Evaluation of new accessions of Oca or New Zealand yam (*Oxalis tuberosa* Mol.)

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Abstract

Oca grown in New Zealand have a narrow genetic base. In their native Andes, cultivars have a wide range of colours, sizes and taste. Twelve accessions from South America, with various combinations and shades of red and yellow colourings, were compared over three years at Lincoln with two locally available oca lines. Trials were harvested in June in 1996; May, June, July and August in 1997, and May, June and July in 1998. Total tuber yields ranged from an average of 12 t/ha in 1996 to 16 t/ha in 1998. Total yields were highest in July 1997 and in June and July 1998. Yields of tubers over 5 cm and weight per tuber were highest in May and June 1997 and in June 1998. One new accession produced yields similar to the local lines. It produced half the number of tubers, but they were twice as heavy. The other accessions yielded less than the local lines, mainly because they produced fewer tubers over 5 cm long. However, they may have a place in the market because of their colour or taste.

***Additional key words:** yield, tuber size, tuber number, time of harvest, new crops*

Introduction

Oca (*Oxalis tuberosa* Mol.) is a tuber crop that originates from the Andes of South America where it has been a staple food since pre Inca times. It is still an important food crop, second only to potato (Brucher, 1989; National Research Council, 1989; Vietmeyer, 1991). Oca has been grown in New Zealand for over 100 years (Vietmeyer, 1991). Here it is known as yam, a name causing confusion with the tropical yam (*Dioscorea* spp.). New Zealand is the only country outside South America where oca is grown commercially. Tubers have a tangy flavour. In New Zealand they are mainly roasted with meat.

Until recently, Oca lines grown in New Zealand have had a narrow genetic base, producing only pink coloured tubers. In the Andes, over 50 distinguishable types are recognised with a range of tuber colours, including red, purple, pink, yellow, and also multi-coloured and spotted tubers (Brucher, 1989; National Research Council, 1989). Commercial growers are interested in new cultivars that may increase the appeal of oca to New Zealand consumers, and also lead to the development of overseas markets for New Zealand-grown oca.

In these trials, tuber yield and size of the 12 introduced accessions were compared over three years with two lines of oca (L1 and L2) that had been grown in New Zealand for many years.

Materials and Methods

Samples of oca were collected from local markets in southern Bolivia and northwestern Argentina in 1992 by Alfredo Grau on a New Zealand Ministry of Agriculture plant collection expedition. Accession details were given by Martin *et al.* (1997), and skin colour details are given in Table 1. Upon arrival in New Zealand samples were placed in quarantine until they were found to be free of virus. Twelve accessions were released in 1994 and planted out in spaced tuber or cutting trials (Martin *et al.*, 1997). Enough tuber material was collected from those trials to plant the first of the fully replicated trials reported here. Tubers saved from the previous years' trial were used in the second and third years.

Tubers of L1 and L2 were obtained from the Dunedin and Christchurch vegetable markets at the start of the trials respectively. Different harvest times were also examined in the second and third years.

All three trials were carried out at the Crop & Food Research Lincoln farm on a Templeton Silt Loam (New Zealand Soil Bureau, 1968). Trial 1 was planted on 14 November 1995, Trial 2 on 12 November 1996 and Trial 3 on 20 November 1997. In Trials 1 and 2 there were

Table 1. Oca accession numbers, tuber skin colour, and country of origin (adapted from Martin *et al.*, 1997).

Accession	Tuber skin colour	Country of origin
26	dark red with clear eyes	Argentina
30	cream-red with darker eyes	Argentina
32	white-red, uniform	Argentina
33	white red with red eyes	Argentina
34	cream white with dark red eyes	Argentina
35	red	Argentina
36	cream white with red eyes	Bolivia
37	dark red	Bolivia
38	red-white	Bolivia
39	red-purple	Bolivia
40	yellow with red markings	Bolivia
41	yellow with red eyes	Bolivia
L1, L2	pink	New Zealand

four replicates of single row plots of each accession. The rows were 20 m long with 50 cm between seed tubers within the row and 80 cm between rows. In Trial 3, plant and row spacings were the same, but there were three replicates with three row plots of each accession. All accession plots were laid out in a randomized block design.

