The evidence for osmotic adjustment as a mechanism to prevent water loss from sweetpotato wounds.

D. Rees and Q.E. van Oirschot

Introduction

Conversion of starch into soluble sugars is one mechanism by which plant tissues can increase their osmotic potential and thereby slow down water loss. For this reason, in leaves it has been observed that water deficit leads to the accumulation of soluble sugars. This appears to be brought about by several processes: stimulation of sucrose synthesis, inhibition of starch synthesis and stimulation of starch breakdown. Specifically, there is evidence that activation of Sucrose Phosphate Synthase (SPS) by reversible protein phosphorylation is involved. It appears that the same mechanism occurs to protect potato tubers from the effects of water deficit. The water content of potato tubers can fluctuate between 10 and 20% during the day (Geigenberger *et al.* 1997 and references therein).

We have shown previously that sweetpotato cultivars differ significantly in their ability to heal wounds when kept at moderate humidities. We have often observed a relationship between wound-healing efficiency and dry matter content, with low dry matter cultivars having more efficient wound-healing. We have no physiological explanation as to how such a relationship can exist. However, there is a close relationship between dry matter content and sugar levels. It could be that we are really observing a relationship between sugar levels and wound healing efficiency.

Objective

To determine whether the ability of sweetpotato cultivars to lignify wounds at sub-optimal humidities is related to their ability to increase sugar levels in tissues close to wounds in order to slow down desiccation by the increased osmotic potential.

Methods

Roots from 10 sweetpotato cultivars were grown by CIP, Nairobi and airfreighted to NRI, UK.
12 roots of each were wounded by removing a thin section from one side of the root.. After removal of most of the periderm, this section was freeze dried for subsequent sugar analysis.
Wounded roots were placed at 65% RH 25°C and allowed to heal for 5 days.
The rate of weight loss was followed during this time.
After 5 days, the lignification index (L.I.) was measured, and a tissue slice (approximately 4mm thick) cut from under the wound for freeze drying and subsequent sugar analysis.

Further details of methods are given in previous interim reports (and can be supplied on request).

Results

Table 1: Wound healing ability and sugar levels for roots from 10 sweetpotato cultivars

Cultivar no.	Cultivar name	Initial sugar level [mg/g dry wt]	Final sugar level under wound [mg/g dry wt]	Sugar increase [mg/g dry wt]	% sugar increase	DM 1	DM 2	LI
2	Bilagala	107.69	117.97	10.28	11.82	27.32	28.71	0.18
3	Cemsa-74-228	134.63	146.65	12.03	10.68	23.77	23.48	0.88
4	Hernandez	194.62	193.95	-0.66	1.01	22.17	21.03	0.10
5	Kemb 10	112.36	118.78	6.42	8.53	28.39	31.93	0.30
6	Kemb 37	133.50	160.08	26.58	20.46	24.91	24.59	0.32
7	Naveto	132.86	142.54	9.68	8.38	25.54	25.26	0.44
9	Polista	98.85	96.86	-1.98	4.97	32.23	32.65	0.23
10	Sinia	121.79	129.36	7.57	12.98	29.74	28.66	0.53
11	Yanshu	152.16	155.48	3.32	2.66	21.21	20.20	0.48
12	Zapallo	173.96	239.90	65.94	40.53	20.72	19.62	0.65
	Mean	136.3	150.1	13.8	12.1	25.60		0.41
	Cult effect	***	***	***	**	***		***
	LSD	23.09	26.13	13.65	19.89	2.16		0.24

DM 1 is the dry matter content calculated using samples cut from each root which were subsequently freeze dried.
DM 2 is the dry matter content calculated using 3 roots and standard oven drying techniques at the start of the experiment
The two methods of calculating DM give similar results. The correlation between the cultivar values is very strong (R = 0.962 significant to 0.1%)

The main results obtained in this experiment are summarised in Table 1. Our main findings are as follows.

- As previously observed there is a significant difference among cultivars in ability to wound heal (L.I.).

- As predicted there was a general trend for the tissues close to wounds to accumulate sugars. The extent to which they did this was cultivar dependent.

