1960s (Beal 1976). Five varieties selected in the programme and released in industry in 1975 for commercial testing have been described (Beal 1979). The screening and isolation of potentially useful accessions has continued since 1975. The aim of this work has been to extend the commercial cropping period by isolating accessions with acceptable fruit quality and a different ripening season to Kensington Pride. The present paper reports progress in the variety evaluation programme from 1974-77.

II. MATERIALS AND METHODS

The performance of 43 local and recently introduced varieties, including the present commercial cultivar Kensington Pride was compared at Bowen Horticultural Research Station during the 1974-75 to 1977-78 cropping seasons. Ripe fruit was obtained from grafted trees established in the field at 3.0 x 3.0 m between February 1972 and February 1974. Only one grafted plant was established for some accessions because of a shortage of land.

BEARING BEHAVIOUR. Average yield (fruit number) per tree was recorded each year from the first year of cropping. Average fruit weight was calculated from a 10-fruit sample where possible in the first year of cropping and used to determine yield (kg) per tree.

The ripening season was determined by recording the total number of soft ripe fruit each week in all trees of each accession when cropping involved 10 or more fruit per tree per year. Average ripening season was calculated from the summation of the ripe fruit recorded from the same weekly period in all years of cropping. The length of the average ripening season (weeks) was calculated after omitting the first and last 5% of crop. The week of median cropping or the weekly interval when 50% of fruit were soft ripe was the characteristic selected to define precisely the average ripening season.

Cropping records were discontinued after 1 year for accessions with unacceptable fruit quality. Evaluation of the promising accessions with only 1 year's cropping was continued after 1977-78.

FRUIT QUALITY. Fruit quality for the fresh market was rated over a range of 1 to 5 after assessing general palatability, skin colour, endocarp fibre, presence of turpentine flavours and average fruit weight of ripe fruit samples. The characteristics considered desirable for high commercial acceptability were attractive skin colour, low endocarp fibre, absence of turpentine flavour, and an average fruit weight of 0.2 kg or more in otherwise palatable fruit. A fruit quality rating of 3 was selected as the culling level above which accessions were worth retaining.

EMBRYO TYPE. Embryo type was determined by an examination of seed of five to 10 fruit of each accession.

III. RESULTS

BEARING BEHAVIOUR. The average ripening season and week of median cropping of each of 43 mango accessions are listed in table 1, together with year of planting and mean tree yields.

Nineteen varieties including Kensington-S produced a first crop of 10 fruit or more per tree by their third year. Fourteen varieties fruited in their fourth year and the remaining 10 varieties had their first acceptable crop in their fifth or sixth year. Average yield (fruit number) per tree per year of all varieties over 1 to 4 years ranged from 10 (in Jehangir) to 232 (in Julie). Average yield (kg) per tree per year of all varieties over 1 to 4 years ranged from 4.9 in Willard to 52.1 in Common-T.

The average ripening season of all accessions over the 1974-75 to 1977-78 season inclusive extended over 18 weeks from 25 November to 24 March. The length of the average ripening season was of 4 weeks duration in Smith, Jones-late, Sabre, Irwin and Banganpalli, 5 to 8 weeks in 31 varieties, and of 9 to 10 weeks in Anderson, Julie, Common-T, Kent, Joe Welch and Keitt, and 16 weeks in Neelum.

The week of median cropping ranged from 9 to 16 December in three accessions to the latest of 3 to 10 February in two accessions. Twelve accessions had the same week of median cropping 23 to 30 December as Kensington-S with 10 accessions 1 to 2 weeks earlier and 20 accessions 1 to 6 weeks later.

The length of ripening season and week of median cropping were determined in two or more years in 24 accessions. Both the length of ripening season and the week of median cropping varied between years by 2 weeks or less in 18 varieties (including Kensington-S) and by 3 to 4 weeks in six varieties.

The varieties with short (4 weeks) ripening seasons had intense flowering seasons of similar duration. The varieties with ripening seasons of 9 to 10 weeks or more had extended flowering seasons of similar duration and were later maturing than Kensington-S.

The early maturing varieties Banana-1, Palmer and Willard generally flowered during the mid June to early August period. The late varieties Keitt, Neelum and Manoranjan flowered over the August to mid October period with Kensington-S flowering during July and August at an intermediate time.

FRUIT QUALITY. Selected fruit characteristics as well as the embryo type and the fruit quality rating of 43 mango accessions are listed together with their source in table 2. Eleven of the 26 introduced accessions and 11 of the 17 local accessions had a fruit quality rating greater than 3.

