GROUNDNUT VARIETY EVALUATION IN THE SOUTHERN HIGHLANDS OF PAPUA NEW GUINEA

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Department of Primary Industry
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Food Crops Agronomists

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<u>AFTSEMU</u>

The Agricultural Field Trials, Studies, Extension and Monitoring Unit (AFTSEMU) was established as a component of the Southern Highlands Rural Development Project (SHRDP). Part of its work was to research the subsistence agricultural systems of the province so as to provide a better understanding of these systems and develop guidelines for their improvement.

The results of AFTSEMU's research are published as a series of Technical Reports, of which the following are complete or in press.

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   (D.J. Radcliffe)

2. Land Evaluation for Food Crop Production in Papua New Guinea.
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3. The Land Resources of Pomiorine Experimental Farm.
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4. A Study of Gardening Activity and Bodyweight in the Southern Highlands of Papua New Guinea.
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5. The Land Resources of Kiburu Experimental Farm.
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6. The Land Resources of Piwa Experimental Farm.
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7. The Land Resources of Kuma Experimental Farm.
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9. Maize Variety Evaluation in the Highlands of Papua New Guinea.
   (C.N. Floyd)

10. Evaluation of Introduced Vegetable Varieties on Volcanic Ash Soils in the Southern Highlands of Papua New Guinea.
    (M.B. Kanua and E.J. D'Souza)

11. Groundnut Variety Evaluation in the Southern Highlands of Papua New Guinea.
    (C.N. Floyd and E.J. D'Souza)

ABSTRACT

A series of experiments are reported which evaluated ten varieties of groundnuts (Ararchis hypogeae) from within Papua New Guinea, and sixty varieties imported from ICRISAT, India, in the Southern Highlands.

Varieties which gave increased yields relative to local varieties are recommended from the evaluation of the Papua New Guinea germplasm. In particular, a Virginia bunch variety appeared well suited to the environment and further study is required to determine its acceptibility to local growers. Because of the large numbers of varieties involved, the evaluation of the ICRISAT germplasm was comparatively restricted. However, seven varieties gave significantly greater yields than the local varieties, with a maximum of a 60% yield increase. It is recommended that further more extensive evaluation of this germplasm be undertaken.

The results of two disease surveys of groundnuts which were undertaken to complement the variety evaluation programme are summarised. In the Southern Highlands, early leaf spot (Cercospora arachidicola) appeared to be a major constraint to groundnut production. As none of the evaluated varieties showed marked resistance to early leaf spot, the identification of resistant varieties is recommended as a priority. No economically important virus disease of groundnut was identified in the survey, and this result warrants that strict quarantine regulations on the import of groundnut seed into Papua New Guinea be maintained.

Priorities for further study and extension with groundnuts are discussed.

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Groundnut disease surveys were carried out in co-operation with National DPI staff, and in particular we wish to thank Dr. Tomlinson (DPI Plant Pathology) and Mr. Arigena (DPI Bubia) for their involvement.

We are also grateful to the ICRISAT Groundnut Improvement Program for supplying germplasm, and to Dr. D.V.R. Reddy for visiting Papua New Guinea to conduct his survey.

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1. INTRODUCTION

In the Southern Highlands of Papua New Guinea groundnuts (Arachis hypogaea) are grown at altitudes below approximately 1800m, but particularly below 1400m, and in areas of soils derived from limestone: for example, in the Poroma sub-district and the West Wiru area of Pangia. Although groundnuts are a minor crop in terms of area cultivated they are a popular cash crop which is sold as a snack food (roadside prices for groundnuts are approximately K 3.00/kg seed).

In addition to their importance as a cash crop, groundnuts are potentially an important supplementary food crop in the staple diet of sweet potato. In comparison to sweet potato, groundnuts are protein and energy rich. Groundnut seeds contain 332 to 548 kcal per 100 g edible portion in comparison to 108 to 114 kcal per 100 g edible portion for sweet potato (SPC, 1983; WHO, 1979). The protein content of groundnuts varies between 15 and 25 g per 100 g edible portion in comparison to the 1 to 1.5 g per 100 g edible portion for sweet potato (SPC, 1983; WHO, 1979). In addition to being nutritious, groundnuts are also a highly palatable and appetising food.

Unfortunately, despite the advantages of groundnuts as a food and cash crop, they must be regarded as a somewhat marginal crop for much of the Southern Highlands for the following reasons.

1. The relatively warm and humid climate of the Southern Highlands is ideally suited to the occurrence of leaf spots of groundnuts. Leaf spots are important diseases of groundnuts worldwide, although early leaf spot (Cercospora arachidicola Hori) is of lesser importance than late leaf spot (Phaeoisariopsis personata). However, in the highlands of Papua New Guinea, and in a few countries with similar environmental conditions, for example Malawi, Cercospora early leaf spot is the more important disease. Yield losses of 50% from these leaf spots in groundnuts have been recorded (Martin, 1984) and the possibilities for disease control are limited at present to the use of an adequate break between crops.

2. Soils derived from volcanic ash are the predominant soils of the area and are regarded as unsuitable for groundnut production, as they are for many non-traditional crops (Radcliffe, 1983). As groundnuts are a legume, soil fertility considerations must include, not only the requirements for plant growth, but also the requirements of rhizobia persistence, infection and function. Thus volcanic ash soils will tend to be deficient in phosphorus and potassium for plant growth, and in calcium and trace elements for effective rhizobia

infection and function. Like other legumes, groundnuts may make limited demands on soil nitrogen, but, in the absence of effective inoculation, as is probably often the case in these soils (see 3 below), the nitrogen requirements of groundnuts are similar to those of comparable non-legume crops. Thus, for groundnuts, the levels of available soil nitrogen may also be deficient in volcanic ash soils.

3. The presence in the soil of suitable strains of rhizobia is necessary for successful infection. Groundnuts require rhizobia of the cowpea type and field experience supports the view that rhizobia inoculation of groundnuts is not widespread in these soils. Two reasons seem likely for this. Firstly, cowpea-rhizobia infected legumes are not widely distributed and this limits the incidence of suitable rhizobia. Secondly, soils may not be well suited to the survival of the rhizobia. However, it does seem that where groundnuts are grown successively that rhizobia populations build up in the soil and that groundnuts are then well nodulated.

