Screening sweetpotato cultivars for wound-healing efficiency

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INTERIM REPORT

This report summarises the progress of a programme for screening sweetpotato cultivars for their wound-healing efficiency. This work is funded through the Department for International Development's (UK) Crop Post-Harvest Programme. It is led by the Natural Resources Institute, University of Greenwich (UK), in collaboration with the International Potato Center, The Tanzanian National Root and Tuber Crops Programme, USDA-ARS and Cranfield University, UK.

Background

Short shelf-life is a major constraint for the use of sweetpotato as a food security crop in East Africa. Previous work has indicated that under normal handling and marketing conditions in East Africa (moderately rough handling, sub-optimal humidity, tropical temperatures) a large range in the storability of sweetpotato exists among the available germplasm. Under these conditions deterioration is dominated by water loss through unhealed or incompletely healed wounds. An important factor in the variation between cultivars is their ability to heal wounds under non-ideal curing conditions, specifically at sub-optimal humidities.

A protocol was developed to assess wound-healing at low humidity by staining for lignin, which forms an important part of the new wound periderm that grows underneath a wound. Initial results indicated that high dry matter cultivars tended to be less efficient at wound-healing at moderate humidities. This has led to the working hypothesis that there is a critical moisture content, below which healing cannot occur, and that as wounds desiccate, high dry matter cultivars reach this level more rapidly than low dry matter cultivars. One implication of this hypothesis is that at high humidities the differences between low and high dry matter cultivars will be reduced. This has been verified.

The finding that cultivars with higher dry matter content have less efficient wound healing is unwelcome. Mealiness, associated with high dry matter content was one of the main consumer criteria for sweetpotato cultivars identified in Lake Zone of Tanzania. High dry matter content is also very important where roots are used for processing, and world-wide the characteristic is considered so important that CIP has a specific initiative to breed for higher dry matter cultivars. It thus becomes very important to determine whether it is possible to breed for cultivars with high dry matter content AND good wound-healing characteristics. . We already have some evidence that this might be successful. Three cultivars tested in Tanzania (two Tanzanian cultivars (Kagole, Bilagala) and one clone introduced by CIP (440088)) were found to have better keeping qualities than predicted from their dry matter content. However their wound healing efficiency was not specifically determined. There are also indications that North American germplasm has better keeping qualities than East African germplasm (J. Bohac, USDA, pers. comm.).

The results presented here cover 20 cultivars grown by CIP, Nairobi (Fifteen of these are the cultivars being tested as part of a world-wide trial on GxE interactions) and 18 cultivars grown by Janice Bohac of the U.S. Vegetable Laboratory (USDA-ARS).

Methods

For assessment of wound-healing efficiency at moderate humidity roots were maintained in three humidity controlled chambers at 65-70% R.H., 25-26ºC. After one day a shallow wound was cut. Staining for lignin was carried out using phloroglucinol after a further 5 days. Each wound was scored subjectively between 0 and 1 on the basis of the extent and continuity of lignification seen in 3-4 sections across the wound. (See Table 1 for exmples).

For assessment of wound-healing efficiency at high humidity the same protocol was used, but roots were placed in an enclosed chamber with water in the base. Measured relative humidity was greater than 95% throughout

Table 1: Scores for lignification of sweet potato wound sections

	Score	Completeness of the lignin layer
	Lignification score	Distribution of lignin in wound = lignin
Complete lignification	1	
Patchy lignification	0.5	
No lignification at all	0	

Results for cultivars grown by CIP Nairobi.

