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YAM BEAN (Pachyrhizus spp.) VARIETY TRIALS IN TONGA, SOUTH PACIFIC: FRESH TUBER YIELDS, DRY MATTER AND NITROGEN CONTENTS

M. Grum, O. Stolen and M. Sorensen

Department of Agriculture,
P.O. Box 14, Nuku'alofa, Tonga and
Royal Veterinary and Agricultural University
Thorvaldsensvej 40, DK-1871
Copenhagen, Denmark.

ABSTRACT

A total of 16 accessions of Yam Bean (14 *Pachyrhizus erosus*, 1 *P. ahipa* and 1 *P. tuberosus*) were tested in a yield trial in Tonga. In addition 29 other accessions representing four different species of Yam Bean (24 *P. erosus*, 2 *P. ahipa*, 2 *P. tuberosus* and 1 *P. panamensis*) were observed in multiplication plots. In the yield trials fresh weight tuber yields were up to 72 tons/ha. Dry matter percentages ranged from 8.0 to 20.8 with dry matter yields ranging from 1,130 Kg/ha to 7,460 Kg/ha. Nitrogen contents of raw peeled tubers were between 0.82 to 1.57% giving crude protein yields of 71-540 Kg/ha, or about twice as much as sweet potatoes (*Ipomoea* spp.) when grown under similar conditions in Tonga.

INTRODUCTION

In continuation of the Yam Bean Project the first field trials and multiplication involving the germ plasm collected in Central and South America were initiated in the Kingdom of Tonga (South Pacific) during the Spring of 1989. The result from these first trials are presented below.

The material multiplied in Tonga has subsequently been distributed to INRA, Guadeloupe, F.W.I.; University of the West Indies, Trinidad; University of Benin, Benin; CATIE, Costa Rica and CIFAP / INIFAP, Mexico where field trials are presently being conducted in order to evaluate and isolate specific cultivars suitable for cultivation under different climatic conditions.

MATERIALS AND METHODS

A total of 16 accessions of Yam Bean (14 *Pachyrhizus erosus*, 1 *P. ahipa* and 1 *P. tuberosus*) were planted in a randomized complete block-design with 3 replicates. Each plot consisted of four rows, 5.25 m long and 0.75 m apart. Seeds were sown 0.35 m apart within the row.

The soil was a very fine clayey, halloysitic, isohypothermic, Typic Tropudoll, in a field that had been used for pasture for at least the five previous years. No fertilizers or pesticides were used. The land was ploughed and disc-harrowed.

The trial was planted 13th March, 1989 and irrigated once on 17th March. The weather was as summarized in table 1. Inoculants were applied on 5th April, 1989 by mixing 100 g of rhizobium culture with 300 l water and watering the field (approx. 1200 m^2) with the solution. The trial was weeded 12th April, 17th May and 22nd June. The inflorescences were removed from plants in the inner rows as this has been found to increase tuber yield (Noda and Kerr, 1983). The guard rows were left for seed production.

Table 1. Meteorological data

	March	April	May	June	July
Total rainfall/month (mm)	159.9	185.6	172.2	61.7	123.9
Monthly mean temperature(°C)	25.9	24.8	23.7	22.3	20.7
Total evaporation/month (mm)	128.6	155.9	105.2	93.3	106.7

Observations on defoliation caused by leaf feeders were done 11th July. Damage was evaluated on a 1-9 scale, as described in CIAT (1987), where "1" represents no defoliation and "9" represents more than 50% of the leaf area destroyed.

Replicates 1 and 2 were harvested on 28th July 1989 and replicate 3 on 1st August. The number of plants/plot were counted and tuberweight was recorded in the field. Three tubers, i.e., large, medium and small, were picked at random from each plot, for dry matter analysis.

The dry matter analyses were done by cutting a wedge out of each tuber, peeling and cutting it into small pieces and drying in an oven at approx. 65°C until constant weight (approx. 60 hrs.). Peeling the dry matter samples affected the calculations of dry matter yield. The data on the edible part of the tubers were given the highest priority.

