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A Review of the Present Status of the Genetic Resources of the ICRISAT Regional Groundnut Improvement Program, of the Southern African Cooperative Regional Yield Trials, and of Rosette Virus Resistance Breeding

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Abstract

The status of the groundnut genetic resource collection at the ICRISAT Regional Groundnut Program in the southern African region and of the ICRISAT Peanut Germplasm Center for groundnuts in Southern Africa is reviewed. The role of introductions in the improvement of local varieties is discussed with particular emphasis on the valencia types in the region.

Two years' results from the ICRISAT Southern African Cooperative Regional Yield Trials are presented. While reviewing the progress made in breeding groundnuts for rosette virus (GRV) resistance, it is suggested that resistance to this disease is governed by two recessive genes. Transfer of this resistance into early maturing groundnut varieties will require large F_2 populations.

Sumário

Uma revisão do presente estado dos recursos genéticos no Programa Regional de Melhoramento do Amendoim do ICRISAT, dos ensaios regionais cooperativos para o rendimento na África Austral e do melhoramento para a resistência ao vírus de roseta. *É revista o estado das colecções de recursos genéticos de amendoim dos programas nacionais da África Austral e do Programa Regional de Melhoramento do Amendoim do ICRISAT para a África Austral. A importância das 'introduções' no melhoramento do amendoim nesta região é discutida com particular realce nos amendoins do tipo valencia.*

São apresentados dois anos de resultados dos ensaios regionais cooperativos para o rendimento na África Austral do ICRISAT. Durante a revisão do progresso feito no melhoramento para a resistência ao vírus da roseta do amendoim é sugerido que a resistência a esta doença é governada por genes recessivos. A transferência desta resistência para variedades de maturação precoce vai requerer grandes populações F_2.

Since the inception of the ICRISAT Regional Groundnut Program for Southern Africa in July 1982, significant progress has been made in various aspects of groundnut improvement in the region. The research requirements for groundnut improvement in the region (Nigam 1984) and the progress up to 1984, were reviewed at the previous Regional Workshop in 1984 (Nigam and Bock 1985).

This paper deals mainly with two specific aspects, i.e., genetic resources and regional yield trials, which were discussed at length in the concluding session of the ICRISAT-IDRC Regional Groundnut Breeders'

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Group Tour (Zimbabwe-Zambia-Malawi), 25 Feb-1 Mar 1985. A brief review is also given of the breeding for the Groundnut Rosette Virus (GRV) resistance program, which has expanded greatly in the last two years.

Genetic Resources

Germplasm is an important raw material for any crop-breeding program. The extent of genetic diversity for characters of economic importance in an available germplasm collection plays a significant role in the success of a breeding program.

A collection of groundnut germplasm consisting of 11 548 accessions of *Arachis hypogaea* L. is currently available with the Genetic Resources Unit of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India. This material has been evaluated for various morpho-agronomic characters, including resistance to diseases and insect pests (Rao 1985).

The most complete catalogued collection of approximately 4000 accessions, is maintained in the USA by the Southern Regional Plant Introduction Station, Georgia. Several other countries and programs maintain their own collections.

ICRISAT Center has a special interest in wild species of *Arachis*. This genus includes 50 or more species from seven clearly differentiated taxonomic sections. Wild species collections are also maintained in some U.S. universities.

A review of the genetic resources available within national programs in the region indicates that some of them not only maintain sizeable collections of germplasm but have also exploited them successfully. The largest collection of over 2000 lines is maintained by the Zimbabwe national program at Harare. The collection includes introductions from various countries in Africa; Brazil, Bolivia, and the USA in the Americas, and from ICRISAT Centers in India and Malawi (Chiteka 1985).

The Oilseeds Research Project at Mtwara, Tanzania has more than 1000 lines in its collection. The majority of these lines have been obtained from ICRISAT Center, India. In a recent joint collection mission with ICRISAT, the national program has collected more than 80 diverse groundnut samples from the central region of Tanzania (Mwenda 1985). The Groundnut Project at the Msekera Regional Research Station, Chipata, Zambia maintains a collection of 850 lines (440 local landraces and 410 exotic lines). These lines have been evaluated and catalogued for important agro-morphological characters including disease resistance (Sandhu 1985). The Malawi national groundnut program maintains a collection of 317 lines that have been evaluated for seed color, seed size, and resistance to rosette disease.

The Mozambique collection consists of 216 local landraces and 157 exotic lines from ICRISAT, USA, Burkina Faso, Malawi, and Tanzania. Botswana has recently acquired cultivars from Burkina Faso, Senegal, the Republic of South Africa, Zimbabwe, and ICRISAT, and plans to develop this collection further and maintain it annually (Mayeux 1985). Although ICRISAT has recently supplied groundnut germplasm lines, cultivars, and breeding lines to programs in Angola, Lesotho, and Swaziland, nothing is known about the status of their germplasm collections.

Genetic resources available with the national programs have been successfully exploited as direct "introductions" or in hybridization programs. Introductions from South America, especially those from Bolivia in the long-season group, and from Brazil in the short-season group, have shown particular promise in Zimbabwe (Chiteka 1985). Similarly, the cultivars from West Africa and the USA showed promise in the preliminary trials in northern Mozambique (Malithano et al 1985).

Of the nine cultivars released in Zimbabwe (Valencia R1, Valencia R2, Jacana, Natal Common, Swallow, Plover, Makulu Red, Egret, and Flamingo), all except Swallow and Flamingo are 'introductions' or re-selections from introductions. Similarly, of the six currently-recommended cultivars in Malawi (RG1, Chitembana, Chalimbana, Mani Pintar, Mawanga, and Malimba), only the first two are the product of hybridization. All four cultivars in Zambia (Chalimbana, Makulu Red, Natal Common, and Comet) and the two recent releases in Tanzania (Spancross and Robut 33-1) are 'introductions'. Selections from the local landraces (Bebiano Branco, Bebiano Encarnado, Jonca, Napalala) and an introduction, RMP 12 from Senegal, have been recommended for production in Mozambique.

Germplasm Collection at the ICRISAT Regional Program

The selected introduction of germplasm lines from various sources, their evaluation under Chitedze conditions, and their proper documentation occupy a significant place in the activities of the breeding program.