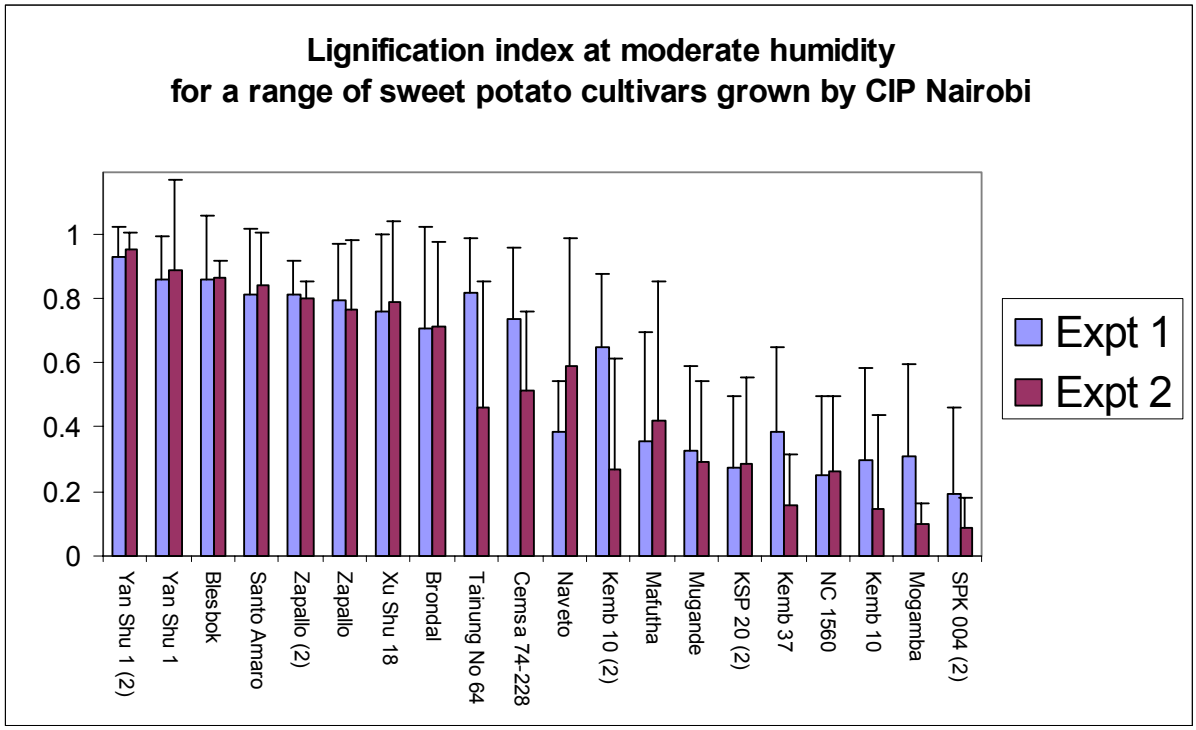

Figure 1: Lignification was measured in two separate experiments, Expt 1 and Expt 2 carried out 2 and 4 weeks after harvest respectively. Each data point is the mean +/- standard deviation of 12 or 9 roots