TABLE 1
RIPENING SEASON OF MANGO ACCESSIONS AT BOWEN H.R.S. 1974-1978

Accessions	Year Planted	Av. No. Fruit/Tree/year (No. Trees)	No. Yrs.	Average ripening Season (Cumulative percent ripe fruit in week ending)																	Length ripening season (weeks)	Week of median cropping		
				Nov.		Dec.				Jan.				Feb.				Mar.						
				18	25	2	9	16	23	30	6	13	20	27	3	10	17	24	3	10			17	24
Banana-1	1974	48 (3)	1	1	4	7	26	62	79	98	99	100											3	9-16/12
Chatfield-Indian ..	1972	66 (1)	1		3	8	40	52	76	96	99	100											5	
Smith	1972	60 (2)	2			3	36	50	61	98	99	100											4	
Banana-2	1972	31 (1)	2		3	8	20	44	67	84	97	100											6	16-23/12
Palmer	1972	30 (4)	3	2	4	12	30	47	66	90	96	98	100										6	
Strawberry-K	1972	74 (1)	2			7	16	44	65	68	90	100											7	
Willard	1972	35 (2)	4			2	12	48	62	87	94	97	99	100									6	
Oaks-Early	1972	66 (1)	1			20	27	39	61	97	98	100											5	
Kama	1972	37 (1)	1		3	3	5	19	51	76	100												5	
Jones-Late	1972	20 (1)	1					35	50	75	100												4	
Haden	1972	67 (2)	2	2	4	8	16	25	45	79	86	91	96	100									8	23-30/12
Zill	1972	55 (3)	3	1	4	10	14	24	40	76	84	90	99	100									8	
Strawberry-Y	1972	79 (1)	4		3	12	22	34	47	74	87	94	100										8	
Roberts-1	1972	63 (1-2)	2				3	6	26	71	82	89	100										8	
Kensington-S	1972	43 (2)	3			1	4	10	34	68	89	91	98	100									8	
Kensington-M	1972	19 (2)	1					3	63	76	83	87	97	100									8	
Roberts-3	1972	21 (1-2)	2	2	2	5	12	19	33	62	76	93	100										8	
Manzano	1972	42 (1)	3			1	4	14	25	61	84	91	98	100									8	
Jehangir	1972	10 (2)	1			10	10	30	55	75	95	100											6	
Valencia Pride ..	1972	93 (1)	1		2	4	12	13	25	74	90	100											6	
Gulliver's Triumph ..	1972	13 (1)	1				1	6	15	54	77	100											7	
Pairi	1973	126 (1)	1					22	51	88	99	100											6	
Menzo-2	1972	34 (1)	3		2	10	12	18	33	50	65	78	100										8	
Anderson	1972	17 (1)	1		6	6	12	18	18	35	71	81	100										9	
Julie	1972	232 (1-2)	3		5	7	17	29	39	50	58	75	87	97	99	100							10	
Youngs-Late	1972	72 (1)	3		2	2	11	21	41	47	80	88	100										7	
Mundappa	1972	57 (1)	2		2	10	18	40	46	54	86	93	100										8	
Common-T	1972	186 (2)	2			4	6	20	31	44	58	68	83	90	95	100							9	
Carrie	1972	75 (1)	2				2	3	9	44	54	69	93	97	100								8	
Blue	1972	80 (1)	3				1	7	21	47	57	66	91	92	98	100							6	
Swarnarekha	1973	33 (1)	2					6	21	33	50	62	89	99	100								7	
Sabre	1974	29 (1)	1							34	62	76	100										4	
Irwin	1974	13 (2)	1							34	56	84	100										4	
Saigon	1974	32 (2)	1				3	8	14	32	37	44	95	100									6	13-20/1
Banganpalli	1974	27 (1)	1							20	31	67	74	81	100								4	
Ah Ping	1974	144 (2)	1					2	3	11	20	31	64	79	99	100							6	
Joe Welch	1974	38 (1)	1				8	8	8	38	46	46	54	85	85	100							10	
Kent	1972	24 (2)	2						2	13	38	41	56	69	79	85	94	98	100				9	
Goldsworthy	1972	58 (1)	1							2	19	28	47	71	86	98	100						6	20-27/1
Bangalora	1974	26 (1)	1							15	15	15	27	62	92	100							7	
Keitt	1973	28 (1)	2							18	24	26	36	54	79	85	91	91	96	98	100		9	
Manoranjan	1973	40 (1)	2								1	1	5	39	66	81	90	96	99	100			6	3-10/2
Neelum	1973	46 (1-3)	2			1	6	6	6	6	8	10	22	28	36	54	68	81	83	92	94	99	16	

TABLE 2

FRUIT CHARACTERISTICS, EMBRYO TYPE, QUALITY RATING AND SOURCE OF MANGO ACCESSIONS AT BOWEN H.R.S.