By the end of the 1984/85 crop season, the regional program had acquired 765 *Arachis hypogaea* germplasm lines, mainly from ICRISAT Center, India. These lines have been critically evaluated for various agronomic and morphological characters, assigned ICGM (ICRISAT Groundnut Malawi) numbers, and are properly documented in the Germplasm Accession Register. Five hundred and four of these lines belong to *A. hypogaea* ssp *fastigiata* and 249 to *A. hypogaea* ssp *hypogaea*. The remaining 12 are yet to be classified. Three hundred and ninety-two of the lines originated in North and South America, 260 in Africa, 40 in Asia, 5 in the Middle East, 1 in Australia, and the remaining 27 are of unknown origin.

In response to the recommendations of the Regional Groundnut Breeders Tour, the regional program has acquired this year 145 lines from the Zambian collection and 40 lines from the recent Tanzanian collection for evaluation and documentation. Forty-five promising lines of the Mozambican collection have already been evaluated in the 1984/85 season.

The regional program also holds a collection of 32 *Arachis* wild species accessions received from ICRISAT Center in India. They are being screened for early leaf spot (*Cercospora arachidicola*) resistance under field conditions at Chitedze.

Field Evaluation of the Germplasm

Four hundred and eighty-eight germplasm lines and 111 elite parents and sources of resistance to diseases and insect pests were evaluated in 1982/83, together with 9 important regional varieties as controls, in single 6-m row plots. Pod yield of control varieties ranged from 0.62 to 1.09 kg plot⁻¹ and seed yield from 0.38 to 0.65 kg plot⁻¹. Fifteen promising lines, having a pod yield equal to or greater than 1 kg plot⁻¹, or a seed yield equal to or greater than 0.60 kg plot⁻¹, were selected for further evaluation in a replicated yield trial in 1983/84. Another 162 lines were retained for re-evaluation due to their poor plant stand in the trial.

The top 10 lines on the basis of seed yield were ICGM 336 (0.83 kg), 471 (0.80 kg), 437 (0.80 kg), 48 (0.79 kg), 197 (0.78 kg), 479 (0.75 kg), 177 (0.78 kg), 189 (0.73 kg), 449 (0.73 kg), and 456 (0.72 kg). ICGM 336 belongs to the Nambyquarae group, 437 and 456 to the spanish group and the rest either to the valencia or the Mansema group. From the preliminary evaluation it appears that some of the valencia types, particularly those from the South American region, perform well under Chitedze conditions. These observations, in general, are in agreement with results from Zimbabwe on the performance of long season varieties from Bolivia and short season varieties from Brazil under Zimbabwe conditions. The top ranking line ICGM 336 originated in Bolivia and the second and third ranking lines ICGM 471 (spanish) and 437 (valencia) originated in Brazil.

None of the lines showed any appreciable level of resistance to early leaf spot. Some lines (NC 3033, PI 259747, and PI 270608), earlier reported as resistant to early leaf spot in the U.S. (Sowell et al. 1976; Hassan and Beute 1977), had no resistance under Chitedze conditions.

Preliminary Germplasm Trial

One hundred and sixty-two ICGM lines and 108 new germplasm introductions were evaluated in a non-replicated trial in the 1983/84 season. Nine standard cultivars from the region and India (Mani Pintar, Egret, Chalimbana, Mawanga, RG1, Robut 33-1, Spancross, JH, and JL 24) were used as repeated controls. The performance of single 6 m row test entries was judged against the results of the controls after making an appropriate statistical adjustment of the data to eliminate the influence of a soil-fertility gradient in the field.

Of the 270 test entries, 70 yielded more than the highest control yield of 0.63 kg plot⁻¹. Of these, 38 had an alternate-branching habit (ssp *hypogaea*) and 32, sequential branching habit (ssp *fastigiata*). The top 10 lines, with their adjusted pod yield plot⁻¹ values, were ICGM 623 (1.04 kg), 627 [illegible] kg), 91 (0.96 kg), 526 [illegible] kg), [illegible] (0.94 kg), 484 [illegible] kg), 652 (0.93 kg), 653 (0.91 kg), 499 (0.90 kg), and 528 (0.89 kg).

Advanced Germplasm Yield Trial

Fifty-one ICGM lines, selected on the basis of their performance in the 1982/83 evaluation, together with 13 control cultivars from the region and India were evaluated in an 8 × 8 lattice with two replications. ICGM 285, belonging to the sequential-branching group, yielded the highest (Table [illegible]). It was followed by ICGM 336, 286, 281, 284, 1[illegible] and

Table 1. Advanced Germplasm Yield Trial (groundnut), Chitedze, Malawi, 1983/84.

ICGM Number	Origin	Branching habit	Days to maturity	Pod yield (kg ha⁻¹)	Shelling %	100-seed mass (g)
285	Brazil	S[1]	133	2650	71	37
336	Bolivia	A[2]	144	2640	75	50
286	Brazil	S	137	2550	73	37
281	Bolivia	S	130	2400	72	36
284	Brazil	S	135	2390	73	32
177	Brazil	S	134	2370	72	35
197	Bolivia	S	136	2330	79	37
189	Brazil	S	134	2080	72	36
292	Brazil	S	136	2060	76	34
23	Brazil	S	119	2040	77	36
282	Bolivia	S	130	2010	74	37
288	Brazil	S	106	1980	72	32
Control						
Sellie	S. Africa	S	106	1750	71	39
Egret	Zimbabwe	A	147	2280	72	44
Mani Pintar	Malawi	A	148	2130	73	42
SE (Mean)				±185.7		
CV (%)				11		

1. S = Sequential branching (ssp *fastigiata*).
2. A = Alternate branching (ssp *hypogaea*).

197. Except for ICGM 336, all belonged to the sequential-branching group. All these lines yielded significantly more than the highest-yielding, sequential-branching control, Sellie. When compared with Egret, the highest-yielding alternate branching control, yield differences were not significant. However, both ICGM 285 and 336 had significantly higher yields than Mani Pintar, the second highest-yielding, alternate-branching control from Malawi. ICGM 336, 177, and 197 ranked first, seventh and fifth respectively in the 1982/83 germplasm evaluation.

Promising germplasm introductions from the 1983/84 trials were regrouped into three replicated yield trials in 1984/85 with larger plot sizes.

Preliminary Germplasm Trial

The trial consisted of 53 lines selected from the 1983/84 Preliminary Germplasm Trial and 11 cultivars of the region included as controls. It was planted in an 8 × 8 lattice design with three replications.

Twenty-one of these lines have been retained for further evaluation. Of these, 6 belong to the sequential-branching and 15 to the alternate-branching group.