- The data for individual roots supports our hypothesis, in that for individual roots, L.I. is significantly positively correlated with sugar level increase (r = 0.302 significant to 1%) and % sugar increase (r = 0.302 significant to 1%). See Figures 1 and 2.. *Note the correlation is affected by outlying points , but if I remove the 4 main outliers the significance of the correlation hardly changes.*
- This is slightly stronger than the relationship between L.I. and DM. (r = -0.270, significant to1%)

- The data by cultivar is less convincing. Although there is a positive trend when plotting L.I. against sugar increase and % sugar increase, the correlation is not significant (Figure 3).

Models for lignification index of cultivars in terms of sugar changes and in terms of dry matter content have been calculated, and are given below. The models indicate that although sugar increase is a factor controlling wound-healing efficiency, (and probably a stronger factor than DM). However, there are still other cultivar factors that are more important.

L.I. = 0.356 +0.005 % sugar increase
9.6% variance accounted for

L.I. = 0.130+0.004 % sugar increase + cultivar
36.8 % variance accounted for

L.I. = 0.974 – 0.022 DM
6.4% variance accounted for

L.I. = 1.006 – 0.030 DM + cultivar
34.1 % variance accounted for.

L.I. = 0.175 + cultivar
31.1% variance accounted for.

Future plans

The data from this experiment supports our hypothesis that carbohydrate metabolism is involved in controlling wound-healing efficiency. However, one possible inaccuracy in our experiment would have been introduced by variations in the thickness of the sample taken after wound-healing. We believe that more accurate results can be obtained if we use precut tissue blocks and follow their wound-healing behaviour.

References

Regulation of sucrose and starch metablism in potato tubers in response to short-term water deficit.
Geigenberger, P., Reimholz, R., Geiger, M., Merlo, L., Canale, V., and Stitt, M. (1997)
Planta 201: 502-518

