MANGO SELECTION AT THE CSFRI AND RECOMMENDATIONS FOR A BREEDING PROGRAMME

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HISTORY

Seedlings were established at Nelspruit and Messina which represent substantial differences in climate, soil and quality of irrigation water. These orchards received the same treatment as commercial orchards with regard to fertilisation, irrigation etc, with the exception of copper sprays for bacterial black spot (*Xanthomonas campestris* pv *mangiferaeindicae*), since one of the selection criteria was resistance to this disease.

In Nelspruit, 1 210 seedlings were planted at a spacing of 4 *m* × 4 *m*, in 1970/72. These were from seed of open-pollinated trees, mostly Sensation. In 1981/82, another 260 seedlings from seed of Fascell, Tommy Atkins, Zill, Sheil, Sensation and Haden, were established.

A total of 840 seedlings was planted in Messina in 1974/75, at a spacing of 7 *m* × 4 *m*. These seeds were also from open-pollinated trees. The cultivars from which these seeds were collected were Smith, Sandersha, Kent, Fascell, Palmer and Lippens. The characteristics which were taken into consideration in the evaluation of the seedling trees were vigour, resistance to diseases, regular yield and dwarfing. The characteristics for fruit evaluation were shape, colour, resistance to bacterial black spot (BBS), size, seed/flesh ratio, fibre, aroma and taste. The last characteristic was evaluated by a panel of five to eight staff members, mostly women.

In order to improve the chances of achieving crossings between chosen parents, mature trees were topworked in January 1972 with different cultivars. These are as follows:

- Smith x Sensation
- Fascell x Davis Haden
- Haden x Irwin
- Haden x Keitt
- Haden x Tommy Atkins
- Early Gold x Zill
- Tommy Atkins x Florigon
- Florigon x Nimrod
- Tommy Atkins x Early Gold
- Fascell x Sensation

The first seeds from these (hopefully) cross-pollinated trees were planted in 1986/87.

PRESENT SITUATION AND ACHIEVEMENTS

Messina

Of the original 840 seedlings planted at Messina, 357 were eliminated either because of natural causes, eg salinity or inadequate irrigation water, or because the trees showed no promise.

Amongst the remaining 483 seedlings, 30 were initially identified as promising and were grafted onto Sabre rootstocks and planted out at Nelspruit and Levubu. From these 30 promising selections, five were identified as very promising and have been released under contract to growers for evaluation under semi-commercial conditions. These are E9-1/23, E9-12/24, E10-4/17, E10-6/9 and E10-12/28. A brief description of these selections is as follows:

E10-6/9
Fruit size:
390 *g* (good)
Colour:
Attractive combinations of red, orange and yellow
Shape:
Oval with rather pointed nose
Flesh defects:
None
Flavour:
Very good
BBS resistance:
Good
Yield:
Good
Season:
Mid- to late season, may be harvested over an extended period
Comments:
This is the most promising selection from Messina.

E10-12/28
Fruit size:
499 *g* (good)
Colour:
Attractive - red, pink and yellow
Shape:
Oval to oblong
Flesh defects:
None
Flavour:
Good - sweet with a slight hint of coconut
BBS resistance:
Good at Messina and Levubu but susceptible at Nelspruit
Yield:
Medium yield, but trees are dwarfed
Season:
Late
Comments:
This selection is polyembryonic and may show additional potential as a dwarfing rootstock.

E10-4/17
Fruit size:
260 *g* (small, although variable in some samples)
Colour:
Extremely attractive combinations of red, pink and yellow
Shape:
Oval
Flesh defects:
None
Flavour:
Flat - sweet with no acidity or additional flavour
BBS resistance:
Good
Yield:
Good
Season:
Late
Comments:
This would be a very promising selection, but fails as far as size and taste are concerned. This is to be included as a parent in the breeding programme because of its outstanding colour, high yield and resistance to BBS.