Of the six sequentially-branched valencia germplasm lines only two, ICGM 525 and 559, yielded significantly more than the control cultivar Sellie (Table 2).

The highest yield in the alternate-branching group was produced by ICGM 623. It was followed by ICGM 484. However, both these lines did not differ significantly from the control cultivar Mawanga (Table 2).

Advanced Germplasm Trial

Twenty-four lines from the 1983/84 Advanced Germplasm Trial and 13 control varieties were evaluated in a 6 × 6 lattice design with four replications.

Of the 11 lines retained for further evaluation, ICGM 550, 554, and 522 yielded significantly more than the highest-yielding control JL 24 (Table 3).

Elite Germplasm Trial

Twenty-four germplasm lines that performed well in the 1983/84 Advanced Germplasm Trial were promoted to this trial. They were evaluated with 12 controls in a 6 × 6 lattice design with four replications.

The highest yield was produced by ICGM 286 (Table 4). Fifteen other valencia lines yielded significantly more than the highest-yielding sequential control JL11. The yield of ICGM 336, an alternate-branching line, was significantly more than JL11, but was not different to that of Mani Pintar, the highest-yielding, alternate-branching control. However, ICGM 336 had a better shelling percentage and a larger seed size than Mani Pintar, and ranked first in 1982/83, second in 1983/84, and fourth in the 1984/85 evaluation. It stood first in all the three seasons in the alternate-branching group.

The top 8 valencia lines in Table 4 also appeared in the top 8 in the 1983/84 Advanced Germplasm Trial.

Table 2. Preliminary Germplasm Yield Trial (groundnut), Chitedze, Malawi, 1984/85.

Identity	Cultivar[1] group	Origin	Days to maturity	Pod yield (kg ha⁻¹)	Shelling (%)	100 seed mass (g)	Seed colour	Mean ELS score (1-9 scale)[2]
ICGM 525	Valencia	Argentina	126	2510	65	47.6	Purple	8.0
ICGM 559	Valencia	Israel	118	2350	68	44.0	Purple	8.0
Sellie Control	Spanish	S. Africa	107	1700	75	30.2	Tan	9.0
ICGM 623	Virginia	USA	147	3000	74	65.0	Tan	7.0
ICGM 484	Georgia	Bolivia	145	2820	71	44.6	Red	7.0
Mawanga Control	Virginia	Malawi	148	2750	72	56.1	Variegated	6.5
SE (Mean)				±136.6				
CV (%)				12.6				

1. Source: Gibbons et al. 1972.
2. Early leaf spot score at 90 days after emergence.

With slight differences in ranking.

All the germplasm lines that were retained for further evaluation in the 1984/85 season have been re-grouped into trials during 1985/86 as per their botanical types, i.e., Elite Germplasm Trial (valencia), Elite Germplasm Trial (spanish), and Elite Germplasm Trial (virginia). This will be the final evaluation before outstanding lines are included in the Cooperative Regional Yield Trials.

Many of the valencia types have performed well in the last three seasons' evaluation at Chitedze. Valencias have not received enough attention in the region, with the exception of Zimbabwe where the cultivar Valencia R2 is still recommended. It is expected that some of these lines will find suitable recognition in the region, provided they maintain their performance at other locations.

Table 3. Advanced Germplasm Yield Trial (groundnut), Chitedze, Malawi, 1984/85.

Identity	Cultivar[1] group	Origin	Days to maturity	Pod yield (kg ha⁻¹)	Shelling (%)	100-seed mass (g)	Seed colour	Mean ELS score (1-9 scale)[2]
ICGM 550	Valencia	Sudan	125	2360	64	43.4	Purple	8.0
ICGM 554	Valencia	Zimbabwe	121	1980	69	35.7	Purple	8.0
ICGM 522	Spanish	India	118	1770	75	30.0	Tan	8.5
JL 24 (Control)	Spanish	India	108	1390	73	27.5	Tan	9.0
SE (Mean)				±88.1				
CV (%)				10				

1. Source: Gibbons et al. 1972.
2. Early leaf spot score at 90 days after emergence.

Table 4. Performance of the groundnut lines retained for further evaluation in the Elite Germplasm Trial, Chitedze, Malawi, 1984/85.

Identity	Cultivar[1] group	Origin	Days to maturity	Pod yield (kg ha-1)	Shelling (%)	100-seed mass (g)	Seed color	Mean ELS score (1-9 scale)[2]
ICGM 286	Valencia	Brazil	123	3330 (3)[3]	75	37.3	Red	7.0
ICGM 285	Valencia	Brazil	124	3200 (1)	69	35.3	Red	7.0
ICGM 284	Valencia	Brazil	119	3190 (5)	75	35.3	Red	7.5
ICGM 336	Nambyquarae	Bolivia	145	3060 (2)	78	53.0	Variegated	7.0
ICGM 197	Valencia	Bolivia	124	3030 (7)	74	35.5	Red	7.0
ICGM 281	Valencia	Bolivia	123	2970 (4)	73	38.2	Red	7.0
ICGM 189	Valencia	Brazil	119	2770 (8)	75	40.7	Red	7.0
ICGM 292	Valencia	Brazil	124	2650 (9)	75	29.5	Red	7.0
ICGM 177	Valencia	Brazil	124	2620 (6)	73	38.8	Red	7.5
ICGM 282	Valencia	Bolivia	123	2520 (11)	74	33.0	Red	7.5
ICGM 48	Valencia	Brazil	120	2480 (19)	74	38.2	Red	9.0
ICGM 23	Valencia	Brazil	110	2420 (10)	74	39.5	Red	8.0
ICGM 288	Valencia	Brazil	110	2380 (12)	72	36.3	Red	7.5
ICGM 300	Valencia	Brazil	105	2250 (18)	71	29.3	Red	9.0
ICGM 119	Valencia	India	106	2210 (20)	74	27.2	Red	8.5
ICGM 472	Valencia	-	107	2120 (13)	74	40.4	Red	9.0
ICGM 504	Valencia	Argentina	108	2100 (17)	74	37.5	Red	9.0
Mani Pintar (Control)	Nambyquarae	Malawi	141	3010	76	47.9	Variegated	7.0
J 11	Spanish	India	108	1650	76	24.8	Tan	9.0
SE (Mean)				±141.0				
CV (%)				12				

1. Source: Gibbons et al. 1972.
2. Early leaf spot score at 90 days after emergence.
3. Ranking for pod yield in the 1983/84 Yield Trial.