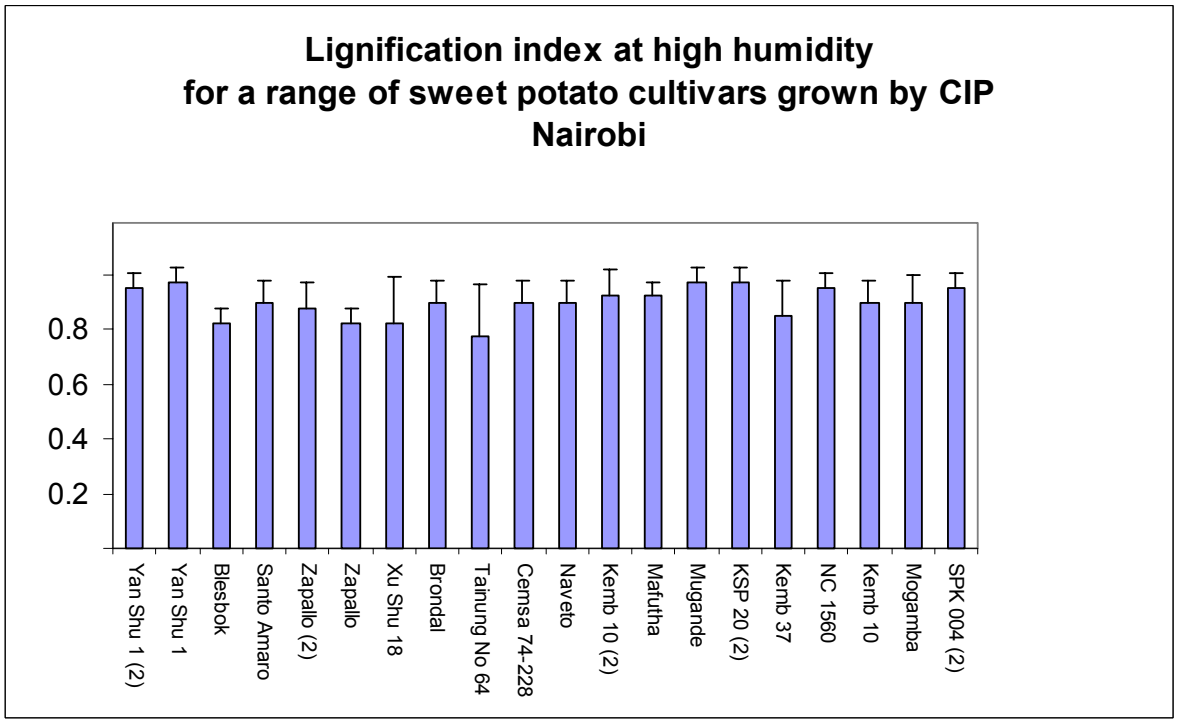

Figure 2: Lignification was measured in a single experiment carried out 4 weeks after harvest. Each measurement is the mean +/- standard deviation of 4 roots.

