Papua New Guinea

AGRONOMIC STUDIES ON PEANUTS IN PAPUA NEW GUINEA

by
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Edited by
Jane M. George

RESEARCH BULLETIN no. 42

Department of Primary Industry
Port Moresby 1987

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1987

ISBN 9980-66-074-0

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SUMMARY

1. VARIETY EVALUATION AND SELECTION

A. Early Studies and the Release of Selection 454

Studies over five years compared local White Spanish commercial varieties and selections with twelve overseas varieties. Local White Spanish selection 454 proved superior to other varieties yielding an average of 1131 $kg.ha^{-1}$ kernels over five experiments. Its large uniform kernel size and greater disease resistance were also advantageous. It was released for commercial use in 1973.

Poor yield of existing commercial seed was mainly associated with small kernel size and a 13 percent decline in size was observed in the Atzera seed over five years. Most overseas varieties tested had either inferior yields or poor kernel size compared with the local seed. One variety of early promise, Florunner, showed greater susceptibility to peanut rust (*Puccinia arachidis*) and was not considered for release.

B. Preliminary Studies on Rust Resistant Lines

Fourteen F3 lines exhibiting rust resistance were introduced from the USA in 1974 and initial observations indicated that the level of resistance varied both within and between lines. However, all were more resistant than the local commercial varieties.

Selection for resistance, desirable kernel characteristics and yield over several generations has revealed a few lines of promise which have yielded as well as the improved local White Spanish selection 454 without fungicide treatment. However, none have yielded as well as 454 treated with either mancozeb or daconil fungicides to control rust.

2. THE EFFECTS OF SEED TREATMENT ON GERMINATION AND ESTABLISHMENT

Studies showed that germination of peanut varieties possessing post harvest dormancy could be improved by storage over time, heat treatment at 45°C-5Ø°C for 7 days or testa removal.

Field establishment of machine hulled White Spanish kernels was increased from 71.3 percent to over 87.3 percent by treating the seed with either captan or ceresan (Ø.21 % w/w).

3. NUTRITION STUDIES

On previously cropped fertile alluvial soils there was no response to inoculation or to N, P, K, Ca, S and trace element application. However, in one pot trial a complete trace element foliar spray gave a significant ($P < Ø.Ø1$) yield response.

On virgin soil N and S were shown to be most likely limiting yield. In one experiment on a soil with adequate P status (18 $mg.kg^{-1}$) a significant ($P < Ø.Ø5$) yield response to DAP (2Ø % N, 2Ø % P, 3 % S) application was attributed to these elements.

4. LEAF DISEASE AND FUNGICIDE STUDIES

Studies over three years showed that peanut rust could be controlled in Whit Spanish selection 454 with three applications of either mancozeb, daconil o fentin hydroxide (1.36, 1.28 and 0.32 kg.ha^{-1} a.i., respectively) at two weekl intervals commencing approximately eight weeks after planting.

Disease control prevented defoliation, increased kernel yield and size an allowed harvesting to be delayed without yield loss. Top yields varied from 1. to 1.9 t.ha^{-1} depending on the site and season and losses of over 70 percen were recorded in the untreated plots where harvesting was delayed.

Daconil and fentin hydroxide also controlled leaf spot but this disease was o much less importance than rust.

5. HERBICIDE STUDIES

Terbacil at 0.9 kg.ha^{-1} a.i. showed the most promise for broadspectrum wee control out of 14 herbicides screened. However crop tolerance was insufficien for general use crop yield was halved at 1.8 kg.ha^{-1} a.i..

Trifluralin at 1.8 kg.ha^{-1} a.i. was the most effective of 5 herbicides screene for the control of Rottboellia exaltata. This weed has become a problem i areas cropped to grain sorghum as it is not controlled by the herbicid atrazine. A grain sorghum, legume crop rotation with the use of selectiv herbicides is suggested as a way of obtaining weed free conditions an maintaining productivity.

INTRODUCTION

Peanuts (Arachis hypogea) have been an important cash crop in the Markham Valley for twenty years with up to 1500 ha being sown annually during the 1960's. Initial production was under a labour intensive system but more recently owing to high labour costs and low peanut yields, growers have been changing to other enterprises such as grain sorghum and cattle production. Demand for peanuts, both for the fresh market and for processing (peanut butter), is high. This programmme of agronomic studies which started in the late 1960's was designed to investigate factors causing the decrease in peanut yield noted by a number of growers. This research bulletin summarises the results obtained from these agronomic studies.

Location

All sites for the agronomic studies were in the Markham Valley of Papua New Guinea. The valley, located on the north coast of the mainland, extends from Lae in a north west direction for 150 km where it joins with the Ramu valley. It is enclosed by high mountain areas on both sides.

Climate

The area has seasonal rainfall with peaks occuring in the December to March period and again in July and August. Annual rainfall varies along the length of the valley from 4500 mm at Lae to 1200 mm at Erap (45 km inland) to 1900 mm at Gusap (140 km inland) (DASF 1973). Altitude reaches 300 m inland at Gusap. A slight cooling effect is evident at the elevated inland locations (DASF 1973).

Soils and Vegetation

The alluvial soils of the valley range from clay loams to silts and sands overlying gravel. The vegetation is grassland with two species predominating Themeda australis on the shallow soils and Imperata cylindrica on the deeper soils. Soils supporting a stand of I. cylindrica are considered to be of higher fertility than those with a pure stand of T. australis or a mixed stand of both spicies.

General Experimental Procedures

In all experiments seeds were hand planted into a 4 - 5 cm hand or tractor made furrow, except where trials were superimposed on a commercial crop. Seed was covered immediately after planting. Interrow spacing varied from 60 - 90 cms according to local commercial practise. In all trials except the herbicide series, crops were hand weeded as required.

All trials were hand harvested. Plants were lifted, nuts threshed and bagged immediately then hulled, graded and weighed. Yields are expressed at 14 percent moisture. Kernel size is expressed as weight of 100 seeds, and culls are those of less than 49 $g.100^{-1}$ seed weight. Shelling percentage is calculated as weight of kernels as a percentage of weight in pod.

PART 1

VARIETY EVALUATION AND SELECTION

A. EARLY STUDIES AND THE RELEASE OF SELECTION 454

INTRODUCTION

Declining peanut yields had been noted by a number of growers which was partly attributed to the absence of selection of kernels for seed. This first study examined the possibility of improving yields by selection within commercial seed and by the introduction and evaluation of overseas varieties. The work was carried out before peanut rust (Puccinia arachidis) was first recorded in Papua New Guinea in 1972 (Shaw and Layton, 1975). Preliminary studies on rust resistant lines formed the basis for the subsequent work on variety evaluation reported in Part 1B.

MATERIALS AND METHODS

Local Selections

One hundred plants were selected for high yield at each of six commercial sites in the Markham Valley during 1968. Similar selections were made at Bubia from seed stocks received from four locations near Madang.

The nuts were threshed from the individual plants and hulled and plants were ranked by yield and kernel size within sites. The seed from the top 19 plants from each site was then sown at Bubia A.R.C. A commercial seed sample, Aztera 68, obtained from the Aztera Cooperative (near Mutsing) was sown in an adjacent block for comparison. Vegetative characteristics and yield were recorded on each line. Two separate multiplications and observations were then made at Bubia during 1969 and 1970, on the best overall 19 selections compared to Aztera 68.

Introduced Varieties

Twelve introductions were made during the period 1969 to 1973 and are listed in Table 1A.1. The introductions were grown out under quarantine at Laloki Plant Introduction Station, Port Moresby, and then multiplied at Bubia A.R.C. and observations on plant type, yield and kernel size were made. A plot of Aztera 68 was usually sown alongside for comparison. Introductions which compared favourably with Aztera 68 were then included in formal yield evaluation experiments.

Formal Yield Evaluation

Specific experimental details are given in Table 1A.2, and general techniques used, recording and sites are as described in the introduction. No fertiliser was applied in any of these experiments and all were sown by hand.

Table 1A.1

Introduced peanut varieties from overseas for evaluation in the Markham Valley

Entry No.	Year of entry	Original name	Country of origin	Source 1/	Other Information
NG 6636	1969	Florunner	U.S.A.	U.S.A	
NG 6651	1969		U.S.A.	N.T.A.	CPI161312
NG 6652	1969		U.S.A.	N.T.A.	CPI259800
NG 6653	1969	Argentine	U.S.A.	N.T.A.	
NG 6654	1969	Spantex	U.S.A.	N.T.A.	
NG 6739	1970	NC17	U.S.A.	U.S.A.	
NG 6724	1970		India	D.P.I.	CPI130087
NG 7026	1973	Schulamit	Israel	N.T.A.	
NG 7205	1973		n.r.	W.A.	
NG 7206	1973		n.r.	W.A.	
NG 7207	1973		n.r.	W.A.	
NG 7208	1973		n.r.	W.A.	

Notes: 1/ Sources of seed

N.T.A. Northern Territory Administration
D.P.I. Kingaroy, Queensland.
W.A. Department of Agriculture, Kununurra, Western Australia

Table 1A. 2

Peanut variety evaluation programme experimental details

Trial No.	Site	Sowing date	No. of entries	Design	Plot size		
					Row no.	Width (m)	Length (m)
1	Bubia	08.69	25	RB x 4	1	0.91	3.2
2	Bubia	04.06.70	9	LS	4	0.91	3.7
3	Mutsing	28.05.71	11	LS	4	0.71	3.4
4	Munum	26.07.71	11	LS	4	0.71	3.4
5	Wawin	29.12.72	7	RB x 3	2	0.76	70.0
6	Mutsing	07.03.73	7	RB x 5	2	0.76	37.0
7	Umi	13.03.73	7	RB x 5	2	0.76	37.0

Experiment 1 compared the best 19 and the poorest 5 lines from the initial comparison with Atzera 68 at Bubia in 1969.

Experiment 2 compared 7 local selections with a promising introduction NG 6636 and Aztera 68 at Bubia in 1970. Due to poor establishment and high variability in experiment 1 a higher seeding rate, larger plots and increased replications were used in subsequent experiments in an attempt to overcome these problems. Heavy rains during the season caused soil compaction and soil around the plants was loosened with forks to facilitate harvesting.

Experiments 3 and 4, at Mutsing and Munum in 1971, compared six promising local selections 454, 616, 551, 129 and 464 with NG 6636, NG 6652, Aztera 68 and two commercial seed lots Munum 71 and Aztera 71. Selection 616 and NG 6652 were replaced by NG 6739 and NG 6724 at Munum.

Farm Demonstrations

Experiments 5, 6 and 7 were set up at 3 sites in 1972-73 to compare the 3 promising entries from experiments 3 and 4, selections 454, 551 and NG 6636, with commercial seed under commercial conditions, and also to demonstrate differences in growth, development and yield to farmers. The seed from NG 6636, a non-Spanish type, was used for market acceptability tests. Commercial seed Aztera 68 and Munum 71 were included at three sites whilst at two of the sites the current commercial seed Aztera 73 and Wawin 72 were also included. Experiments consisted of long 2 row plots (37 - 70 m) which were sown with commercial equipment. Specific details are given in Table 1A.2.

In experiment 5 at Wawin heavy rain in the second week after sowing caused erosion and soil wash across some plots. Similar damage also occurred later in the season. At harvest only areas not affected and adequately guarded were sampled.

At harvest in experiments 6 and 7, the plants were lifted, the nuts threshed and weighed immediately . Two random samples were taken per plot and weighed oven dried, hulled, graded and reweighed, and the dry weight:fresh weight ratio was used to convert fresh yields to kernel yields. Kernel size was also determined from the subsamples. For experiment 6, remaining plot samples were pooled for each entry, these were sun dried and a 10 kg sample forwarded to the Aztera Co-operative for commercial hulling and appraisal.

