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The potential for extending the shelf-life of sweetpotato in East Africa through cultivar selection

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The potential of sweetpotato is limited by the perishable nature of the storage tubers. An extension of storage-life could be brought about, both by improving the storage environment and by breeding for extended shelf-life. The latter has the advantage in that it would result in an increased storage-life, both under conditions designed for long-term storage and under normal marketing conditions without incurring additional costs for producers and traders. To determine the feasibility of selecting cultivars for extended shelf-life, it is important to determine the genetic range in perishability among existing germplasm and the effect of the growth environment. In addition, a practical methodology for selection should be established. If possible, physiological characteristics associated with perishability should be identified to allow the development of indirect selection techniques. The progress of collaborative work conducted in Tanzania to address these issues is presented. Twenty-nine sweetpotato varieties, representative of the wide genetic variability of germplasm available in Tanzania, were assessed for their perishability. Under simulated Tanzanian marketing conditions, the major forms of deterioration observed were weight loss (primarily due to water loss) and rotting. Varieties varied considerably in both their rates of weight loss and of rotting, and these two characteristics were significantly correlated. Market observations have indicated that roots are subjected to considerable mechanical damage during normal transport and marketing. Thus, a range of varieties were tested for their rate of deterioration following simulated damage. In initial trials the ranking of varieties was not affected by the damage treatment, indicating that simulated damage need not be used during the selection procedure. These results suggest that indirect selection on the basis of physiological parameters may form part of the breeding programme in Tanzania.

Keywords: Sweetpotato; Shelf-life; Germplasm; Deterioration; East Africa

The short shelf-life of the sweetpotato storage tuber after harvest is a serious constraint to the use of the crop for food security in tropical regions. Sweetpotato can be kept for several months if it is maintained at 13–15°C (Picha, 1986; Woolfe, 1992). Even at tropical temperatures it is possible to maintain tubers in good condition for up to 4–5 months (Devereau, 1995), if the tubers are undamaged and stored in pits. However, in the tropics, marketing may involve transport over long distances and it is often not possible to maintain tubers consistently under ideal conditions, and they deteriorate rapidly. In Tanzania, it has been observed that tubers rarely keep for longer than two to three weeks (NRTCP, 1997; Bancroft, R. pers. commun.). An extension of shelf-life through better handling techniques and the use of cultivars with better keeping quality would improve the potential for transporting and trading the commodity. With the increasing urbanization of the East African population, the provision of food to urban centres is of growing importance.

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A study of Tanzanian markets (NRTCP, 1997) has shown that the main forms of deterioration are rotting and weight loss, both of which were assessed in these trials. It has also shown that the level of tuber damage in the market can be very high, with a high proportion of tubers showing cuts, breaks, bruises, insect infestation, and rodent damage. Damage increases the rate of deterioration with breaks and cuts having the greatest effect. In this study the effect of damage of tubers by cutting, on the subsequent rate of deterioration, was tested for a range of cultivars to determine if cultivars differ in their susceptibility.

This would allow the examination of the potential for breeding for less perishable cultivars with the following specific objectives:

(i) to determine whether a sufficient range of storability exists within sweetpotato germplasm available in East Africa for breeding to be successful;
(ii) to establish a suitable method for screening germplasm for storability; and
(iii) to identify physiological characteristics associated with storability and thereby facilitate cultivar selection.

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Materials and Methods

During 1996–97, trials were conducted at A.R.T.I. Ukiriguru (Lake Zone, Tanzania) on a wide range of sweetpotato germplasm, including local cultivars, recent crosses, and recently introduced cultivars. Storage tubers were tested for their rate of deterioration when stored under conditions simulating those to which tubers are normally subjected during marketing.

Storage tubers were obtained from two field trials. Nine cultivars were included in Trial 1 and 22 cultivars in Trial 2. Two cultivars (SPN/0 and Mwanamonde) were common to both trials. Cultivars were selected from local and introduced germplasm to provide a wide range of known characteristics, but included only those cultivars known to give reasonable yields.

Both trials were planted on 28 December 1996, with planting of extra cuttings on 17 January 1997 due to poor establishment as a result of drought. Both trials were planted as RCB designs. Trial 1 had four replicates with plots of 6 m × 6 m (3 plants m^{-1}), while Trial 2 had two replicates with plots of 6 m × 2 m. Trials were harvested on 23 June 1997.

