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Resistance to Groundnut Diseases in Wild *Arachis* Species

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P. Subrahmanyam, A.M. Ghanekar, B.L. Nolt, D.V.R. Reddy, and D. McDonald[1]

Abstract

Diseases are major constraints to groundnut production. The most economically-important fungal diseases on a worldwide scale are leaf spots (Cercospora arachidicola, Cercosporidium personatum), *and rust* (Puccinia arachidis). *Sources of resistance to these diseases have been identified within the cultivated groundnut and are being utilized in resistance breeding programs. High levels of resistance, and/or immunity to the diseases have been identified among wild* Arachis *species and cytogeneticists have been successful in incorporating some of these resistances into the cultivated groundnut.*

Groundnuts are also subject to several damaging virus diseases and few sources of resistance to these have been found in the cultivated groundnut. However, high resistances to groundnut rosette, peanut mottle, peanut stunt, and tomato spotted wilt viruses have been found in some wild Arachis *species, and it is important that these resistances should also be incorporated into the cultivated groundnut. Similarly, resistance to some nematode diseases has also been found in wild* Arachis *species and efforts should be made to incorporate this into the cultivated groundnut.*

Résumé

Résistance aux maladies de l'arachide dans les espèces sauvages d' Arachis *L. Les maladies constituent l'un des principaux facteurs limitants de la production arachidière. Au niveau mondial les maladies cryptogamiques économiquement les plus importantes sont les cercosporioses* (Cercospora arachidicola, Cercosporidium personatum) *et la rouille* (Puccinia arachidis). *Des sources de résistance à ces maladies identifiées dans l'arachide cultivée sont actuellement utilisées dans les programmes de sélection pour la résistance. Des niveaux de résistance et/ou d'immunité élevés aux maladies ont été identifiées parmi des espèces sauvages d'* Arachis *et des cytogénéticiens ont réussi à introduire certaines de ces résistances dans les arachides cultivées.*

Les arachides sont également sensibles à plusieurs maladies à virus, et les sources de résistance suffisantes découvertes jusqu'ici dans les arachides cultivées sont peu nombreuses. Cependant, certaines espèces d' Arachis *sauvages se sont révélées présenter une bonne résistance aux virus de la rosette, de la marbrure foliaire, du nanisme, et de la maladie bronzée de la tomate.*

Il est donc important que ces résistances soient également introduites dans les arachides cultivées. De même, une résistance à certains nématodes a été trouvée parmi les espèces d' Arachis *sauvages, des efforts devront être mis en oeuvre pour introduire cette résistance dans l'arachide cultivée.*

Introduction

A large number of fungal, virus, and nematode diseases of groundnut have been reported, and with few exceptions, they are commonly present in all groundnut-growing regions of the world. The most important fungal diseases causing severe yield losses on a worldwide basis are the leaf spots (*Cercospora arachidicola* Hori and *Cercosporidium personatum* [Berk et Curt.] Deighton) and

1. Plant Pathologist, Virologist, International Intern, Principal Virologist, and Principal Pathologist, Groundnut Improvement Program, ICRISAT, Patancheru P.O., A.P. 502 324, India.

International Crops Research Institute for the Semi-Arid Tropics. 1985. Proceedings of an International Workshop on Cytogenetics of *Arachis*, 31 Oct - 2 Nov 1983, ICRISAT Center, India. Patancheru, A.P. 502 324, India: ICRISAT.

rust (*Puccinia arachidis* Speg.). Losses in yields due to leaf spots of around 10% have been estimated in the USA despite the widespread application of fungicides (Jackson and Bell 1969) In the semi-arid tropics, where chemical control is rarely used, losses in excess of 50% are commonplace (Gibbons 1980). Loss in yields of around 70% was estimated in India due to a combined attack of leaf spots and rust (Subrahmanyam et al 1984) Although these diseases can be controlled by certain chemicals, this approach is not at present feasible in many less developed countries Research on identification of resistance to these diseases has received much attention over the last decade, not only in the developing countries, where chemical control is rarely practised, but also in developed countries where costs of chemical control have become very high (Gibbons 1982) There has been intensive research on screening groundnut germplasm for resistance to various fungal diseases, and several lines with high levels of resistance to these diseases have been identified (Subrahmanyam et al 1980, 1982, 1983, Porter et al 1982)