Accessions	Source	Skin col.	Endocarp fibre	Turpentine flavours	Average weight (kg)	Quality rating (1-5)	Embryo type
Ah Ping	Hawaii	PGY	V. Subst	Nil	0.23	3	P
Anderson	Florida	RY	Mod	Mod	0.50	1-2	M
Banana-1	Home Hill, Q.	Y	Slt-Mod	Nil	0.30 ± 0.02	4-5	P
Banana-2	Ayr, Q.	Y	Mod	Nil	0.40	3-4	P
Bangalora	India	PYG	V. Slt	Mod-Subst	0.44 ± 0.04	1-2	M
Banganpalli	India	Y	Slt-Mod	Mod-Subst	0.43 ± 0.02	1-2	M
Blue	Bowen, Q.	BY	Slt	Nil	0.24 ± 0.01	3-4	M
Carrie	Florida	Y	Slt	Slt	0.32 ± 0.01	3-4	M
Chatfield-Indian*	Ayr, Q.	PY	V. Subst	Nil	0.20	3	P
Common-T	Townsville, Q.	GY	Subst	Nil	0.28	3	P
Gulliver's Triumph	Bowen, Q.	GY	Mod-Subst	Slt	0.48 ± 0.02	3	P
Goldsworthy	Clare, Q.	GY	Mod	V. Slt	0.37 ± 0.03	3	P
Haden	Florida	RY	Mod	Slt	0.27 ± 0.01	3-4	M
Irwin	Florida	RP	Slt-Mod	V. Slt	0.34 ± 0.02	3-4	M
Jehangir	India	GY	V. Slt	Subst	0.24 ± 0.01	1	M
Joe Welch	Hawaii	PY	Slt	V. Slt	0.38 ± 0.02	3-4	M
Jones-Late	Ayr, Q.	GY	V. Subst	Nil	0.22 ± 0.02	3	P
Julie	West Indies	GY	V. Subst	Nil	0.19 ± 0.01	3	P
Kama	Ayr, Q.	PYG	Mod-Subs	Nil	0.20	3	P
Keitt	Florida	RG	Slt	Nil	0.47	4	M
Kent	Florida	RGY	V. Slt	Nil	0.47 ± 0.01	4-5	M
Kensington-M	Bowen, Q.	BY	Slt	Nil	0.33 ± 0.02	4-5	M
Kensington-S	Bowen, Q.	RY	Mod	Nil	0.31 ± 0.02	4-5	P
Manoranjan	India	YG	Slt	Mod-Subst	0.27	1-2	M
Manzano	Virgin Islands	RY	Mod	Nil	0.37 ± 0.02	4-5	P
Menzo-2	Ayr, Q.	GY	Slt	Nil	0.36 ± 0.06	4	P
Mundappa	India	GY	Subst	Nil	0.21 ± 0.02	3	P

SCREENING MANGO VARIETIES AT BOWEN

TABLE 2—continued

FRUIT CHARACTERISTICS, EMBRYO TYPE, QUALITY RATING AND SOURCE OF MANGO ACCESSIONS AT BOWEN HIR.S.—continued

Accessions	Source	Skin col.	Endocarp fibre	Turpentine flavours	Average weight (kg)	Quality rating (1-5)	Embryo type
Neelum	India	GY	Slt	Slt	0.22 ± 0.01	2-3	M
Oaks-Early	Ayr, Q.	RY	Mod	Nil	0.28 ± 0.02	3	P
Pairi	India	GY	V. Subst	Nil	0.15 ± 0.01	3	P
Palmer	Florida	RY	Slt	Nil	0.36 ± 0.01	4-5	M
Roberts-1	Rita Island, Q.	RY	Subst	Nil	0.30	3-4	M
Roberts-3	Rita Island, Q.	RY	Slt	Nil	0.47 ± 0.04	4	P
Sabre	South Africa	RY	Subst	Nil	0.30 ± 0.02	2-3	P
Saigon	Florida	Y	V. Slt	Nil	0.19 ± 0.02	3-4	P
Smith	Florida	RY	Mod	Nil	0.33 ± 0.01	4	M
Strawberry-K	Ayr, Q.	RY	Slt-Mod	Nil	0.17 ± 0.01	3-4	P
Strawberry-Y	Ayr, Q.	RY	Slt-Mod	Nil	0.17 ± 0.01	3-4	P
Swarnarekha	India	YG	Mod-Subs	Nil	0.20 ± 0.01	2-3	P
Valencia Pride	Hawaii	RY	V. Slt	Mod	0.44	2	M
Willard	Sri Lanka	RY	Slt-Mod	Nil	0.14 ± 0.01	3	M
Youngs-Late	Ayr, Q.	Y	Mod	Nil	0.24 ± 0.02	3-4	M/P
Zill	Florida	RY	Slt	Slt	0.23 ± 0.01 ± SE	3-4	M

Skin Colour

R = Red
 P = Pink
 B = Blue/Green
 G = Green
 Y = Yellow

Embryo Type

M = Monoembryonic
 P = Polyembryonic

Endocarp Fibre

Very slight—Less than 1 cm in length
 Substantial/More than 4 cm in length and abundant

Turpentine Flavour

Nil to substantial

* Termed an introduction

EMBRYO TYPE. Seventeen of the 26 introduced accessions and four of the 17 local accessions had monoembryonic seed.