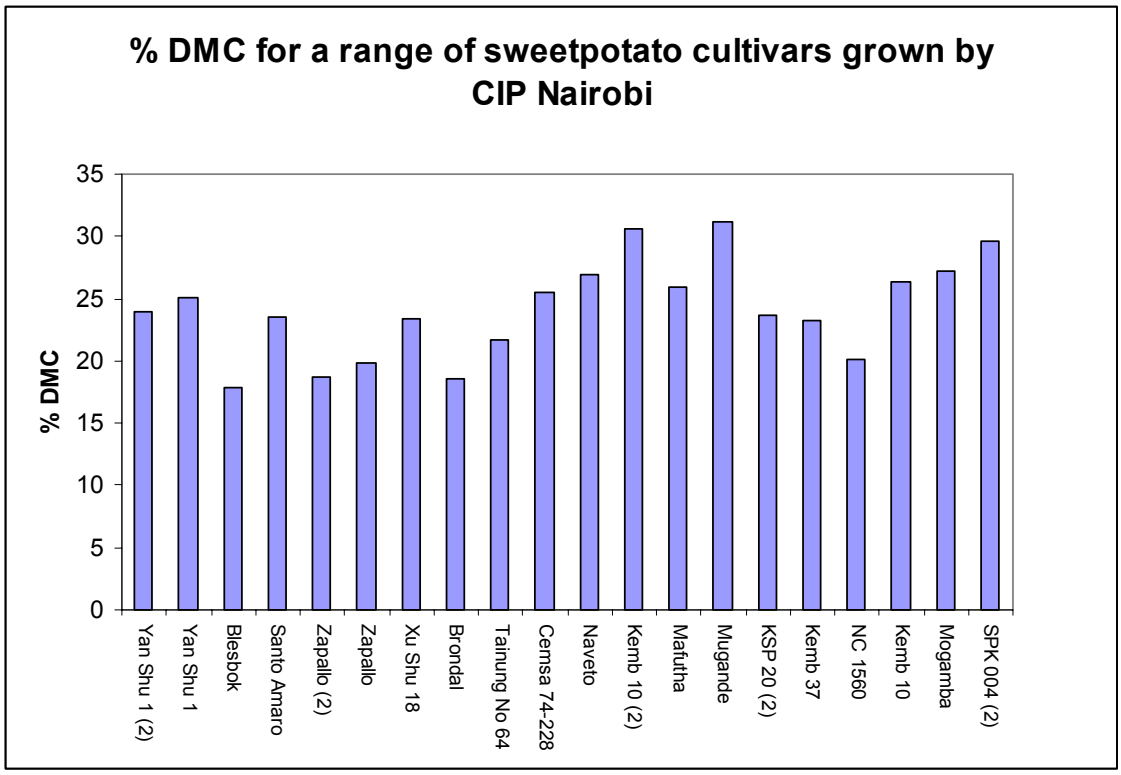

Figure 3: Dry matter content is the average of two roots for each cultivar.

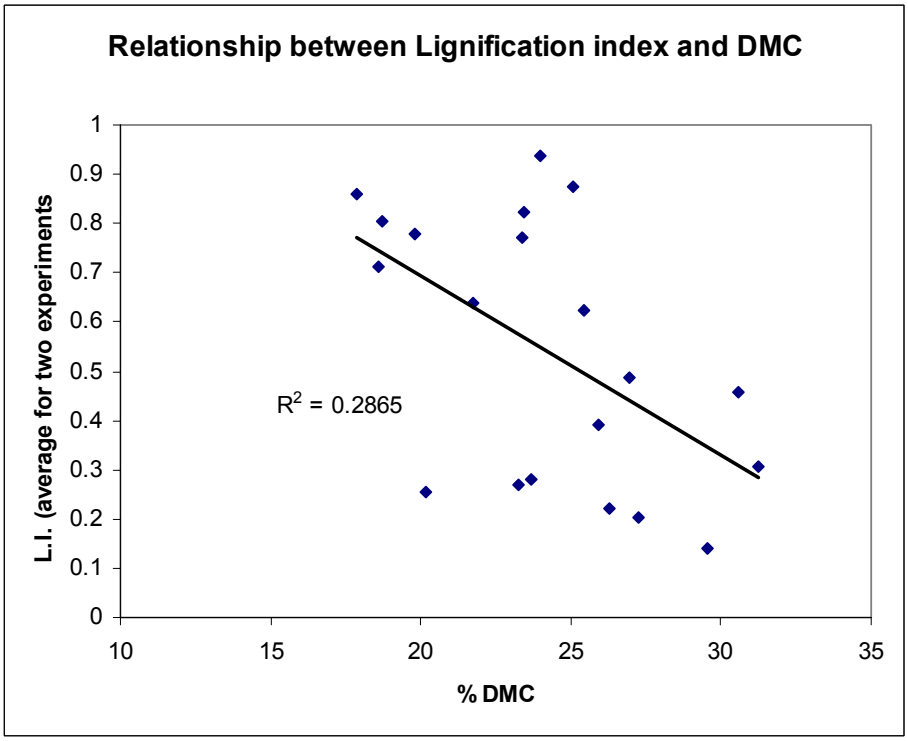

Figure 4: the Lignification index used is the mean for the two experiments carried out (see Figure 1). The %DMC is the data shown in figure 3
The correlation is significant to 5%.

