Overview of breeding and evaluation of orange-fleshed sweetpotato in South Africa

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Introduction

The sweetpotato research programme at the Agricultural Research Council (ARC) Roodeplaat Vegetable and Ornamental Plant Institute (ARC-Roodeplaat) has been operational since the 1950s. The program has contributed to the sweetpotato industry in South Africa in two ways: through breeding of almost all the commercially grown sweetpotato cultivars, and by a scheme for making available virus-tested propagation material. The cultivar Blesbok, released by ARC in 1989, is the top selling cultivar (accounting for about 80% of national production) with yields averaging 45 t/ha when grown commercially.

Since 1996, three SARRNET (Southern Africa Root Crops Research Network) projects have increased the research capacity of the resource-poor agriculture sector. Breeding was aimed at improving the ARC cultivar Mafutha (which has a sweet and dry taste, favoured by the local Africans), in terms of yield and quality as well as storability and early maturity. In the 2000/2001 season 28 improved genotypes from ARC-Roodeplaat and eight imported cultivars were released for off-station evaluation. Resource-poor farmers invited to select preferred genotypes chose 10 ARC genotypes and five imported cultivars for on-farm evaluation. Virus-tested propagation material of these lines will be established in nurseries at five sites and made available to the farmers.

ARC-Roodeplaat also conducts in research in biotechnology and in virus elimination. Recently the Kenya Agricultural Research Institute (KARI) and ARC-Roodeplaat initiated a collaborative research project for the genetic transformation of sweetpotato varieties to introduce resistance to sweetpotato feathery mottle virus (SPFMV). Monsanto funds this project. ARC-Roodeplaat is concentrating on a construct containing the SPFMV CP and inverted repeat sequence. In the virus-elimination work, about 25 landraces collected in rural sweetpotato-producing areas of South Africa have been successfully cleaned in the past five years.

The sweetpotato industry is fairly small compared to those in other African countries, with annual production officially stated as 60,000 t (although when the production of the resource-poor agriculture sector is included, the total is estimated at 120,000 t). But this crop is a more valuable food than the normal diet of maize, bread and rice, because it is an excellent source of energy and important nutrients.

Orange-fleshed sweetpotatoes have been included in the ARC programme since the 1980s, but the work was aimed mainly at the frozen-food industry, and the sweetpotato lines that were studied generally had low dry-matter content and poor storability, and tended to have curved shapes. But in 1996 ARC expanded its work on orange-fleshed sweetpotato. This renewed programme was complemented by a smaller breeding programme, started at the University of Pietermaritzburg in 1994.

Methodology

Selection from old material

The renewal of orange-fleshed sweetpotato breeding in 1996 began by examining breeding lines used in the 1980s, and selecting some lines, with higher dry-matter content and acceptable shape, for further evaluation. The old material had been conserved in the glass house.

In addition, in 1996/97 some orange-fleshed cultivars were obtained from the germplasm collection of the International Potato Center (CIP). More cultivars were imported in subsequent years, bring the total to 13. Imported material is quarantined for about six months, after which the cultivars are evaluated in single plots at ARC-Roodeplaat. Cultivars showing potential for use in South Africa are then evaluated in replicated plots at ARC-Roodeplaat and eventually proceed to multi-locality trials.

Polycrosses

Orange-fleshed cultivars/lines were also increasingly included in polycrosses. At first the orange-fleshed materials were just added as parents in Mafutha-type polycrosses; usually 20–25 parents are used, planted with five replicates and pollinated naturally by insects. Stringent selection was done in the polycross nursery of around 2100 seedlings, with 80–100 lines being selected. Since 1996, the number of orange-fleshed lines selected in this first phase has increased from 9.3 to 20–30% of the total number of lines kept for further evaluation. The first orange-fleshed material was included in the polycross in 1997/98 – Eland (an old ARC cultivar) and five ARC lines. Since 1998/99 imported cultivars were also used in the polycross, especially the US cultivars Resisto, Excel and W-119. In 1999/2000 and 2000/2001 three more ARC lines were included in the polycrosses. This season (2001/2002) the polycross is focused on orange-fleshed material. Seventeen parents were selected of which only three are cream orange-fleshed, the rest are orange-fleshed.