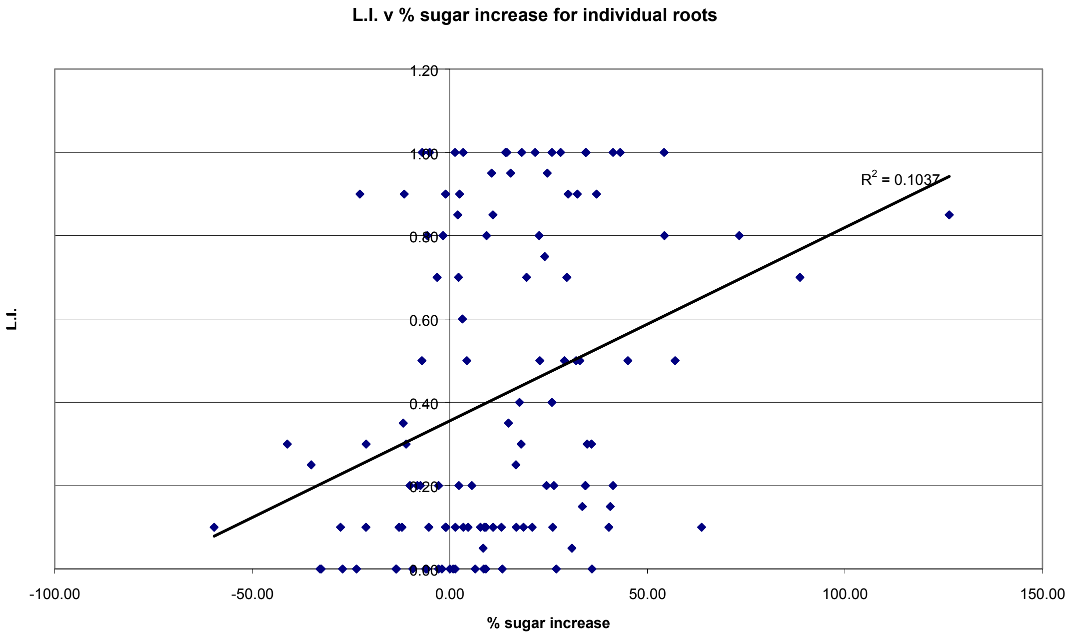


Figure 1

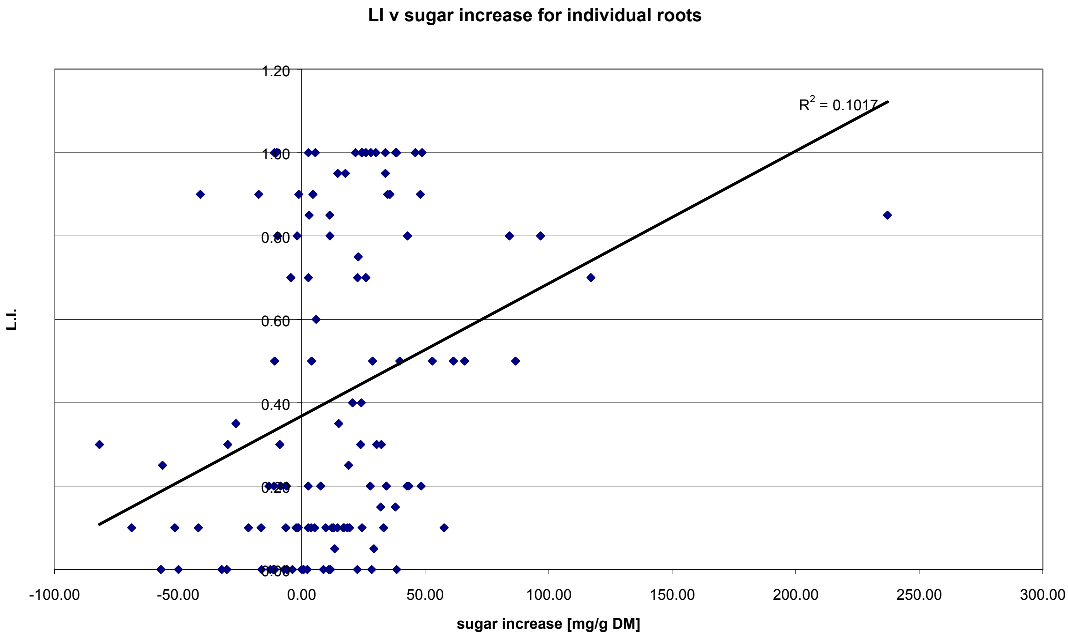
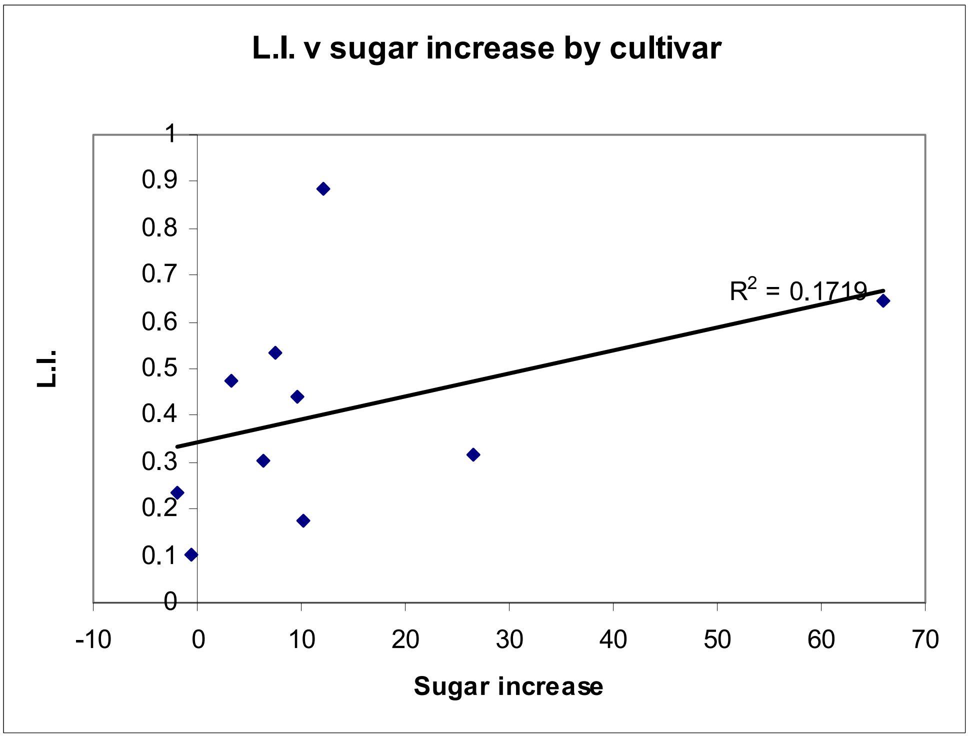


Figure 2



L.I. v sugar increase by cultivar
L.I.
Sugar increase
R2 = 0.1719
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-10
0
10
20
30
40
50
60
70

Figure 3