RESULTS AND DISCUSSION

Local Selections

In the initial sowing of the best 19 selections from each site, marked differences in growth habit between lines were noted but within lines growth was very uniform. Growth habit ranged from plants with a short main stem to plants with a completely upright bunchy habit. Peg and nut formation in all was typically Spanish with most of the nuts being produced around the crown and only a few along the laterals. Flowering commenced 3 to 4 weeks after sowing and all were ready for harvest at 100 days.

At harvest, differences in size and shape of nuts and size of kernels between selections were noted, as well as marked differences in size between sites. Selections grown at Reids and Dumpu sites showed greater mean kernel size than the same selections grown at Bubia and Sasiang, which fell below cull size (see Table 1A.3). At Bubia early harvest owing to wet field conditions may have limited kernel size.

Table 1A. 4 shows a comparison of kernel size for the 19 selections between actual selection and line; Aztera 68 is included as a reference. Kernel size differences were maintained in the line but generally size decreased. The exception to this was the Madang line which yielded kernels of 57 - 63 g size compared to the selection yield size of 41 - 48 g. This is probably due to more favourable conditions during the season and later harvest than in the previous year. Differences in size between lines were not as marked as differences between selections, but the Sasiang line still yielded kernels of cull size. Many lines outyielded Atzera 68, with 129, 378, 464 and 562 showing the most potential.

Introduced Varieties

Of the overseas introductions NG 6636 showed a yield advantage over Aztera 68. NG 6739, whilst of similar yield to Aztera 68, had the desirable characteristic of large kernel size. Further multiplication showed a variation in the vegetative characteristics of NG 6739; different types were labelled and kept seperate for inclusion in later observations. NG 6724 showed a slight yield advantage over Aztera 68; NG 6651 and NG 6654 were notable only for their small kernel size.

In the multiplication plots line 464 which had yielded well under observation showed poor establishment. The plants that did emerge showed symptoms of a curled radicle and leaf margin indentation and an unidentified virus was thought the probable cause (Shaw, personnal communication). Seedlings of Aztera 68 were almost free of the virus. Seed sown in December 1971 was rogued for virus infected plants, 72 percent of seed sown emerged and 23 percent were rogued out.

Formal Yield Evaluation

In experiment 1, owing to poor establishment and use of an inefficient experimental layout there was high variability and significant differences between lines were not detected. In subsequent experiments, higher seed rates were used and a Latin Square design adopted to improve the precision of the trials.

Table 1A. 3

Mean kernel size for the 19 selections from 7 sites in the Markham Valley

Site	kernel size
J.Reids (nr Maralumi)	70.6
Dumpu	67.4
Munum	59.0
Pyramid Hill (nr Maralumi)	55.5
Gabamazung	53.3
Bubia (ex Madang)	43.8
Sasiang (nr Leron)	43.7

Table 1A. 4

Comparison of original kernel size with kernel size and yield in the first line sowing of 19 selections at Bubia

Selectn. no.	Origin	Kernel size		Kernel yield of line ($kg.ha^{-1}$)
		selection	line	
43	Pyramid Hill	72.8	61.7	2302
106	Munum	61.7	59.1	2165
136	Munum	56.8	46.5	2199
113	Munum	61.7	51.6	2630
129	Munum	66.0	60.4	2863
208	Sasiang	48.9	48.1	2639
269	Sasiang	52.6	48.9	2156
378	Gabmazung	54.6	52.6	2941
477	Madang	48.1	69.2	2510
454	Madang	48.1	59.1	2147
464	Madang	44.3	63.1	4183
413	Madang	41.1	57.9	2484
562	Dumpu	69.2	66.0	3036
551	Dumpu	56.8	55.6	2320
587	Dumpu	64.5	57.9	2182
519	Dumpu	72.8	67.6	2501
640	Reids	74.7	67.6	2458
616	Reids	78.8	67.6	2458
671	Reids	69.2	64.5	2372
Aztera 68	Commercial seed	n.r.	66.0	2319

In experiment 2, differences in growth habit between selections were noted, ranging from upright and semi-upright bushy types to types with prostrate laterals and one prostrate variety. Variety NG 6636 was 7 days later to both flower and mature compared with the more upright types.

Heavy rains before harvest compacted the soil around plant roots and forks had to be used to loosen the soil to facilitate harvesting. For the white Spanish types which form nuts close to the crown this enabled nuts to be lifted whilst still on the plant. Varieties such as NG 6636 which produce nuts along the laterals were more difficult to harvest. Some nuts were left in the ground when the plants were lifted and these had to be dug up after harvest. They amounted to about 12 percent of the total yield (Table 1A. 5). In this experiment only selection 464 showed a significant ($P < 0.05$) yield increase over the commercial variety Aztera 68.

Experiments from 1971 were carried out in the Markham Valley and two additional commercial varieties, Aztera 71 and Munum 71, were included for comparison. Dry conditions throughout the growth period of experiment 3, with only 110 mm rainfall measured, delayed establishment and subjected young seedlings to moisture stress. The final population of 97,000 was considered to be not limiting to yield in the light of optimum populations of 100,000 having been suggested for a similar area at Katherine, Northern Territory (Wood, 1970). Block 1 in particular suffered from moisture stress. The soil on this block was only 40 cm deep and overlies a free draining gravel, whilst soil on each of the other blocks is at least 100 cm deep. Mean yield for block 1 was 611 $kg.ha^{-1}$

which was much lower than the mean yield for other blocks in the experiment. NG 6636 was the most tolerant of moisture stress and showed moderate Cercospora infection whilst NG 6652 was most affected by moisture stress and showed low Cercospora tolerance. No significant differences were detected between the highest yielding seven selections. The two additional commercial varieties were outyielded by Aztera 68 and six of the selections. No measure of kernel size was taken in this experiment.

In experiment 4, favourable conditions throughout the growing period produced very high yields. NG 6636 significantly ($P<0.05$) outyielded all other varieties. Local selection 551, significantly ($P < 0.01$) outyielded all remaining varieties including the three commercial varieties (see Table 1A.5). Differences in kernel size were noted NG 6739 producing very large kernels (925 g 1000 kernel weight), whilst NG 6724 produced only cull kernels. It is interesting to note the decline in kernel size of Aztera 68, over three years experiment, of 8 percent . This may partly account for a yield decline of 6 percent during the same period.

Farm Demonstrations

In experiment 5 at Wawin emergence was good but early seedling growth was slow. In the early stages some leaf margin necrosis was visible through all selections. This may have been caused by atrazine herbicide residue from the previous sorghum crop. Nutritional deficiency may have been a problem but soil analysis for the previous sorghum crop showed only nitrogen to be limiting (Vance 1981).

Yields for experiment 5 were low, possibly as a reflection of poor early growth. Yields of Atzera 68 and selection 454 were significantly ($P<0.05$) higher than yields of all other entries. Only these two selections yielded kernels of marketable size, all other selections yielded mainly cull sized kernels (Table 1A. 6). Peanut rust, Puccinia arachidis, first recorded in P.N.G. in 1972 (Shaw and Layton 1975) was noted on a number of plots in this experiment. Only variety NG 6636 was severely affected, and the rust infection caused premature leaf drop.

In experiment 6, selection 454 significantly ($P<0.05$) outyielded all other entries. This can in part be attributed to a low percentage of diseased plants at harvest, namely, 1.8 percent (Table 1A.6) and large kernel size. Again Atzera 68 was the highest yielding commercial variety. Evident here, as well as in experiment 4, was the apparent decline in kernel size of Atzera 68. During the period 1968 to 1973 the decline was of the order of 11 percent.

At Umi in experiment 7 very poor yields were obtained, which may have been caused by nutrient deficiency. This site was shown to be of low nutrient status during sorghum trials (Vance 1981). Heavy rainfall at the site may have promoted the establishment of Puccinia and Cercospora which probably depressed yields (Table 1A. 6).

GENERAL DISCUSSION

The mean yields for the five varieties tested in experiments 3 to 7 are given in Table 1A. 7. Local selection 454 consistently yielded well over range of sites and conditions. Commercial appraisal of this selection by the Atzera Co-operative suggested it was as acceptable as any other variety tested. This selection was multiplied and released for general distribution in late 1973, and was adopted as the standard in further studies.

Table 1A.5

Yield of kernels and components of yield for experiments 2,3 & 4

Variety or selection	Kernel yield ($kg.ha^{-1}$) Total 1/	Plants only 2/	kernel size	Shelling percent	Cercospora rating (days from sowing) 3/ 49	74	91	Growth habit at 49 days 4/	Moisture stress rating
Experiment 2									
464	2039	1980	54.1	68.0	0.1	0.5	2.4	2	
NG 6636	2013	1768	51.7	65.1	0	0	2.0	1	
562	1986	1949	52.7	68.6	0.1	0.6	2.6	2	
129	1892	1809	45.5	70.7	0	0.8	3.7	3	
Atzera 68	1849	1807	52.4	67.3	0.1	0.8	3.2	2	n.r.
612	1688	1637	52.2	66.1	0.1	0.7	2.7	2	
208	1679	1601	38.4	65.8	0	0.3	3.6	4	
378	1558	1539	39.6	64.8	0	1.0	2.4	3	
113	1538	1511	39.0	65.0	0	0.9	2.1	2	
Mean	1805	1733	47.3	66.8	0	0.6	2.7		
s.e.d.	94.0	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.		
Experiment 3									
454	1318			65.8			2.8		2.3
NG 6636	1310			59.6			1.6		1.8
616	1260			64.3			2.7		2.1
551	1247			62.3			2.6		2.4
562	1246			64.5			2.9		2.1
129	1244	n.r.	n.r.	65.3	n.r.	n.r.	2.7	n.r.	2.4
Atzera 68	1236			63.9			2.8		2.4
Atzera 71	1087			61.5			2.8		2.2
464	1082			59.5			2.8		2.5
Munum 71	1005			56.4			2.6		2.3
NG 6652	902			56.7			4.0		2.7
Mean	1176			61.8			2.8		2.3
s.e.d.	55.5			n.a.			n.a.		n.a.
Experiment 4									
NG 6636	2184		57.1	72.0					
551	2063		52.2	71.8					
129	1908		52.7	72.0					
NG 6724	1873		47.8	69.0					
NG 6739	1851		92.5	63.5					
Atzera 68	1846	n.r.	60.3	67.5	n.r.	n.r.	n.r.	n.r.	n.r.
Munum 71	1842		49.8	67.8					
464	1829		60.8	66.1					
454	1820		58.2	67.8					
562	1745		59.9	66.3					
Atzera 71	1734		55.7	66.6					
Mean	1881		58.8	68.2					
s.e.d.	54.0		n.a.	n.a.					

Notes: 1/ Total yield represents kernels harvested from plants as well as those dug from the ground.

2/ Plants only yield represents kernels harvested from pods remaining attached to plants.

3/ Cercospora incidence
moisture stress score : 1 - nil
3 - moderate
5 - severe

4/ Growth habit : 1 - prostrate
2 - semi-upright and bushy
3 - upright and bushy
4 - upright main stem with laterals close to ground.