4. The altitudinal limit of approximately 1800m for groundnuts means that many people in the Southern Highlands cannot grow groundnuts, or if they do, yields will be poor because the altitude is too high.

Despite the nutritional importance of groundnuts, AFTSEMU devoted a limited amount of its agronomic work to groundnuts. Taking into account the likely restrictions to groundnut production and the agronomic research resources available, it was decided to concentrate only on variety identification work on a limited scale. However, in conjunction with variety identification, seed multiplication of varieties was increased for distribution to individuals and institutions in order to stimulate the production of groundnuts in the Southern Highlands. It was considered that a limited awareness of groundnuts as a crop, and the scarcity of seed in areas where the crop was not established, represented important constraints to production.

Variety identification work evaluated germplasm from two sources. Firstly, the germplasm available within Papua New Guinea (PNG), and secondly, germplasm imported from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India.

The evaluation of PNG and ICRISAT germplasm are reported, respectively, in Parts 2 and 3 of this report. Virus disease surveys carried out in conjunction with these evaluations are reported in Part 4. Part 5 discusses the results of these evaluations, particularly in terms of their implications for further work. Conclusions are given in Part 6.

Table 1: Varieties tested in PNG variety Trials I and II.

Variety	Type	Source of seed
Markham White	White seeded spanish	DPI, Keravat
Gazelle White	White seeded spanish	DPI, Keravat
Kiburu White*	White seeded spanish	DPI, Mendi
White Spanish	White seeded spanish	DPI, Bubia
New Ireland Red	Red seeded spanish	DPI, Keravat
Gazelle Red 1	Red seeded spanish	DPI, Keravat
Gazelle Red 2	Red seeded spanish	DPI, Keravat
Kiburu Red	Red seeded spanish	DPI, Mendi
Red Spanish	Red seeded spanish	DPI, Bubia
Virginia Bunch	Virginia bunch	DPI, Bubia

* Not included in trial II

2. PNG GROUNDNUT VARIETY TRIALS

Varieties from within Papua New Guinea were evaluated in two trials. As these two trials, MAH 1 (1)* and MAH 1(4)*, had slightly different treatment combinations, experimental designs and methods they are reported separately as Trials I and II respectively .

NOTE

* Experiment identity number from DPI Biometrics, Department of Primary Industry, Konedobu, NCD, Papua New Guinea. A set of experimental data for trials reported in this document is held by DPI Biometrics.

Ten groundnut varieties were evaluated in Trial I and nine of them in Trial II. The varieties tested are listed in Table 1. Both trials were conducted on an alluvial volcanic ash soil (Kiburu series) at Kiburu Farm, Mendi, Southern Highlands Province. A description of the Kiburu series is given in Appendix I.

2.1. PNG variety Trial I

2.1.1. Method

In this trial, the ten varieties were evaluated in factorial combination with two levels of an inoculation treatment (inoculated and not inoculated) with rhizobium inoculum CB 756. The twenty treatment combinations were combined in a randomised factorial in two replications. Plot size was four 5m rows 30cm apart and the crop was planted at a within row spacing of 20cm, giving a plant population of 166,666 pl/ha. At harvest, all plants in the central two rows of each plot were used for yield determination.

A fertilizer application of 20kg N, 40kg P, 40kg K and 50kg Mg per ha as, respectively, ammonium sulphate, triple superphosphate, muriate of potash and Epsom salts, was applied to the experimental area and incorporated during seedbed cultivation. As the seeds from some sources had already been treated with Captan when received, all seeds to be used in this trial were treated with Captan two weeks before planting.

Table 2: Effect of inoculation treatments on experimental variables in PNG variety Trial I.

Inoculation treatment	Seed yield t/ha	Plants at harvest '000/ha	Shelling %	Test wt 100 g	Pod no per plant	Seed no per plant
Not inoculated	0.93	137	71	53	8.1	13.1
Inoculated	0.86	127	71	54	7.9	12.6
LSD (5%)	0.14	15	2	2	1.6	2.3

	Seed no per pod	Leaf loss score	Leaf greeness score	Nodule no per 5 plants	Nodule wt per 5 plants
Not inoculated	1.66	2.55	2.85	186	0.46
Inoculated	1.65	2.55	3.15	230	0.61
LSD (5%)	0.16	0.32	0.33	58	0.13

On the day of planting (26 January 1984), seeds to be treated were inoculated with rhizobium CB 756 as recommended. The bacteria was supplied on agar jelly and was washed from its container using repeated washings of a 10% sugar solution. The bacterial suspension was then divided into 10 aliquots and each aliquot mixed with equal weights of seed from each variety. The seed was thoroughly wetted during inoculation and was allowed to dry in a cool, shady place, before planting.

During growth, the crop was kept weed free by hand weeding and no other plant protection measures were taken.

Four months after planting, 5 plants were taken at random from the discard rows of each plot. These plants were immediately scored for leaf colour on a scale of 0-5, where 0 represented light green and 5 represented dark green. Plant roots were washed in water to remove soil and oven dried at 80 C. After drying, nodules were removed from the roots using a scalpel and the number of nodules present and total nodule weights determined.

Varieties were harvested at maturity. Immediately before harvest each plot was scored for the amount of leaf loss on a scale of 0-5, where 0 represented no leaf loss and 5 complete leaf loss. The number of plants harvested was recorded and after air drying the pod numbers, pod yield, seed yield and seed test weight were recorded.

2.1.2. Results

a) Inoculation

The effect of inoculation on experimental variables is given in Table 2. Inoculation had a significant effect only on nodule weight per 5 plants which increased with inoculation. Although the effect was not significant, inoculation also increased nodule number per 5 plants, and resulted in a darker green leaf colour. Inoculation had a negative, but not significant effect, on seed yield and other yield related variables.

There was an approximately 25% loss of plants during early growth as a result of germination failure and collar rot (Sclerotium rolfsi). This effect was slightly greater in inoculated plots, probably because inoculation reduced the effectiveness of the fungicidal seed treatment.

Table 3: Variety means for leaf loss, leaf greeness, nodule number and nodule weight in PNG variety Trial I.