OTHER OBSERVATIONS. Necrotic lesions consistent with anthracnose infection were observed in January 1973 on new leaves of two 1-year-old trees in high incidence in Willard and nil to slight incidence in Zill, Palmer, Kent, Roberts special and Samar Behist Chausa.

The varieties and estimated percentage of mature unripe fruit with lesions consistent with bacterial black spot infection observed in November 1976 were Kent (90 to 100), Haden (40 to 60), Keitt (20 to 40), Smith (20), Roberts-3 and Zill (5 to 20) and Palmer and Kensington (0 to 10).

IV. DISCUSSION

BEARING BEHAVIOUR. Thirty-three of the 43 mango accessions fruited by their third or fourth year with all having fruited by the sixth year after planting out (table 1). Haden, Zill, Palmer and Kent were, with Kensington-S, among the most precocious cultivars, having a substantial advantage over Goldsworthy, Gulliver's Triumph and Kensington-M which produced their first acceptable crop 6 years after planting out. It usually takes 5 to 7 years (Stephens 1963) or up to 10 years (Valmayor 1968) for a seedling to start flowering. It may be feasible to exploit such precocity by using dense plantings to produce heavy crops within 2 to 3 years or so from planting, after which plants are removed. This suggestion seems worth testing in any subsequent commercial plantings of promising varieties.

The contribution of variety to the wide range in yield was confounded with other influences such as age of tree, years of cropping and varying seasonal conditions. Also, Meulen (1971) stated that no new cultivar can be conclusively judged until it is about 15 years of age when the biennial bearing habit has generally developed. This indicated that the maximum period of 4 years' cropping recorded for any cultivar was inadequate to indicate yield potential or consistency in bearing with any certainty and yields were largely incidental in the variety screening.

High yield in most varieties, and in Common-T, Julie and Smith in particular, was associated with a high percentage of hermaphrodite flowers (in the range 30 to 50%) and heavy blossoming. In contrast, low yields in 1976 in varieties Carrie and Goldsworthy were associated with 9% of hermaphrodite flowers and a low incidence of flowering respectively. Prasad and Patek (1970) recognised that sex ratio (hermaphrodite to hermaphrodite plus male flowers) and flowering intensity have significant roles in determining yielding ability. Also, the variation in these characteristics between varieties suggests that high sex ratio and high flowering intensity could be useful selection criteria in isolating potentially productive cultivars.

The unacceptably low yield of Kensington-S and most other varieties in 1975 was associated with high and unseasonal rainfall during the August to September period when flowering occurred. This supports the statements by Simmonds (1965), Singh (1968) and Grattidge (1978) of the adverse effect of rainfall during blooming on fruit set and final yield. The acceptable yields of Willard, Julie and Strawberry-Y in 1975 suggests that these varieties had some advantage over Kensington-S in adaptability to humid environments or resistance to disease.

Climatic influences are considered by Prasad and Patek (1970) and Valmayor (1968) to be major factors contributing to irregular bearing. Hence such types may be worth growing in regions with high humidity to confirm their adaptability to adverse environments and also to determine their value in reducing the problem of alternate bearing.

The small tree size of Willard, Irwin, Swarnarekha, Kent, Keitt and Neelum suggests that orchard productivity could be enhanced by using such low-vigour or dwarf varieties in spite of their moderate tree yields. Selecting plant spacing to suit the variety is a routine practice when establishing mango orchards in South Africa (Meulen, 1971). Also, dwarf varieties tend to be regular bearing (Kurup (1967) and Singh (1968)). These varieties could be established at a density of 140 trees per hectare, around twice that normally used in Kensington orchards, to test these suggestions.

The week of median cropping and length of ripening season were relatively stable from one season to another in most varieties. Further, the early varieties Banana-1, Smith and Palmer, and the late varieties Carrie, Irwin, Kent and Keitt, had ripening peaks in the same sequence with the standard Kensington-S in each year of cropping in spite of up to 2 weeks' variation in week of median cropping between seasons. This indicated that week of median cropping was a dependable and useful criterion for determining time of maturity in variety evaluation.