Tubers of marketable size (greater than 2.5 cm diameter) and good quality (i.e., low damage) were selected for post-harvest evaluation. For each cultivar these were divided into replicates (6 for Trial 1 and 3 for Trial 2) with 25 roots per replicate wherever possible.

To simulate normal marketing conditions, roots were stored in woven polythene sacks, which were closed by tying for two days to allow curing, then opened and rolled down to half height for the remainder of the storage period.

Two treatments were carried out for each cultivar for Trial 1. Tubers were either stored undamaged, or with simulated damage, consisting of two latitudinal cuts on each tuber. The cuts were made one third of the way along the tuber from each end, to a depth to reach the centre of the tuber.

At the start of the trial, tubers of each cultivar were assessed for a range of physiological and morphological characteristics including cortex thickness, latex production, hardness (measured by a penetrometer), concentration of soluble solids in root sap [measured by refractive index (R.I.)], and dry matter (DM) content. The methods used for these assessments are summarized in Rwiza *et al.* (1996).

For measurement of weight loss, six roots were selected at random from each replicate and were numbered using a marker pen. The weight of each of these roots was recorded at the start of the trial and at weekly intervals.

The extent of external rotting for each replicate was assessed at the start of the trial and at weekly intervals by sorting the tubers into six categories of visible per cent surface rotting (0; 1–10; 11–25; 26–50; 51–75; and 76–100 designated 1, 2a, 2b, 3, 4, and 5, respectively). An overall rotting score for each cultivar was calculated for each replicate as $(n_1 + 2.n_{2a} + 2.5.n_{2b} + 3.n_3 + 4.n_4 + 5.n_5)/(n_1 + n_{2a} + n_{2b} + n_3 + n_4 + n_5)$ where n_1 is the number of tubers with a score of 0; n_{2a} is the number with a score between 1 and 10% and so on.

At the start of the trial and at weekly intervals two tubers were selected randomly from each sack for destructive assessment of internal rotting, and soluble solid content (R.I.) of tuber sap. For internal rotting, tubers were cut in half and scored in a similar way to that used for external rotting.

Results

Tubers for Trial 1 were stored in an undamaged or damaged state to determine the effect of damage on the rate of deterioration of tubers of different sweetpotato cultivars. The effect of damage on the rate of weight loss and the rate of rotting at one, two, and three weeks of storage is shown in Table 1. Although the difference between treatments was significant in some cases, no interaction between treatment and cultivar was observed and the two treatments were, therefore, combined for all subsequent analyses and results are present by variety only.

The extent of externally observable rotting could be assessed using all the tubers of each

Table 1 Trial 1 — The effect of damage treatment on the rate of deterioration of tubers

(a) Weight loss

Treatment	% Wt loss (at one week)	% Wt loss (at two weeks)	% Wt loss (at three weeks)
Undamaged	12.0	23.6	35.7
Damaged	12.1	25.9	38.6
Treatment effect	ns	*	+
C.V. %	14.8	15.2	16.2

(b) Rotting[1]

Treatment	Overall rotting (at one week)	Overall rotting (at two weeks)	Overall rotting (at three weeks)
Undamaged	1.51	2.45	3.64
Damaged	1.38	2.57	3.60
Treatment effect	*	+	ns
C.V. %	10.80	7.20	8.30

ns, Not significant; +, *, significant at 10% and 5% level of probability, respectively

[1]Average score when tubers were sorted into the following categories: (1, 0% surface showing visible rotting; 2a, 1–10%; 2b, 11–25%; 3, 26–50%; 4, 51–75%; and 5, 76–100%)

C.V. is Coefficient of Variation

sample, whereas internal rotting was assessed each week by destructive sampling of two randomly selected tubers of each sample. For this reason the coefficient of variation for internal rotting was high (23.4%). Nevertheless, in all cases the cultivar effects were very significant, and there was a wide range of perishability observed for the cultivars used in these trials. For example, in Trial 2, the weight loss over a two-week period ranged from 8.4 to 30.6%, while the overall rotting score ranged from 1.44 to 2.82 (data not shown). The ranking of cultivars was consistent over the whole period of storage (data not shown).

The yields for Trial 2 (14.43 t fresh wt ha^{-1}) were considerably higher than for Trial 1 (6.19 t fresh wt ha^{-1}), probably as a result of better drainage and lower pest pressure.