Among the virus diseases of groundnut, peanut mottle virus (PMV) is the most widespread (Reddy et al. 1978) and causes yield losses up to 30% (Kuhn and Demski 1975) Other economically-important virus diseases have more restricted distributions. For instance, groundnut rosette virus (GRV) is important in Africa south of the Sahara, peanut clump virus (PCV) in West Africa and in India; bud necrosis disease (BND) caused by tomato spotted wilt virus (TSWV) in India, and witches' broom in Southeast Asia (Reddy 1980, Ghanekar 1980, Porter et al 1982) The control strategy for many of the virus diseases has traditionally been a manipulation of cultural methods, either to evade the peak populations of the vector, or to avoid infection at the susceptible seedling stage of crop growth Although these alternative methods of control do help in reducing the disease, they are usually location-specific and are not therefore universally acceptable In addition, farmers in the developing countries, where the majority of the world's groundnut crop is grown, are reluctant to modify their age-old cultural practices The use of insecticidal sprays to control vectors of these viruses is not a practical proposition for most farmers in developing countries Therefore use of host plant resistance is, where possible, the most practical, effective, and hence the best way to control virus diseases.

Diseases caused by nematodes are economically important in some parts of the world The principal species involved are in the genera *Meloidogyne*, *Pratylenchus*, *Belonolaimus*, and *Macroposthonia* (Porter et al 1982) In recent years germplasm screening for resistance to various nematode diseases has been carried out in the USA, and several sources of resistance have been reported (Porter et al 1982)

The sources of resistance to various fungal virus, and nematode diseases in cultivated groundnut germplasm reported so far represent a narrow range of variability that could be improved by the discovery of additional genes for resistance to these diseases Wild *Arachis* species are potentially useful for broadening the genetic base of the cultivated groundnut In recent years there has been considerable emphasis on screening wild *Arachis* species for resistance to various diseases and some species have been reported to have high levels of resistance to diseases caused by fungi, viruses, and nematodes Cytogenetic research aimed at incorporating disease resistance and other useful traits from wild *Arachis* species into cultivated groundnut is in progress at several research institutions (Moss 1980 Singh et al 1980, Stalker 1980, Wynne and Gregory 1981)

In this paper, the literature on identification of sources of resistance to various fungal virus and nematode diseases of groundnut in wild *Arachis* species is reviewed

Disease Resistance in Wild *Arachis* Species

Fungal Diseases

Leaf spots

Gibbons and Bailey (1967) reported that three *Arachis* species, *A hagenbeckii* Harms, *A glabrata* Benth and *A repens* Handro did not develop any *C arachidicola* lesions when grown in plastic pots in the open under natural disease pressure in Malawi Abdou et al (1974) screened 94 accessions of *Arachis* species for resistance to *C arachidicola* and *C personatum* under laboratory conditions Resistance was evaluated by measuring the number of lesions per leaflet, lesion diameter, percentage leaf area damaged, percentage defoliation, and sporulation index They found several immune and highly resistant species in the sections *Arachis* Krap et Greg nom nud., *Erectoides* Krap et Greg nom nud., *Rhizomatosae* Krap et Greg nom nud., and *Extranervosae* Krap.

et Greg nom nud Kolawole (1976) reported an unnamed diploid species as resistant to both leaf spot pathogens in Nigeria Sharief et al (1978) believed that this species was probably *A stenosperma* (HLK 410) Foster et al (1981) evaluated nine *Arachis* species for resistance to *C arachidicola* by measuring various disease parameters and concluded that the number of lesions per leaf, and percentage defoliation were most useful for evaluation of resistance to *C arachidicola* *A chacoense* and *A stenosperma* were found to be highly resistant Abdou et al (1974) reported that *A chacoense* Krap et Greg nom nud was highly resistant to *C arachidicola* but susceptible to *C personatum* However, Subrahmanyam et al (1980) found only a few, tiny, non-sporulating lesions of both leaf spot pathogens on *A chacoense* under both field and laboratory conditions Melouk and Banks (1978) and Sharief et al (1978) observed no lesion development on *A chacoense* when inoculated with *C arachidicola* under artificial inoculation conditions *A cardenasii* Krap et Greg nom nud was susceptible to *C arachidicola* but immune to *C personatum* (Abdou et al 1974, Sharief et al 1978, Subrahmanyam et al 1980) Nevill (1979) did not observe any lesions on *A cardenasii* and *A stenosperma* when inoculated with *C personatum* in Nigeria Company et al (1982) evaluated *A chacoense* and *A cardenasii* for their reaction to *C arachidicola* during an investigation on cytology and leaf spot resistance in interspecific hybrid derivatives Both species showed the presence of *C arachidicola* lesions in field trials but did not produce any lesions in laboratory tests Abdou et al (1974) reported that three accessions of *A villosulicarpa* Hoehne were immune to both leaf spot pathogens in the USA However, Gibbons and Bailey (1967) observed considerable damage to the foliage of this species due to *C arachidicola* infection in Malawi Subrahmanyam et al (unpublished) observed lesions of *C personatum* on *A villosulicarpa* but the lesions were small and non-sporulating An unidentified species of *Arachis* (GKP 10596, PI 276233) in section *Rhizomatosae* was reported immune to both leaf spot pathogens in the USA and India (Abdou et al 1974, Subrahmanyam et al. 1980). However, Melouk and Banks (1978) in the USA observed small, non-sporulating lesions on this species when inoculated with *C arachidicola* (Table 1).