In all trials, 10 cm deep furrows were opened by machine, the tubers planted by hand, and the rows covered by machine with a slight mould. The plots were moulded again after crop emergence. Around 500 kg/ha of 15N:10P:10K fertiliser was applied by hand and incorporated at either planting or moulding. Trial 3 also received an application of 100 kg urea (46%N) which was broadcast along the rows in February and watered in. Trials 2 and 3 were sprayed with Gesagard (1.5 kg/ha) immediately after planting to control weed seedlings, and the trials were subsequently hand weeded. The crops were irrigated every two weeks if there was no significant rainfall. Four irrigations were applied to Trial 1 and 7 irrigations to Trials 2 and 3. Seventy-five to 100 mm were applied per irrigation to all three trials, using hand shift pipes and sprinklers.

In Trial 1, the whole 20 m in each plot was harvested between 17 and 25 June 1996. In Trial 2, 3 m lengths of each plot selected at random were harvested on 15 May, 13 June, 9 July, or 12 August 1997. In Trial 3, 3.5 m lengths of all three rows in each plot selected at random were harvested on 18-20 May, 22 June, or 27 July 1998. Thus, harvests formed a split plot treatment for Trials 2 and 3. Harvested tubers were washed, weighed and a 2 kg subsample taken to assess tuber numbers and weights in two grades, either over or under 5 cm long, the former approximating a marketable size.

Results for each trial were analysed separately with analysis of variance using the Genstat statistical package (Genstat 5 Committee, 1993). For the 1998 harvests, where there was poor establishment in places due to *Fusarium* infection, results were adjusted in the analysis by using plant population as a covariate.

Results and Discussion

Climate

Rainfall over the October-June period for the 1995-96, 1996-97 and 1997-8 seasons was 325, 418 and 232 mm respectively. The long term mean (1975-1991) was 443 mm at Lincoln. Mean temperatures over the same period were 12.9, 12.5 and 14.2°C respectively while the long term mean was 13.0°C. It was exceptionally warm during the early months of 1998. The February mean temperature was more than 3°C higher than the long term mean, and the March and May means were 1.8°C higher. There were no air frosts in 1998 until June, compared to April in the two previous seasons.

Pests and diseases

In the first two seasons, when the crops were grown on land which had previously had cereal trials, there was little problem with diseases and pests, although weed control was a problem in Trial 1. In Trial 3, planted after a short term pasture, plant establishment was reduced by over 50% in some plots, and tubers were badly affected by *Fusarium* spp., grass grub and wireworms.

Accession

Figures 1 to 4 present accession means and standard errors averaged over the three trials. Means in the text below are also averaged over the three trials. Although there were some minor differences in the ranking of accessions among trials, these differences do not affect the overall conclusions reported below.

There was little difference in the number of plants/m^2 between accessions, except in Trial 3 where accessions 26 and 37 established more poorly than the other accessions (data not presented). None of the introduced accessions had an average total tuber yield higher than the mean of the two local lines (17.2 t/ha), and half of the accessions yielded less than 13.7 t/ha, which was significantly ($p<0.05$) less than the local lines (Fig. 1).

