ARCHAEOLOGY IN NEW ZEALAND

REKAMAROA KUMARA, SAND AND SOIL

Huntly Horn
Wards Road, R.D.2, Christchurch

The southernmost limit of pre-European kumara (*Ipomoea batatas*) growing in New Zealand is thought to have been just south of Banks Peninsula (Shortland 1851, Leach 1984). Cultural practices may have strongly influenced success at these margins. Soil modification was a feature of Maori garden culture, often described in archaeological sites (Leach 1984), but practical studies have been rare (Rigg and Bruce 1923, Challis 1976, a, b). To further these, an experimental study of the role of sand, either as a surface mulch or as soil texture modifier, was carried out near Christchurch between 1986 and 1992.

The kumara was the Rekamaroa cultivar, from stock generously supplied by Ian Lawlor. This has a white flesh and usually rather long straggly and fragile tubers. It can be rather difficult to dig up unbroken. Initial difficulties with sprouting led to some experimentation on propagation (tissue culture, mist propagation on aerial parts). Striking single node leaf cuttings in sand proved simple and effective, and favoured some uniformity of starting size. As plants were wanted in spring, the cuttings had to be taken from a plant grown in greenhouse conditions over the preceding winter. In local conditions the uncertain rate of sprouting is added to the uncertain survival of tubers in winter storage because of fungal attack.

A characteristic of practical importance is the rather variable vigour of growth. For any one set of growing conditions, tuber or root weight per plant varies 100% or more, so considerable replication is necessary. Total green weight of roots was the measure of yield in the experiments. Roughly 90% of this were useful tubers (finger thickness or more); large tubers (4+ cm diam.) were rare.

In 1986-90 the kumara were grown in a Waimakariri silt loam. This had no abnormal fertility or drainage problems. In 1991-92 the site chosen for the experiment was on Motukarara fine sand - which in fact was nearer a clay texture in the topsoil, of similar fertility to the Waimakariri soil, but with slow drainage. To minimize any hidden fertility irregularities, each season the test beds were dug out down to subsoil, mixed twice and replaced.

The greywacke sand, low in silt, clay and humus, came from a commercial pit near Taumutu. It was a medium grey colour. Small pits in nearby similar material are suspected of having pre-European origins (site S93/36).

TREATMENTS

On the Waimakariri site (at Halswell) one large rectangular bed was prepared each spring, and randomised blocks of the various soil treatments were placed on a square grid pattern within it at 70 cm spacing.

1. The control plots were untreated, homogenised topsoil.
2. A mulch of 2 litres of straight sand was spread evenly over a 30 cm diameter circle, resulting in a depth of about 3 cm.
3. Cylindrical pits were dug at the selected plant sites, and refilled with a sand soil mixture, which also was the surface presented to the sun.

The parameters are tabulated:-

Year	1987-88	1988-89	1989-90
Pit diameter:depth, cm.	33:12	24:27	28:27
Soil:sand ratio	3:1	1:1	1:1
Volume of pit, litres	9	15	20
Litres of sand per pit	2	8	10

4. Small mounds of the topsoil were formed, about 10-12 cm high, and after the rooted cuttings were transplanted, were covered with the sand. The sand tended to run off the hill, so its area and the depth varied. This treatment was done only in 1988-89.

On the Motukarara soil (at Tai Tapu) trenches, two 30 cm wide and one 15 cm wide, were dug and the sides lined with polythene, with polythene cross pieces every 70 cm to separate the plants. There were 8 such compartments and plants per trench.

5. Experience at this site in 1991-92 showed the desirability of having some sand added to the clay soil in order to lessen damage to the Rekamaroa tubers at harvest. The control soil was therefore a 2:1 soil:sand mixture, and this filled one wide trench (and was its surface).
6. The other two trenches, one wide, one narrow, were filled with a 1:2 soil:sand mix. This mix has only half the soil content (or twice the sand content) of the control. This mix was also exposed as the surface.
   The volume of mix offered to the plant was 30 litres per compartment in the narrow trench, 60 litres for the wide ones.

RESULTS

[Standard deviations and relative s.d.s are in brackets after the means. Relative yields (means) and relative s.d.s are on the basis of each relevant seasonal control = 100.]