Analyses - in duplicate - were made of the nitrogen content of peeled tubers from 14 of the 16 accessions tested plus one sample of cassava and one of sweet potato. A medium and a small sized tuber were picked from each accession. A semi-micro Kjeldhal procedure was used for estimating the nitrogen content.

An additional 29 other accessions representing four different species of Yam Bean (24 P. erosus, 2 P. ahipa, 2 P. tuberosus and 1 P. panamensis) were planted in multiplication on 13th March 1989. Rows were planted 50 cm apart and the within-row distances varied from 5-30 cm. The plots were harvested 27th July 1989. The dry matter content was recorded as described for the yield trials.

RESULTS AND DISCUSSION

An analysis of variance of the fresh weight tuber yield is presented in Table 2 and the means are illustrated in Figure 1.

In Table 3 an analysis of variance of the dry matter percentages is presented. The large, medium and small tubers taken as samples were analyzed as subplots to see whether there was a significant difference between dry weight percentages of different tuber sizes. The differences between individual blocks as well as between accessions are highly significant indicating that both genotype and environment influence dry matter percentages. The means are shown in Table 4.

The yield results of the trial were greatly influenced by the poor germination of some accessions. This, combined with the low seed rate, resulted in very poor stands in some plots. An analysis of covariance was made. The germination rates observed in the trial do not necessarily reflect the actual germination ability of the accessions. The effect of the very varied conditions under which the seeds have been produced and stored prior to planting influenced the germination rates. The coefficient of correlation between stand and dry weight tuber yield is 0.637. A plot of yield against stand is presented in Figure 2.

An analysis of variance of dry weight tuber yield is presented in Table 5 together with an analysis of covariance of dry weight tuber yield with stand. The adjusted means for the dry weight tuber yields are presented in Table 6 alongside the actual means and the rankings from a Duncan test.

The F-value for the analysis of covariance, though much smaller than the F-value for the analysis of variance, is still highly significant. This indicates that even if all accessions had germinated evenly the accessions would still have shown significant differences. The adjustment of the means for stand did not alter the ranking of the first eight varieties, but the Duncan test of the adjusted means indicates that the differences may not be as significant as implied by the Duncan test of the unadjusted means.

Table 2. Analysis of Variance of Fresh Weight Tuber Yield in kg/ha.

Source of variation	df	sums of squares	Mean square	F
Total	47	23456689547.1		
Blocks	2	1358120739.9	679060369.9	12.4***
Accessions	15	20458315263.1	1363887684.2	25.0
Error	30	1640253544.1	54675118.1	

Coefficient of Variation = 16.70%
* Significance level - 0.05
** Significance level - 0.01
*** Significance level - 0.001

Table 3. Analysis of Variance of Dry Matter Percentages.

Source of variation	df	sums of squares	Mean squares	F
Total	133	2014.6		
Blocks	2	27.3	13.7	6.0***
accession (A)	14	1760.8	125.8	54.9
Error	28	64.2	2.3	
Tuber size (B)	2	1.2	0.6	0.4
AB	28	65.6	2.5	1.6
Error	59	91.6	1.6	

Coefficient of Variation = 11.30%

Table 4. Mean Dry Content (%) and Duncan Test*

AC524	20.84	a
TC118	18.32	b
EW229	12.44	c
EW228	11.51	cd
EC041	11.03	cde
EW227	10.54	def
EC120	10.27	def
EC040	10.08	def
EC033	9.44	efg
EC204	9.25	fg
EW230	9.04	fg
EC219	8.21	g
EC214	8.20	g
EC006	8.10	g
EC2046	8.00	g

* * Means followed by same letter are not significantly different at P = 0.05.

Table 5. Analysis of Variance of Dry Weight Tuber Yield (Y) in kg/ha and an Analysis of Covariance of DW Tuber Yield with Stand (X) in plants/plot.

Source of variation	df	Sums of squares and products SSX	SXY	SSY	MSY	F
Total	44	737.8	227705.1	172830484		
Blocks	2	24.6	21235.6	18956737	9478368.5	12.0***
Accessions	14	564.4	196304.8	131779749	9412839.2	11.9***
Error	28	148.8	10164.7	22093998	789071.4	
Accessions + error	42	712.44	206469.52	153873747		

	df	Y adjusted for X SS	MS	F
Error	27	21399416.0	792571.0	
Accessions + error	41	94146137.1		
Accessions adjusted	14	72746721.1	5196194.4	6.6***

Table 6. Mean Dry Weight Tuber Yields in kg/ha and adjusted means.