E9-1/23
Fruit size:
370 *g* (good)
Colour:
Attractive - red and pink
Shape:
Oval to oblong
Flesh defects:
Slight fibre
Flavour:
Acceptable with a strong aroma
BBS resistance:
Susceptible in Nelspruit
Yield:
Good
Season:
Mid-season
Comments:
This selection may be suitable only for certain areas because of BBS susceptibility, but cannot show long-term promise because of its fibre content.

E9-12/24
Fruit size:
490 *g*
Colour:
Disappointing combination of purple and green
Shape:
Oval to oblong
Flesh defects:
Some 'jelly-seed'
Flavour:
Acceptable with good sweet/sour balance

Yield:
Low
Season:
Late
Comments:
Detracting features of this selection are low yield and disappointing external colour development.

Nelspruit

Of the original 1 470 seedlings, 204 were eliminated because they did not show any potential. From the remaining 1 266 seedlings, 58 showed initial promise and were grafted onto rootstocks and planted out. Of these, 39 were discarded after further evaluation, which left a balance of 19 selections which progressed to the next stage of evaluation. Only four of the remaining 19 selections are considered promising at this stage and have been released to the contract growers. They are as follows:

I IV B -18/3

Fruit size:
557 *g* (large)
Colour:
Attractive pink and yellow
Shape:
Oval to oblong
Flesh defects:
None
Flavour:
Sweet and rich with only a slight aroma
BBS resistance:
Appears to be resistant
Yield:
Fair (five on a scale of one to 10)
Season:
Late mid-season
Comments:
Fruit size is too big but may decrease as yield increases.

I III B - 13/4

Fruit size:
337 *g* (almost ideal)
Colour:
Attractive pink and yellow
Shape:
Oblong
Flesh defects:
None
Flavour:
Sweet but somewhat flat
BBS resistance:
Appears to be resistant
Yield:
Fair, five
Season:
Mid-season
Comments:
Flavour is acceptable although could be better.

I I C - b 12/4(i)

Fruit size:
309 *g* (small)
Colour:
Red, green and pink
Shape:
Oblong
Flesh defects:
None
Flavour:
Very good, sweet and rich
BBS resistance:
Appears to be resistant
Yield:
Good, seven
Season:
Early mid-season
Comments:
Despite its unsatisfactory size, this selection is considered to be very promising.

I IV B - 8/2

Fruit size:
499 *g* (large)
Colour:
Attractive pink and yellow
Shape:
Oblong
Flesh defects:
None
BBS resistance:
Appears to be resistant
Yield:
Fair, five
Season:
Mid-season
Comments:
Fruit too big, may decrease in size with increased yield.

RECOMMENDATIONS

Current selection programme

Once the required information has been gathered, all superfluous seedlings should be removed to allow for replanting. Evaluation of existing promising selections should be carried out in more detail. Important additional evaluation criteria are time and duration of ripening, correlation between fruit size and yield, tree vigour, and shelf-life under simulated shipping conditions.

Breeding

All the cultivars at present available in South Africa have one or other detracting feature eg internal quality of Tommy Atkins, low productivity of Haden, the susceptibility to BBS of Keitt and Kent, small size and harvesting problems of Sensation and the high fibre content of Peach. The low quality of these cultivars restricts returns to farmers and prevents the development of large consistent markets in South Africa and abroad.

The object of this breeding programme is to develop improved cultivars in terms of yield, BBS resistance, external and internal quality, external colour and shelf-life. A further objective is to extend the harvesting and marketing season.

In order to increase the chances of obtaining desirable cultivars, it is necessary to establish breeding plots of selected, suitable parent plants with the view to controlled pollination. This will be carried out by topworking adjacent trees to two parent cultivars. These

TABLE 1 Characteristics of parent mango cultivars to be used in the breeding programme.