Variety a)	Leaf loss score #	Leaf greeness score	Nodule no per 5 plants	Nodule wt g per 5 plants
Markham white	2.25 ab	2.75 ab	208	0.48
Kiburu Red	3.00 bc	2.75 ab	282	0.58
Virginia Bunch	1.75 a	3.50 a	267	0.58
New Ireland Red	2.75 bc	3.50 a	161	0.55
Gazelle Red 2	2.75 bc	3.00 ab	154	0.38
Kiburu White	2.25 ab	2.50 b	162	0.40
Gazelle White	2.50 bc	2.75 ab	238	0.58
Red Spanish	3.25 c	3.50 a	169	0.63
White Spanish	2.75 bc	2.50 b	232	0.63
Gazelle Red 1	2.25 ab	3.25 ab	208	0.55
LSD (5%)	0.72	0.73	130	0.30
CV%	19.1	16.4	42.2	38.1

a) Varieties are ranked by descending order of seed yield from Table IV.
\# Duncans multiple range test - means followed by the same letter are not significantly different ($P<0.05$) from one another.

Table 4: Variety means for yield variables in PNG groundnut variety Trial I.

Variety a)	Seed yield t/ha	Plant no '000/ha	Shelling %	Test wt g/100 seed	Pod no per plant	Seed no per plant	Seed no per pod
Markham White	1.40 a	130 a	71	63 a	10.9	14.1	1.39 d
Kiburu Red	1.16 ab	140 a	73	58 abc	7.7	14.8	1.97 ab
Virginia Bunch	1.02 bc	155 a	67	57 bcd	8.1	11.5	1.45 cd
New Ireland Red	0.94 bc	125 a	73	49 ef	8.2	14.9	1.86 abc
Gazelle Red 2	0.86 bc	125 a	74	45 f	6.6	13.2	2.03 a
Kiburu White	0.86 bc	150 a	70	53 bcde	6.5	10.4	1.58 bcd
Gazelle White	0.82 c	130 a	73	59 abc	7.6	11.9	1.61 bcd
Red Spanish	0.81 c	158 a	69	47 f	6.9	10.7	1.61 bcd
White Spanish	0.80 c	150 a	73	57 bcd	6.3	9.5	1.49 bcd
Gazelle Red 1	0.27 d	30 b	70	50 ef	11.4	17.5	1.56 cd
LSD (5%)	0.31	30	5	3	3.5	5.1	0.36
CV%	23.5	16.7	4.2	6.4	29.4	26.9	14.6

a) Varieties are ranked by descending order of seed yield.

\# Duncans multiple range test - means followed by the same letter are not significantly different ($P<0.05$) from one another.

b) Varieties

Variety means for leaf scores and nodule related variables are given in Table 3, and for yield related variables in Table 4.

There were no significant differences between varieties in nodule number or nodule weight per 5 plants. Virginia Bunch, New Ireland Red and Red Spanish had the greenest leaves followed, as a group, by the red Spanish and white Spanish types. These differences are characteristic of these different types of groundnut. Differences in leaf loss between varieties followed a similar pattern and the differences were significant. Leaf loss was greatest in the two red Spanish varieties Red Spanish and Kiburu Red, and least in Virginia Bunch. The remaining red Spanish varieties and the white Spanish varieties gave intermediate levels of leaf loss (Table 3).

There were significant differences between varieties in seed yield, seed test weight and seed number per pod; the significant difference among varieties in number of plants harvested was due to the poor establishment of Gazelle Red 1. Markham White was the highest yielding variety with a seed yield of 1.4 t/ha although this was not significantly greater than the next highest yielding variety Kiburu Red. There were no significant differences between other varieties in the trial except for Gazelle Red 1 which gave a low yield as a result of its low plant population.

There were no significant interactions between inoculation and variety treatments for any variable.

c) Replicate differences

There was a significant difference between replicates for many of the experimental variables; replicate I had a higher yield, less disease, and a greater number and weight of nodules. The reason for this is not certain but is probably related to soil fertility differences between the replicate sites. A result of the differences between replicates was that correlations between variables across all experimental units suggested many interesting significant relationships, notably that seed yield was positively correlated with nodule numbers and weight, and negatively with leaf loss score. These correlations were not obtained when data for treatment combinations meaned over the two replicates was used.

Table 5: Variety means for experimental variables in PNG variety Trial II.

Variety a)	Days to harvest	Leaf loss score (0-5)	Shelling %	Seed yield t/ha	Test wt 100 seed g
Virginia Bunch	200	2.8abcd	62.7d	1.71 a#	69.1a
Markham White	152	2.5abc	67.9ab	1.12 b	59.7b
White Spanish	152	2.2a	65.0bd	1.10 bc	58.4b
Kiburu Red	137	2.3ab	67.3abd	1.09 bc	51.2c
Gazelle White	161	3.2cde	66.8abd	1.05 bc	59.8b
Red Spanish	146	3.5def	71.0a	0.93 bc	42.2de
New Ireland Red	137	3.5def	70.4a	0.90 cd	39.0e
Gazelle Red 1	154	4.0ef	68.1ab	0.90 cd	46.9cd
Gazelle Red 2	145	4.2f	63.4bd	0.72 d	41.8d
LSD (5%)	18	0.79	4.4	0.18	5.8
CV%	41.6	21.3	5.6	13.8	7.8

a) Varieties are ranked by descending order of seed yield.
\# Duncans multiple range test - means followed by the same letter are not significantly different ($P<0.05$) from one another.

Table 6: Relationship between seed yield, maturity and leaf loss for variety means in PNG variety Trial II.

Variables			Coefficients			
Y	X_1	X_2	a	b	c	r
Seed yield	Maturity		-0.85	0.01		0.85**
Seed yield	Leaf fall		1.74	-0.22		0.57ns
Maturity	Leaf fall		4.00	-0.01		0.14ns
Yield	Maturity	Leaf fall	-0.15	0.01	-0.17	0.96***

** - P<0.01   *** - P<0.001

2.2. PNG variety Trial II

2.2.1. Method

All the varieties from Trial I, except Kiburu White were evaluated in this trial which was conducted on an adjacent site to Trial I on the Kiburu series. A description of the Kiburu series is given in Appendix I.

A randomised block design in six replicates was used with a plot size of two rows 30cm apart and 5m long. At harvest all plants from each plot were used for yield determination. Replicates were arranged in a contiguous block and two rows of Red Spanish groundnuts were planted around the experiment to provide a discard area.