Table 1A.6

Yield of kernels and components of yield for experiments 5,6 & 7

Variety or selection	Plant popn. ('000.ha^{-1})	Kernel yield (kg.ha^{-1})	Cull Yield	kernel size	No. of kernels per plant	Percent diseased plants	Leaf disease rating 1/
Experiment 5							
454	129	582	31	53.3	8.7		
Atzera 68	116	579	50	50.0	10.0		
551	121	474	78	47.3	8.4		
Wawin 72 2/	165	460	85	39.6	7.1	n.r.	n.r.
Munum 71	134	419	89	41.8	7.5		
NG 6636	109	266	79	43.1	5.8		
Mean	129	463	67	45.9	7.9		
s.e.d.		40.8					
Experiment 6							
454	108	1395	84	63.0	21.5	1.8	2.0
Atzera 68	99	1293	59	63.5	24.4	3.5	2.0
551	100	1267	94	56.2	21.0	7.0	2.5
NG 6636	110	1251	169	55.2	21.5	3.2	3.1
Atzera 71	104	1211	77	60.1	24.9	3.8	2.0
Munum 71	99	1189	88	50.8	20.2	3.9	2.0
Atzera 73	95	1139	119	55.2	22.5	2.9	2.4
Mean	102	1221	99	57.7	22.3	3.7	2.3
s.e.d.		44.7					
Experiment 7							
454	110	538	23	52.8	9.7	4.6	1.9
NG 6636	107	450	77	52.2	8.4	4.2	2.8
Atzera 73	110	445	39	50.5	9.3	11.3	1.9
Atzera 71	106	435	30	47.3	9.7	12.5	2.0
551	108	413	36	46.9	10.2	20.2	2.6
Atzera 68	99	406	28	53.3	8.8	12.2	2.2
Munum 71	105	383	36	42.2	9.2	6.7	2.0
Mean	106	439	38	49.3	9.3	10.2	2.2
s.e.d.		26.1					

Notes : 1/ Leaf disease score 1 - nil
3 - moderate
5 - severe

2/ Wawin 72 included in only 2 replicates, excluded from the analysis

Of the other inclusions, NG 6636 showed yield potential, but its susceptibility to Puccinia and Sclerotium were seen as possible future problems. This was also the case with NG 6739, but one line from this introduction, S3B, was included in further experiments. Both of these overseas introductions showed post-harvest dormancy and further work would need to be done on this feature before the varieties could be released.

An important point to come from this investigation is that kernel size and hence yield, decrease over time. This is especially noticable with commercial variety Atzera 68 where kernel size declined by 11 percent over five years. This emphasises the importance of using the best kernels for seed.

Table 1A. 7

Mean yield (kg.ha $^{-1}$) of 5 entries in experiments 3,4,5,6 and 7

Entry	Experiment No.					Entry
	3	4	5	6	7	mean
454	1318	1820	582	1395	538	1131
551	1247	2063	474	1267	413	1093
NG 6636	1310	2184	266	1251	450	1092
Atzera 68	1236	1846	579	1293	406	1072
Munum 71	1005	1842	419	1189	383	968
Expt mean	1223	1951	464	1279	438	

B. PRELMINARY STUDIES ON RUST RESISTANT LINES

INTRODUCTION

Peanut rust (Puccinia arachidis) was first recorded in PNG in December 1972 and an account of its possible origin and early spread has been presented by Shaw and Layton (1975). Whilst the disease can be controlled in the field using fungicides, the use of rust resistant lines was thought to be a more desirable means of control. Preliminary studies included observations and formal trials on both local and introduced lines for rust resistance.

MATERIALS AND METHODS

Observation Sowings

Fourteen F3 rust resistant lines (USDA 1973) were introduced from the USA and quarantined and multiplied at Laloki in 1974. Assessments were made at harvest on the level of rust infection for each plant in each line. Levels of leaf spot (Cercospora spp.) and leaf fall were also noted. Improved local White Spanish selection 454 was sown alongside for comparison. As there were obvious differences in resistance between plants within the same line the nuts from each plant were kept separate and designated by the line number and plant number.

In the following year observation plots were set up at two sites in the Markham Valley, Maralumi and Mutsing. Unreplicated plots of each line were sown with seed from one plant occupying a particular row in the plot. Rows were 3 m long, Ø.7 m apart with seed sown every 15 cm. Observations were made on growth, development and disease resistance. For some rows there was insufficient seed to sow 3 m, so yield was determined only for rows of at least 10 plants. Any nuts which remained in the ground at harvest were left, following normal commercial practice. Yield was expressed in terms of sun-dried shell weights, which were assumed to be at 14 percent moisture content.

A second observation block at Mutsing was used to assess the rust resistance of 24 varieties grown in PNG. It included local and commercial varieties and early introductions from overseas of unknown rust resistance. At Mutsing and Maralumi in 1976 lines not selected for inclusion in formal yield evaluation experiments were sown in observation blocks with the selected lines to review 1975 performance. Owing to poor establishment for many entries no yield comparison could be made. Seed from this trial was harvested and multiplied at Bubia for inclusion in experiment 7 at Mutsing.

Formal Yield Evaluation

Six experiments were set up in 1976 to compare the general adaptability, disease resistance and yield of promising rust resistant lines with commercial varieties (Table 1B.1). Ten promising lines from the 1975 experiments were multiplied at Bubia to provide sufficient seed. Plants were mass selected and any with low yield or poor disease resistance were discarded. Within four of the lines two distinct testa colours occurred and these were separated and treated as separate entries.

Table 1B. 1

Peanut rust resistant line evaluation
experimental details

Expt. no.	Site	Sowing date	No. of entries	Design	Rainfall (mm)	Fertiliser applied (N.P.S)
1	Maralumi	Ø5.Ø3.76	22	RB x 4	163	Ø.Ø.Ø
2	Mutsing	27.Ø2.76	16	RB x 4	189	Ø.Ø.Ø
3	Gusap	12.Ø3.76	12	RB x 3	411	5Ø.5Ø.5Ø
4	Laloki	Ø4.Ø5.76	12	RB x 4	2Ø7 1/	5Ø.5Ø.5Ø
5	Aiyura	28.Ø4.76	18	RB x 4	629	95.95.15
6	Bubia	19.Ø8.76	22	RB x 4	n.r.	75.25.5Ø
7	Mutsing	21.Ø1.77	15Ø	RB x 3	555	Ø.Ø.Ø

Note : 1/ Plus irrigation.

Specific details of the experiments are given in Table 1B.1, plot size varied between experiments from 3 to 4 rows 7Ø cms apart and 4 m to 5.3 m in length. General experimental proceedures were as described in the introduction. A shortage of seed prevented the inclusion of all entries at all sites. A complete list of entries and their yield at each site is given in Table 1B.2.

Three sites outside the Markham Valley were included. These were Gusap in the Ramu Valley, Laloki on the southern coastal plains and Aiyura in the eastern highlands. The sites were chosen to assess the performance of different varieties in areas where peanuts are widely grown in subsistence gardens.

White Spanish 454 was included as a standard in all experiments. Other commercial varieties, Virginia Bunch and Red Spanish, were included at some sites. Commercial varieties treated with the fungicides mancozeb and daconil were also included, rates and timing of applications for each experiment are given in Table 1B.3. Fungicide treatment for experiment 4 was incorrectly applied and so is not included. Levels of rust and leaf spot infection and leaf fall were assessed at harvest for each experiment.

Experiment 7 at Mutsing compared promising selections with non-selected lines. White Spanish 454 was included as a standard. A randomised block design with three replicates was used, plots were a single row 4 m long. At harvest a visual assessment of yield was made and only promising lines were retained for yield determination and further testing.

Table 1B. 2

Mean kernel yield ($kg.ha^{-1}$) for entries in experiments 1 to 6

Entry and treatment	Experiment number 1	2	3	4	5 1/	6
454 + daconil	2006	2268	1889		295	2562
454 + mancozeb	1993	2170	1901		189	2329
Virginia Bunch + daconil	1816		1170		196	2232
Virginia Bunch + mancozeb					164	
454	1616	1625	1685	2067	201	2204
Virginia Bunch	1320		980		208	1663
Red Spanish + daconil						2298
Red Spanish	1474				511	1745
11/10 white	1446	1858	1060	798		1392
13/8 white	1355	1787	1059	737		1771
10/1 white	1207	1474		801	32	1274
8/1 white	1249	1479		750	23	1191
2/6 red	1100	1062	855	1002		1087
9/4 white	839	1443	946	572	154	929
7/3 white	821	1368				1160
S3B (ex NG 6739)	701	967	694		199	
12/12 white	1157	1262				735
12/12 brown	1042	1295			126	1206
2/6 brown	1554	1350	1195	1319	37	1722
13/8 brown	989					1135
4/6 red	897					836
4/6 white	857					710
7/3 red	788					1684
5/10 white	1251	1893	1316	781		1286
Trial mean	1249	1548	1229	1237	179	1507
s.e.d	166.9	122.7	182.6	177.6	55.9	271.7
c.v. (%)	18.9	10.3	18.2	20.3	44.2	25.5

Note : 1/ Unshelled yield

Table 1B. 3

Fungicide application in the formal variety evaluation trials

Trial No.	Rate $kg.ha^{-1}$ commercial product	Timing of application (weeks post planting) 1	2	3
1	1.7	8	10	12
2	1.7	8	10	12
3	1.7	11	12	13
5	1.7	12	14	16
6	1.7	8	10	12

RESULTS AND DISCUSSION

Observation Sowings

Rust infection scores for the quarantine and initial observation sowings show 454 to be highly susceptible to rust along with lines 3 and 14. Many of the introductions showed low infection levels suggesting some resistance to rust infection (Table 1B.4).

Table 1B.4

Rust infection scores at three sites in quarantine and initial observation sowings of rust resistant lines

Line	Site			
	Laloki 1/	Mutsing 2/	Maralumi	Mean
11	1.4	0	0	0.5
12	1.7	0	0	0.6
4	1.2	1	0	0.7
7	2.4	0	0	0.8
8	2.6	0	0	0.9
6	1.9	1	0	1.0
9	1.9	1	0	1.0
10	3.2	0	0	1.1
2	1.2	2	1	1.4
5	2.3	2	0	1.4
13	2.4	0	2	1.5
1	2.7	1	3	2.2
3	3.8	3	3	3.3
14	3.6	4	3	3.5
454	n.r.	4	3	3.5

1/ Mean of individual plant scores for each line at harvest (Brown pers comm).

2/ Overall line score 2 to 4 weeks before harvest.

Crop Growth and Development

At Mutsing all lines had commenced flowering 30 days after planting. Harvesting was at 100 days after planting for 454, 107 days for lines 10,13 and 14, other lines were harvested after 114 days. At Maralumi, 454 was harvested at 100 days, all introductions were harvested after 114 days.

Line 14 showed a growth habit similar to 454, except that the main stem was much taller. Other introductions were varied in growth habit with many producing nuts along the laterals. Some variation within lines was evident, at Maralumi in lines 1, 3, 4, 11, and 14, and at Mutsing in line 4. Testa colour was also variable, line 2 showed pink-red, line 3 light brown, line 14 red, all other lines showed a grey white testa.

Yield and Kernel Size

Little emphasis was placed on yield in the quarantine and observation sowings. Generally yields and kernel size of introductions were inferior to those of 454, but some lines, 3, 10 and 11 and selections 10/11 and 10/1 showed promise (Table 1B. 5).

Selection Criteria

Low susceptibility to rust was the main criteria for selection. On this basis lines 1, 3 and 14 were excluded from further trials. Line 6 was also excluded at this stage, even though it was of low rust susceptibility, on the basis of low yield. All other lines and some of the line selections were included in the formal yield evaluation experiments.

Of the 24 entries multiplied and observed at Mutsing in 1975 only S3B, a selection from NG 6739 showed low rust susceptibility and good yield potential and was included in further tests.

Table 1B. 5

Yield and kernel size of rust resistant lines and selections at three sites in quarantine and initial observation sowings

Site	Unshelled Yield			Kernel size (g)
	Laloki $g.plant^{-1}$	Mutsing $kg.ha^{-1}$	Maralumi	Laloki
Line				
454	n.r.	2118	2337	550
11	40	1859	2393	470
10	35	2007	2063	470
3	44	1569	2202	520
5	33	1812	1912	430
13	27	1747	1546	460
14	41	1283	2003	680
8	38	1667	1610	440
12	19	1637	n.r.	490
9	24	1530	n.r.	590
7	25	1517	n.r.	520
1	39	1611	1203	440
4	31	1137	1598	550
2	32	1339	n.r.	470
6	17	997	n.r.	500
Selection				
11/10	61	2066	2673	570
10/1	45	1759	2487	470
5/10	35	2170	1971	450
13/8	55	2488	n.r.	500
8/1	77	2037	1610	580
12/12	20	2223	n.r.	490
9/4	36	2288	n.r.	600
7/3	49	1887	n.r.	540
4/6	43	n.r.	2113	590
2/6	37	2002	n.r.	520

NOTE: n.r. insufficent plants

Formal Yield Evaluation

All sites established well to give adequate plant populations except for entries 10/1W and 7/3W at Maralumi in experiment 6. Moisture stress was also evident in some plots in this experiment but not at other sites.