A. On the Waimakariri soil at Halswell,

Season	1987-88	1988-89	1989-90
Planting date	16/11/87	31/10/88	4/12/89
Growing days	126	149	121
Litres of sand in mix per site	2	8	10
No. of replications/treatment	4	13	19
Mean grams total root per plant:			
control	260 [91]	1060 [254]	510 [111]
mulch only	510 [198]	1380 [273]	680 [123]
hill + mulch	- -	1270 [312]	- -
sand/soil mix	262 [16]	840 [287]	380 [100]

Relative yields and R.S.D.s			
control	100 [34]	100 [24]	100 [22]
mulch only	190 [73]	130 [26]	133 [22]
hill + mulch	- -	120 [26]	- -
sand/soil mix	100 [6]	79 [27]	74 [23]

COMMENT

Statistical confidence in the yield differences was well below the conventional threshold of acceptance of 95% for every treatment every season, but probably around 70% or so.

The first year's data are out of line mainly because of the inadequate replication. The next season (1988-89) had higher yields all round because of earlier planting and a warmer spring and early summer, and a good proportion of the crop eventually survived storage through the winter. This tempted the planting of tubers instead of cuttings, but the project failed - a high number rotted in the ground. The few sprouts produced were very uneven in number, so the rooted sprouts were uplifted and planted singly as if they had been cuttings. This made a late start and contributed to the lower yield that third season.

The base-line temperature for calculating degree days growth is about 15°C (Yamaguchi 1983), while useful rates of production are said to require 20°C (Coleman 1978). Soil temperatures at Lincoln exceed threshold from early November to March, and are barely over 20°C in January. The consistently increased yields under sand mulch must be due to higher soil temperatures. This can only occur up to the time that the kumara canopy shades the sand from the necessary solar radiation. Early extra warmth would seem to be the key for a good crop in these circumstances.

The absolute yields found vary 100% or more from season to season. Yen (1961) also records marked yield swings locally. The relative yields between treatments within each season are much more consistent; if the relative data for 1988-89 and 1989-90 are combined, the (relative) yields stay much the same, whereas their std. deviations drop to about 17, with a corresponding increase in credibility. The 30% yield increase under mulch, here, could change with mulch thickness, grit size, albedo, and slope to the sun. The slight reduction with hilling again is not well supported statistically; but hilling would seem not to offer any advantage. Further work is obviously called for.

If sand on top enhances yield, sand below in the soil lowers it. Again the statistical support is poor, but not zero. For the first year, besides inadequate replication, the amount of sand mixed down was small (see table above). In all the other years the amount of sand was substantial and comparable - even at Tai Tapu - and the effects consistent.

The Taumutu sand lacks fertility and the depressed yield is almost certainly due to dilution of the (fertile) soil matrix by infertile sand. Other sands, and used in other proportions, would be expected to provide other degrees of reduced yield. A sandy mix should be drier if the drainage can escape, and therefore easier to warm up; absorption of solar radiation will also play a part. The yields found are the net effect of all these.

The experiment at Tai Tapu supports the findings at Halswell as regards sand mix and lower fertility. This project was undertaken in the hope of finding ways to reduce the amount of materials needed, the laborious task of mixing them, and the even more laborious task of recovering the roots. The results below suggest this could be taken further.

Tai Tapu, sand ratio trial, total roots, 8 replications			
Trench width	30cm	30cm	15cm
Sand:soil ratio by volume	1:2	2:1	2:1
Yield mean and (s.d.) g/plant	212 (67)	143 (33)	137 (54)
Relative yield & rel s.d.	100 (32)	67 (15)	64 (26)

The Maori reputedly did not water kumaras, and one may wonder if this may have limited productivity or even survival of the kumara in southern seasonal drought, particularly on some (dry) hillslope gardens. The 1988-89 season suffered a severe drought, but the Rekamaroa kumara then produced their best to date, with only one (anxious) watering in December. When the drought was repeated in 1989-90 a watering treatment was imposed on 8 selected blocks from mid-December until significant rain fell in late February.

These blocks were given 2 litres to each plant at about 5 day intervals - this may have been somewhat excessive.

Halswell, 1989-90, watering trial, mean total roots per plant:				
	No. of plants	grams	s.d	relative
Dry	33	550	(53)	100 (10)
Watered	24	500	95	90 (17)

Guesses about causes for the (uncertain) slightly depressed yield include cooling by the water, or by transient waterlogging at depth. Watering limits need a more careful study.

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