Seeds were planted at a plant population of 166,666 pl/ha with one seed per station, i.e. at 20cm spacing in the rows. The stand was gap filled when emergence of the initial planting appeared complete. At planting, a seed dressing of Captan was used.

Fertilizer was applied three days before planting, during seed bed preparation, at rates of 20kg N/ha, 40kg K/ha, 40kg P/ha and 5kg Mg/ha as, respectively, ammonium sulphate, triple superphosphate, muriate of potash and Epsom salts. The experiment was planted on 9 November 1984 and varieties were harvested when judged mature. The days to harvest for each variety are given in Table 5. The experiment was kept weed free by hand weeding and no other plant protection measures were taken.

At harvest, each plot was scored for leaf loss on a scale of 0 (no leaf loss) to 5 (complete leaf loss). Leaf loss was mainly as a result of *Cercospora* early leaf spot.

2.2.2. Results

Results are given in Table 5. Virginia Bunch was the highest yielding variety, its yield of 1.7 t seed/ha was significantly greater than all other varieties. Varieties are listed in order of descending yield in Table 5, but, except for Gazelle Red 2, the significance of yield differences between varieties, other than Virginia Bunch, were small. Of the white and red Spanish types of groundnut the varieties Markham White and Kiburu Red were respectively the highest yielding variety. There were also significant differences between varieties in leaf loss, shelling % and seed test weight.

The relationships between variety seed yield, maturity and leaf loss were examined in single and multiple regression and results are summarised in Table 6. Seed yield was positively correlated with time to maturity, and negatively correlated with leaf loss. The significance and pattern of results differed little whether values for all experimental units or those for variety means (across replicates) were used in the regressions. Results given in Table 6 are for variety means.

2.3. Discussion

a) Inoculation treatment

The inoculation treatment in Trial I had a very limited effect. Inoculum CB 756 is known to be effective for groundnuts under field conditions although it may not compete well with indigenous rhizobia. This does not, however, appear to be the case in this trial as nodulation was poor in plots which were not inoculated, this suggests that the indigenous soil population of groundnut inoculating rhizobia was low.

Further possible explanations for the lack of inoculum effectiveness are that the inoculant contained too few rhizobia, that the rate of inoculant application was too low, or that CB 756 is not adapted to the volcanic ash soil used. As the rate of inoculation application used was approximately ten times that recommended, it seems unlikely that inoculation rate was too low. It is possible that the inoculum was not viable or that the Captan seed dressing had deleterious effect on the rhizobium.

CSIRO (private communication) report that it is unlikely that the soil pH of 5.2 is, per se, sufficiently low to prevent nodulation of groundnuts with CB 756. CSIRO further suggest that a rhizobia for inoculating groundnuts in a volcanic ash soil could be prepared from the inoculation of groundnuts growing in a rhizobia-free substrate with the volcanic ash soil taken from the base of a legume already growing in that soil. This treatment should yield nodules and the most effective looking nodules should yield a strain of rhizobia suitable for further inoculation.

b) Varieties

The yield of the common varieties in the two trials were positively, but not significantly, correlated to each other. The ranking of varieties in each trial were, however, positively and significantly correlated. The major deviation in performance was the relatively poor yield of White Spanish in Trial I, and its good yield in Trial II.

There was a distinction between the mean yield over both trials between the three top yielding varieties and the other varieties as follows:

	Variety	Mean seed yield t/ha
1.	Virginia Bunch	1.36
2.	Markham White	1.26
3.	Kiburu Red	1.12
4.	White Spanish	Ø.95
5.	Gazelle White	Ø.93
6.	New Ireland Red	Ø.92
7.	Red Spanish	Ø.87
8.	Gazelle Red 2	Ø.79
9.	Gazelle Red 1	Ø.58

On the basis of this result it is recommended that Virginia Bunch, Markham White and Kiburu Red replace Kiburu Red and Kiburu White as varieties for multiplication in the Southern Highlands.

3. ICRISAT VARIETY TRIALS

Two trials were used to evaluate ICRISAT germplasm. The first, MAH 1(2), evaluated all sixty four of the imported ICRISAT germplasm lines, and the second, MAH 1(3), evaluated eighteen of these lines. These two trials are reported separately below in sections 3.1 and 3.2 respectively. The MAH trial numbers refer to DPI biometrics reference numbers as described in 2. above.

3.1. ICRISAT variety trial at Kiburu

3.1.1. Method

In this trial all of the ICRISAT elite breeders and germplasm lines were evaluated against one local variety, Red Spanish. A list of the varieties evaluated in this trial is given in Table 7. The trial was conducted at Kiburu farm, Mendi, Southern Highlands Province, on an alluvial volcanic ash soil of the Kiburu series. A description of the Kiburu series is given in Appendix I.

Because of the limited amount of seed available, the large number of varieties to be evaluated and restrictions in the configuration of available land, an unsatisfactory experimental design was used. This was a randomised block design in three replicates with a plot size of one 60cm row 8m long. At harvest all plants from each plot were used for yield determination. A row of the local variety Red Spanish was grown as every tenth row to provide a control yield. Thus each replicate consisted of 75 adjacent rows.

Seeds were planted at 20cm spacing in the row, giving a plant population of 83,333 pl/ha, with one seed per station. The stand was gap filled when emergence of the initial planting appeared complete. At planting, a seed dressing of Captan was used.

Fertilizer was applied two days before planting, during seed bed preparation, at rates of 20kg N/ha, 40kg K/ha, 40kg P/ha and 5kg Mg/ha as, respectively, ammonium sulphate, triple super phosphate, muriate of potash and Epsom salts. The experiment was planted on 21 May 1984 and varieties were harvested when judged mature. The days to harvest for each variety is given in Table 7. At harvest, each plot was scored for leaf loss on a scale of 0 (no leaf loss), to 5 (complete leaf loss). The experiment was kept weed free by hand and no other plant protection measures were taken.

Table 7: Variety means for experimental variables in ICRISAT trial at Kiburu.