Cultivar	Colour	BBS resist	Internal quality	Size	Shelf-life	Harvest time			Yield	Dwarf-ing
						Early	Mid	Late		
Keitt	–	–	++	+	++			++	+	
Brooks	–	++	++	++	+			++	++	+
Zill	+	+	–	+	–	++			+	
T/Atkins	++	+	–	+	+		+		++	
Haden	++	–	++	++	–	+			–	
Sensation	++	+	+	–	+			++	++	+
Kensington*	–	++	+	++	+?		+		++	
E10-6/9	++	++	++	++	?		+?	+?	+?	+?
E10-4/17	++	++	–	–	+?			+	++	
E10-12/28*	++	–	?	++	+?			+	++	+?
E9-1/23	++	–	+	++	?	+			++	?
Van Dyke	++	–	?	+	?		?		?	?

* Polyembryonic - may only be used as a pollen-source
++ Very good
\+ Good
– Weak
? Unknown or doubtful

trees will be enclosed with a fine mesh cage during flowering, to prevent cross-pollination with unknown pollen. At peak flowering, a hive of honey-bees will be placed in the cage so that cross-pollination can occur. Expert advice on bee husbandry will be sought because the amount of food available within the cage will be insufficient to sustain a whole hive of bees.

Parent cultivars that will be used for the breeding programme and their qualities are presented in Table 1.

The following parent combinations are suggested in the light of the information presented in Table 1.

Keitt x Haden
Sensation
T/Atkins
E10-4/17
E10-6/9
Kensington
E10-12/28
Van Dyke

T/Atkins x Haden
Zill
E10-6/9

E9-1/23 x Zill

Brooks x Sensation
T/Atkins
E10-4/17
E10-6/9
Van Dyke

Haden x Zill
E9-1/23

E10-12/28 x Sensation

For the practical implementation of the above combinations, it is recommended that orchard L3 (Nelspruit) be altered according to Figure 1. This is a 12-year-old orchard with most of the recommended parent cultivars already available. The topworking of some of these trees to other recommended parent cultivars would yield quicker results than the planting of a new orchard.

Establishment of seedling plots

Because of the nature of the data to be collected in terms of times of flowering and harvesting, it is important that the seedling plots are established in Nelspruit and in close proximity to Nelspruit. Such areas include Malelane, Lisbon Estates and Hoedspruit, where climatic conditions will allow for more dependable yields than in Nelspruit. For the purpose of evaluation of seedlings, Messina is not ideal because of the distance from Nelspruit, which makes regular visits to the orchards time-consuming and expensive. For the evaluation of promising selections, however, Messina must be included.

Screening for BBS resistance

If a suitable technique can be developed, the seedlings should be screened for BBS resistance while they are still in the nursery, so that only those resistant to BBS will be planted out in the orchard. This will expedite the initial screening of individuals.

Planting distances

To allow for easy access of tractors and simultaneously result in a high density of seedlings per hectare, a spacing of $5\,m \times 2\,m$ (1 000 per hectare) is recommended. Such a breeding or selection programme is a game of numbers, therefore the chances of