Accession	Means		Adjusted means	
EC120	7460	a	7254.7	a
EC040	6698	ab	6493.7	ab
EC041	6185	abc	5980.9	abc
EC033	5827	bc	5736.4	abcd
EW230	5727	bcd	5499.3	bcde
EW227	5456	bcde	5227.9	bcde
EC006	4832	cdef	5060.1	bcdef
EC204	4803	cdef	4666.3	cdef
EW228	4123	def	3963.2	ef
EC104	4009	ef	3940.4	ef
EC214	3834	ef	4243.5	def
EW229	3472	f	3449.5	f
EC219	3355	f	3810.1	ef
TC118	1563	g	1881.8	g
AC524	1131	g	1373.8	g

Tonga 1989.

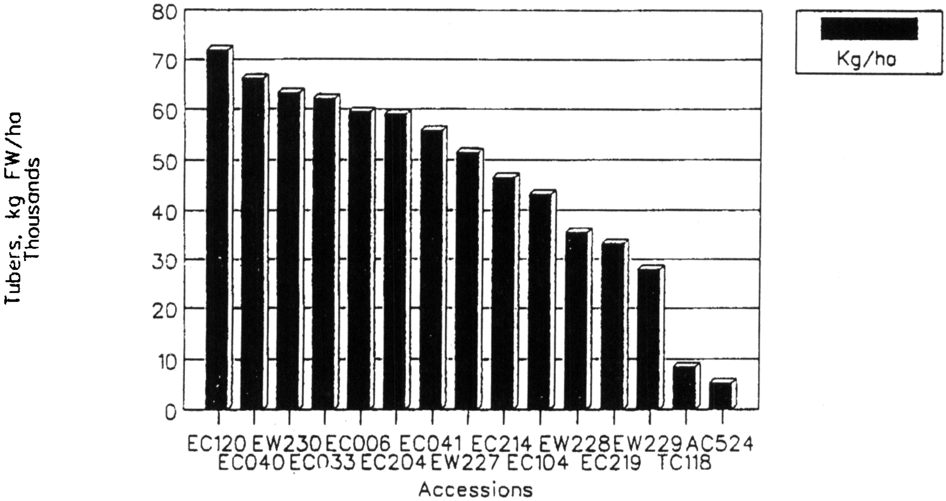

Fig. 1. Fresh weight yields.

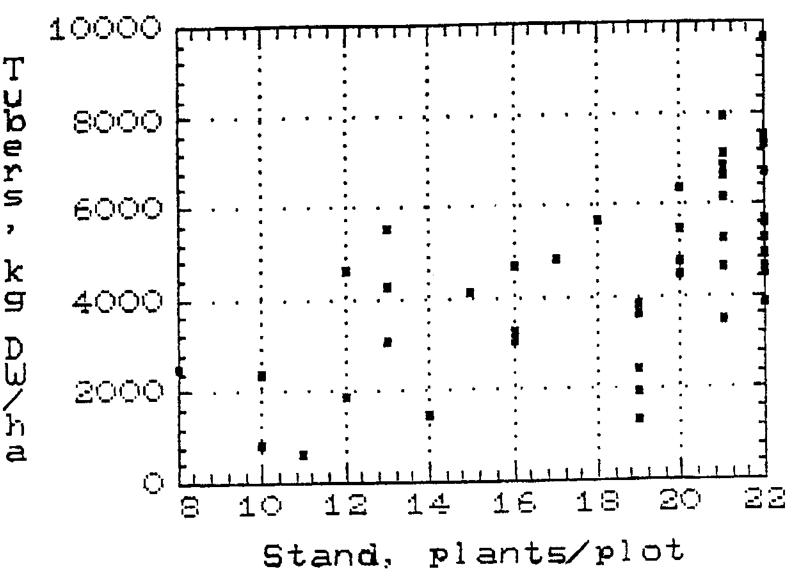

Fig. 2. Dry weight yield against stand.