Variety NG no	Variety ICGS no	Days to harvest	Leaf Hopper damage (0-5)	Leaf loss score (0-5)	Seed yield g/row #
8619	6029	178	3	1.5	251a
8645	6829	182	2.7	1.5	246ab
8628	6251	192	2.5	2	185abc
8643	6694	NR	2	1.5	183abc
8624	6207	192	1.7	1.5	175abc
8646	7244	227	1	NR	171bc
Red Spanish		178	3.4	2	163c
8658	7425	189	2	3.5	162c
8627	6250	170	2.3	2.5	162c
8601	34	192	1.3	3.3	154c
8615	5156	178	1.5	3.5	147c
8616	5967	221	1	NR	141c
8599	30	185	1.7	2.3	139c
8654	7398	170	2	4.5	135c
8594	17	221	1	2	133c
8623	6203	242	2	2.3	132c
8635	6261	185	1	3	125c
8612	4091	181	2.7	2	121c
8640	6400	174	2.5	3	121c
8596	19	238	1	NR	119c
8639	6390	170	1.5	4.5	119c
8631	6256	259	1	NR	117c
8597	20	203	1	2	117c
8642	6443	205	1.7	1	114c
8659	7429	192	2	3	113c
8636	6282	178	1.3	3.3	111c
8638	6370	178	2.3	3	110c
8602	35	238	1	NR	110c
8600	31	194	1.7	3	108c
8611	372	170	1.5	3.8	107c
8656	7412	174	1	4.5	103c
8609	51	198	1	2.5	102c
8653	7388	170	2	3	101c

Table 7: (Continued)

8633	6258	192	1	4	97
8592	5	249	1	NR	91
8626	6235	206	1	0.5	91
8632	6257	192	1	1.5	89
8651	7314	242	1	NR	85
8655	7400	171	1.5	3.5	85
8641	6407	170	1	4	83
8604	45	196	1.7	1	81
8617	6012	178	2	0.5	80
8613	4103	198	1.3	3	77
8647	7257	242	1.3	NR	77
8644	6733	189	2	2	77
8625	6233	196	1.5	2.3	76
8610	56	249	1	NR	75
8605	47	249	1.3	NR	74
8649	7304	198	2	2.3	73
8650	7310	170	2	4.5	71
8618	6028	192	2.5	1.3	70
8595	18	227	1.3	NR	69
8637	6330	256	1	NR	68
8621	6183	256	1	NR	64
8606	48	230	1.3	1	62
8620	6149	249	1	NR	59
8591	4	244	1	NR	58
8634	6259	185	1	4	56
8608	50	249	1.7	1.5	52
8657	7423	249	1	NR	46
8660	7443	249	1.5	NR	46
8652	7345	249	2	NR	41
8614	4989	256	1.5	NR	13
8622	6184	207	1	0.5	12
8630	6255	254	1	NR	11

Duncans multiple range test - means followed by the same letter are not significantly different ($P<0.05$) from one another. Separation is only given for means that are greater than or equal to Red Spanish.

3.1.2. Results

Variety means for days to harvest, leaf hopper damage score, leaf loss score and seed yield per row are given in Table 7. In Table 7 Duncan's multiple ranges for seed yield are given only for varieties with yields greater than, or not significantly different from, the control Red Spanish. Only two varieties, NG 8619 and NG 8645, gave a significantly greater yield than Red Spanish. Yields were in general low, the yield of NG 8619, the highest yielding variety, only being Ø.53t/ha. In addition, the coefficient of variation for yield was high (41.6%). This lack of precision was to be expected in view of the limited plot size, number of replications and lack of blocking within replicates containing a large number of experimental units.

The relationships between yield and maturity period, leaf hopper damage scores and leaf loss score were examined by regression analysis. Yield was signficantly negatively correlated with maturity and positively, but not significantly, with leaf hopper damage scores. There was no correlation between yield and leaf loss scores.

Leaf hopper damage can be severe in this environment and in this trial, the local variety Red Spanish had the highest incidence. Although resistance to leaf hopper damage might be desirable, the lack of relationship between leaf hopper damage and yield shows leaf hopper damage to be a minor constraint to yield. However, the level of variability within the trial could have prevented the identification of such a relationship.

The inverse relationship between yield and maturity contradicts that found in PNG groundnut variety Trial II (2.2 above). It is suggested that, in this trial, the low yields of the later maturing varieties was caused more by their failure to mature properly in an environment to which they were poorly adapted, rather than by their later maturity.

Table 8: Varieties tested in ICRISAT variety trial at Piwa.

Variety: NG No	Variety: ICGS No	Growth habit	Origin
NG 8591	4	Spreading bunch	ICRISAT breeders elite lines
NG 8592	5	"	"
NG 8594	17	"	"
NG 8595	18	"	"
NG 8596	19	"	"
NG 8597	20	"	"
NG 8599	30	Erect bunch	"
NG 8600	31	Spreading bunch	"
NG 8601	34	"	"
NG 8602	35	Erect bunch	"
NG 8604	45	"	"
NG 8605	47	Spreading bunch	"
NG 8606	48	"	"
NG 8609	51	Erect bunch	"
NG 8610	56	Spreading bunch	"
NG 8611	372	Erect bunch	ICRISAT germplasm ex Bolivia
NG 8614	4989	Spreading bunch	" "
NG 8628	6251	Erect bunch	" ex Zimbabwe
Markham White #		Spreading bunch	DPI, Papua New Guinea
Red Spanish #		"	"

- Local varieties

Table 9: Variety means for experimental variables in ICRISAT variety trial at Piwa.

Variety[a]	Days to harvest	Leaf loss score (0-5) #	Shelling %	Seed yield t/ha	Test wt 100 grain g
NG 8594	186	1.00a	67.0cdefgh	1.40a	61.7abcde
NG 8591	186	1.00a	67.8cdefg	1.31a	66.9abcd
NG 8596	186	1.00a	67.0cdefg	1.26ab	69.0abc
NG 8600	186	1.00a	62.2gh	1.24ab	72.8ab
NG 8599	162	2.25c	71.6abc	1.24ab	56.0cde
NG 8597	165	1.75b	75.8a	1.02bc	62.4abcde
NG 8614	165	1.00a	61.6h	1.02bc	73.3a
NG 8605	190	1.00a	69.7bcdef	0.97cd	64.5abcde
NG 8601	162	1.75b	71.1ab	0.93cd	55.0cde
Markham White	176	1.75b	73.7ab	0.86cde	64.2abcde
Red Spanish	165	1.75b	71.4abcde	0.85cdef	55.5cde
8609	165	1.25a	68.9bdef	0.82cdef	67.0abcd
8595	176	1.00a	64.4fgh	0.74cdefg	52.4e
8606	181	1.00a	65.5efgh	0.70defg	53.5de
8592	176	1.00a	62.1gh	0.70defg	59.0bcde
8610	181	1.00a	65.7defgh	0.70defg	56.7cde
8602	181	1.25a	65.0fgh	0.65efg	60.7abcde
8628	181	1.75b	72.0abc	0.58efg	53.2de
8611	162	3.00d	76.4a	0.56fg	38.2f
8604	176	2.00bc	71.0abcd	0.46g	67.2abcd
LSD (5%)		0.45	4.9	0.25	11.9
CV%		22	5.1	19.8	6.9

a) Varieties are ranked in descending order of seed yield.
Duncans multiple range test - means followed by the same letter are not not significantly different ($P<0.05$) from one another.