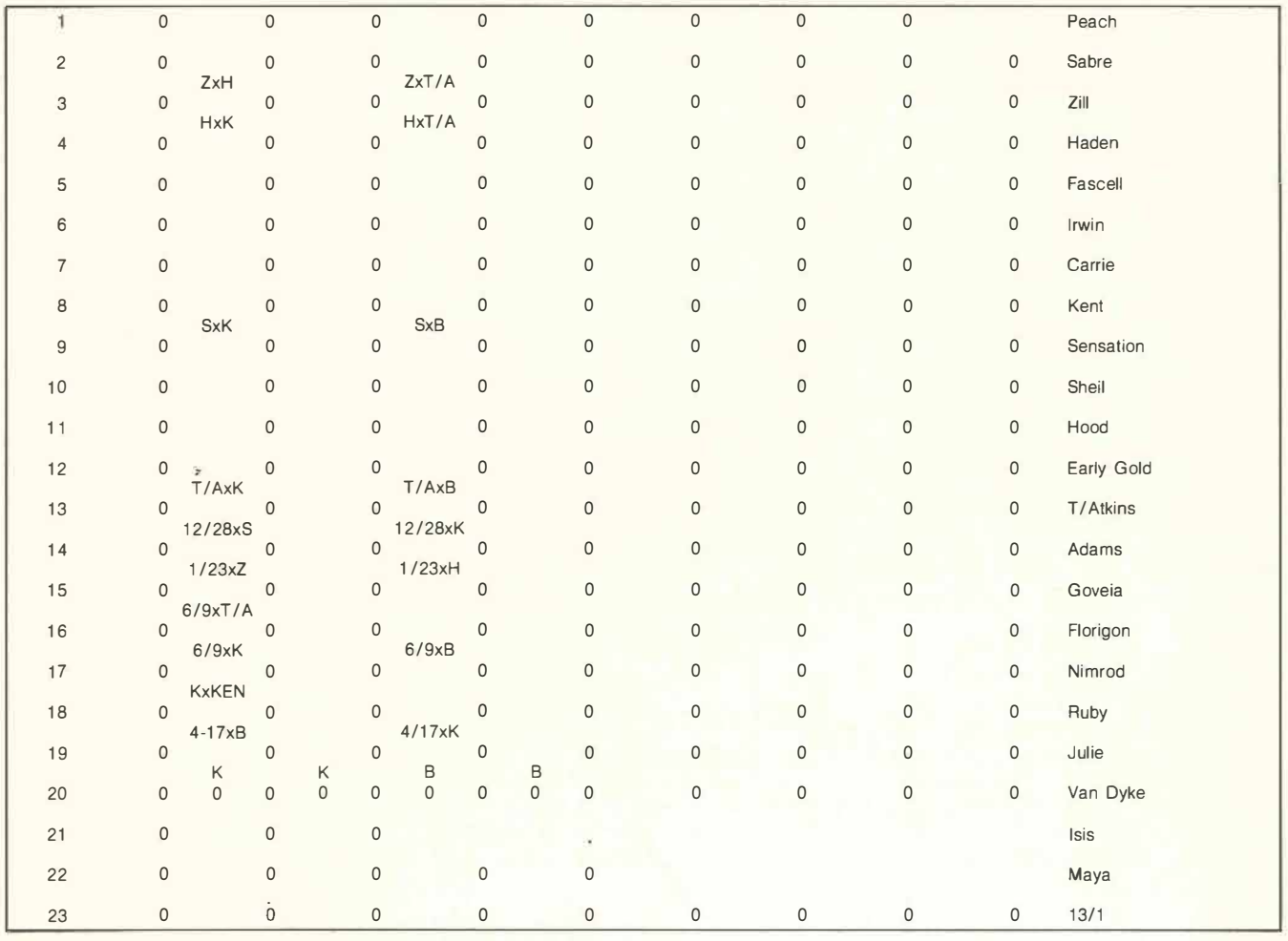

Fig 1 Ammended orchard plan of Nelspruit L3 after topworking with parent cultivars to allow for controlled cross-pollination.

Planting dates:
Rows 1 - 19; 10/09/76
Rows 20 - 21; 12/12/84
Rows 22 - 23; 28/10/86

Key of cultivar names:
Z — Zill
H — Haden
T/A — Tommy Atkins
K — Keitt
S — Sensation
B — Brooks
KEN — Kensington
12/28 — E10-12/28
1/23 — E9-1/23
6/9 — E10-6/9
4/17 — E10-4/17

success are increased by planting greater numbers of seedlings.

Management
It is of utmost importance that sound horticultural practices be applied to the seedling plots. The loss of a single year's crop adversely affects the continuity of data recording and reduces the possibility of earlier conclusions. Pests and diseases should be controlled as efficiently as possible, no weed competition should be allowed in the orchards and fertilisation and irrigation schedules should be as accurate as possible.

Bearing age
Techniques to shorten the juvenile period of the seedlings to allow for evaluations should be established as soon as possible. Some suggested techniques are girdling and the use of growth retarding chemicals (eg paclobutrazol). Such treatments should not hinder data recording by affecting selection characteristics (eg tree or fruit size).