Time of maturity and length of ripening season appeared to be highly correlated with time of flowering and length of flowering season respectively. Also a useful correlation between extended flowering season and late maturity may also exist. However, the validity of these correlations and their usefulness in practice have yet to be confirmed. Fewer harvests would be required with varieties with concentrated ripening and utilization of varieties with this characteristic (for example, Smith) would be of advantage in orchard management. Varieties with ripening seasons exceeding the 6 weeks' season of Kensington-S may be of advantage in extending the production season. However, extended ripening season is of limited value if the variety (for example, Zill) has the same ripening peak as the standard or if the ripening season is strongly influenced by season as in Julie.

DISEASE REACTION. The incidence of anthracnose in ripening fruit was similar in all varieties from 1974-77 and was most severe in wet seasons such as 1975. No varieties appeared to be more resistant than Kensington Pride which is susceptible to anthracnose under Queensland conditions. However, differences could have been obscured by the random nature of natural infection, and differences in rates of maturation, ripening, or environmental conditions.

Other varieties with reputed anthracnose resistance were not included in this study. These include Carrie, Saigon, Earlygold and Florigon from Florida (Campbell and Malo 1967), Tommy Atkins (Malo 1977) from Florida and Carabau from the Philippines (Pegg, personal communication). These could be screened in a future study when a suitable method for assessing anthracnose reactions has been developed. Such a study should take into account the variables referred to above and the fact that other fungi, such as *Dothiorella dominicana* and *Botryodiplodia theobromae*, cause substantial post harvest wastage in Queensland (Muirhead, personal communication).

Anthrachnose lesions were observed in mature green fruit in extremely susceptible varieties, namely Willard, Neelum and Manoranjan. The latter two varieties ripen in late summer during the wet season when conditions are most favourable for disease development (Grattidge 1978). Neelum is regarded as anthracnose-susceptible in India where it ripens at the outbreak of the monsoon season (Kurup 1967). Hence it is particularly important that the late varieties for use in Queensland be anthracnose resistant. The reactions of the late varieties Keitt and Kent still need to be determined.

In addition to green fruit, new foliage of Willard was susceptible to anthracnose. In comparison, new foliage of Zill, Haden, Palmer, Kent, Roberts Special and Samar Behist Chausa appeared to be more resistant. The relationship between susceptibility of young foliage and susceptibility of flowers and fruit is not clear. Further investigation of this aspect is desirable since a knowledge of the relationship would be useful in screening varieties in future.

Anthrachnose-susceptible varieties such as Kensington Pride have a useful place in Queensland in low rainfall areas such as the dry tropics. They may also be of value if early enough to avoid the wet season or if sprayed according to the schedule described by Grattidge (1978). Also, varieties such as Palmer, Zill, Haden and Kent, which are susceptible to anthracnose in Florida, may have useful resistance in Queensland where different strains of *Colletotrichum gloeosporioides* may be present. The relationship between strains in Queensland and Florida has not been established and is worthy of study.

The reaction of eight varieties to bacterial black spot caused by *Pseudomonas mangiferaeindicae* was tentatively determined after observations of infections on green fruit with typical symptoms in the variety planting in November 1976. The infections were associated with 144 mm of rainfall in October. The disease spread rapidly and blemished green fruit so severely in susceptible varieties as to make the total crop unmarketable. Kent and Haden were considered highly susceptible; Keitt, Smith, Roberts-3 and Zill as intermediate; and Palmer and Kensington as resistant. Some support is provided for this classification by experience in South Africa where Palmer, Kent and Keitt are termed very susceptible; Haden and Smith intermediate; and Zill and Kensington resistant (Wood, personal communication). Zill may be a useful alternative variety to Kensington in overcoming this potentially serious disease. However, resistance to bacterial black spot remains an important selection criterion which should be considered in future screening of mango varieties.

The standard

The commercial variety Kensington Pride, the standard to which all other accessions were compared from 1974-1977 in the screening programme at Bowen Horticultural Research Station, was represented by the accession Kensington-S. Kensington-S had an average ripening season of about 6 weeks' duration from early December with the week of median cropping being from 23 to 30 December (table 1). This was similar to the ripening behaviour of this variety generally observed in commercial orchards in the immediate Bowen district. However, the normal commercial production season of this cultivar is from mid November to early January as only mature unripe fruit is harvested in commercial practice. The Kensington-S accession had large fruit, lightly blushed with red and with moderate endocarp fibre, as well as polyembryonic seed (table 2). These characteristics were regarded as typical of the variety by Tree (1959), Stephens (1963) and Beal (1979).

Early varieties

The Palmer, Smith, Banana-1, Banana-2 and Strawberry-K accessions had a week of median cropping 1 or 2 weeks earlier than standard Kensington-S (table 1) and fruit with an acceptable quality rating (table 2). Smith and Palmer were also observed to have an early ripening season at Walkamin in far north Queensland, similar to Bowen (Watson, personal communication). However, the ripening season for the introduced varieties Smith and Palmer in Queensland is quite different from that recorded overseas. Palmer and Smith reached maturity between 1 to 2 months later than Kensington during the 1977-78 season at Nelspruit in South Africa (Grobler, personal communication). These two cultivars are regarded as medium-late types in Florida by Lynch and Mustard (1955) and Campbell and Malo (1967). The cause of the unexpected behaviour in Queensland, whether of genotypic or environmental origin or due to some interaction, is unknown. However, as the fruit characteristics of these two cultivars generally agree with the description given by Campbell and Malo (1967), environmental factors seem most likely to be involved.