ICRISAT Southern African Cooperative Regional Yield Trials

The two cooperative regional yield trials, started in 1983/84, were conducted in Malawi (2 locations), Mozambique (2 locations), Zambia (3 locations), and Zimbabwe (1 location) in the first year. In 1984/85 these trials were repeated at the same locations. Botswana (1 location) and Tanzania (2 locations) were supplied seeds for these trials for the first time. In 1985/86 these trials were extended to Angola. Swaziland also indicated interest to participate in these trials, but in the absence of an import permit, seed could not be supplied.

ICRISAT Southern African Cooperative Regional Yield Trial (Sequential Branching)

Thirty-four ICGMS (ICRISAT Groundnut Malawi Selection) lines and two local control varieties were recommended for evaluation in a 6 × 6 lattice design with four replications. The results received from various locations are discussed by country. Tables 5 and 6 present performance of lines that merit further testing.

No data for the 1984/85 season were received from either location in Tanzania.

Table 5. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Sequential Branching, 1983/84.

	Malawi				Mozambique	Zambia			Zimbabwe			
	Chitedze		Lupembe		Sabie	Msekera		Magoye	Gwebi		Overall mean	
ICGMS lines	(a)[1]	(b)[2]	(a)	(b)	(a)	(a)	(b)	(a)	(a)	(b)	(a)	(b)
1	1630**	1250	1790**	1140***	1210	1800	1330*	2420	1630	1360	1690	1320
2	1850***	1440*	1500	1130	1450	1970*	1500*	1950*	820	600	1620	1160
5	1660**	1160	1540*	1090	1180	2240***	1490*	1710*	3290*	2200	2090	1490
9	1500	1170	1580*	1120	1240	2000*	1410*	1340*	1520	1110	1670	1210
11	1380	980	1850***	1270**	1310	2100*	1330*	1920*	3510*	2390	2150*	1500
12	1440	1520	1640*	1130	1180	1880	1240	1500	2960	1980	1690	1340
14	1280	890	1860**	1200**	1340	1690	1070	810*	2560	1940	1690	1280
18	1340	1040	1270	980	1260	2000*	1440*	[illegible]	1510	1140	1430	1150
21	1560	1160	1410	1050	1170	980	1130*	[illegible]	2160	1740	1660	1130
22	1760**	1520	1400	1020	1330	1820	1300*	1610*	1690	1470	1750	1360
23	1760**	1170	1190	810	1220	2010*	1510*	1210	2620	2090	1600	1470
28	1550	1160	1250	830	1280	1960*	1420	1350	3210	2420	1870	1470
30	1230	890	930	630	1840	2180**	1250	1420	2160	400	1590	1040
31	1800**	1130	1420	950	1240	1670	1100	[illegible]	4110**	3320*	2310	1630*
33	1230**	1130	1610	1260**	1380	1840	1350*	880*	3130	2930	2060	980
Control 1	1450	1090	1540	910	1050	1830	1320	1810	2690	1940	-	
Control 2	1300	1080	1440	980	750	2080	2150	1470	4610	2930		
SE	±63.5		±114.2	±74.4		±114.2	±75.9	±222.6	±154.2		-	
Trial mean (n=36)	1500		1330	930		1850	1280	1560	2580			
CV (%)	12		17	16	-	12	12	28	12			

1. a = Pod yield kg ha-1.
2. b = Seed yield kg ha-1.
3. Significant over lower control only.
4. Nonsignificant with the higher ICGMS line.
5. Significant over higher control.
6. Highest yield among the ICGMS lines (Value not included in the overall mean.)

Table 6. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Sequential Branching, 1984/85.

ICGMS	Botswana	Malawi			Mozambique	Zambia				Zimbabwe			
	Sebele	Chitedze		Lupembe	Boane	Msekera		Magoye		Gwebi		Overall mean	
lines	(a)[1]	(a)	(b)[2]	(a)	(a)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
1	1180	2040[3]	1510	710[3,4,6]	670	2040	1270	1180	680	600	370	1470	1050
2	1040	2220[3,4]	1640[4]	710[3,4,6]	550	2810[4,5]	1620	1390[4]	650	1070	700	1870	1320
5	-	2040[3]	1470	240	1050[4]	2880[4,5]	1860[4,5]	1430[4,6]	410	1430[4]	960[4]	1950	1430[6]
9	1170	1970	1460	770[3,4]	670	2330	1430	1140	580	940	700	1600	1200
11	-	2010[4]	1410	450[4]	1160[4]	2980[4,5,6]	1860[4,5,6]	1770[3,4,6]	590	1530[4,6]	1020[4]	2070[6]	1430[6]
12	1080	1620	1120	350	880[4]	2650[5]	1540	1630[4]	400	1080	720	1750	1130
14	-	1290	790	700[3,4]	1210[4,5,6]	2000	1310	1260	640	1060	730	1400	880
18	-	1540	1170	530[4]	630	2620[3]	1750[3,4]	1370[4]	570	830	630	1590	1180
21	1140	1620	1220	760[3,4]	600	2070	1310	1520[4]	720	880	660	1520	1060
22	1110	1560	1170	710[3,4]	640	2380	1520	1500[4]	710	780	570	1560	1360
23	-	1760	1302	760[3,4]	920[4]	2320	1380	1320	620	1180	890	1380	1190
28	-	1640	1180	470[4]	930[4]	2100	1360	1310	550	2030	770	1520	1100
30	-	2340[4,5,6]	1590	100	470	2640[4]	1660	1120	480	1310[4]	840	1850	1360
31	-	1900	1410	250	630	2240	1340	1630[4]	1020[5,6]	1490[4]	1120[5,4,6]	1820	1290
33	-	1450	1090	250	600	1860	1140	1070	680	1020	770	1350	1000
Control 1	650	1690	1270	590	780	2250	1490	1330	690	1310	940	1650	1230
Control 2	-	1950	1480	350	790	2350	1590	1370	560	2570	1850	2060	1640
SE	-	±104.7	-	±97.3	±145.1	±107.6	±63.6	±147.3	±90.4	±86.4	±61.1	-	-
Trial Mean (n=36)	-	1730	-	430	690	2290	1410	1330	610	1580	760	-	-
CV (%)	-	12	-	39	42	9	9	22	30	18	16	-	-

1. a = Pod yield kg ha⁻¹.
2. b = Seed yield kg ha⁻¹.
3. Significant over lower control only.
4. Non-significant with the highest ICGMS line.
5. Significant over higher control.
6. Highest yield among the ICGMS lines.
(Sebele, Lupembe, Boane, and Magoye (b) excluded from the overall mean.)