Evaluation and selection

Following selection of seedlings from the polycross progeny, lines are evaluated in preliminary yield trials for one to three years, in single plots of 40 plants. Promising lines proceed to the intermediate yield trial, which consists of two replicates of 30 plants. The best lines are then evaluated in the advanced yield trial, consisting of three replicates of 30 plants. And finally the best ones are released for evaluation in multi-locality trials.

Planting materials of genotypes preferred by farmers are made available through nurseries in target areas.

Progress

Orange-fleshed genotypes in multi-locality trials

In 1996/97 the orange-fleshed breeding line 1989-20-6 was included in the multi-locality trials at seven sites. This was the first time that orange-fleshed sweetpotatoes were introduced to these areas. After harvesting the trial, storage roots were cooked and members of the community attending the event had the opportunity to taste the sweetpotatoes included in the trial. In KwaZulu-Natal Province (Pietermaritzburg and Empangeni) and Eastern Cape Province (Addo) the people did not like line1989-20-6, but in Western Cape Province (Vredendal, Saron and Caledon) resource-poor farmers showed interest in growing and eating it.

In 1997/98 orange-fleshed entries included ARC line 1989-20-6 and the imported cultivars Zapallo and Jewel. The people in KwaZulu-Natal Province (Makhatini and Pietermaritzburg) did not like Zapallo and 1989-20-6, but at the University of Fort Hare in Eastern Cape Province, 1989-20-6 and Jewel people were interested in growing and eating the orange-fleshed material.

In 1998/99 Jewel and Resisto, and ARC lines 1989-20-6, 1989-23-1 and 1997/Orange, were included in the multi-locality trials. At Bathurst in Eastern Cape Province the white staff judged 1989-23-1 to have poor taste and only a fair colour. In Western Cape Province (Haarlem, Wupperthal and Saron) the farmers showed interest in the orange-fleshed material and also indicated a preference for certain cultivars. Resisto and Jewel were judged to have very good taste, but 1989-20-6 very poor taste.

The 1999/2000 trials evaluated Resisto, Excel and W-119, and ARC lines 1989-20-6 and 1997-14-17. At Bathurst in Eastern Cape Province the taste of Excel was rated bad to fair, 1989-20-6 poor and Resisto average. In Mpumalanga Province the people liked the taste of Resisto; at Nelspruit it was also judged to have good taste, and at Thembalethu it was considered the best tasting genotype in the trial.

In 2000/2001 Resisto, Excel, W-119, 1989-20-6 and 1997-14-17 were evaluated again, together with 1989-20-4. In addition, the first genotypes from the breeding programme at the University of Natal (A15, A45 and A59) were included in multi-locality trials. Based on taste and yield potential, the following genotypes were chosen by farmers:

- Excel at Thembalethu (Mpumalanga Province)
- Excel, A45 and W-119 at Tompi Seleka, A59 at Venda, W-119 and Excel at Bushbuckridge (Northern Province)
- W-119 at Mafikeng (North West Province)
- Resisto and 1989-20-4 at Vulindlela near Pietermaritzburg (KwaZulu-Natal Province)

Evidently people in South Africa who eat orange-fleshed sweetpotatoes prefer medium-dry to dry types, that is, types with a dry-matter content higher than 18%.

The characteristics of the orange-fleshed genotypes available in South Africa, are shown in Table 1, and the beta-carotene (pro-vitamin A) contents of some of the materials are listed in Table 2.

Table 1: Traits of orange-fleshed genotypes available in South Africa

Genotype	**Origin**	**Yield[a] (t/ha)**	**Storability[b] (%)**	**Taste**
Watery (<15% dry matter)				
1989-23-1	ARC	65 Some curved	20 %	Poor
1997/Orange	ARC	60 Some curved	25 %	Not tested off-station
Slightly watery (16–17% dry matter)				
1989-20-4	ARC	35	15 %	Fair
Medium dry (18–21 dry matter)				
Excel	USA CIP440016	42	28 %	Good
1997-14-17	ARC	55	88 %	Fair
A15	University of Natal	45	58 %	Fair
A45	University of Natal	51	15 %	Good
A59	University of Natal	61 Many veins	78 %	Good
Dry (>22% dry matter)				
Resisto	USA CIP440001	49	84 %	Good
W-119	USA CIP440004	48	55 %	Good