Commercial use of accessions from this small group of early types could ultimately add 1 to 2 weeks to the present Bowen production season of Kensington Pride. A 3-weeks-earlier ripening season of Common-T as described by Beal (1976) is not apparent in table 1, but its extended ripening season is obvious. The fruit quality of these promising early accessions was rated higher than that of the accession Common-T (table 2). Consequently, these varieties should have a greater market advantage than that of the Common which is marketed commercially 2 to 3 weeks earlier than Kensington, and loses market appeal as soon as Kensington is available.

Although Palmer was released in Queensland in 1975, extensive commercial evaluations have not yet been possible. The accession Banana-1 of local origin, and Smith and Palmer from Florida, with their fruit having a similar high quality rating, seem equally promising. Smith and Banana-1 seem worth strong consideration for future release, although additional cropping data from Banana-1 are desirable to confirm selection of this variety as a useful early type.

The accession Willard from Sri-Lanka was also early and had very palatable fruit, although its average fruit size at 0.1 kg was very small. However, this variety, particularly with its small tree size, may have some value in the home garden.

A need for early varieties still remains urgent considering the slight extension of season so far offered and growing conditions in the dry tropics and marketing advantage being most favourable for these varieties. Dry tropics research into flower induction techniques may be an alternative worth pursuing particularly with the success of this practice in the Philippines (Mendoza and Ceuvás 1974) and with the present dearth of early varieties. However, Earlygold and Florigon are recently introduced varieties that are not yet bearing but which may have great potential as they are reputed to be the earliest varieties in Florida (Campbell and Malo 1967).

Mid season varieties

The eight accessions having the same week of median cropping as Kensington-S and with acceptable fruit quality were Haden, Strawberry-Y, Zill, Kensington-M, Manzano, Roberts-3, Menzo-2 and Roberts-1. The average Bowen ripening season of Haden, Zill and Kensington was generally consistent with that observed

at Nelspruit, South Africa, in the 1977-78 season (Grobler, personal communication). Only Haden and Zill of this group with their red-blushed fruit, may have substantial commercial appeal as attractive alternatives to Kensington, and these varieties were released in 1975 (Beal 1976).

Haden and Zill were ranked with Neelum for turpentine flavour (table 2). These flavours although mild in Neelum were distributed throughout the mesocarp. They were stronger in Haden and Zill but mainly restricted to the flesh of the shoulders.

Late varieties

The accessions having a week of median cropping 1 to 2 weeks later than Kensington-S and with acceptable fruit quality were Youngs-Late, Carrie, Blue and Irwin. The order of ripening of Kensington and Irwin and Carrie at Bowen was very similar to that observed at Nelspruit in 1977-78 (Grobler, personal communication). While these varieties could possibly extend the commercial production season by another week, Irwin, with its palatable, very attractively coloured fruit, is the most promising and worth considering for release. Carrie was released to Queensland applicants in 1975 (Beal 1976) although it is losing favour as other promising varieties are obtained.

The varieties Neelum and Manoranjan both had extended cropping seasons and were very late with the 3 to 10 February as their week of median cropping, 6 weeks later than that of Kensington-S. However, Manoranjan fruit had excessive turpentine flavour and fruit of both varieties was poorly coloured and usually blemished by anthracnose ripe fruit rots. Hence these accessions were culled from the programme.

The accessions having a week of median cropping much later than that of Kensington-S and with acceptable fruit quality were Kent, Joe Welch and Saigon (3 weeks later) and Keitt (4 weeks later). Kent and Keitt are well known as late cultivars in Florida (Lynch and Mustard 1955; Campbell and Malo 1967) and were observed to mature a month or two later than Kensington at Nelspruit, South Africa in the 1977-78 season (Grobler, personal communication). This supports the observation of a Bowen ripening season for Kent and Keitt as a month or more later than for Kensington. However, Saigon is regarded as an early type in Florida (Lynch and Mustard 1955; Campbell and Malo 1967). In any case, additional Bowen cropping data from the two cultivars Saigon and Joe Welch are desirable to more firmly establish their ripening season and to determine their potential value. At this stage, Kent and Keitt are most promising accessions with high quality and could almost certainly add a further 3 or 4 weeks to the local production season. Kent was released to industry in 1975 (Beal 1976) and Keitt, with some additional advantage in ripening season over Kent, seems worth considering for early release.