The mean yields are given in Table 1B.2. The overall results of experiments 1, 2, 3 and 6 (9 different lines tested under low altitude conditions) showed that application of mancozeb or daconil significantly ($P<0.05$) increased the yield of 454. Both fungicides appeared to control rust infection and consequently prevent premature defoliation. Kernel size was increased and shelling percentage not affected by their application (Table 1B.6). Of the rust resistant lines all showed lower levels of rust infection and leaf fall than untreated 454 but were consistently outyielded by 454 both treated and untreated (Table 1B.2 and 1B.5). Yields of 2 $t.ha^{-1}$ from treated 454 were unusually high.

Table 1B.6

Mean yield data and disease scores for the 9 entries in experiments 1, 2, 3 and 4

Entry and treatment	Kernel yield $kg.ha^{-1}$	Kernel size	Shelling %	Rust incidence scores	Leaf fall
454 + daconil	2181	67.4	70.2	2.35	1.62
454 + mancozeb	2098	67.5	69.2	2.07	2.37
454	1763	64.0	69.7	3.06	3.12
13/8 W	1493	66.7	59.3	0.89	1.55
2/6 B	1455	71.4	65.6	1.99	1.39
11/10 W	1439	61.4	63.7	0.86	0.88
5/10 W	1437	68.2	65.4	1.02	0.46
9/4 W	1039	73.3	58.0	1.44	0.96
2/6 R	1026	64.2	57.1	1.09	0.98

In experiment 2, rust resistant lines 5/10W and 11/10W significantly outyielded untreated 454. In experiment 3, line 5/10W was the only rust resistant line with yield comparable to 454 (Table 1B.2).

In experiment 4, all rust resistant lines showed yields significantly lower than untreated 454 ($P<0.05$) (Table 1B.2). This experiment was harvested later than normal for 454 to accomodate slower maturing rust resistant varieties, even with this delay in harvesting many lines did not achieve good kernel yields. Lower yields for rust resistant lines may also be attributed to problems with harvesting in heavy clay soil. Many of the rust resistant lines have a spreading fruiting habit (as compared to the compact fruiting habit of 454) causing many nuts to be left in the ground at harvest. Error in application of the fungicide treatments excluded this experiment from further analysis and comparison.

Experiment 5 at Aiyura (1550 m a.s.l.) gave a very low mean yield of 179 $kg.ha^{-1}$ this may be attributed to a period of low temperatures in the growing season. August and September recorded mean minimum temperatures of 9.7 °C and 9.2 °C respectively. Stern (1968) suggested that a minimum temperature of less than 16 °C for five consecutive days was detrimental to kernel yield. Records show that the mean minimum temperature at Aiyura throughout the growing season was generally below 16 °C. Aiyura Red Spanish line significantly ($P<0.05$) outyielded all other entries in this experiment and was considered to be more tolerant of the cold conditions. Yield depression due to cold temperature had not been previously noted at Aiyura (Kimber pers comm). Only one rust pustule was found in the trial area and plants retained their leaves until maturity.

Distinctive kernel characteristics were noted in these experiments for line 5/10W which had good even sized kernels with a white testa, while lines 11/10W and 13/8W produced small irregular kernels with grey-brown testa, giving a discoloured appearance. Only line 2/6B had a pink testa similar to 454. Commercial appraisal of these varieties would be necessary before they could be recommended for general use.

Experiment 7 was used as a backup to test lines with desirable kernel characteristics which would otherwise have been discarded. Of the 150 lines tested, selections from line 13 showed good yields (Table 1B.6) and 8 lines were chosen to be included in further trials.

Table 1B.7

Mean yield of nut in shell ($kg.ha^{-1}$) from 3 lines in experiment 7

Entry	yield	Entry	yield	Entry	yield
454	2815	454	2693	454	1553
13/ 8 B	2594 1/	11/2 R	1963	12/12 W	2121
13/ 6 B	2594	11/13 W	1953	12/16 B	1909
13/13 B	2547	11/10 W	1823	12/12 B	1860 1/
13/ 7 B	2404	11/10 W	1764 1/		
13/ 8 W	2337 1/	11/2 W	1696		
13/ 8 W	2234	11/14 W	1193		
13/ 7 B	2080	11/15 B	892		
13/12 B	1875				
13/ 6 R	1853				
Mean	2269		1739		1553
s.e.d.	250.1		259.8		266.3
c.v.(%)	13.5		18.3		21.0

Note : 1/ Represents an advanced line.

GENERAL DISCUSSION

The yields of 454 in all of these trials were found to be increased by the use of fungicides to control the incidence of peanut rust. The yields of the fungicide sprayed plots of 454 were substantially higher than the yields from the unsprayed rust resistant lines and in some of the trials the unsprayed plots of 454 outyielded the rust resistant lines. Clearly the rust resistant lines are unsuitable for multiplication and general distribution at this time. Further research is needed with emphasis on yield and quality improvment as well as assessing their usefulnes in situations where fungicide treatment may be impractical.

PART 2

THE EFFECT OF SEED TREATMENT ON GERMINATION AND ESTABLISHMENT

INTRODUCTION

Introduction NG 6636 (variety name Florunnner), whilst showing promise in yield evaluation trials, was known to demonstrate post harvest dormancy (Florida FSPI, 1969). This may be considered advantageous in preventing seeds germinating on the mother plant before harvest, but may be a problem where freshly harvested seed is needed for immediate planting. Studies on breaking post harvest dormancy were, therefore essential before this variety could be recommended for general use.

Early work suggested three possible methods for breaking post harvest dormancy, by removing the testa (Toole et al 1964), by heat treatment (Bailey et al 1958) or by exposure to ethylene (Toole et al 1964). The first two methods were used in this study as the most applicable to widespread use in PNG.

Poor establishment of White Spanish crops was noted in the upper Ramu Valley, whereas crops in the Markham Valley where fungicides were used established well. The second aspect of this study looks at some of the effects of the fungicide seed dressings captan and ceresan on peanut establishment.

MATERIALS AND METHODS

Duration of Post Harvest Dormancy

Standard laboratory germination tests were carried out on NG 6636, using seed of five different post harvest ages, from 5 to 12 weeks. In each test ten kernels were used with four replicates.

Effects of Heat Treatment on Dormancy

Kernels from two varieties known to show post harvest dormancy NG 6636 and NG 6739 were compared with Atzera 68 and NG 6724 (non dormant Spanish types) under heat treatment and subsequent germination. Testa removal either before or after heating was included as a further treatment. The seeds were heat treated by exposure to temperatures of 45 to 50 ^{o}C for periods of 4 and 7 days immediately post harvest (Table 2.1).

Effect of Fungicides on Field Emergence

Machine hulled commercial White Spanish types were treated with 16 combinations of captan and ceresan (Table 2.2). Seeds were planted in a randomised block design using 100 kernels per plot. The site, Dumpu, had previously produced three successive crops of peanuts. Plant counts at 19 days were taken to compare germination rates under different fungicide treatments.

Table 2.1

The effects of duration of heat treatment and testa removal on percent germination of four peanut varieties

Variety	Testa 1/ treatment	Duration of heat treatment (days) Ø	4	7	Mean
NG 6636	t.n.r.	Ø	Ø	40.Ø	13.3
	a.h.	26.3	37.5	41.5	35.1
	b.h.	36.7	60.Ø	70.Ø	55.6
Mean		21.Ø	32.5	50.5	
NG 6739	t.n.r.	15.Ø	20.Ø	70.Ø	35.Ø
	a.h.	35.Ø	50.Ø	100.Ø	61.7
	b.h.	55.8	100.Ø	91.7	82.5
Mean		35.3	56.7	87.2	
Atzera 68	t.n.r.	90.Ø	100.Ø	100.Ø	96.7
	a.h.	68.8	100.Ø	100.Ø	89.6
	b.h.	67.5	20.Ø	70.Ø	52.5
Mean		75.4	73.3	90.Ø	
NG 6724	t.n.r.	65.Ø	100.Ø	100.Ø	83.3
	a.h.	95.Ø	100.Ø	100.Ø	98.3
	b.h.	75.Ø	60.Ø	67.5	67.5
Mean		78.3	86.7	89.2	

Note : 1/ t.n.r. testa not removed

a.h. testa removed after heating

b.h testa removed before heating

Table 2.2

The effect of fungicide seed treatment on field emergence (percent mean plant emergence) in White Spanish peanuts at Dumpu

Fungicide (g.kg^{-1} seed) ceresan	captan Ø	Ø.5	1	2.1	Mean
	71.3	83.8	89.5	87.3	83.Ø
1	79.5	87.5	86.3	92.8	86.5
2.1	88.5	84.3	91.5	92.8	89.3
4.1	90.Ø	91.5	89.8	91.Ø	90.6
Mean	82.3	86.8	89.3	91.1	87.4

RESULTS AND DISCUSSION

Duration of Post Harvest Dormancy

Laboratory germination tests on NG 6636 showed an increase in germination rate from 60 percent at five weeks post harvest to 100 percent at twelve weeks.

Effects of Heat Treatment on Dormancy

Germination rates showed a response to both heat treatment and testa removal in both NG 6636 and NG 6739 (Table 2.1). Heat treatment alone increased germination rate, the highest rate being reached after the seven day heat treatment. Testa removal also caused an increase in germination rate, but a relatively small increase. Heat treatment for seven days combined with pre-treatment testa removal gave the highest germination rate for NG 6636, but NG 6739 responded to the treatment of testa removal followed by 4 days heat treatment or 7 days heat treatment followed by testa removal, suggesting a stronger dormancy mechanism in NG 6636.

The two White Spanish types gave acceptable germination rates without treatment. Heat treatment for 4 days increased germination to 100 percent. Testa removal generally had a detrimental effect, lowering germination rates. This was especially marked where the testa was removed before heating, which may be as a result of physical damages to the embryo.

Effect of Fungicide on Field Emergence.

Plant counts at 19 days showed increased seedling emergence with application of either fungicide, but little extra benefit when the two were applied in combination (Table 2.2). Germination with no fungicide treatment was over 70 percent, which suggests that there was only a low infection of soil borne fungi at this site.

GENERAL DISCUSSION

Experiments have shown that the varieties NG 6636 and NG 6739 show post harvest dormancy which can be controlled by seed management. These experiments give a good indication of the methods which can successfully break this dormancy, namely heat treatment and testa removal. Heat treatment would be feasible in a commercial situation but cannot be recommended for use by subsistence growers. For the latter seed would have to be held for at least 12 weeks before planting.

PART 3

NUTRITION STUDIES

INTRODUCTION

It had been suggested that a possible decline in soil fertility may have limited peanuts production. This is reviewed in the first part of this study. Both major elements and trace elements were included as it was thought that the alkaline pH of some of the areas being cropped may render elements such as iron, zinc and manganese unavailable. Hill (1970) reported a sulphur response in peanuts at Bubia in the Eastern end of the valley outside the main cropping area, and this was also investigated.

The second part of this study was based on the shifting cultivation of peanuts on virgin land, originally practised on plantations, but now practised solely by small holders with sufficient land. Under this system three or four successive peanut crops are grown, but usually after four crops weed competition becomes too great and the site has to be abandoned. In this situation it has been noted that the second crop is often the highest yielding. Various reasons have been suggested for this, e.g. the yield of the first crop may be restricted by nutrient deficiency caused by inadequate land preparation, whilst yields of the third and fourth crops are being restricted by weed competition.