3.2. ICRISAT variety trial at Piwa

3.2.1. Method

In this trial fifteen of the introduced ICRISAT elite breeders lines and three germplasm lines were evaluated against two local varieties. A list of the varieties evaluated is given in Table 8. The trial was conducted at Piwa Agricultural Station, Tari District, Southern Highlands Province, on an alluvial soil, the Piwa series. A description of the Piwa series is given in Appendix I.

A randomised block design in four replicates was used with a plot size of two rows 60cm apart and 5cm long. At harvest all plants from each plot were used for yield determination. Seeds were planted at a plant population of 83,333 pl/ha, i.e. 20cm spacing in the rows. The trial was planted on 5 July 1984 and missing stations replanted on 18 July when the crop was fully emerged.

Fertilizer was applied the day before planting during seed bed preparation, at a rate of 20kg N/ha, 40kg K/ha, and 40kg P/ha as, respectively, ammonium sulphate, triple superphosphate and muriate of potash respectively.

The experiment was kept weed free by hand and no other plant protection measures were taken. Varieties were harvested when judged mature and the maturity of varieties, as days to harvest, are given in Table 9. At harvest, each plot was scored for leaf loss on a scale of 0 (no leaf loss) to 5 (complete leaf loss).

3.2.2. Results

Results are given in Table 9, where varieties are ranked in descending order of yield. The two local varieties Markham White, and Red Spanish, gave similar yields, respectively 0.86 and 0.85t/ha. Five ICRISAT elite varieties, NG 8594, NG 8591, NG 8596, NG 8600, NG 8599 (ICGS 17, ICGS 4, ICGS 19, ICGS 31 and ICGS 30) gave significantly higher yields than the local varieties. The significant yield increases ranged from 63 to 44%.

Although variety seed yield increased with variety maturity and decreased with extent of leaf loss, the correlation between the variables was not significant.

Table 10: Ranking by decreasing yield of ICRISAT varieties tested at both Kiburu and Piwa.

Variety		Site	
NG no	ICGS no	Piwa	Kiburu
8594	17	1	5
8591	4	2	18
8596	19	3	6
8600	31	4	9
8599	30	5	4
8597	20	6	7
8614	4989	7	19
8605	47	8	15
8601	39	9	3
Red Spanish		10	2
8609	51	11	11
8595	18	12	16
8606	48	13	17
8592	5	14	12
8610	56	15	14
8602	35	16	8
8628	6251	17	1
8611	372	18	10
8604	45	19	13

Spearman rank correlation coefficient
$r_S = 0.07$ $Z = 0.31$

3.3. Discussion

Eighteen of the introduced ICRISAT varieties and one local variety were common to the trials at Kiburu and Piwa. The Spearman rank correlation between the ranking of varieties at the two sites was not significant (Table 10).

It seems unlikely that the marginal difference in altitude (60m) between the sites would be sufficient to result in a significant site by variety interaction. The Piwa site had the higher level of soil fertility, as indicated by the yield differences, and the greater precision in the Piwa trial means that the Piwa results are regarded as better initial indicators of the performance of the ICRISAT varieties under Southern Highlands conditions.

In both these trials, all the varieties except one (NG 8599 - ICGS 30 - in the Piwa trial), that gave a higher yield than the local variety Red Spanish, also had a lower leaf loss score. However, only for four varieties (NG numbers 8594, 8591, 8596 and 8600 - ICGS numbers 17, 4, 19 and 31 - in the Piwa trial), were both the yield increase and leaf loss decrease significantly different from Red Spanish.

These four varieties are ICRISAT breeders elite lines and therefore selected primarily on the basis of multi-location yield performance. Although improved disease resistance may be associated with that yield improvement these varieties are not specifically selected for resistance to *Cercospora* early leaf spot. Thus the increased yield obtained from these varieties serve only to indicate the potential yield increase that might be achieved by variety selection in this environment.

The ICRISAT Groundnut Improvement Program has a regional breeding programme based in Malawi where, like the highlands of Papua New Guinea, *Cercospora* early leaf spot of groundnuts is a major production constraint. Early leaf spot resistance and tolerance is a major concern of the Malawi programme and it would therefore seem, on the basis of these results, worthwhile obtaining and evaluating material from this programme. Because of the apparent absence of serious virus diseases of groundnut crop in Papua New Guinea, it is essential that stringent quarantine regulations be enforced to ensure that no economically important groundnut virus dieases are imported with this material.

The yield increases of up to 60%, which were obtained with some of the ICRISAT varieties, indicate the validity of further testing of the promising varieties which have already been imported, preferably at a greater range of sites. Such a programme has already commenced at Kiburu with promising varieties undergoing further evaluation and multiplication.

4. VIRUS DISEASE SURVEY

In 1961, marginal chlorosis, a virus disease of groundnut, was reported from the Lowlands Agricultural Experiment Station, Keravat, East New Britain, (see COPR, 1973). The main symptoms were yellowing of the leaf margins and crinkling of the lamina, and the disease was reported to be seed transmitted to 100%. Since then further reports have been made of suspected virus diseases of groundnuts in Papua New Guinea (Shaw, 1984), but no positive identifications were made.