Results for cultivars grown in the US

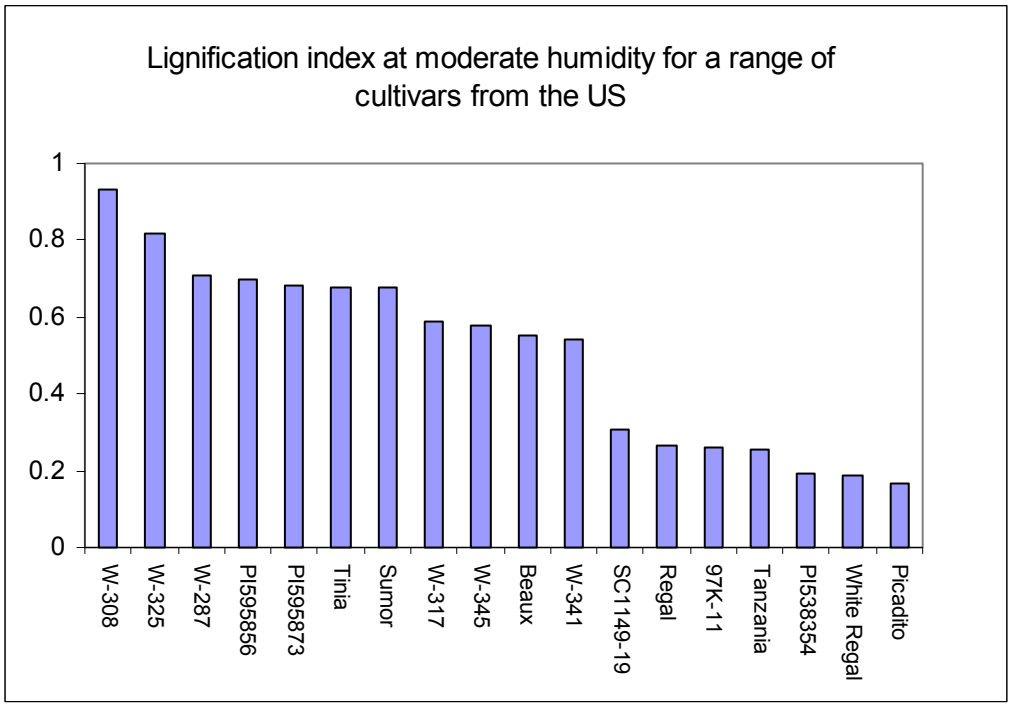

Figure 5: Lignification indices are the mean of values obtained in between 1 and 4 experiments, for each of which 18 roots were measured.

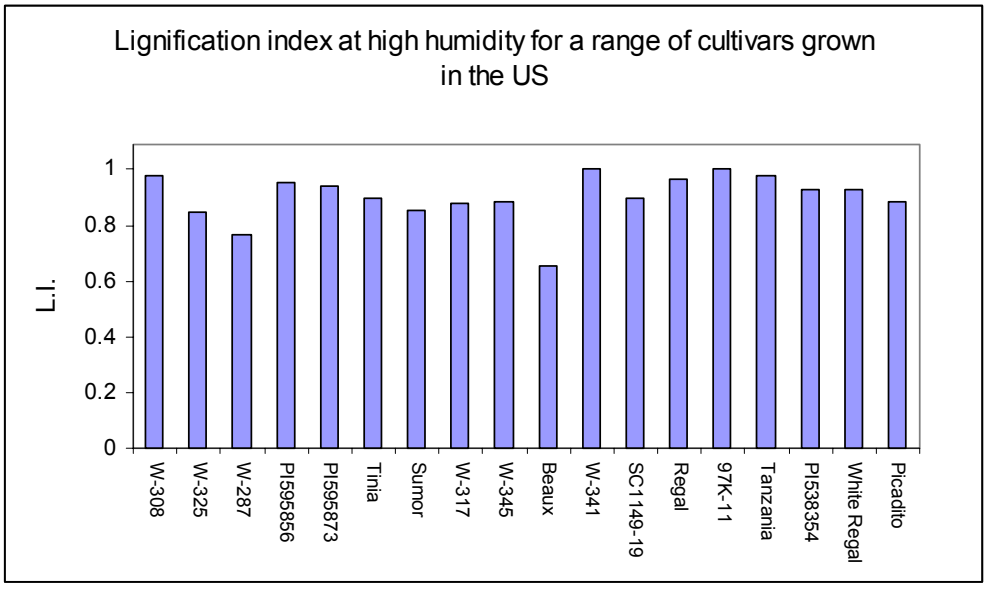

Figure 6: Lignification was measured in a single experiment and was the mean for 6-9 roots per cultivar.