MATERIALS AND METHODS

In total nine experiments were carried out. Two pot trials, two trials on land previously cropped to peanuts, one as a second crop on virgin soil and four trials on virgin soil. Experiment 2 was a foliar spray trial superimposed on a commercial crop.

Soil samples were taken at all sites. Soil analysis for each site is given in Table 3.1. All samples were taken to a depth of 20 cms except Dumpu which was taken to only 15 cms.

Table 3.1

Topsoil analysis data for 5 sites used in experiments
2, 4, 5, 6, 7 and 9

Expt. No.	Site	pH	Total soluble salts %	Olsen P $mg.kg^{-1}$	Exchangeable cations m.e.% Ca	Mg	K	Na	C.E.C. m.e. %	Base satn %	N %	C:N
2,4	Maralumi	7.1	0.004	28.5	47.7	15.9	2.95	1.55	66.4	100	0.16	11
5	Dumpu	6.1	0.019	13.8	16.0	1.0	0.67	0.12	32.5	55	0.41	11
6	Umi	6.0	0.017	10.4	14.0	3.5	0.90	0.65	23.8	80	0.47	10
7	Mutsing	6.6	n.r.	17.0	34.8	14.8	1.64	0.01	53.5	96	0.24	10
9	Mutsing	6.4	0.013	18.0	42.0	9.0	0.85	2.00	53.1	100	0.16	11

Table 3.2 gives specific details for each of the nine experiments.

Table 3.2

Experimental details for the 9 nutrition studies

Expt. No.	site	sowing date	design	treatments
1	Bubia 1/	20.12.68	RB x 4	foliar application of Rainamina and trace elements Mn, Zn, Fe, Cu.
2	Maralumi	24. 6.69	RB x 4	foliar application of Rainamina and trace elements Mn, Zn, Fe, Cu.
3	Bubia 1/	10.11.70	RB x 6	foliar application of Rainamina and Zn.
4	Maralumi	23.12.68	3x3x3 2/	band application of P, K, S.
5	Dumpu	22.10.68	RB x 4	lime broadcast and inoculum used
6	Umi	11. 5.73	4x4x2 3/	band application of N, P, K and trace elements Zn, Fe, Mn.
7	Umi	19. 3.74	3x3x3 2/	band application of P, K, S.
8	Mutsing	15. 3.74	3x3x3 2/	band application of P, K, S.
9	Mutsing	19. 6.75	4x4x2 3/	rate form and method of application of P.

Notes: 1/ Pot trial using Maralumi soil.

2/ 3x3x3 factorial in single replicate with treatments arranged in blocks of 9 plots confounding the high order interaction.

3/ 4x4x2 factorial in single replicate with treatments arranged in blocks of 16 plots confounding the high order interaction.

Responses on Previously Cropped Soils

Experiments 1 to 4 were all conducted on soil from the Maralumi site which had been under cultivation for a number of years. Experiments 1 and 3 were pot trials carried out using topsoil (0 to 20 cms depth) from Maralumi in 91 plastic buckets. These trials were conducted at Bubia.

In experiment 1, a 1 percent solution of each trace element was made up using distilled water, the amount required for each plot was made up to a constant volume and applied using a hand sprayer. New solutions were made for each treatment period. Rainamina, a complete trace element mix and a blank treatment were included for comparison. Experiment 3 was set up to attempt to define the optimum rate of application for Rainamina, and to identify the elements causing the response which was thought to be zinc. The pots were kept in a covered house and distilled water was used to maintain soil moisture.

Experiment 2 was a foliar feed trial superimposed on a commercial crop. It aimed to translate the responses of experiment 1 to the field situation.

Experiment 4 was set up to investigate a reported yield increase of 25 percent in a commercial crop treated with 250 $kg.ha^{-1}$ NPK compound fertiliser (13:13:21).

The site for experiment 5 was naturally under *Themeda australis*. The first commercial crop gave a low yield of 400 $kg.ha^{-1}$ kernels. As the soils of this area were known to be more acidic than those of the Markham Valley, and as the first crop showed poor nodulation, liming and inoculation treatments were studied.

Responses on Virgin Soils

Experiments 6 to 9 were all conducted on virgin soil using seed from improved local White Spanish selection 454. The main aim of these experiments was to identify what nutrients if any were limiting yield in the first peanut crop on virgin soil.

Experiment 6, unfortunately, was disturbed by cattle 9 weeks after sowing and many of the plants were uprooted. As the variety used was developed from single plant selection comparisons on a per plant basis were considered appropriate, but plot yield data could not be obtained. At first harvest 20 plants were sampled per plot, at maturity only 10 were sampled. An analysis of variance was carried out on the weight of mature nuts at first harvest only.

For experiment 7, land preparation was carried out almost a year before planting. Experiment 8 was planted on a site naturally under *Imperata cylindrica* which was ploughed and the land prepared over four months prior to planting.

Experiment 9 was set up to compare the performance of a number of commercial compound fertilisers containing the elements thought to be limiting yield, based on the indications from previous results. The site was prepared following standard commercial practise for the area, and was surrounded by a commercial crop. The *Imperata cylindrica* vegetation was harrowed and burnt 6 weeks before sowing, the ground was then disc ploughed and harrowed.

RESULTS AND DISCUSSION

Responses on Previously Cropped Soils

In experiment 1 kernel yield from Rainamina treated plots was significantly ($P<0.01$) higher than for any other treatment. Treatments including zinc appeared to be higher yielding than those with no zinc, but differences were not significant. Associated with increased yield were an increase in plant height and number of kernels per plant, but kernel size was unaffected (Table 3.3). Also notable was the difference in colour between treated plants, those treated with the complete trace element mix, Rainamina, (containing Mn, Zn, Cu, Fe, Mg, B, Mo and Co) retained a dark green foliage whilst others treated with only Mn, Zn, Cu and Fe in combination showed varying degrees of yellowing.

Table 3.3

Mean height and yield of plants for various trace element treatments in experiment 1

Treatment	plant height (cm) after		yield of kernels $plant^{-1}$		kernel size
	2nd spray	3rd spray	no	wt (g)	
Rainamina	20.4	28.0	36.3	21.25	58.6
Mn+Zn+Fe	19.6	22.6	32.0	16.50	51.6
Zn+Cu+Fe	18.8	24.5	28.5	15.25	53.6
Mn+Zn+Cu+Fe	17.0	22.3	24.8	14.50	58.7
Mn+Zn+Cu	18.6	22.4	24.0	14.00	58.5
Mn+Cu+Fe	13.6	18.8	21.0	11.75	56.6
Control	16.0	19.4	20.3	11.75	58.3
Sed ($P<0.05$)				2.70	

The highest yields in experiment 2 again came from plants treated with Rainamina at low and intermediate concentrations. The plants treated with the high rate of Rainamina (96 $kg.ha^{-1}$) gave the lowest yields and showed stunted growth and yellowing of leaves suggesting Rainamina is toxic at high concentrations (Table 3.4).

Experiment 3 was designed to investigate the effect of concentration of Rainamina on peanut yields but no response was noted. Average yield in this experiment was low, at only 8 g kernels per plant but no specific reason for this was noted.

As no response occurred to the major elements P, K, S and Ca applied in the two experiments 4 and 5 on previously cropped ground, detailed results have not been presented. In experiment 4 generally high soil levels of P and K could account for the lack of response (Table 3.1). The mean kernel yield was only 361 $kg.ha^{-1}$ and a high coefficient of variation (49.4 percent) obscured any treatment effects. The low yield may have been caused by a build up of Sclerotium rolfsii which caused pegs to rot and many nuts to be left in the ground at harvest.

In experiment 5 a high mean yield of 991 $kg.ha^{-1}$ of kernels give some indication that the soil nutrient status was adequate. The poor performance of the first commercial crop at this site may have been due to either inadequate ground preparation or lack of moisture, as the crop was sown at the start of the dry season. Dry conditions could also account for the lack of nodulation in the crop. Inoculation gave a slight increase in the number of nodules per plant and slight improvement in nodule colour at both assessments, 6 and 12 weeks after sowing. However, as the uninoculated treatments nodulated and yielded well it can be assumed that the naturally occurring strain of rhizobium was effective. The number of nodules per plant ranged from 200 to 400.

Table 3.4

Mean kernel yield and yellowing and stunting scores for various trace element treatments in experiment 2

Treatment (rate kg.ha^{-1}) 1/	kernel yield kg.ha^{-1}	yellowing score 2/	stunting
Rainamina (24)	679	3.5	0.2
Rainamina (48)	667	11.3	0.7
Zn	609	12.0	0.2
Zn+Fe	569	10.5	1.0
Mn+Zn+Cu	569	11.5	1.0
Mn+Zn+Fe	554	7.0	0.7
Mn+Zn+Cu+Fe	553	10.5	1.7
Zn+Cu+Fe	540	10.0	1.7
Mn+Cu+Fe	517	4.8	1.5
Control	497	5.0	0.2
Fe	473	3.8	0.2
Rainamina (96)	432	14.3	2.7
significance level	n.s.		

Notes : 1/ Rates are the totals applied over 4 sprayings, 4, 6, 8 and 10 weeks after sowing. Trace element levels were equivalent to levels in 48 kg.ha^{-1} Rainamina.

2/ Score based on number of plants per plot showing yellowing of youngest leaves.

Responses on Virgin Soils

Experiment 6 was disturbed by cattle, so only comparisons on a per plant basis were used. Number and weight of nuts at 9 weeks and weight of nuts at maturity showed a response to P application up to 100 kg.ha^{-1}, however the response was not significant (Table 3.5). There appeared to be a response to N but only to a level of 25 kg.ha^{-1}. Plots treated with 50 to 100 kg.ha^{-1} showed stunted growth and low yields. Moisture stress was the most likely cause of low yield in this experiment (mean yield only 274 kg.ha^{-1}) as both the rainfal and moisture holding capacity of the soil (sandy clay loam overlying gravel) were low.

Table 3.5

The effects of N, P, K and trace element application on mean yield (g.plant^{-1}) for two harvests in experiment 6

Nutrient (rate kg.ha-1)	Yield of Nature Nuts at 9 weeks	Kernel Yield at Maturity
N0	2.94	2.46
N25	2.97	2.59
N50	2.51	2.47
N100	2.49	2.35
P0	2.26	2.18
P25	2.56	2.18
P50	2.92	2.67
P100	3.17	2.84
K + traces 1/	2.88	2.56
K + traces 0	2.57	2.38
significance level	n.s.	

1/ K as muriate of potash at 50kg.ha^{-1}.
Traces as Zn, Fe + Mn at 10kg.ha^{-1} as sulphate.

In experiment 7 no significant responses to P, K or S were noted, yields were generally low, (mean yield of 365kg.ha^{-1}) and no trend was evident. Low mean yields may again be attributed to moisture stress as the experiment was sown in May, later than the optimum suggested by Holloway (1976).

P application in experiment 8 significantly (P<0.05) increased yield. Associated with the yield increase were an increase in kernel size, number of kernels per plant and improved shelling percentage (Table 3.6). Significant differences were evident between blocks with mean yields of 1079 and 1189 kg.ha-1 respectively for blocks 2 and 3, but only 194 kg.ha-1 for block 1. This can be partly attributed to moisture stress as block 1 was sited on a localised area of shallow top soil with low moisture holding capacity. As soil P levels were considered non limiting it is possible that the apparent P response was a response to S applied as sulphate in superking at 1.8 and 3.6kg.ha^{-1} in the P25 and 50 kg.ha^{-1} treatments of Superking (1.5%).

In experiment 9 significant yield increases occurred over P application of 12.5kg.ha^{-1} ($P<0.05$). Yield increase above this level was not significant (Table 3.7). Di-ammonium phosphate (DAP) significantly ($P<0.05$) out yielded the other sources of P over a range of application rates (0 - 100 kg.ha^{-1} P) (Figure 1). This may indicate in part a response to N as DAP is the only source of P used that contains N. S levels in DAP of 3 percent may also indicated a response to this element.