The coefficient of variation for the analysis of variance for the dry weight tuber yield was 19.25%, only slightly higher than for the fresh weight tuber yield. This indicates that the sampling method used for the dry matter analysis was sufficiently accurate and the number of tubers sampled was large enough.

The yield of AC524 (P. ahipa) was greatly affected by a fungal disease, caused by Cercospora canescus. Spraying would undoubtedly have given this accession a substantially higher yield.

The P. ahipa accessions have generally much smaller plants than the other accessions and hence should be planted at much higher densities to give optimum yield. The P. tuberosus, on the other hand, grew very long vines and developed a thick foliage easily covering the ground despite the low number of plants/plot. Generally, plant density appeared to be too low, with very few accessions having a canopy sufficiently dense for optimum photosynthesis.

Nitrogen content

Observations on nodulation were carried out 30th June, when tuber growth was well advanced. The plants showed no signs of active symbiotic fixation. No pink or red nodules were found. On the other hand all plants had a lush green color indicating that nitrogen was in plentiful supply. This could either be the result of very high soil fertility in the field or of earlier nitrogen fixation.

Figures for mean nitrogen content, percentage crude protein (N x 6.25) and protein yield of tubers are presented in Table 7. Two replicates were not sufficient to test the significance of the observed differences, but a fair consistency was observed. There was a tendency for small tubers to have a lower nitrogen concentration than the overall given the accession.

A negative correlation of -0.71 was obtained between nitrogen content and dry matter yield when the outlier results from AC524 had been removed (Figure 3.).

Pests

Two kinds of leaf feeder damage were observed. One was caused by an unidentified larvae which attacked the leaf edges. This damage was observed in all accessions, but was never serious. The other type observed was caused by the Rose Beetle, Adoretus versutus. The amount of damage caused varied greatly among varieties, i.e., some showing no damage while others had more than 10% of the leaf area destroyed. Defoliation did not show linear correlation with yield. The combined scores are shown in Table 8.

Table 7. Nitrogen Content, Crude Protein yield per ha of the different accessions.

Accession no.	Nitrogen % of DM	Crude protein % of DM	Crude protein kg/ha
EC120	1.19	7.4	540
EC040	1.05	6.6	426
EC041	1.23	7.7	458
EW230	1.38	8.6	465
EW227	1.14	7.1	372
EC006	1.33	8.3	420
EW228	1.33	8.3	324
EC104	1.57	9.8	388
EC214	1.37	8.5	362
EW229	1.35	8.4	291
EC219	1.40	8.8	333
AC524	0.82	5.1	71
Cassava	0.31	2.1	-
Sweet potato	.27	1.8	180

Table 8. Leaf feeder defoliation on a 1-9 scale.

Accession no.	Replicate no. 1	2	3
AC524	3	3	3
EC006	3	3	3
EC033	5	5	5
EC040	2	2	2
EC041	3	2	2
EC104	4	4	4
EC120	2	2	2
EC204	2	2	2
EC214	6	5	5
EC219	5	5	5
EW053	2	1	1
EW227	2	2	2
EW228	2	2	2
EW229	2	2	2
EW230	2	2	2
TC118	3	3	2