An important observation was that the amount of weight loss and the amount of rotting were highly correlated for both trials. This is illustrated in Figure 1 (a, b) which shows the relationship between rotting and weight loss at two weeks. Of particular note are the high correlations between weight loss after one week and subsequent rotting. This suggests a causative link between weight loss and rotting and the possibility that initial rate of weight loss could be used to predict susceptibility to rotting.

A number of physiological parameters that might be associated with rates of deterioration were measured to see if they could be used for indirect assessment of perishability. Latex contains a high level of phenolics, and is thought to be associated with resistance to pathogens. The extent of latex release when roots were broken was therefore assessed subjectively using a 1–5 score. During farmer assessment of cultivars in Tanzania, farmers have indicated that they perceive that cultivars with a thick cortex are less susceptible to damage and keep better. Cortex thickness was therefore recorded. Tuber hardness, sugar content (indicated by refractive index of the root sap), and DM content were also assessed. The only variable that showed a consistent relationship with rates of deterioration (indicated by weight loss and rotting after two weeks), was DM content at the start of storage. Contrary to the normal perception that tubers with low DM deteriorate more rapidly, a significant positive correlation was found between DM content and both weight loss and rotting for both trials (Figure 2a, b).

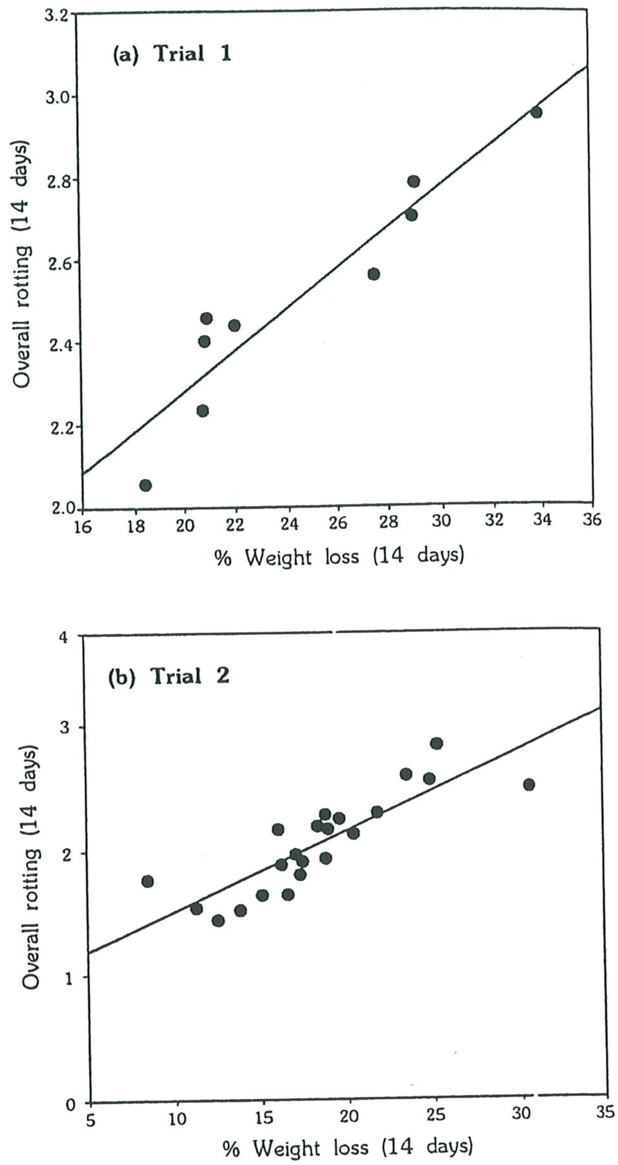


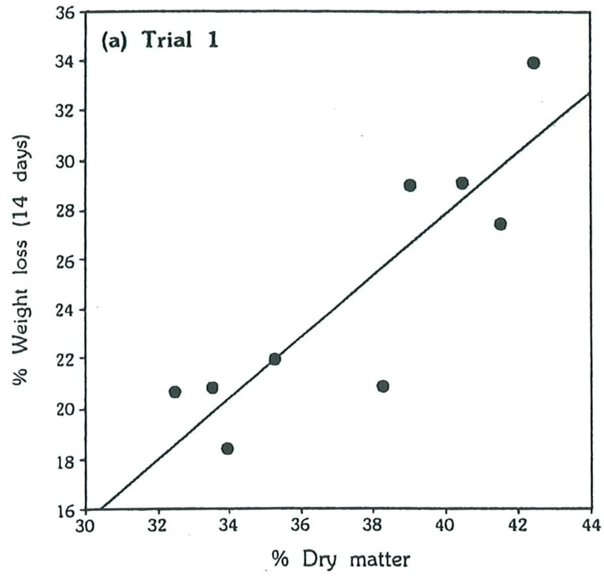
Figure 1 The relationship between overall rotting and per cent fresh weight loss after two weeks of storage of roots of (a) 9 sweetpotato cultivars in Trial 1 and (b) 22 sweetpotato cultivars in Trial 2; Correlation coefficient $r = 0.943^{***}$ in Trial 1 and 0.846^{***} in Trial 2

Discussion

The results presented show a wide range in storability within both local and introduced sweetpotato germplasm, which indicates that there is great potential for breeding for extended shelf-life. Although the results of only a single trial are presented here, these are consistent with the results of less extensive trials carried out at the same location during the previous two years. This finding agrees with that of studies that have previously been conducted in other regions of the world (Campbell and Collins, 1987; Woolfe, 1992).