There was no significant effect in rate and form interaction nor in method of application, but rate and method interaction showed a significant ($P<0.05$) effect in favour of banded application of intermediate levels of fertiliser. There were no significant differences in kernel size or number of kernels per plant, but generally higher values could be associated with higher yielding treatments.

Plots treated with DAP were notably greener throughout the growing season but some yellowing and necrosis occurred at the highest rate of application (100 kg ha^{-1}). This was especially marked where the fertiliser had been applied as a banded treatment rather than broadcast.

Table 3.6

The effects of P, K and S application on mean yield and its components in experiment 8

Nutrient kg.ha^{-1}	Yield kg.ha^{-1} in shell	kernels	kernel size	shelling %	no of kernels per plant
P0	1323	693	71.1	42.0	10.0
P25	1622	856	74.0	46.8	12.2
P50	1647	913	76.6	50.8	12.7
LSD P(0.05)		165			
K0	1551	799	74.4	46.0	11.4
K25	1544	847	75.4	49.4	12.0
K50	1498	817	71.9	44.1	11.6
S0	1503	784	73.0	47.5	11.3
S25	1543	810	73.6	43.5	11.3
S50	1547	869	75.0	48.5	12.4
significance level		n.s.			

Table 3.7

The effect of P rate, form and method of application on mean yield and its components and leaf colour rating in experiment 9

Treatment	Yield kg.ha^{-1} kernels	culls	kernel size	no of kernels per plant	leaf colour[2]
Rate					
P0[1]	1033	87	49.4	23.7	2.5
P12.5	1215	89	54.3	25.8	2.8
P25	1323	91	55.9	26.9	3.1
P50	1326	82	55.2	27.5	3.1
P100	1393	121	57.5	28.2	3.4
LSD (P<0.05)	90				
Form					
DAP	1433	71	57.6	27.7	4.0
Superphosphate	1322	107	55.6	28.3	2.6
Superking	1237	96	54.9	25.8	3.1
Sulphur	1266	109	54.8	26.5	2.6
LSD (P<0.05)	90				
Method of application					
Banded	1315	99	55.2	27.7	3.2
Broadcast	1314	93	56.2	26.5	2.9
significance level	n.s.		n.s.	n.s.	

Notes: [1] Mean results of 4 untreated observation plots not used in the analysis of variance.

[2] Leaf colour rating at harvest 1 = yellow
5 = green

GENERAL DISCUSSION

A major factor which must be taken in to account in these experiments is the yield reduction which occurs when peanuts are grown under conditions of moisture stress. This may, in part, be responsible for the poor response to applied fertiliser throughout these experiments. Generally the soils of the Markham and Ramu Valleys are fertile alluvial soils, which can supply adequately, the nutritional needs of the peanut crop, and hence response to applied fertiliser would be expected to be minimal. This fact is clearly emphasised throughout these nutritional studies.

From this work further studies on less fertile soils appear to be needed to investigate the nutrient requirements of peanuts, these could then be used as a basis for comparison of the nutrient requirements under the two different cropping situations.

PART 4

LEAF DISEASE AND FUNGICIDE STUDIES

INTRODUCTION

Peanut leaf spot (Cercospora arachidicola and C. personata) have been present in PNG for some time. While varieties grown were susceptible, incidence was seldom high and an early study by Hill (197Ø) showed no reduction in disease or increase in yield with Captan application. Successful control of leaf spot with fungicides was reported from the Atherton Tableland of Queensland (O'Brien, 1974) but as losses in PNG appeared negligible the agronomic studies presented earlier in this bulletin were given priority.

Peanut rust (Puccinia arachidis) was first recorded in PNG in December 1972. An account of its possible origin and early spread has been presented by Shaw and Layton (1975). Observations in 1973, both in commercial sowings and in the variety evaluation programme showed all local and introduced varieties under test to be susceptible to rust, but infection level varied between sites. In severe outbreaks plants lost all their leaves before reaching maturity, rust appeared to be the main cause. The effects of leaf spot were not clear.

In order to define the effects of rust and leaf spot on production and investigate control, fungicide studies were carried out over three years. A second approach to this problem was the introduction of 14 peanut lines showing some rust resistance (USDA, 1973) for comparison with local varieties, reported earlier in Part 1B of this bulletin.

MATERIALS AND METHODS

Five experiments were conducted from 1973 to 1975 at two sites in the Markham Valley, Maralumi and Mutsing. White Spanish selection 454 was used in all experiments. Table 4.1 gives specific details of sites and experimental designs, Table 4.2 gives the details of fungicides used and rates of application.

Table 4.1

Details of fungicide experiments

Expt no.	site	no of treatments	sowing date	rainfall (mm)	design
1	Maralumi	4	6.Ø9.73	263	unreplicated
2	Maralumi	7	19.Ø2.74	462	latin square
3	Mutsing	7	15.Ø3.74	1ØØ	latin square
4	Mutsing	27	31.12.74	962	{3x3x3 factorial
5	Maralumi	27	1Ø.Ø1.75	566	{unreplicated

Table 4.2

Chemical composition and rates of application of fungicides used in 1 to 5 experiments

Chemical name	commercial name	rate kg.ha^{-1} product	a.i.
mancozeb	Dithane M45	1.7	1.36
benomyl	Benlate	Ø.28	Ø.14
copperoxychloride	Cuprox	1.Ø	Ø.5Ø
daconil	Bravo	1.7	1.28
fentin hydroxide	Duter	1.7	Ø.32

Experiment 1 was set up to compare mancozeb, recommended for rust control (Shaw, pers comm), under two different spray regimes, with benomyl, used for leaf spot control (O'Brien, 1974) in combination with mancozeb. Treatments commenced 9 weeks after sowing. 4 rows of plants in each block were treated. The chemical was applied using a mist sprayer in 169 L.ha^{-1} water with Agral wetting agent.

Experiments 2 and 3 compared the 4 treatments of experiment 1 with benomyl, daconil, and copper-oxychloride applied on three occasions at 14 day intervals. Copper-oxychloride was only included in experiment 2 as it is a cheap, readily available treatment. The spraying programme commenced at the first sign of infection, 9 weeks after sowing at Maralumi and 1Ø weeks at Mutsing. Treatment was applied in 1125 L.ha^{-1} water using Agral wetting agent, with a knapsack sprayer. 3 rows were treated, leaving 1 untreated guard row between each plot. At Maralumi DDT was sprayed regularly from flowering to maturity in an attempt to control earwigs which had been a problem in experiment 1. Three harvests were made at weekly intervals, the first being the centre row of each plot. Dry weight of plant tops was recorded at final harvest at Maralumi in an attempt to use leaf fall as a measure of disease incidence. Disease score and a leaf fall rating were taken at first harvest only.

Experiments 4 and 5 used a 3 x 3 x 3 factorial design to compare the following treatments.

For rust control	For leaf spot control	Number and timing of applications
(i) mancozeb	(i) benomyl	(i) 2 every 14 days
(ii) daconil	(ii) fentin hydroxide	(ii) 3 every 14 days
(iii) no treatment	(iii) no treatment	(iii) 4 every 7 days

Fentin hydroxide was included as it had been shown to give good control of leaf spot in Queensland (O'Brien, 1974). The number of applications was varied to see if less frequent applications could be used to give adequate disease control. Treatments were unreplicated but arranged in sub-blocks of 9 to confound the higher order interaction. Layout and application techniques were as for experiments 2 and 3. Treatments commenced 8 weeks after sowing. At each harvest the number of plants that lost most of their nuts on lifting (diseased plants) was recorded and expressed as a percentage of the total number of plants as a further measure of disease level.

RESULTS AND DISCUSSION

Establishment was good in all experiments, and plant populations of 100 000 ha^{-1} were achieved at maturity. Rainfall was adequate in all experiments except experiments 3, where low rainfall and the free draining soil at this site induced moisture stress in the peanut crop.

In experiment 1 treatment commenced nine weeks after sowing at moderate rust levels with the last five compound leaves generally free of pustules. The rust level increased as the crop matured and the first indication of a treatment response was not evident until three weeks after the first spraying. Mancozeb applied either every 7 days or with benomyl gave noticeably better control than the other two treatments. A yield response to mancozeb sprayed at 7 day intervals (Table 4.3) confirmed visual observations. Treated plants produced larger kernels than untreated ones. Earwigs caused considerable damage despite frequent spraying and could have been the reason for the relatively low yield of this experiment compared with later experiments.

Table 4.3

Yield response to fungicide treatment in experiment 1

Treatment	frequency of applications	number	kernel yield kg.ha^{-1}	kernel size
control			689	50.0
mancozeb	14 days	3	644	57.3
mancozeb	7 days	5	964	55.6
mancozeb + benomyl	14 days	3	734	57.3

In experiment 2 a decline in yield with delayed harvest was evident for all treatments (Table 4.4). Wet conditions after the first harvest caused pegs to rot, and nuts to be left in the ground at harvest. Effective spraying allowed for greater flexibility in the timing of harvest. As in experiment 1 kernel size increase was associated with effective spray treatment (Table 4.5).

Table 4.4

Mean yield at three harvest dates, dry yield of plant tops, at final harvest disease and leaf fall rating in experiment 2

Treatment	kernel yield kg.ha^{-1} 100 days after sowing	107	114	dry yield of tops kg.ha^{-1}	disease score rust	leaf spot	leaf fall score
Control	1100	935	356	1269	2.1	2.8	1.5
benomyl	1207	1073	661	1568	1.9	4.1	3.6
copperoxychloride	1171	1069	537	1390	2.1	2.7	1.7
daconil	1383	1210	1147	1829	2.2	3.4	4.6
mancozeb	1171	1100	1020	1979	3.4	2.0	3.8
mancozeb (7 days)	1302	1286	1233	2289	4.2	2.1	4.8
mancozeb + benomyl	1372-	1336	1298	2231	2.4	4.2	4.9

Note : All treatments as 3 applications at 14 day intervals except mancozeb (7 days) which was 5 applications at 7 day intervals.

Table 4.5

Mean kernel size at three harvest dates and overall mean in experiment 2

Treatment 1/	kernel size 100	107	114 days after sowing	Mean kernel size
Control	57.5	57.1	57.7	57.4
benomyl	60.4	59.4	59.0	59.6
copperoxychloride	56.7	56.7	59.6	57.7
daconil	63.4	60.5	64.7	62.9
mancozeb	61.2	61.0	62.3	61.5
mancozeb (7 days)	62.7	62.8	66.8	64.1
mancozeb + benomyl	61.6	61.7	63.1	62.1

Note : 1/ All treatments as 3 applications at 14 day intervals except mancozeb (7 days) which was 5 applications at 7 day intervals.

Yields from plots treated with mancozeb and benomyl, mancozeb (7 days) and daconil outyielded all other plots. It appears that provided rust is controlled (mancozeb applied every 7 days) leaf spot does not reduce yield. Where rust is incompletely controlled (Mancozeb applied every 14 days) leaf spot control with benomyl will increase yield (Table 4.4). Treatments showing low level of leaf fall were generally the higher yielding treatments, and dry yield of plant tops at 114 days indicates higher plant yields where disease is controlled. Table 4.6 gives an indication of the effects of rust and leaf spot, both individually and in combination, on yield. The effect of rust increases with delay in harvest, whereas the effect and leaf spot is constant throughout the harvest period. The combined effects of rust and leaf spot cause a decline in yield which becomes progressively more marked with time.