Virus diseases are economically important in the majority of groundnut producing countries of the world. Consequently, the incidence of groundnut virus diseases in Papua New Guinea is of major significance as it determines the quarantine restrictions that must be placed on viable groundnut seed entering Papua New Guinea. Of particular concern is the need to ensure that the import of groundnut germplasm into PNG, with the aim of improving productivity, is not impaired by quarantine regulations which protect against virus diseases already existing in the country.

The first step in establishing a rational quarantine policy for imported groundnut germplasm is to establish the presence of virus diseases in the country. Therefore, as part of the evaluation programme reported here, and in co-operation with Department of Primary Industry Plant Pathology, and with ICRISAT, surveys of groundnut diseases in the Southern Highlands and in the Markham valley were carried out.

Two surveys were carried out. The first survey was carried out in June 1984 by agronomists working in the Southern Highlands and in the Markham Valley in collaboration with DPI Plant Pathology, Konedobu. In this survey, healthy and suspect plants were collected from the field and sent to Konedobu for examination. The second survey was carried out by Dr. D.V.R. Reddy, Principal Groundnut Virologist, ICRISAT, on a visit to Papua New Guinea in September 1984.

Only the major findings of these surveys will be reported here. The DPI Plant Pathology survey has been reported in an internal memorandum (Tomlinson, private communication), and Dr. Reddy's survey has been reported to ICRISAT (Reddy, 1984).

4.1. DPI Plant Pathology survey

Although many of the samples collected in this survey showed symptoms of chlorosis and were stunted, there was no obvious mottling of leaves.

Sap from samples showing possible virus symptoms was tested for the presence of peanut mottle, cowpea mild mottle and Bapatha PCV viruses using standard aglutination tests with antisera supplied by ICRISAT. Selected samples were also sent to Rothamsted Agricultural Research Station, Harpenden, England, and to the University of Auckland, New Zealand, for electron microscopy examination for the presence of viruses and mycoplasma-like-organisms (MLOs). Seed from affected plants were grown in pots at Konedobu and standard sap transmission studies were carried out.

All antisera and sap transmission studies carried out at Konedobu gave negative results. Results from Rothamsted reported the presence of isometric particles 30 - 35 nm in diameter in very small numbers. This description suggests the presence of peanut stunt virus but is not confirmation of its presence. No MLOs were detected.

A tentative conclusion of the survey was that, in the absence of positive identification of viruses and MLOs, the possibility of the virus-like symptoms, e.g. leaf chlorosis, being caused by nutritional deficiencies must be seriously considered.

Samples from both areas appeared to be infected with an unidentified leaf blight which may have been bacterial in nature. Although spores of <u>Leptosphaerulina trifolii</u> have subsequently been isolated from groundnut samples having similar symptoms elsewhere in Papua New Guinea, <u>L. trifolii</u> is only a weak pathogen.

4.2. ICRISAT survey

Groundnut crops on DPI stations, and in farmers' fields, in areas around DPI Laloki, DPI Kuk, DPI Bubia and Mendi were surveyed. During the survey no external symptoms of economically important virus diseases of groundnuts were observed. Isolated plants with witches broom symptoms were observed at DPI Laloki and a few plants infected with cowpea mild mottle virus (CMMV) symptoms were found at Bubia. The presence of CMMV virus was subsequently confirmed by electron microscopy. In particular, no symptoms resembling those of marginal chlorosis were observed in the survey areas. Although the report of marginal chlorosis came originally from Kerevat and this area was not surveyed, the reported rate of seed transmission and free exchange of groundnut seed in Papua New Guinea would be expected to spread a virus to other groundnut growing areas in the country. It was concluded that marginal chlorosis may not have been a virus disease but judgement was reserved until its occurrence and viral etiology could be confirmed.

In lowland areas, rust (_Puccinia arachidis_) and _Phaeoisariopsis_ late leaf spot were judged economically important. In the highlands, _Cercospora_ early leaf spot was more important than late leaf spot and rust was not observed. Also in the highlands, symptoms of an unidentified non-fungal leaf blight disease were observed. This observation may be related to the incidence of _Leptosphaerulina trifolii_ as mentioned in the Plant Pathology survey. Nutrient deficiency symptoms of nitrogen, phosphorus and potassium were observed particularly in the Southern Highlands and it was suggested that rhizobium innoculation and fertilizer use would be beneficial.

The lack of virus diseases, even in experimental stations, was taken as evidence that quarantine regulations were effective in excluding seed borne virus diseases and it was recommended that these regulations be continued.

5. DISCUSSION

AFTSEMU's work on groundnuts was constrained to variety identification. Despite the limited scale of the work, improvements in variety selection have been made. These improvements have been discussed as appropriate in parts 2 and 3 above, and conclusions are given in part 6. This discussion concentrates on the other issues raised during variety identification, especially in terms of the further work which could be carried out.

Variety mean yields in these trials ranged from 0.5 to 1.7 t seed/ha. Although these yields were achieved with some fertilizer input, field experience suggests that this order of yield is also applicable to farmers' fields, although no reliable data for farmers' yields are available. Martin (1984) gives the mean groundnut yield for developing countries as 0.93 t/ha, so the Southern Highlands yields must be considered adequate, especially considering the altitudes of test sites were 1620 and 1680 m.

Of particular interest is the fact that even the moderate yield levels of 1 t/ha means a gross return of K3,000/ha/crop at the Southern Highlands roadside price of K3/kg seed. As these returns could probably be achieved on natural soil fertility with only the inputs of labour, seed and land, then groundnut production represents a very attractive economic proposition for small holders. The importance of this is that small holder groundnut production in the Southern Highlands would seem to warrant greater research and service support from government agencies. Initially this should concentrate on the factors discussed below which constrain yield and involves primarily the Division of Primary Industry. In the longer term, support from other divisions, in for example, marketing and processing may be necessary.

5.1. Disease incidence

Results have shown that leaf loss, primarily as a result of Cercospora early leaf spot, is a major determinant of yield in this environment. The best method of disease control is the use of resistant or tolerant varieties. In practice this method is limited by the lack of progress in breeding for resistance and in the availability of resistant varieties. Nevertheless, steps should be taken to evaluate potentially resistant material from germplasm sources, in particular ICRISAT's Groundnut Programme Improvement in Malawi. This must be done in co-operation with National DPI or must be the responsibility of a regionally based National DPI unit.