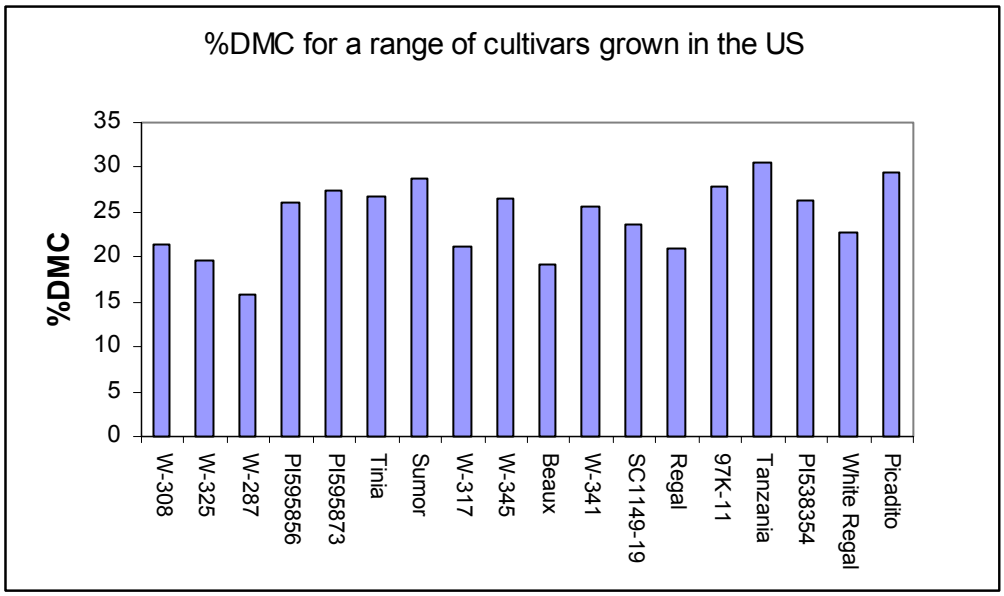

Figure 7: Dry matter content is the average of three roots for each cultivar.

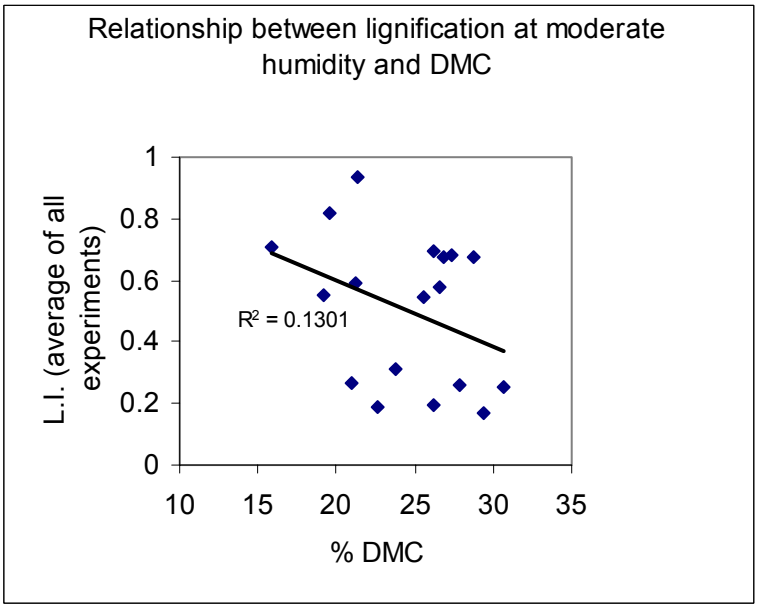

Figure 8: the Lignification index used is the data as shown in figure 5 and the %DMC as shown in Figure 7.
The correlation is not significant.