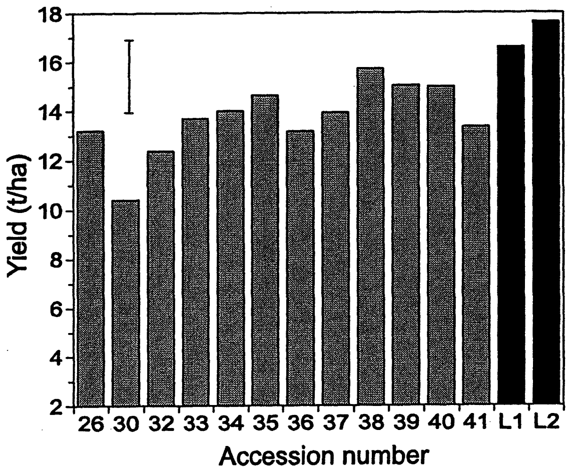

Figure 1. **Oca total tuber fresh weight yield (t/ha) for 12 accessions (hatched bars) and 2 local lines (solid bars) averaged over three years. Vertical line is the mean s.e.m. (5%) over the three trials (d.f. = 25 to 39).**

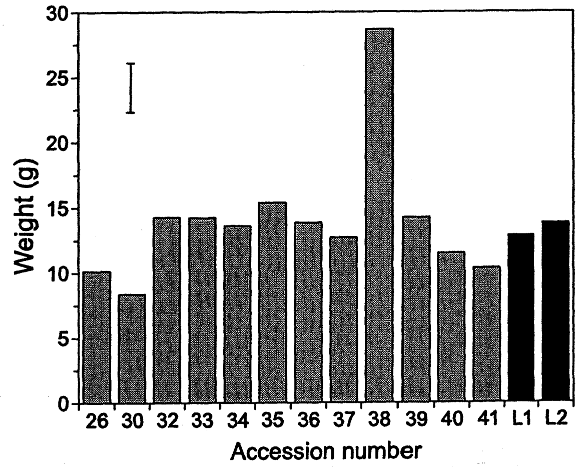

Figure 3. **Mean oca tuber fresh weight (g) for 12 accessions (hatched bars) and 2 local lines (solid bars) averaged over three years. Vertical line is the mean s.e.m. (5%) over the three trials (d.f. = 25 to 39).**

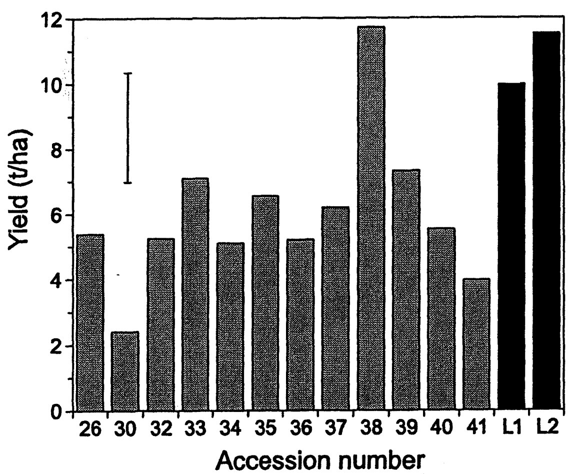

Figure 2. **Fresh weight yield of Oca tubers over 5 cm long (t/ha) for 12 accessions (hatched bars) and 2 local lines (solid bars) averaged over three years. Vertical line is the mean s.e.m. (5%) over the three trials (d.f. = 25 to 39).**

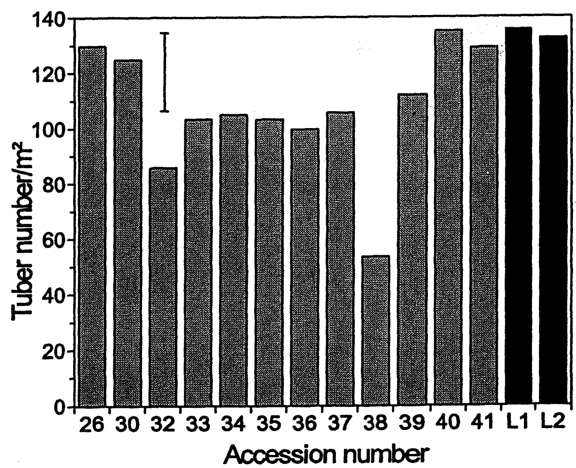

Figure 4. **Oca tuber number/m^2 for 12 accessions (hatched bars) and 2 local lines (solid bars) averaged over three years. Vertical line is the mean s.e.m. (5%) over the three trials (d.f. = 25 to 39).**