Some of these differences in disease reactions could be due to variation in the pathogen; interaction between host, pathogen, and environment; or confusion in identification of, or variation within, the host species

Rust

Subrahmanyam et al (1983) screened 61 accessions of wild species, representing five sections of the genus *Arachis*, under field and laboratory conditions for reaction to groundnut rust Most were immune, six were highly resistant, and two were susceptible to the pathogen Some of the immune and highly resistant accessions are listed in Table 2 Several accessions of *A glabrata* were found immune when tested in the USA and India (Bromfield and Cevario 1970, Subrahmanyam et al 1980, 1983) However, rust was observed on an accession of the same species collected in Brazil (Bromfield 1971, V Ramanatha Rao and J F Hennen, personal communication) *A glabrata* is a very variable species and many need to be reclassified It is not surprising that different accessions of a species can vary in disease reaction, and more attention should be given to recording diseases present on wild *Arachis* spp when collecting

Attempts are being made to use species that are resistant and immune to *P arachidis* as practical sources of rust resistance They may have genes for resistance to rust different from those in *A hypogaea*, thus providing the possibility of combining the rust resistance of wild and cultivated species to give more effective and stable resistance in the cultivated groundnut (Subrahmanyam et al 1983) Even if the genes are identical, they may be linked to different desirable characters or may produce more effective allelic combinations

Singh et al (1984) evaluated the first generation hybrid progenies of two rust-susceptible groundnut cultivars crossed with rust-immune *A batizocoi* Krap et Greg nom nud diploid and autotetraploids, and its amphiploid with two other immune diploid wild species for reaction against groundnut rust They concluded that rust resistance in diploid wild species is of a partially dominant nature, unlike in *A hypogaea*, where it is recessive The transfer of rust resistance from wild species should be straightforward because of the dominant nature of the genes

The tetraploid or near-tetraploid lines derived from crosses between *A hypogaea* and wild species immune and highly resistant to rust, were systematically evaluated for their rust reaction during the 1981 and 1982 rainy seasons at ICRISAT Center A very high degree of resistance to rust was

Table 1. Sources of resistance to leaf spots in wild *Arachis* species.

Species	*Section*	Collector initial and number or other identity	Disease reaction[1]		Investigators
			C.arachidicola	*C.personatum*	
A.chacoense	*Arachis*	GKP 10602, PI 276325	HR	S	Abdou et al. (1974)
A.chacoense	*Arachis*	GKP 10602, PI 276325	HR	HR	Subrahmanyam et al. (1980)
A.chacoense	*Arachis*	GKP 10602, PI 276325	I		Melouk and Banks (1978)
A.cardenasii	*Arachis*	GKP 10017, PI 262141	S	I	Abdou et al. (1974) Subrahmanyam et al. (1980)
A.stenosperma	*Arachis*	HLK 410, PI 338280	HR	HR	Subrahmanyam et al. (1980)
A.stenosperma	*Arachis*	HLK 410, PI 338280	HR		Melouk and Banks (1978)
A.repens	*Caulorhizae*		I		Gibbons and Bailey (1967)
A.repens	*Caulorhizae*			HR	Subrahmanyam et al (unpub.)
Arachis species	*Erectoides*	GK 10573, PI 276225	HR	HR	Abdou et al. (1974)
A.appressipila	*Erectoides*	GKP 10002		HR	Subrahmanyam et al. (unpub.)
A.paraguariensis	*Erectoides*	KCF 11462		HR	Subrahmanyam et al. (unpub.)
A.villosulicarpa	*Extranervosae*		I		Abdou et al. (1974)
A.villosulicarpa	*Extranervosae*	ICG 8142		HR	Subrahmanyam et al. (unpub.)
A.hagenbeckii	*Rhizomatosae*		I		Gibbons and Bailey (1967)
A.hagenbeckii	*Rhizomatosae*	HL 486, PI 338267		HR	Subrahmanyam (unpub.)
A.glabrata	*Rhizomatosae*		I		Gibbons and Bailey (1967)
A.glabrata	*Rhizomatosae*	GKP 9830, PI 262797	HR	HR	Abdou et al. (1974)
A.glabrata	*Rhizomatosae*	GKP 9830, PI 262797		HR	Subrahmanyam (unpub.)
Arachis species	*Erectoides*	GKP 10574	HR	HR	Abdou et al. (1974)
Arachis species	*Rhizomatosae*	GKP 10596, PI 276233	I	I	Abdou et al. (1974) Subrahmanyam et al. (1980)
Arachis species	*Rhizomatosae*	GKP 10596, PI 276233	HR		Melouk and Banks (1978)

1. I = Immune; HR = Highly Resistant; S = Susceptible

Table 2. Sources of resistance to rust in wild *Arachis* species.