Although further work needs to be done to investigate the basis of differences in storability, the strong relationship between rates of weight loss and rotting suggests either that there is a causative link between the two (e.g., weight loss may promote rotting) or that there is a common factor providing resistance against both. An investigation of periderm structure in a range of cultivars and its role in perishability would be very valuable.

The positive relationship between initial DM content and rate of deterioration needs further investigation. At this stage it is not known



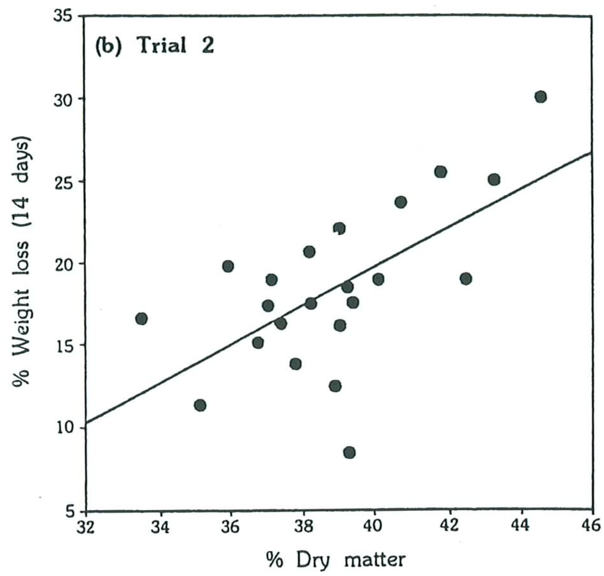


Figure 2 The relationship between initial per cent dry matter content and per cent fresh weight loss after two weeks of storage for roots of (a) 9 sweetpotato cultivars in Trial 1 and (b) 22 sweetpotato cultivars in Trial 2; Correlation coefficient r = 871** in Trial 1 and r = 0.63** in Trial 2

whether this is a causative relationship or not. In East Africa, high DM is very important for consumer acceptability, so it would be counter-productive to breed for low DM. For this reason, cultivars that keep well, and yet have high DM (falling below the line in Figure 2a, b) will be particularly useful within breeding programmes. A notable example is Bilagala in Trial 2.

For a breeding programme, in the absence of indirect selection techniques, any method for assessing rates of deterioration needs to be as simple as possible. Measurement of weight loss is simpler and more objective than assessment of rotting. The results presented here suggest that weight loss during the first week of storage is a good indicator of subsequent rates of deterioration. If further studies confirm this, then it may be possible to select on the basis of weight loss alone.

In this study the effect of damage (cuts) on rates of deterioration did not vary with cultivar, indicating that effective cultivar selection could be carried out without the use of a damage treatment. In previous years other methods of damaging have been tried, which involved battering the tubers to scuff and bruise the surface. This methodology did not affect the ranking of cultivars. Despite these results, given the extent of damage which has been observed in Tanzanian markets, it is still believed that other forms of damage (e.g., breaking tubers) should be tested.

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