Rapid elimination of seedlings
Elimination of seedlings should commence as soon as the first fruit has been harvested and should continue in this way, so that by year five or six, the selection of a specific seedling orchard is completed. In the seedling blocks at both Messina and Nelspruit, where all the possible information has been collected and graftwood taken, the trees should be removed. The area at Messina should be used for the next stage of the selection programme (planting of promising selections on standard rootstocks). The area in Nelspruit can be used for the establishment of new seedling blocks.

Advanced evaluation plots
Advanced evaluation plots are where the promising selections, now grafted on standard rootstocks (Sabre), are evaluated under semi-commercial conditions. Such plots already exist at Nelspruit and Levubu, and at contract growers in the main mango producing areas of Kaapmuiden, Hazyview, Hoedspruit, Tzaneen and Deer Park, and will be established at the research station at Messina. Such plots should be expanded by planting out Sabre seedlings at a spacing of $8\,m \times 4\,m$. Graftwood of promising selections will first be grafted out at the Institute's stations for initial bulking up and will then be sent to the contract growers for grafting in the advanced evaluation plots. This provides the additional advantage that large quantities of graftwood will be available at the time of release, which will avoid the unnecessary movement of material between areas.

More detailed, final evaluations of the promising selections in these plots, will be conducted. In terms of spacing, rootstocks and cultural practices, these plots will be run on a semi-commercial basis. A very important consideration in the evaluation of the promising selections is the comparison with commercial cultivars. At least five trees of each selection should be grafted in each plot. This will provide sufficient fruit for more detailed work on shelf-life and response to post-harvest treatments. Collection of data, decisions for topworking and the running of the post-harvest experiments must be done by the research team.

Selections should not remain in these plots indefinitely. Evaluations should be conducted regularly so that either graftwood is taken for commercial release, or trees are topworked to further promising cultivars.

GENERAL COMMENTS

The mango industry in South Africa has tremendous potential but a greater effort is required by both the farmer and the researcher. The farmer should aim to improve management practices to increase yield and the researcher must develop new cultivars, methods of BBS control, and should gain more information about irrigation and tree-size control.

This project of development of new cultivars involves a considerable amount of travelling, data collection and supervision. Data collection from both seedling and advanced evaluation blocks (in the different production areas), both in the field and in the laboratory, and the collection of seed and graftwood must all be conducted within a very short three-month period. It is thus imperative that more staff be provided for this project during this period.

Since the success of the breeding and selection programme depends upon the number of off-spring tested, it is of extreme importance that new plantings are conducted every year. At the same time it is also clear that this project is a long-term one, where success cannot be guaranteed within a limited period of time.

It has been emphasised that the development of a single cultivar is a long-term undertaking. It is important, therefore, that the industry is involved in the final stages of evaluation, and in the decision of whether or not to release the selection as a cultivar. The contract growers, at present testing the selections under semi-commercial conditions, must present detailed reports on the performance of the selections annually at the meeting of the Mango Technical Committee. This will hasten the release of new cultivars and will maintain contact between the farmer and the researcher.

The co-operation between South Africa and Israel and the exchange of information between the two countries is important for a number of reasons:

- South Africa and Israel do not compete for the same markets but rather complement each other. Large quantities of good quality fruit on the European markets over an extended season, would create a demand and simplify the marketing of the fruit.
- It has been mentioned that success will be achieved sooner with larger numbers of seedlings and thus the use of information from both countries immediately increases the number of seedlings evaluated.
- The evaluation of individuals in both countries provides a wider range of climate types so that the effect of environment upon phenotypic expression can be examined.
- The programmes in the two countries have been under way for approximately the same period of time and show similar achievements. More expertise, however, is being developed and utilised in Israel, with the inclusion of a geneticist in the research team.

It is important that there is regular contact between workers of the two countries so that they are kept up to date with new developments and techniques.

Since the selection and breeding programme is being carried out both in South Africa and Israel (although with slightly different aims), it is important that the evaluation methods are similar in both countries. Data collection should be carried out to allow for computerisation of details. This will simplify the exchange of information between researchers in the two countries.