Botswana

1984/85. Unfortunately the trial at Sebele Research Station was located in part of a recently extended field, where two full replications and a part of the third were planted on reclaimed land that was previously a road. This resulted in suppressed plant growth in those plots, which were rejected for yield observations. Based on pod-yield data from the remaining plots, six lines, ICGMS 1 (1180 kg ha⁻¹), ICGMS 9 (1170 kg ha⁻¹), ICGMS 21 (1140 kg ha⁻¹), ICGMS 22 (1110 kg ha⁻¹), ICGMS 13 (1080 kg ha⁻¹), and ICGMS 2 (1040 kg ha⁻¹), which yielded well above the control Sellie (650 kg ha⁻¹), have been selected by the national program for further testing. Seed has been sent to Botswana so that the trial can be repeated in the 1985/86 season.

Malawi

1983/84. At Chitedze, pod yields of ICGMS 2, 6, 22, 23, 31, and 33 were significantly more than that of the higher-yielding control variety Malimba. ICGMS 2 yielded the highest. Other lines, which did not differ significantly from ICGMS 2, included ICGMS 1 and 5. The top 5 lines for seed yield were ICGMS 2, 23, 31, 33 and 22.

At Lupembe, 8 ICRISAT lines yielded more than the higher-yielding control Malimba, but yield differences were not significant. When compared with the lower-yielding control Spancross, ICGMS 11, 14, and 1 had significantly more pod yield. ICGMS 11 yielded the highest; other lines that did not differ significantly from it included ICGMS 14, 1, 32, 12, 9, 7, and 5. For seed yield, ICGMS 1 yielded the highest, followed by ICGMS 11 and 33. All three lines were significantly superior to the higher-yielding control Malimba. Two other lines that did not differ significantly from ICGMS 1 were ICGMS 14 and 32.

On a country mean basis, ICGMS 1 was highest for both pod and seed yield, but only ICGMS 33 was common among the top five for seed yield at both the locations.

1984/85. At Chitedze, ICGMS 30 gave the highest pod yield and was significantly superior to the higher-yielding control Spancross. ICGMS 2, 1, 5 and 11 yielded more than Spancross, but the yield differences were not significant. However, these lines were significantly superior to the other control, Malimba. The yield difference between ICGMS 30 and 2 was not significant. The top 5 lines for seed yield were ICGMS 2, 30, 1, 5, and 9.

At 60 days after emergence, ICGMS 30, a selection from the rust-resistant population (NC 4, [illegible] × NC Ac 17090), had a lower early leaf spot score [illegible] on a 1-9 scale compared to other lines in the trial. Disease development on this line was slower by about 2 weeks. [illegible] were defoliated.

The trial at Lupembe was sown in a randomized-block design. It was poorly managed and suffered from drought from flowering through to harvest. Pod yield varied from 100 to 770 kg ha⁻¹ with a mean of 430 kg ha⁻¹. The coefficient of variation was [illegible] (39%). The top 5 lines [illegible] and 14, which had yielded significantly [illegible] the higher-yielding control in the 1983/84 season.

Mozambique

1983/84. The emergence of test entries at Boane was highly variable and of local controls, very poor. Data from this location were neither analyzed (replicated data not provided) nor included in the overall mean. However, among the ICGMS lines 29, 30, 32, 3, and 20 occupied the first 5 ranks.

1984/85. The trial was carried out at Boane in a randomized-block design. Pod yield ranged from 270 to 1210 kg ha⁻¹ with a mean of 690 kg ha⁻¹. Data were again of poor quality, as indicated by the high coefficient of variation (42%), so [illegible] interpretation of results was precluded. However, [illegible] ICGMS lines yielded more than the higher-yielding control, Starr. The top 5 ICGMS lines [illegible] ICGMS 14, 11, 5, [illegible] 13 and 28.

Zambia

1983/84. The trial at Msekera Regional Research Station suffered [illegible] damage which resulted in an unsatisfactory plant stand. It was also planted relatively late.

Only ICGMS 5 yielded significantly more pods than the higher yielding control variety Natal Common. The lines which did not differ significantly from ICGMS 5 included ICGMS 30, 11, 32, 27, 2, [illegible] 10, 18, 19, 23, 26, and 34. Although ICGMS 2 gave the highest seed yield, the yield did not differ significantly from that of Natal Common. ICGMS 5, 9, [illegible]

11, 22, 23, 32, and 34 did not differ significantly from ICGMS.

Lines ICGMS 29 and 30, both rust-resistant populations, had lower rust scores in comparison with other ICGMS lines. All the lines were equally susceptible to early leaf spot.

At Magoye, the plant stand was satisfactory, but the trial was harvested late, which resulted in heavy pod loss in the soil. Seed yield was not determined at this location. Only ICGMS 21 yielded significantly more than one of the control varieties, Natal Common. The yield difference between ICGMS 21 and the other control, Comet, was not significant. Lines which did not differ significantly from ICGMS 21 were ICGMS 3, 2, 11, 29, 15, 26, 27, and 33.

ICGMS 29 and 30 scored lowest (4.3) on a 1-9 scale for leaf spots. This observation was made rather early, at a time when disease levels were moderate (highest score 6.8).

ICGMS 11 and 2 were the common lines in the top 5 entries at both locations in Zambia.

1984/85. On the basis of pod yield, ICGMS 11 ranked first at Msekera. It was followed by ICGSM 5, 2, and 12. All these lines had significantly higher pod yield than Comet, the higher-yielding control. In addition to these lines, ICGMS 30 and 18 had significant yield differences with the other control, Natal Common. Only ICGMS 11 and 5 maintained a significant superiority for seed yield over control Comet. The third place was occupied by ICGMS 18. In the 1983/84 trial at Msekera, ICGMS 5, 30, and 11 had occupied the first three places for pod yield and ICGMS 2, 5, and 34, for seed yield.