The need for late varieties still exists in spite of the substantial advantage offered by Kent and Keitt. Poor skin colour in Keitt, vivipary and bacterial black spot in Kent and anthracnose fruit rots in Neelum were in sufficient incidence at times that a major part of their crop was unacceptable. The isolation of late varieties less subject to these fruit blemishes is desirable. Also, further extension of the cropping season may be possible by exploiting later varieties than Kent and Keitt. The variety Brooks a recent introduction which has later maturity than Keitt in Florida (Ledin 1958) has yet to be tested.

Commercial utilization

Utilization of selected varieties from the early and late groups together with Kensington Pride could extend the mango production season in the Bowen district from about 6 to at least 12 to 14 weeks. This would be more comparable with the 4-month production season reported in Florida (Malo 1977) than the present Bowen production based on the varieties Common and Kensington Pride. Also, the advantage offered by the selected varieties over commercial Kensington in Queensland is expected to persist in localities over the 13 to 28° range of latitude although this suggestion remains to be tested.

It is also possible that varieties with acceptable fruit quality and early or late maturity will be selected from the accessions established since 1975. Forty-five accessions established at Bowen Horticultural Research Station between 1975 and 1977 have yet to be tested. Sixteen accessions are being introduced from overseas sources including Florida, South Africa, Philippines and Thailand.

Embryo type and breeding potential

Thirteen of the 17 local accessions examined to date were polyembryonic (table 2). Poly types originate in Malaysia, Indo China and the Philippines and mono types in India (Singh 1968, and Mukherjee 1972) and the Australian varieties came from both sources (Stephens 1963). Seventeen of the 26 introduced accessions had monoembryonic seed (table 2) which was expected, as the source of many of these accessions was India and Florida. Malo (1970) acknowledged the importance of India as a source of original introductions to Florida in the late 1800s.

The current mango collection includes 21 monoembryonic accessions (table 2) which typically produce sexual embryos and variable progeny (Singh 1968). Hence, vegetative propagation will be necessary in these monoembryonic accessions for maintenance of type. The local accession Young-Late was not typically monoembryonic in that three of the six seeds examined were polyembryonic. However, the origin of the additional embryos in an otherwise monoembryonic type remains to be determined.

The commercial cultivars Kensington-S and Common-T were polyembryonic types which are typically propagated by seed. An asexual origin for the embryos of polyembryonic types is regarded as normal by Singh (1968). However, the frequency of production and survival of any sexual embryos to the juvenile seedling stage in Kensington and Common is unknown because certain identification of sexual and asexual seedlings at that stage is not possible. In any case, the occurrence of off-types in Kensington Pride orchards of seedling origin in the Bowen district suggests a possible 5% survival of sexual seedlings to bearing stage in the cultivar. This suggests that vegetative propagation is desirable in all cultivars.

The local accession Kensington-M, while very similar to Manzano and Kensington-S in fruit characteristics and average ripening season, differed in being monoembryonic. There is potential for breeding and selection within the progeny of monoembryonic cultivars (Mukherjee 1972) which suggests the monoembryonic accessions including Kensington-M would be useful in breeding. However, a comprehensive programme of selection within the progeny of the monoembryonic cultivars, although planned, has yet to be carried out in practice in Queensland.

Misidentification

Seven introduced accessions had fruit or other characteristics which conflicted with the vegetable type descriptions. The introduced variety Manzano from the Virgin Islands was not distinguishable from Kensington-S in fruit characteristics or ripening behaviour. Firm conclusions about the true identity or origins of the accession Manzano are not possible as a type description of Manzano is not available at this time.

The Jehangir accession at Bowen had small round fruit with flesh containing very slight endocarp fibre. Gangolly *et al.* (1957) described Jehangir as large, oblong-ovate in shape, with fibreless flesh. The likelihood of misidentification exists and re-introduction may be worthwhile.

The accessions Pairi, Julie, Ah Ping and Mundappa from the Bowen collection all had small elongate fruit with substantial endocarp fibre and with polyembryonic seed, not distinguishable from fruit of the local Common variety. Gangolly *et al.* (1957) described Mundappa as having large fruit, ovate in shape, with fibreless flesh, and Meulen (1971) described Pairi as having medium sized fruit, ovate in shape, with fibreless flesh. The Mundappa and Pairi accessions at Bowen have obviously been incorrectly named and these varieties may be worth re-introduction. Original descriptions have not yet been obtained for Julie and Ah Ping and the status of these accessions has yet to be confirmed.

The Bowen accession of Swarnarekha, while having fruit generally similar to that of the Common variety in colour, size and shape, can be readily distinguished by a more tapered fruit, less endocarp fibre and more narrow seed. Singh (1968) described Swarnarekha as having fruit of medium size, ovate-oblong in shape, and with fibreless flesh, thus suggesting possible misidentification of the Bowen accession of Swarnarekha.