[a] Yield means marketable yield as measured at ARC-Roodeplaat
[b] Storability means percentage marketable roots after two weeks' storage

Table 2: Beta-carotene contents of some genotypes as analysed by the Medical Research Council (C; PO Box 19070, Tygerberg 7505, South Africa)

Genotype	**Origin**	**Flesh colour**	**Beta-carotene (micro g per 100 g)**
Resisto	USA (CIP440001)	Dark orange	11900
Tainung 64	Taiwan (CIP440189)	Orange	8940

W-119	USA(CIP440004)	Orange	8240
A59	University of Natal	Dark orange	7770
A15	University of Natal	Dark orange	7360
1997-14-17	ARC	Orange, cream specks	3800
A45	University of Natal	Orange	3740
Mafutha	ARC	Cream orange	1870

Orange-fleshed genotypes in nurseries

Orange material was distributed to primary nursery sites in South Africa for the first time in 2000/2001. (The function of primary sites is to distribute cuttings more widely, to secondary sites, from where farmers may obtain cuttings.) The material was the cultivar Resisto; 20 pots were distributed to Thembalethu (Mpumalanga Province), five pots to Nebo near Tompi Seleka (Northern Province) and 50 cuttings to Venda (also Northern Province). Virus-tested planting material of cultivars preferred in the 2000/2001 multi-locality trials (Excel, W-119, Resisto, A45 and A59) was supplied to established nurseries at five sites during October–November 2001. At each site farmers will be offered training in cultivation of sweetpotato and in multiplication techniques, and will be able to obtain some cuttings in November–December 2001. Cuttings will be taken at intervals until March 2002 to establish secondary sites. The main distribution of cuttings to farmers will be in September–October 2002.

Material distributed to other countries

At the onset of phase II of SARRNET in 2000 the ARC-Roodeplaat breeding program was expanded to serve the dryer countries in southern Africa – Botswana, Lesotho, Namibia, Swaziland and Zimbabwe. In Namibia and Swaziland vitamin A deficiency is a major problem. Planting material of Resisto, Excel and W-119 was supplied to most of the five countries between August 2000 and January 2001.

The potential of orange-fleshed genotypes in alleviating vitamin A deficiency

A pilot project was conducted in Ndunakazi community adjacent to the Valley of Thousand Hills in KwaZulu-Natal Province, in partnership with the Medical Research Council, to test the food-based approach for alleviation of vitamin A deficiency, (Faber and Benade, 2002). A high percentage of preschool children in the community had low blood serum retinol levels. The project involved training agricultural monitors in production practices of vitamin A rich crops including orange-fleshed sweetpotato, carrots, butternuts and spinach. Then formal gardens of these vitamin A rich vegetables were established to demonstrate to mothers how to establish their own gardens; the monitors were available to give them advice. To monitor the production of vitamin A rich crops, an ARC technician visited the gardens at intervals to assess yields, to advise trainers, and to identify problems and provide possible solutions. Also education in nutrition and in monitoring intake of vitamin A rich foods by health monitors, under the

supervision of the MRC, was given together with the establishment of vitamin A rich food gardens.

Cuttings of the orange-fleshed sweetpotato cultivars Resisto and Excel were established in the formal gardens at Ndunakazi in 1999. These two cultivars were chosen only because there was sufficient planting material available, but the choice was fortuitous because Resisto was later found to have a very high beta-carotene content, and to be an excellent cultivar to use for this purpose. Mothers of pre-school children obtained cuttings of the orange-fleshed cultivars from the formal gardens to plant in their home gardens. Resisto was judged by members of the community to be tastier than other varieties, and they prefer to grow and consume this cultivar.

Conclusions

- The taste requirement for orange-fleshed sweetpotato in South Africa is for a medium-dry to dry type
- Several good orange-fleshed genotypes are already available
- Orange-fleshed sweetpotato can play an important role in a food-based approach to alleviating vitamin A deficiency
- There is a good possibility of orange-fleshed sweetpotato being adopted in place of the cream-fleshed genotypes if consumers are given nutrition education

References

Faber M and Benadè AJS. 2002. *A household food production programme to address vitamin A deficiency: A South African experience*. Paper presented at the VITAA Project Regional Workshop, 9–11 May 2001, Nairobi, Kenya [this proceedings]