At Magoye the trial started with good emergence but subsequent poor and erratic precipitation during Feb-Mar resulted in lower pod and seed yields. Fifteen ICGMS lines produced higher pod yields than the higher-yielding control Comet. However, yield differences were not significant. In comparison with the lower-yielding control Natal Common, only ICGMS 11 had significantly higher yield. Other lines included in the top 5 were ICGMS 12, 31, 10, and 19. In the previous year the top 5 ICGMS lines at this location were 21, 3, 2, 11, and 29. Seed yields, besides being poor, also had a higher coefficient of variation (31%) in this year's trial.

Zimbabwe

1983/84. ICGMS 31 gave the highest pod yield followed by the higher-yielding control Valencia R2. The yield difference between these two was not significant. ICGMS 31, 11, 13, 6, 5, 28, and 24 yielded significantly more than Plover, the second control variety. The top 5 ICGMS lines for pod yield were ICGMS 31, 11, 13, 6, and 5, and for seed yield, ICGMS 31, 6, 28, 24, and 11.

1984/85. The local control Valencia R2 gave the highest pod yield. This variety tends to give higher yields at Gwebi Centre due to its location in the cooler climate of the high veld area. Among the ICRISAT lines, ICGMS 11, 31, 5, and 15 occupied the first four places for pod yield. Although they yielded more than the spanish control Plover, the yield differences were not significant. ICGMS 31 ranked first in seed yield and also had a significantly higher yield than Plover. Next in rank were ICGMS 11, 5, and 8.

In the 1983/84 trial ICGMS 31 had given the highest pod yield and seed yield. ICGMS 11 and 5 were included in the top 5 ICGMS lines.

ICRISAT Southern African Cooperative Regional Yield Trial (Alternate Branching)

Fourteen ICGMS lines and 2 local control varieties were recommended for evaluation in a 4 × 4 lattice design with four replications. Results received from various locations are discussed by country. Tables 7 and 8 present performance data for the years 1983/84 and 1984/85 for those lines that merit further regional testing. Data for the 1984/85 trial were not received from one location in Malawi and one in Mozambique, and from neither of the locations in Tanzania.

Malawi

1983/84. At Chitedze, the highest pod yield was produced by ICGMS 42. It was significantly superior to all other entries in the trial. No other line yielded more than the higher yielding control Mani Pintar.

At Meru, the pod yield of ICGMS 45 was highest and differed significantly from that of the local cultivar Mani Pintar, which was the second in order of performance. For seed yield, ICGMS 45 was ranked first followed by ICGMS 42 and Mani Pintar. Seed yield difference between ICGMS 45 and Mani Pintar was significant, but there was no difference

Table 7. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Alternate Branching, 1983/84.

ICGMS	Malawi				Mozambique	Zambia				Zimbabwe			
	Chitedze		Meru		Namialo	Msekera		Golden Valley		Gweb.		Overall mean	
lines	(a)[1]	(b)[2]	(a)	(b)	(a)	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
35	1660	1210	1690	1020	560	2110	1520	1370[4,6]	840[3,6]	2070	1400	1780	1200
36	1740	1290	1920	1250	1000[4]	2450[4]	1800[4,6]	1120[5]	690[5]	760	520	1600	1110
38	1370	1030	2250	1560	880	1700	1230	1160[5]	690[5]	2340	1640	1770	1230
39	1690	1270	2040	1310	520	2020	1470	1230[5]	740[5]	1860	1290	1770	1210
42	2650[3,4]	1990[6]	2430	1810	630	2530[4,6]	1900[4,6]	1360[4,6]	810[4,5]	3560[4,5,6]	2630[6]	2520[6]	1810[6]
43	1790	1360	2340	1660	590	1800	1260	[illegible]	1000[4,5,6]	3210[4,5]	2390	2170	1530
45	1620	1120	3330[5,6]	2350[5,6]	590	2250[4]	1440	840	470	3520[4,5]	2290	2270	1530
47	1730	1350	2350	1630	410	2300[4]	1740[4]	1040[5]	560[5]	2550	[illegible]	2050	1480
48	1460	1100	2420	1510	670	2240[4]	1550[4]	1450[4,5]	540	[illegible]	[illegible]	1790	1150
Control 1	2300	1260	2400	1670	650	2560	1730	[illegible]	450	3060	2100	2310	1540
Control 2	1720	1290	2130	1520	570	2300	1550	[illegible]	330	2790	1450	1900	1220
SE	±89.9		±193.2	±138.6	-	±130.8	±96.0	±15	±70.5	[illegible]			-
Trial Mean (n = 16)	1630	-	2190	1460	630	1930	1340	1340	660	2420			
CV (%)	11	-	18	19	-	14	4	23	22	9			

1 a = Pod yield kg ha⁻¹
2 b = Seed yield kg ha⁻¹
3 Significant over lower control variety
4 Non-significant with the highest ICGMS line
5 Significant over higher control
6 Highest yield among the ICGMS lines
(Namialo not included in the overall mean.)

Table 8. ICRISAT Southern African Cooperative Regional Groundnut Yield Trial, Alternate Branching, 1984/85.

ICGMS lines	Malawi		Zambia				Zimbabwe		Overall mean	
	Chitedze		Msekera		Golden Valley		Gwebi			
	(a)[1]	(b)[2]	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
35	2400	1680	2030	1220	2150[3]	1400	1790	1290	2090	1400
36	2130	1550	2530[34]	1830[345]	2490[34]	1860[345]	980	650	2030	1480
38	1930	[illegible]	2100[3]	1300	2290[34]	1530[34]	1380	1000	1930	1310
39	2360	1700	2240[3]	1280	2400[34]	[illegible]	1750	1260	2200	1400
42	3200[35]	2400[5]	2430[34]	1750[34]	2630[345]	1680[34]	2630[35]	1900[35]	2720[5]	1930[5]
43	2100	1530	2030	1380[3]	2220[5]	1390	1920	1410	2070	1430
45	2070	1390	2600[345]	1560[3]	2010	1350	2020	1430	2180	1430
47	[illegible]	[illegible]	1920	1400[3]	2250[34]	1470[3]	1460	1130	1810	1270
48	1710	[illegible]	1740	1140	2610[34]	1660[34]	1390	930	[illegible]	1240
Control 1	2490	1710	1770	1150	1700	1050	2520	1740	2120	1410
Control 2	2930	2170	2890	2070	2680	1660	2690	1880	2500	1950
SE	±109.1	-	±112.1	±73.9	±135.4	±133.9	±104.5	±80.4	-	-
Trial Mean (n = 16)	2070	-	1950	1310	2130	1370	1620	1150	-	-
CV (%)	11	-	11	11	12	19	13	14	-	-

1. a = Pod yield kg ha⁻¹
2. b = Seed yield kg ha⁻¹
3. Significant over lower control only.
4. Non-significant with the highest ICGMS line
5. Highest yield among the ICGMS lines

between those of ICGMS 42 and Mani Pintar. On an overall basis for Malawi, ICGMS 42, 45, 43, 47, and 48 obtained the first five ranks for both pod and seed yield.