The selected varieties

Banana-1, Smith and Palmer mature 1 to 2 weeks earlier than Kensington.

BANANA-1, the only local selection has fruit of medium size, long oblong in shape and medium sized seed. The skin is smooth, thin and an attractive pale yellow colour. The flesh is firm, sweet, pale yellow, mild in flavour and with little fibre (Beal 1979). The tree is medium to large in size, vigorous and spreading. The axis of the inflorescence is pink. The 1 to 2 years' yield data recorded in Banana-1 and in Smith were considered inadequate to indicate potential yield and bearing behaviour in these varieties in the dry tropics of Queensland, although Smith is considered a productive cultivar in Florida (Ledin 1958).

SMITH is of Florida origin as were all selected varieties other than Banana-1. It has plump ovate fruit of medium size averaging 0.3 kg with a seed of medium size. The fruit when ripe has a yellow ground colour lightly blushed pink-red, and the skin is very thick. The flesh is very sweet, of moderate firmness and orange-yellow. The inflorescence axis is yellow-green. The tree has long branches and is large, vigorous and spreading with an open habit of growth.

PALMER has fruit which is oblong-ovate in shape and a skin which is orange-yellow with a light red blush on the shoulders. Fruit is large averaging 0.4 kg and the flesh is free of fibre, sweet, aromatic, dull yellow in colour and very smooth in texture (Beal 1976, 1979). The skin is of intermediate thickness and the seed is of medium size. The inflorescence axis is pink. The tree is vigorous, of medium to large size and of open habit. This variety was moderately productive

and it produced acceptable crops in 3 of the 4 years of cropping. This was similar behaviour to that recorded in Kensington which is regarded as irregular bearing rather than strictly biennial.

Haden and Zill mature at the same time as Kensington.

HADEN has ovate and plump fruit averaging 0.3 kg and with seed of medium size. The skin has a yellow ground colour when ripe with an extensive and brilliant red blush. The skin is thick with conspicuous lenticels. The flesh is very firm, sweet, dull yellow in colour with moderate fibre and with mild turpentine flavour near the shoulders (Beal 1976, 1979). The tree is large spreading and vigorous and the axis of the inflorescence is pink. Data from 4 years' cropping suggested that Haden is a moderately productive type with similar bearing behaviour to Kensington.

ZILL has small oval fruit averaging 0.2 kg with a well defined beak. Ripe fruit has an extensive dark red blush on a yellow background. The flesh is firm, very sweet, of medium yellow colour, free of fibre and with a mild turpentine flavour near the shoulders (Beal 1976, 1979). The skin is thick and the seed small. The tree is large, vigorous and rather open and the flower panicles have red axes. This variety had similar bearing behaviour to Kensington.

Carrie and Irwin are a week later than Kensington in time of maturity.

CARRIE has fruit of medium size, oblong-ovate in shape and with seed of medium to large size. Flesh is yellow, juicy, very sweet, moderately firm, free of fibre and of good quality. The skin is rough in texture and of intermediate thickness and yellow in the ripe fruit (Beal 1976, 1979). The tree is of small to medium size, spreading with a dense crown. The inflorescence axis is red. This variety was moderately productive but only produced two acceptable crops from 1974 to 1977 suggesting a possible tendency towards irregular bearing in this variety. It is not regarded highly now that more desirable cultivars have become available since 1975.

IRWIN has fruit which is oblong-ovate in shape and of medium size averaging 0.3 kg and with a medium size seed. The fruit has a very extensive dark red blush with some pink ground colour. Flesh is very sweet, firm, yellow in colour and with low fibre. The tree is of small to medium size. The flower panicles have dark red axes. The 1 to 2 years' yield data recorded in Irwin, Kent and Keitt were considered inadequate to indicate potential yield and bearing behaviour in the dry tropics of Queensland although these varieties are considered very productive cultivars in Florida (Ledin 1958).

KENT is 4 weeks later than Kensington in time of maturity. It has large fruit averaging 0.5 kg which is plump, ovate-oblong in shape and with seed of medium size. The fruit is red blushed when ripe with firm, very sweet, fine textured flesh free of fibre and of an orange-yellow colour (Beal 1976, 1979). The skin is of an intermediate thickness. The tree is only of medium vigour and size and has an erect habit. The inflorescence axis is red.

KEITT is a week later than Kent in time of maturity. It has large fruit, ovate in shape averaging 0.5 kg with seed of medium to large size. The skin is lightly blushed with red when ripe and of medium thickness. Flesh is firm, sweet and orange yellow in colour. The axis of the inflorescence is pink-red in colour. The tree is small to medium in size with an upright habit and with few long branches.

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