Table 4.6

The individual and combined effects of rust and leaf spot on the yield of peanuts in experiment 2

Treatment	Disease Controlled	Yield reduction due to	kernel yield $kg.ha^{-1}$ 114	107	100 days after sowing
Control	nil	Both	356	935	1100
benomyl	Leafspot	rust	661	1073	1207
mancozeb	rust	Leafspot	1020	1100	1171
mancozeb + benomyl	leafspot & rust	nil	1298	1336	1372

Experiment 3 was late sown on a shallow (30 - 60 cms deep) loam soil overlying gravel and suffered moisture stress, causing a marked stunting in all treatments. A low mean yield of 391 kg.ha-1 was obtained, and as no differences between treatments could be detected, detailed results are not presented.

Experiment 4 showed only low infections of both rust and leaf spot. Benomyl treated plots gave yields comparable to other treatments at the first and second harvests but lower yield at the third harvest (Table 4.7). No yield advantage could be detected with four fungicide applications over three, but three applications outyielded two at all harvests. Larger kernel size was associated with plots where disease was adequately controlled.

In experiment 5 leaf spot infection was only slight, but a high level of rust infection promoted early leaf fall and almost complete defoliation of untreated plots by first harvest. Defoliation markedly decreased yields (Table 4.8). Four applications of fungicide outyielded two applications at the last two harvests.

Table 4.7

The effect of fungicide application on mean kernel yield, and percentage of diseased plants at three harvests in experiments 4 and 5

Treatment	kernel yield $kg.ha^{-1}$ harvest 1/			% diseased plants harvest			leaf fall score
	1	2	3	1	2	3	
Experiment 4							
control	1384	874	343	19	38	63	2.7
benomyl	1749	1449	883	1	13	37	0.9
daconil	1819	1659	1111	2	6	17	0.4
fentin hydroxide	1593	1558	1200	1	6	15	1.1
mancozeb	1843	1765	1338	1	6	17	0.6
Experiment 5							
control	914	490	158	13	21	74	3.7
benomyl	1594	895	383	3	31	56	1.9
daconil	1900	1467	771	1	9	23	0.9
fentin hydroxide	1898	1792	995	3	2	46	0.8
mancozeb	1825	1426	650	2	12	39	1.3

1/ Harvest dates were 1-100, 102; 2-107, 109; and 3-115, 116 days after sowing for experiments 4 and 5 respectively.

GENERAL DISCUSSION

Experimental work carried out in this study has demonstrated that yield losses can be avoided in peanuts by controlling rust and leaf spot diseases. Of the chemicals used in these trials mancozeb, daconil and fentin hydroxide appeared to be most effective against rust, daconil and fentin hydroxide also controlled leaf spot and so may be preferred for general use. Problems were noted with the use of fentin hydroxide, with red-brown blotches on the leaves suggesting a toxic effect. The effect was pronounced with more frequent applications and apparently lessened when fentin hydroxide was combined with mancozeb. Similar effects have also been identified on peanuts at Atherton (O'Brien, pers comm). Increased kernel size and greater flexibility of harvest were associated with the use of fungicides.

Control of peanut diseases is necessary in order to achieve high yields, but a general upgrading of farming practise is needed before the widespread use of fungicides will be beneficial. The slow initial appearance of rust symptoms allows the disease to be well established on the plant before the infection is noted by the grower. These studies have demonstrated that little difference between plots can be seen upto three weeks before harvest, but at harvest, yield differences between infected and non infected plots were evident. Inspection midseason of the oldest leaves followed by weekly inspection of plants to harvest would be necessary to detect rust infection and implement early effective control.

PART 5

HERBICIDE STUDIES

INTRODUCTION

Early peanut crops in the Markham Valley were machine sown but crop maintenance, harvesting and threshing were carried out manually. Shifting cultivation was practised within the plantation with only 3 or 4 crops being grown on virgin ground before it was sown to improved pasture or allowed to revert to natural vegetation. Under this system crop maintenance requirements from a weed and disease point of view were minimal. However, due to limited land availability and expansion of the cropping area the fallow period between crops was shortened and weeds became a major problem. Interrow cultivation was practised to some extent together with manual weeding, but poor timing of hand weeding and increasing labour costs caused yields and net returns to decline.

A series of herbicide experiments were carried out by DASF in the sixties to test a range of herbicides used sucessfully in peanuts elsewhere. As a result of this work one herbicide MCPB was recommended for post- emergence control of Euphorbia genticulata (milkweed) and was adopted commercially at specific sites (Blackburn, pers comm). However, at the majority of sites a broad spectrum of weed species occurred and specific herbicide could be recommended. Further screening of herbicides was carried out by DASF in 1969 and the results of these experiments are discussed in the first part of this study.

The introduction of a non legume rotation crop was considered as a possible method of overcoming the weed problem in peanuts. In the late sixties crops such as maize and grain sorghum were considered for this purpose but problems in crop husbandry and marketing of the product prevented immediate implimentation. Considerable progress was made in the early seventies and Vance (1981) reported sucessful cropping of sorghum in areas previously under peanut monoculture. Under this system, using the herbicide atrazine and taking advantage of the rapid early growth of both these crops weed free conditions can be obtained. Problems have recently come to light as one grass species, Rottboellia exaltata, is apparently resistant to atrazine. Whilst cultural control of Rottboellia has been shown to be effective in areas under continuous sorghum cultivation, the desirablity of a rotation offering the possibility of controlling grass weed species in the legume crop was examined. Two experiments on the control of Rottboellia in peanuts are discussed in the second part of this study.

MATERIALS AND METHODS

Initial Screening Trials

Initial screening experiments were set up in 1969 at four sites with major weed problems, Bubia, Mutsing, Gabmazung and Sasiang. The herbicides used in the experiments were selected on the basis of sucessful use in peanuts overseas. Table 5.1 gives a full list of the herbicides used, and their rates and times of application. Herbicides were applied using a Mini Log Sprayer (Chesterford 1964) set to a swath width of 0.91 m to cover a plot length of 18.82 m (in each sprayed row, herbicide concentration decreased logarithmically with distance covered by the sprayer). The volume delivered by the sprayer was 304 $L.ha^{-1}$. The initial dose was applied at twice the manufacturer's recommended rate.

A plot consisted of two sprayed rows (sprayed in opposite directions), each planted with a row of peanuts in the middle. Two unsprayed guard rows were left between each treatment. A visual assessment of weed growth was carried out at three weekly intervals after sowing, and a weed density score was given for each herbicide treatment.

Table 5.1

Herbicide rates and times of application in the initial screening trials

Herbicide	rate kg.ha^{-1} ai	time of application
alachlor	2.4 - 4.7	pre emergence
carbetamide	5.5 - 11.0	pre emergence
chloramben	1.1 - 2.2	pre emergence
diuron	2.7 - 5.4	pre emergence
linuron	1.7 - 3.4	pre emergence
nitralin	1.7 - 3.4	pre emergence
nitrofen	4.0 - 8.0	pre planting
preforan	1.0 - 2.0	pre emergence
terbacil	0.9 - 1.8	pre emergence
trifluralin	0.8 - 1.7	pre planting
vernolate	3.4 - 6.8	pre planting
24DB or MCPB	1.1 - 2.2	post emergence

Formal Herbicide Evaluation

Broad spectrum weed control

These experiments were carried out at the Gabmazung site only, which had a wide range of weed species and an acute level of infestation. The aim of these experiments was to test the promising herbicides selected from the screening trial at different rates of application by observing weed growth and measuring peanut yield.

Experiment 1 was set up in May 1969 to test 20 herbicide treatments. 24D-amine, which had not been used in the initial screening, was included as it is inexpensive, readily available and had been used sucessfully in Queensland for broadleaved weed control. It was used both alone and in combination with alachlor, which had shown grass control but poor broadleaved weed control in the initial screening trial. Herbicides were all applied pre-emergence, using an Oxford Precision Sprayer set to deliver 450 L.ha^{-1}. Two control plots were included for comparison, one unweeded and one hand weeded. The design used was a randomised block with 4 replications, plots were 1.8 m wide and 8.2 m long and included three rows of peanuts.

Weed counts by species were taken at 3 weekly intervals after planting. A quadrat (0.84 m^2) was placed randomly in the crop and weeds falling within the quadrat were counted. A crop herbicide tolerance and weed density visual assessment were taken at 3 weeks, weed density assessments were also made at 6 and 9 weeks to assess the duration of control. The hand weeded plot was clean weeded after the weed density scores had been taken at 3, 6 and 9 weeks. Prior to peanut harvest all weeds in each plot were harvested and weighed. Only the centre row of peanuts was harvested and used to determine yield. As a further yield comparison 8 plots were harvested at random from the surrounding commercial crop.

Experiment 2 was set up to investigate some symptoms of phytotoxicity in terbacil treated plots in experiment 1. The experiment was planted in July 1969 and included terbacil at low rates and in combination with the herbicide diuron in an attempt to control the weeds without damaging the peanut crop. The herbicide mixture was applied at 4 rates, with the ratio of terbacil to diuron held constant at Ø.75 : 2, this was compared with terbacil, diuron and linuron. All were single applications applied pre-emergence using an Oxford Precision Sprayer. Control treatments, design and recordings were as described for experiment 1.

Demonstration blocks were set up in commercial crops using standard commercial field procedures at two sites at Gabmazung in May 197Ø. Treatments at the first site were terbacil Ø.9 $kg.ha^{-1}$, diuron 3.6 $kg.ha^{-1}$, 24D-amine 1.68 kg ha^{-1} and terbacil with diuron at Ø.62 and 1.64 $kg.ha^{-1}$, all applied pre-emergence in 38Ø L water. Treatments were applied to areas Ø.33 ha, and were not replicated. Treated areas were inspected regularly for weed growth, species present and crop tolerance to herbicides. At maturity samples were taken to assess yield response to different herbicides.

A second demonstration block was set up at Nazab to show the phytotoxic effects of high rates of terbacil. Plot size was $6m^2$ and terbacil was applied at a rate of Ø.9$kg.ha^{-1}$. Higher rates of application, 1.8, 2.7, 3.6 and 4.5$kg.ha^{-1}$ were obtained by making several passes over the plot. Treatments were unreplicated. This type of application was thought to represent the most likely method by which overdoses of terbacil may occur. Counts of seedling emergence and observation of any phytotoxicity symptoms were made one month after application. Similar counts were made on untreated control plots. At harvest, yield of nuts in shell was recorded.

Control of Rottboellia exaltata.

Rottboellia was noted as the major weed species in sorghum crops grown in the Markham Valley (Vance 1981). This was attributed to the resistance shown by Rottboellia to the herbicide atrazine. The possibility of controlling this weed in a rotation crop of peanuts was studied in two experiments at Maralumi in 1974 and 1975. Both sites were under a pure stand of Rottboellia which was seeding freely. In 1974 the stubble was slashed and raked clear of the site which was harrowed to give a fine tilth but much Rottboellia remained in the ground at sowing. In 1975 the ground was prepared in the same way but was worked over a much longer period to give a fine tilth with little stubble remaining at sowing.

The 1974 experiment included 12 herbicide treatments, and hand weeded and unweeded controls. Dinitramine, trifluralin and BAS3921h were applied pre-planting and were soil incorporated. Alachlor, preforan and diuron were applied pre-emergence. All herbicides were applied using an Oxford Precision Sprayer in 254 $L.ha^{-1}$ water. Plots in the experiment were 1.8 m wide, 7.6 m long and had 4 rows of peanuts 6Ø cms appart, the two outer rows marked the plot boundary. An untreated area of 6Ø cms was left between each plot and was weed free. The plots were arranged in a randomised block design with 4 replications. Seed was sown into moist soil at a depth of 7 cms. Counts of Rottboellia and Euphorbia seedlings in a randomly placed Ø.1 m^2 quadrat were taken 4 weeks after sowing, and a rating for control of the two species given. At maturity only the two centre rows were harvested for calculation of yield data, and a randomly placed Ø.6 m^2 quadrat was used for weed yield data. Unfortunately, many plots were harvested by intruders so yield data was only collected from the two undamaged replicates.