Yields of tubers over 5 cm long were not significantly different ($p<0.05$) from the two local lines in accessions 33, 38 and 39 only. All other accessions had significantly lower yields of large tubers (Fig. 2). Most of the new accessions had 40% or less of their yield as large tubers. Mean weight per tuber of the new accessions was not significantly ($p<0.05$) different to the locally available lines, except for the lightest accession, 30, and the heaviest, 38 (Fig. 3). Tuber numbers/m^2 of the new accessions were not significantly ($p<0.05$) different to the local lines, except for accessions 32, 36 and 38, which had significantly ($p<0.05$) fewer tubers (Fig. 4).

Introduced accessions did not yield more than local lines, and half of them yielded significantly less than local lines. However, they may fill a market niche alongside the existing lines if their appearance and taste are more acceptable to the consumer (Sangketkit *et al.*, 1999). Accession 38 produced considerably larger tubers, and this accession could have commercial potential if tuber numbers could be increased, possibly by increasing plant population or through other agronomic inputs. However, in Trial 3, there was no overall effect of plant population on tuber size. Little is known about the physiology of oca or its responses to inputs such as irrigation and fertilizer, and there is considerable scope for research in this area.

Visual scoring of the plants in Trial 3 indicated that Accessions 26 and 37, the dark red accessions, appeared to have higher plant mortality and poorer growth than the other accessions or the local lines. Differences in disease susceptibility among accessions, and whether this is associated with biochemical factors, such as oxalate content, warrant further investigation.

Year and time of harvest

The yields of tubers harvested in June increased over the three years from 12.3 t/ha in 1996 to 13.8 t/ha in 1997 and 19.5 t/ha in 1998 (Table 2) due to increased tuber numbers (1997) and increased tuber numbers and size (1998). Yields were higher at the July harvest than the other harvests in 1997 due to higher tuber numbers/m^2. This may have reflected differences in the recovery of smaller tubers between harvests. In 1998 tuber size increased between the May and June harvests, giving much higher yields than in the previous seasons, possibly because of warm conditions during the summer. Also, in 1998, frosts were late and the oca tops were still green at the May harvest, and so tubers would have continued to grow. However, harvestable tuber numbers in Trial 3 fell between the June and July harvests, reducing yields. *Fusarium* and insect damage to the tubers greatly increased after the June harvest, resulting in many rotten or eaten tubers that were not harvested. Unlike the previous years, where the trials followed cereal and other field crops, the 1997-98 trial followed a short term pasture, which may have allowed these pests and diseases to build up.

Conclusions

None of the 12 introduced accessions yielded more than the two local lines, and half of them yielded

Table 2. Effect of year and time of harvst on mean Oca yield, tuber fresh weight and tuber numbers for each harvest (s.e.m. = standard error of the mean (5%), d.f. = degrees of freedom).

Year	Month	Total tuber yield (t/ha)	Tuber yield (t/ha) over 5 cm length	Tuber fresh weight (g/tuber)	Tubers/m^2
1996	June	12.3	7.26	14.6	87
	s.e.m. (d.f. 37)	0.33	0.368	0.41	2.6
1997	May	13.4	6.25	12.0	119
	June	13.8	5.93	12.7	115
	July	15.3	5.07	10.9	149
	August	14.0	5.30	11.3	129
	s.e.m. (d.f. 126)	0.30	0.233	0.32	3.4
1998	May	13.3	4.26	11.9	125
	June	19.5	9.36	16.7	131
	July	15.5	7.61	16.9	99
	s.e.m. (d.f. 126)	0.43	0.380	0.51	5.3

significantly less. Therefore any commercial success of these accessions is likely to result from their acceptability to the consumer in terms of colour, size and taste.

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