1984/85. At Chitedze, ICGMS 42 again gave the highest pod yield. It was followed by controls Mani Pintar and Chitembana. The yield difference between ICGMS 42 and Chitembana was significant.

Mozambique

1983/84. The plant stand density for the trial at Namialo was low across all treatments (21-36% of the normal stand). Data from the trial were neither analyzed (in the absence of replicated data) nor included in the overall mean. However, the top 5 lines at Namialo were ICGMS 36, 38, 40, 37, and 48.

Zambia

1983/84. At Msekera, the pod yield of the local control variety Makulu Red was highest, followed by ICGMS 42, 36, 47, 45, and 48, none of which, however, differed significantly from Makulu Red. The highest seed yield was attained by 2 lines, ICGMS 42 and 36. They were followed by Makulu Red, ICGMS 47, Chalimbana, and ICGMS 48. Both ICGMS 42 and 36 were larger seeded than Makulu Red. ICGMS 45 had the lowest score (2.0) for rust and ICGMS 47 had the lowest score (5.8) for leaf spot (1-9 scale).

General pod and seed yield levels at Golden Valley were low due to late planting. The pod yields of ICGMS 43 and ICGMS 48 were significantly greater than the control (Makulu Red) yield. All other lines except ICGMS 41 and 45 yielded significantly more than the lower-yielding control, Chalimbana. However, the lines that did not differ significantly from ICGMS 43 included ICGMS 48, 42, and 35.

Similarly, for seed yield ICGMS 43 was ranked first, followed by ICGMS 35, 42, 37, and 39. All had significantly greater seed yields than Makulu Red. On an overall basis in Zambia, ICGMS 42, 48, 36, 35, and 43 held the first ranks for pod yield, and ICGMS 42, 36, 47, 35, and 43, the first five ranks for seed yield.

1984/85. The trial at Msekera planted in mid-November suffered from initial soil-moisture stress, causing unsatisfactory seedling emergence. Control Makulu Red gave the highest pod yield, followed by ICGMS 45, but the yield difference between these 2 lines was not significant. Other lines that yielded significantly more than the lower-yielding control Chalimbana included ICGMS 36, 47, 39, and 38. Control Makulu Red had the highest seed yield and was significantly superior to all the ICGMS lines. The lines that yielded significantly more than the other control Chalimbana included ICGMS 36, 42, 45, 47, and 43.

At Golden Valley also, Makulu Red gave the highest pod yield, followed by ICGMS 42, 48, 36, and 38 again; these lines did not differ significantly from Makulu Red. ICGMS 36 gave the highest seed yield which did not differ significantly from those of Makulu Red, ICGMS 42, 48, 38, and 47. In addition to these lines, ICGMS 43 also had a significantly higher yield compared to the other control, Chalimbana.

Zimbabwe

1983/84. At Gwebi, pod yield of ICGMS 42 was highest, followed by ICGMS 45, both being significantly higher than the higher yielding control Egret. ICGMS 43 yielded more than Egret, but the difference was not significant. For seed yield, ICGMS 42 maintained its first rank but the positions of ICGMS 45 and 43 were reversed.

1984/85. Yields at Gwebi were affected by wet weather conditions. The highest pod yield was produced by the control Makulu Red. It was followed by ICGMS 42 and another control, Egret. These lines did not differ significantly between each other. The next 2 lines in rank were ICGMS 45 and 43; however, these had significantly lower pod yields. A similar trend was followed for seed yield, except that ICGMS 42 ranked first.

The Regional Breeders' Group discussed regional yield trials at their meeting in Feb 1985. National program breeders considered that "regional yield trials should run for 2 seasons only; entries which perform poorly should be discarded and replaced on a 2-year basis at maximum." Responding to this consensus of opinion, I have summarized the data for the last 2 years and have selected tentatively those lines that merit further regional testing (Tables 5, 6, 7, and 8). These results will be compared with the 1985/86 results before making final decisions.

From the results obtained from the various regional locations, it is evident that only some of

them can be used for drawing valid conclusions. Unless good quality data are received from all participating locations it will remain difficult to reorganise regional yield trials in 2 years. National programs are encouraged to identify promising lines for their locations in these trials and include them in their own multi-location trials. Malawi and Zimbabwe have already taken a lead in this matter.

Rosette Resistance Breeding

Development of high-yielding, GRV-resistant varieties of varying maturity lengths constitutes an important breeding objective of the program.

Since 1956, groundnut research programs in West Africa have directed their efforts towards developing GRV-resistant varieties suitable to their agroclimatic conditions. Significant progress has been made by the programs in Senegal, Burkina Faso, and Nigeria. Utilizing the resistant sources, which were semierect and late maturing, varieties such as KH-149A, KH-241D, 69-101, RMP 12, and RMP 91 have been developed and released by the programs in Senegal and Burkina Faso (Bockelee-Morvan 1983). The first two of these varieties belong to the spanish and the remaining to the virginia group.

In southern Africa, the pioneering breeding efforts of Gibbons and his team in Malawi culminated successfully in the release of the GRV-resistant variety RG1. Several other GRV-resistant breeding lines with better kernel size are in an advanced stage of testing in Malawi (Sibale and Kisyombe 1980). Other national programs in the region have shown little interest in GRV-resistance breeding.

The regional program has assigned a very high priority to the development of high-yielding, short-season GRV-resistant varieties as the area under short-season varieties in the region is extensive.

Breeding Material

1984/85. After confirming their hybridity, 26 F_1 crosses involving sources of GRV resistance (RG 1, RMP 93, and RRI/6) and promising exotic germplasm and breeding lines were advanced to the F_2 generation.