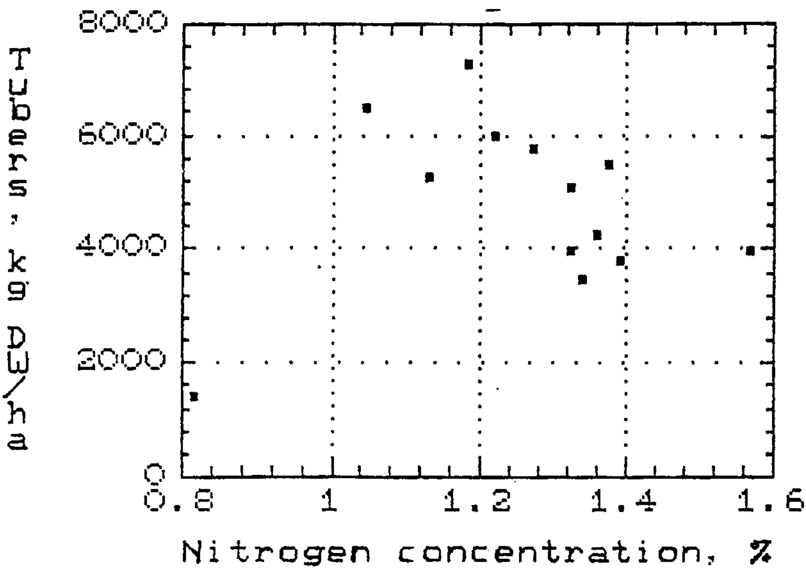

Fig. 3. Dry weight tuber yield as a function of nitrogen concentration.

Multiplication Plots

Table 9 gives the accessions and dry matter percentages from the multiplication plots. The fresh weight tuber yields are shown in Figure 4. The planting distances being so varied and neighbor effects being very obvious, these yields are therefore in no way comparable. Furthermore, the fertile shoots were not removed thus, tuber yields would be expected to be lower than those observed in the yield trials.

Table 9. Dry matter Content of Accessions in Multiplication Plots

Accession no.	Dry matter %
AC102	20.0
AC521	20.2
EC042	10.8
EC043	9.6
EC114	6.7
EC117	8.7
EC205	8.5
EC226	8.6
EC501	10.6
EC502	9.2
EC503	7.9
EC509	8.3
EC510	7.6
EC516	11.6
EC523	8.5
EC525	8.7
EC526	8.5
EW048	23.3
EW049	23.9
EW050	24.3
EW051	23.1
EW054	22.6
EW203	28.6
EW207	22.8
EW209	23.4
EW522	17.1
PW055	27.4
TC122	12.2
TC525	16.9

CONCLUSION

Based on the results recorded from these first field trials it appears that the magnitude of the yield variation between the different species and between the different varieties belonging to the same species indicates that well adapted cultivars for

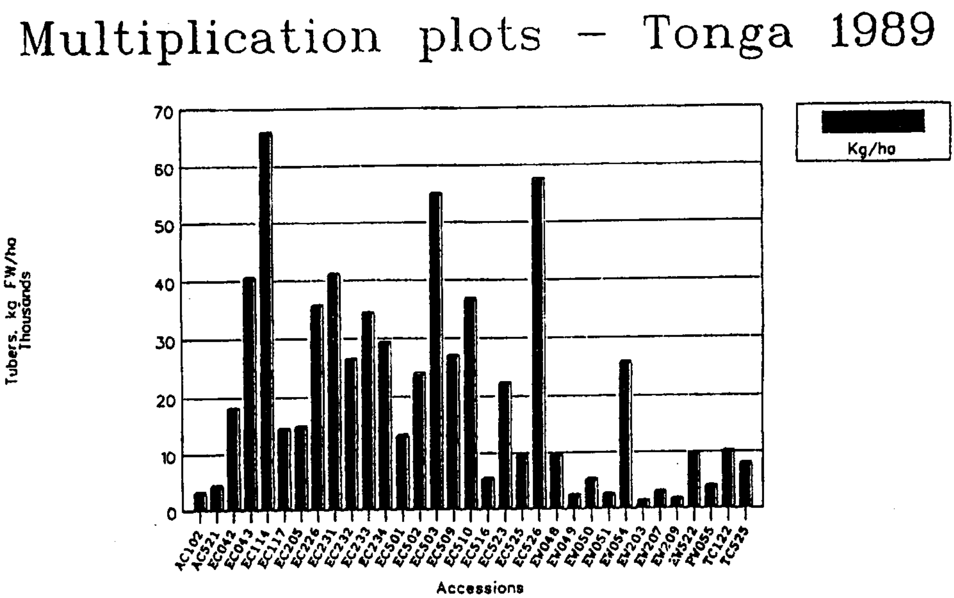

Fig. 4. Fresh weight tuber yields.

the more humid areas of the tropics can be developed. Although these results cannot be used in evaluating/isolating suitable types for cultivation in areas with lower precipitation rates it has been shown that multiplication is in fact possible under more humid conditions. Subsequent trials in the Caribbean and Central America will serve to isolate new cultivars for this region.

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