Results

Lignification is only one of the processes involved in wound-healing. Using staining for lignin as an indicator of wound-healing assumes that lignification is occurring simultaneously with the other processes of wound-healing, which together provide a barrier against water loss and pathogen invasion. Previous work has shown this assumption to be valid. For the experiments reported here, the weight loss of all wounded roots, and the rate at which this decreased during healing was assessed for all experiments. Although analysis is not complete for the screening of CIP cultivars, the results for the US cultivars indicates that lignification parallels a decrease in water loss through the wound (data not shown).

Cultivars obtained from CIP, Nairobi

The data obtained from the first screening of sweetpotato cultivars obtained from CIP, Nairobi, is summarised in Figures 1-4. Fifteen cultivars were grown as part of the worldwide GxE Trials. An additional five cultivars, grown in a separate trial were also included. The latter are marked with a (2). Three cultivars were common to both trials.

A wide range in efficiency of wound healing at moderate humidity was observed (Figure 1). The standard deviations indicate that for the cultivars with intermediate overall efficiency, the performance of individual roots could vary considerably. However reasonable agreement was found between the two experiments.

Of the three cultivars obtained from both field trials, Yan Shu and Zapallo were very consistent, while the third, Kemb10 was much less so. We believe this variabiltiy to be a characteristic of Kemb10 (The behaviour of Kemb10 in the GxE trials may support this.)

As expected all cultivars showed good wound-healing at high humidity (Figure 2).

Figure 3 shows the dry matter contents measured at the start of the screening process. Figure 4 shows that, as previously found, there is a tendency for cultivars with higher dry matter to be less efficient wound healers (Negative correlation significant to 5%). However, several cultivars deviate from this relationship. Notably Yan Shu is more efficient than expected, while NC1560 is less efficient than expected.

Cultivars obtained from US

The data obtained from the first screening of sweetpotato cultivars obtained from the US, is summarised in Figures 5-8. Eighteen cultivars are included. The cultivars had been stored for more than 3 months before the screening was initiated. For this reason we have less confidence in the validity of the data, and plan to repeat the screening.

As for the CIP cultivars, a wide range in efficiency of wound healing at moderate humidity was observed (Figure 5). Good agreement was found between the four experiments conducted (data not shown).

Tanzania is the same cultivar as Kemb10 provided by CIP. The lignification indices measured are consistent between the two sets of screening.

As expected most cultivars showed good wound-healing at high humidity (Figure 6). However, cultivars Beaux and W-287 unexpectedly showed incomplete lignification.

Figure 7 shows the dry matter contents measured at the start of the screening process. Figure 8 shows the relationship between dry matter content and lignification at moderate humidity. In this case there is not a significant relationship between the two parameters.

Discussion

The results so far confirm our previous findings that there is a wide range in wound-healing efficiency among sweetpotato cultivars. Some of the well-known US cultivars, e.g. Regal and Beaux, give results suggesting low efficiency. This might be due to the fact that screening was delayed for such a long-time after the harvest.

A relationship between dry matter content and wound-healing efficiency has been seen in most experiments, appart from the screening of US cultivars. We believe that this is not necessarily a direct effect, and that anyway it is not the only factor controlling wound-healing efficiency. For example we have other data that suggests lignification is associated with monosaccharide levels in the roots (higher levels of glucose and fructose associated with higher lignification). At present we have no explanation for this. However, samples have been taken from the first GxE screening for analysis to follow this up.

Future plans

- We are about to screen a second consignment of roots for the same cultivars provided by CIP, Nairobi.

- A range of Tanzanian cultivars presently being grown by CIP, Nairobi, will be screened later this year.

- We plan to screen the same US cultivars in October/November or this year, and this time the screening will be carried out as soon as possible after harvest.

- Samples have also been taken to allow us to carry out microscopy to check the levels of suberin formed during wound-healing. This will allow us to determine whether some cultivars produce more suberin than lignin and therefore naturally do not stain as well using our protocol. In this context it is notable that potatoes produce primarily suberin and not lignin when they heal. (but note that our data on water loss through wounds suggests that lignification is an indication of wound-healing).