Twenty-eight populations consisting of a total of 5912 F_2 plants were screened for the first time under an infector-row system in the field (for details of technique see Bock, these Proceedings). At the conclusion of the experiment only 678 symptomless F_2 plants remained. Two hundred and seventy-two of these plants had either very few or no pods and were rejected. The remaining 406 plants were harvested individually. A few seeds from each of these symptomless F_2 plants was grown in the glasshouse for testing resistance in F_3 generation. The F_3 plants from 245 symptomless individual F_2 plants were found to be susceptible to rosette, indicating that these either carried susceptible dominant genes in the homozygous condition or that they were heterozygotic. The remaining F_2 seed of these plants was bulked in each cross and has now been grown as F_3 bulks under the infector-row system. It is expected that the seeds from the hyterozygote-susceptible plants in these bulks will segregate into resistant and susceptible plants.

The remaining 161 individual F_2 plants have been progeny-rowed under the infector-row system for further selection. These plants either carry double recessive genes in the homozygous condition or are heterozygotes. The majority of these plants had poor pod yield. One hundred and fifty-three belonged to the virginia bunch, 6 to the virginia runner, and 2 to the spanish group. As expected, the recovery of spanish-type, resistant plants was very low, as both these characters are recessive. In future much larger F_2 populations will be required to isolate such plants in the spanish × virginia combination.

1985/86. The rosette disease nursery, in addition to a full set of rosette inheritance study material, consists of 26 F_2s, 161 F_2 plant progenies, and 35 F_1 bulks.

It is planned to confirm the resistance of two spanish varieties, KH 149A and KH-241D, as they have been referred to as tolerant and resistant in the same publication. If these varieties are found resistant under Malawi conditions, they will be used extensively in the hybridization program.

Preliminary GRV Inheritance Study

In 1958 French workers had reported that the "rosette resistant trait" was determined by two recessive genes (Annual Report IRHO 1958). Later Berchoux (1960) confirmed this observation. Harkness (1977), while discussing the breeding and selection of groundnut varieties for resistance to rosette virus disease in Nigeria, observed that "it has been common to find some rosette appearing in resistant lines." He ascribed the low recovery of resistant plants in some F_2 crosses to the appearance of rosette symptoms in some of the double recessives following early and heavy inoculation. In support of his observations he cited Dhery and Gilbert (1971), who observed that the resistance to rosette was a physiological character under genetic control and that under conditions of heavy infestation with viruliferous aphids early in the life of the plant, apparently resistant lines may show disease symptoms that could be temporary or permanent. He further suggested that the double recessive genotype did not confer resistance in all nuclear environments and loss of resistance from generation to generation in individuals in crossbred material could be expected.

Four crosses were selected for preliminary studies on inheritance of rosette resistance. These included two crosses where F_1 and F_2 generations were available, and two with F_1 reciprocals. Each cross was organized into a set of parents and respective generations. These sets were screened for rosette resistance under glasshouse conditions (for details see Bock, these Proceedings). In each set a susceptible control, Spancross, was also included. The data obtained [illegible] together with Chi-square values for the [illegible] susceptible plants to resistant are presented in Table 9.

Exceptions to the [illegible] inoculations of the susceptible [illegible] were recorded in 98.06% successful [illegible] Repeated inoculations of these symptomless plants proved unsuccessful. However, [illegible] susceptible parents inoculated (JL 24, Mani Pintar, Chitembana, and Chalimbana) became infected with rosette.

All the F_1 plants in crosses, RG 1 × JL 24, JL 24 × RG 1, and Mani Pintar × RG 1 were susceptible. This confirms the dominant or partially dominant nature of the resistance to rosette disease and also shows that at least in the case of RG 1 × JL 24 cross, reciprocal differences are not present.

In the F_2 generation there were several plants, which, though susceptible to rosette, did not express

Table 9. Preliminary inheritance studies on resistance of groundnut to GRV. Chi-square tests for the 15:1 F_2 ratio of plants segregating for susceptibility vs resistance to GRV, Chitedze, Malawi, 1984-85.

Set number	Identity	Number of plants			Chi-square value	P-value
		Inoculated	Susceptible	Resistant		
I	RG 1[1]	9	0	9	-	-
(Virginia × spanish)	JL 24[2]	9	9	0	-	-
	(RG 1 × JL 24)F_1	8	8	0	-	-
	(JL 24 × RG 1)F_1	8	8	0	-	-
	(JL 24 × RG 1)F_2	237	207 (15.6)[4]	30	0.7365	0.5-0.3
	Spancross[3]	45	45	-	-	-
II	RG 1[1]	9	0	9	-	-
(Virginia × virginia)	Mani Pintar[2]	10	10	0	-	-
	(Mani Pintar × RG 1)F_1	8	8	0	-	-
	(Mani Pintar × RG 1)F_2	199	182 (13.6)[4]	17	1.4134	0.3-0.2
	Spancross[3]	53	52	-	-	-
III	RG 1	10	0	10	-	-
(Virginia × virginia)	Chitembana[2]	10	10	0	-	-
	(RG 1 × Chitembana)F_2	273	241 (14.9)[4]	32	13.0369	<.001
	(Chitembana × RG 1)F_2	308	284 (15.0)[4]	24	1.0008	0.5-0.3
	Spancross[3]	57	57	-	-	-
IV	RG 1[1]	7	0	7	-	-
(Virginia × virginia)	Chalimbana[2]	10	10	0	-	-
	(RG 1 × Chalimbana)F_2	129	121	8	0.0256	0.9-0.8
	Spancross[3]	69	68	-	-	-

1 Resistant parent
2 Susceptible parent
3 Susceptible control in each set
4 Number of susceptible plants with suppressed or atypical symptoms

typical symptoms. Such plants were pooled with the normal susceptible plant category. All the apparently resistant plants that remained symptomless in the F_2 generation were further checked for symptomless systemic infection by grafting. All these plants were found to be free of rosette virus.

The F_2 data were subjected to Chi-square analysis for testing the genetic hypothesis of segregation of the 15 susceptible to 1 resistant plant, after making Yate's correction for continuity (Yates 1934). The Chi-square fit for a 15 : 1 F_2 ratio was good in all cases except for the cross RG 1 × Chitembana, where there was an excess of resistant plants. Even after pooling the two reciprocals, the Chi-square value was too high, 10.818 ($P < 0.001$). The heterogeneity Chi-square was high, 3.219, but not significant ($0.10 > P > 0.05$).

From the preliminary studies it is evident that the resistance to rosette disease is recessive in nature and is governed by two recessive genes. Even in the spanish × virginia combination (JL 24 × RG 1) this hypothesis holds true.

A detailed investigation is being carried out this year involving F_1 and F_2 reciprocals and their backcross generations to confirm these results in different botanical backgrounds.

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