Fungicidal control of Cercospora and Phaeoisariopsis leaf spots is possible and, particularly in view of the high value of the crop, may be justified in some situations, for example in DPI multiplication plots. As Cercospora and Phaeoisariopsis leaf spots are caused by an air borne fungus the most immediate practical control method that can be adopted is the use of an adequate break between crops, and the burning of all groundnut crop residues after harvest, in order to limit the source of inoculum in subsequent crops.

5.2. Soil fertility

Although not directly investigated in these trials, soil analyses and field experience suggest that for groundnuts soil fertility is a major problem in the Southern Highlands, particularly on volcanic ash soils. The relative importance of nutrients is probably in the order phosphorus or potasium and then nitrogen (because of poor nodulation). That availability of calcium and sulphur, and possibly some micronutrients, is also important is suggested by the geographical concentration of groundnut production on soils associated with limestone.

Further work is required to determine the extent of soil fertility as a constraint to groundnut yield in these soils. Both organic and inorganic manuring should be explored and the use of high levels of inorganic fertilizers may be justified by the value of the crop. In particular, the testing of the application of lime as a top dressing at pegging is required as a proirity.

5.3. Rhizobium inoculation

Field experience and experimental results showed that nodulation in groundnuts was poor and therefore probably represents a yield constraint. The lack of response to inoculation of CB 756 was not explained by experimental results. However, on the basis of the potential benefit from effective nodulation further work would be justified to establish whether innoculation is both practicable, and beneficial, on these soils.

5.4. Variety type

Results have shown that improved varieties are available and it is important that seed of proven improved varieties be made available in seed multiplication services.

A further aspect of variety choice that warrants some discussion is the choice between groundnut types; those relevant here being the Spanish and Virginia types. The common local varieties of groundnuts grown are of the spanish type, with the Virginia types rarely seen, despite the fact that Virginia Bunch is available through DPI multiplication schemes, and is the DPI recommended variety for the highlands.

It is not known why Virginia types are not grown and this is information that would be useful in identifying both research and extension priorities. A number of factors may be involved, of which the following are possible.

a) Preferences

Growers may exhibit a preference for the Spanish types because:

- Spanish types are earlier maturing than Virginia types and it seems possible that growers are instinctively attracted by earliness per se.
- Spanish types usually produce more than two seeds per pod whereas Virginia types do not.

b) Seed dormancy

Virginia types have a dormancy period after maturity which may last for up to two months. Growers may not understand this effect and thus it may be a disentive to the use of Virginia types.

Early harvesting of groundnuts appears to be common practice in the Southern Highlands and leads to a reduction in yield, as well as in oil and protein contents. The reason for early harvesting may be a lack of awareness of the right maturity for the crop. However it seems more likely that it is because the Spanish types, due to their lack of dormancy, tend to germinate as maturity approaches in the moist soil conditions of the Southern Highlands. Virginia types, because of their dormancy, may be better able to stand to maturity under moist soil conditions and would therefore seem a more suitable type to grow. In contrast, early harvesting may be advantageous because it could limit fungal infection of seed, particularly by Aspergillus spp., and subsequent contamination with aflatoxin. However, this problem can be relatively easily alleviated by adequate drying of the crop soon after harvest.

c) Disease resistance

Virginia types tend to be more resistant to Cercospora leaf spot diseases (Hemingway, 1957) and therefore would seem a more appropriate groundnut type for this environment.

It is necessary to establish the reasons behind the local variety preference. Once this is done, a farmers field evaluation and extension/demonstration programme may be appropriate ways to promote the cultivation of Virginia types of groundnuts.

5.5. Seed Selection

It seems that local practice is to sell the best seed from a crop and retain the poorer seed for replanting. This practice reduces yield and may result from the lack of awareness of the yield benefits from using good seed.

6. CONCLUSIONS

1. The groundnut varieties Kiburu Red, Markham White and Virginia Bunch should be multiplied for distribution in the Southern Highlands.

2. Some lines of the germplasm imported from ICRISAT gave significant and worthwhile yield increases over local varieties, Kiburu Red and Markham White, in a limited evaluation. More extensive evaluation of this germplasm is required to develop improved variety recommendations.

3. Leaf spots, and in particular early leaf spot (Cercospora arachidicola Hori), appear to be a major constraint to groundnut production in the Southern Highlands, and probably elsewhere in the highlands of Papua New Guinea. Some of the germplasm tested in these trials showed improvements in disease resistance but further steps need to be taken to acquire early leaf spot tolerant or resistant material for further testing.

4. The apparent absence of serious virus diseases of groundnut in Papua New Guinea justify that stringent quarantine regulations be enforced for viable groundnut seed entering the country in any form. However, it is important that the necessary quarantine regulations do not prevent the import of germplasm designed to identify suitable varieties to increase productivity, and particularly to introduce tolerance, or resistance, to Cercospora and Phaeoisariopsis leaf spots.

5. Groundnuts are a high value crop in the Southern Highlands and in view of the poor fertility status of the volcanic ash soils, yield trials with inorganic, but preferably organic fertilizers, would be justified to assess the economic potential of their use.

6. Under field conditions groundnuts appear to be poorly nodulated and, as limited testing of rhizobium CB 756 was inconclusive, further work is necessary to assess the potential for inoculation in these soils, and also to isolate a rhizobium strain adapted to volcanic ash soils.

7. There is scope for DPI extension staff to conduct simple evaluations and demonstrations with groundnuts, preferably in farmers fields, of simple husbandry techniques, for example, the use of improved varieties, seed selection, the identification of maturity, manuring and crop hygiene.

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	Soil series	
	Kiburu	Piwa
Parent material	Alluvial resorted tephra	Alluvium
USDA soil taxonomy	(Aquic) eutrandept	(Aquic) entic eutrandept
Altitude (m.a.m.s.l.)	1680	1620
pH (water)	5.2	5.6
Bulk density (g/cc)	0.83	0.70
Organic matter (%)	10.8	10.0
Available P (ug/ml)	4	3
P retention (%)	90	97
Extractable cations (me/100g)		
K	0.15	0.21
Ca	1.30	2.70
Mg	0.32	1.06
Na	0.12	0.25
Al	2.50	0.47
ECEC (me/100g)	4.4	4.7
CEC (me/100g)	15	16
Base saturation (as a % of ECEC)	43	89
Sulphate sulphur (ug/ml)	69	56

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