The 1975 experiment included 5 herbicides, trifluralin, dinitramine, preforan, alachlor and diuron applied at different rates, and hand weeded and unweeded control plots, 14 treatments in total. The BASF experimental herbicide BAS392lh was excluded from this trial as it was not to be released commercially (Cottam, pers comm). Techniques were as for the 1974 experiment but volume of application of herbicide was reduced to 185 $L.ha^{-1}$. Plots were 1.8 m wide and 5 m long with no untreated area between them. Four weeks post- planting an assessment was made of the phytotoxic effects of the different herbicides on the two centre rows of peanuts in each plot. The number of weeds in the central area, over a length of 3 m was counted. No further records could be taken as weed growth was extremely vigorous with plants reaching 2 m in height. Owing to the closeness of the plots, herbicide treatments giving good weed control were shaded by excessive weed growth, and no crop yield data could be obtained.

RESULTS AND DISCUSSION

Initial Screening Trials

The major weed species noted in these experiments were *Boerhaavia erecta*, *Euphorbia geniculata*, *Tridax procumbens*, *Portulaca oleracea*, *Brachiaria reptans* and *Digitaria* species. Terbacil was the only herbicide showing good control of all species (Table 5.2). Linuron and diuron showed inconsistant control of *E. geniculata* and *Digitaria* species. Alachlor and nitrofen showed good grass weed control but failed to control several broadleaved species. Nitralin, chloramben, trifluralin and vernolate showed adequate grass weed control but little control of broadleaved species. MCPB and 24DB controlled broadleaved species only. Preforan gave control of early grass weeds only, whilst carbetamide was completely ineffective. Methabenzthiazuron (not tabulated) was the only herbicide showing phytotoxic effects on the peanut crop.

Table 5.2

Weed density scores at three growth stages for herbicides in the initial screening trials

Herbicide	weeks after planting 3	6	9	mean
alachlor	1.25	1.0	2.25	1.5
carbetamide	3.25	3.75	4.25	3.75
chloramben	1.75	3.25	3.25	2.75
diuron	1.0	0.75	1.75	1.17
linuron	1.0	1.25	1.75	1.33
nitralin	1.25	2.0	3.25	2.17
nitrofen	1.25	1.75	3.0	2.0
preforan	2.25	3.0	4.25	3.33
terbacil	0.0	0.25	1.75	0.67
trifluralin	2.0	3.0	4.0	3.0
vernolate	2.0	3.5	3.75	3.08
24DB or MCPA	n.r.	2.25	3.0	2.63

Formal herbicide evaluation

Broadspectrum weed control

The main weed species found at Gabmazung were *E. geniculata*, *Amaranthus viridis*, *Phyllanthus nirui*, *P. oleracea*, *Passiflora foetida* and *Eleusine indica*. *E. geniculata* grew to over 1 m height whereas the peanut crop reached a maximum height of only 60 cms, hence *E. genticulata* competed strongly with the crop for light, moisture and nutrients. Any herbicide treatment which failed to control this species gave low yield.

Yields in the experiment were generally low (Table 5.3) but yields were significantly increased where weeds were adequately controlled. The highest yielding treatments were the hand weeded control, terbacil at 0.9 kg ha^{-1} and diuron at 5.4 kg.ha^{-1}, there was no difference between these treatments. Toxicity problems were noted with terbacil which were not evident in the screening trials. Symptoms ranged from slight leaf chlorosis at 0.45 kg.ha^{-1} to leaf necrosis and plant death at 1.8 kg.ha^{-1}. Linuron and diuron also caused leaf chlorosis in some plants but only at high rates of application, 3.4 and 5.4 kg.ha^{-1}, respectively.

Table 5.3

Weed density scores at three growth stages and kernel yield for herbicides in the first formal experiment at Gabmazung

Herbicide	rate 1/ kg.ha^{-1} ai	weed density score weeks after planting 3	6	9	yield kg.ha^{-1}
hand weeded control		0	0	1.0	465
unweeded control		2.0	3.0	3.75	176
alachlor	2.35	2.0	2.75	3.25	109
alachlor	4.70	1.0	1.5	3.0	178
diuron	1.35	2.0	2.5	3.75	113
diuron	2.70	1.0	1.5	3.0	230
diuron	5.40	1.0	1.5	2.5	319
linuron	1.70	1.0	2.0	3.0	221
linuron	3.40	1.0	2.0	2.75	162
nitrofen	2.70	2.0	3.0	3.75	135
nitrofen	5.40	2.0	3.0	3.25	273
terbacil	0.45	1.0	2.5	3.0	111
terbacil	0.90	1.0	1.0	2.0	372
terbacil	1.80	0.5	1.0	1.25	250
24D amine	0.84	2.0	3.0	3.75	98
24D amine	1.68	2.0	3.0	3.75	96
24D amine + alachlor	L L	2.0	2.5	3.25	131
24D amine + alachlor	L H	1.0	2.0	2.75	197
24D amine + alachlor	H L	1.0	1.5	2.0	178
24D amine + alachlor	H H	1.0	1.5	2.25	195

1/ For 24D amine and alachlor mixture L and H refer to low and high rates given for single application.

In the second formal experiment at Gabmazung, E. geniculata was the main weed present, and it was noted that on the light soil of this site, E. geniculata seeds could sucessfully germinate and emerge from depths of 7 to 10cms below of the zone of herbicide activity. Good weed control and hence high yield were only achieved in the hand weeded control treatment (Table 5.4). In this experiment terbacil caused chlorosis of leaves at 0.45 kg.ha^{-1} and leaf margin necrosis at 0.9 kg.ha^{-1}. Diuron at 3.6, linuron at 2.3 kg.ha^{-1} and the Terbacil-Diuron mix all caused slight chlorosis of leaves.

Table 5.4

Weed density scores at three growth stages and kernel yield for herbicides in the second formal experiment at Gabmazung

Herbicide	rate kg.ha^{-1} ai	weed density score weeks after planting 3	6	9	yield kg.ha^{-1}
hand weeded control		0	0	1.0	1010
unweeded control		3.75	4.0	4.0	35
diuron	2.70	2.5	3.0	4.0	123
diuron	3.60	1.75	2.5	4.0	66
linuron	1.70	2.25	3.0	4.0	62
linuron	2.30	2.5	3.0	4.0	86
terbaci	0.45	2.5	3.25	4.0	76
terbaci	0.68	1.75	2.5	4.0	78
terbaci	0.90	1.25	2.25	4.0	70
terbacil + diuron	0.37 + 0.98	1.5	2.25	3.75	125
terbacil + diuron	0.50 + 1.31	1.5	2.25	3.75	103
terbacil + diuron	0.62 + 1.64	1.5	2.75	3.75	191
terbacil + diuron	0.74 + 1.96	1.5	2.75	4.0	72

At the first demonstration block at Gabmazung (on a light soil) species present included E. geniculata, Digitaria spp, E. indica, B. erecta, P. oleracea, A. viridis and P. niruri. Control of all species was only achieved with 0.9kg.ha^{-1}. Only a few plants of Amaranthus and Phyllanthus remained at harvest.

At the second site on a heavier soil three weed species showed tolerance to terbacil at 0.9 kg ha^{-1}, R. exaltata, Ipomea batatas and Panicum spp. E. geniculata, the only other species present, was completely controlled by the herbicide. The diuron, 24D-amine and terbacil-diuron mix had little effect on weeds at this site.

In the experiment at Nadzab, weed infestation of the site was low, so it was assumed that yield differences could be taken to represent differences in crop tolerance to terbacil. Terbacil at 0.9 kg ha^{-1} was noted as safe to use (Table 5.5), rates greater than this markedly reduced yields, hence terbacil could not be recommended for widespread commercial use.

Table 5.5

Percent emergence, percent seedlings showing leaf burn and yield of nuts in shell for the terbacil phytotoxicity experiment at Nadzab

Treatment ($kg.ha^{-1}$ ai)	emergence as % of control	seedlings with leaf burn %	yield $kg.ha^{-1}$
unsprayed control	100	12	1035
terbacil 0.9	108	12	1220
terbacil 1.8	106	51	570
terbacil 2.7	91	57	358
terbacil 3.6	74	59	276
terbacil 4.5	64	72	319

Control of Rottboellia exaltata.

In the 1974 experiment the hand weeded control outyielded all herbicide treatments (Table 5.6). The herbicide BAS3921h at 2.0 $kg.ha^{-1}$ and trifluralin at 1.2 $kg.ha^{-1}$ gave good control of Rottboellia but little control of E. geniculata. The effectiveness of herbicides may have been limited by poor soil incorporation and surface trash.

Table 5.6

Weed density score for Rottboellia exaltata an yield of nut in shell for the 1974 Maralumi experiment

Treatment	rate $kg.ha^{-1}$ ai	R. exaltata density score	yield $kg.ha^{-1}$
hand weeded control		0	780
unweeded control		3.7	154
alachlor	3.0	3.7	160
alachlor	6.0	3.2	149
BAS 3921 H	1.0	1.7	165
BAS 3921 H	2.0	0.9	268
dinitramine	0.5	3.0	148
dinitramine	1.0	1.7	241
diuron	2.5	3.7	86
diuron	5.0	3.5	179
preforan	5.0	3.2	146
preforan	10.0	2.7	185
trifluralin	0.6	1.7	144
trifluralin	1.2	0.7	257

In the 1975 experiment hand weeding was carried out only once, following this Rottboellia growth was rapid (Table 5.7). Trifluralin at a high rate of application, 1.8 kg ha^{-1} gave poor control of broadleaved species present, but showed good control of Rottboellia. Grass control using this herbicide has also been reported by Wood (1970b) and Thomas (1970).

Table 5.7

Plant counts and percentage of plants showing phytotoxicity symptoms for the second R.exaltata experiment at Maralumi in 1975

Treatment	rate $kg.ha^{-1}$ ai	plant counts R. exaltata	'000.ha^{-1} broadleaf	% plants with toxicity symptoms
hand weeded control		173	504	7.1
unweeded control		413	988	4.1
alachlor	6.0	548	292	10.0
alachlor	9.0	396	141	7.5
dinitramine	0.5	351	1040	9.1
dinitramine	1.0	181	428	10.9
dinitramine	1.5	143	383	8.3
diuron	5.0	453	366	9.5
diuron	7.5	459	330	9.3
preforan	10.0	280	598	8.1
preforan	15.0	204	559	9.1
trifluralin	0.6	217	1469	7.0
trifluralin	1.2	116	590	7.3
trifluralin	1.8	51	507	7.7

GENERAL DISCUSSION

Of the 14 herbicides screened for broad spectrum weed control in peanuts, only terbacil at 0.9 $kg.ha^{-1}$ showed good control, however, it was considered too phytotoxic for commercial use. Trifluralin gave good control of grasses but not broadleaved species. It was the only commercial herbicide which controlled R. exaltata which is becoming a major problem in sorghum crops as it is resistant to atrazine. As Atrazine gives excellent broadleaf control (Vance, 1981) it may be possible to rotate sorghum and peanuts and maintain weed free conditions by using the respective selective herbicides. Trifluralin may also offer a means of control when used in a soyabean rotation crop, especially as soyabean can be grown using the same equipment as for grain sorghum.

Further work is needed on methods for successful application of herbicides, as many growers are not familiar with the et al use of chemicals.

ACKNOWLEDGEMENT

The authors wishes to express their thanks to Mr.A.E.Charles, Chief Agronomist, and Mr.J. Sumbak, supervising agronomist, for assistance in planning this research programme, and for advice during the preparation of this manuscript, and Dr.S. George with the editing of the bulletin.
Thanks are also due to Dr. Dorothy E. Shaw for her assistance in the introduction and early assessment of the rust resistant lines. For their assistance in the field thanks are due to Mr.K. Wudrag, Mr.P. Ivoro, Mr.L. Kavae, Mr.M. Quinding and Mr.M. Wamma. For assistance in the analysis and interpretation of the soils, thanks are due to Chemistry Section, DPI, Konedobu.

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