Species	Section	Collector initial and number, or other identity	Rust reaction[1]
A batizocoi	*Arachis*	K 9484, PI 298639 PI 338312	I
A duranensis nom nud	*Arachis*	K 7988, PI 219823	I
A spegazzinii nom nud	*Arachis*	GKP 10038, PI 263133	I
A correntina nom nud	*Arachis*	HL 176, PI 331194, GKP 9548	I
A stenosperma nom nud	*Arachis*	HLK 410, PI 338280	HR
A cardenasii nom nud	*Arachis*	GKP 10017, PI 262141	I
A chacoense nom nud	*Arachis*	GKP 10602, PI 276235	I
A villosa	*Arachis*	PI 210554	I
A apressipila nom nud	*Erectoides*	GKP 10002, PI 262140	I
A paraguariensis	*Erectoides*	KCF 11462	I
A pusilla	*Triseminalae*	GK 12922, PI 338449	I
A villosulicarpa	*Extranervosae*	ICG 8142 ex Coimbatore	I
A hagenbeckii	*Rhizomatosae*	HLK0 349, PI 338305	I
A glabrata	*Rhizomatosae*	HLKHe 552, PI 338261	I

1 I = Immune, no rust disease symptoms
HR = Highly resistant, very small necrotic lesions formed but no production of pustules or urediniospores

observed in most of the interspecific hybrid derivatives. On resistant lines, the uredosori were slightly depressed, small, and did not rupture to release the comparatively few urediniospores produced. The affected leaflets showed only limited necrosis.

Virus Diseases

Peanut mottle virus (PMV)

Demski and Sowell (1981) reported that six wild rhizomatous groundnut introductions, (most were probably *A. glabrata*) were not infected by mechanical or aphid (*Aphis craccivora*) inoculation, or in the field under high disease pressure (Table 3).

Fifty wild *Arachis* species accessions have been screened for PMV resistance at ICRISAT Center under greenhouse conditions using mechanical leaf rub, and air brush inoculations. All were infected except *A. pusilla* Benth (12922), *A. cardenasii* (10017), *A. chacoense* (10602), and *A. correntina* (Burk.) Krap et Greg nom nud (9530). Two of these species, *A. chacoense* and *A. pusilla*, after repeated graft inoculations remained free from infection as determined by assays on *Phaseolus vulgaris* (cv Topcrop) and by enzyme-linked immunosorbent assay (ELISA).

Table 3. Wild *Arachis* species resistant to peanut mottle virus[1].

Identity	Species
PI 262794	*A glabrata*
PI 421707	*A glabrata*
AM 3867	*A glabrata* (?)
PI 262818	*Arachis* sp
PI 262817	*Arachis* sp
PI 262839	*Arachis* sp

1 After Demski and Sowell (1981)

Groundnut rosette virus (GRV)

Very little published information is available about the identification of sources of resistance to groundnut rosette virus in wild *Arachis* species. Gibbons (1969) in Malawi tested eleven wild *Arachis* species including four annuals and seven perennials, by aphid (*Aphis craccivora*) and graft inoculation. He observed that *A. repens*, diploid and tetraploid, and *A. glabrata* remained free of rosette virus infection. However, Klesser (1967) using similar experimental methods in South Africa, reported that *A. glabrata* was a symptomless carrier of groundnut rosette. Immune lines which do not show rosette virus symptoms should be confirmed as virus-free using ELISA.

Tomato spotted wilt virus (TSWV)

At ICRISAT Center, a total of 42 wild *Arachis* species accessions were tested in the greenhouse by mechanical and thrips (*Frankliniella schultzei*) inoculation. Three species, *A. pusilla* (12922), *A.*

correntina (9530), and *A. cardenasii* (10017), although infected by mechanical and thrips inoculation in the laboratory, showed no infection under field conditions,based on observations over many seasons. Only *A. chacoense* remained free from TSWV infection after mechanical and thrips inoculation as determined by indexing on *Vigna unguiculata* (cv C 152), and by ELISA. However, TSWV could be detected in *A. chacoense* following graft inoculation. Additionally, *A. chacoense* always remained free from infection under field conditions. Therefore, *A. chacoense* can be considered highly resistant to TSWV and a potential source of resistance genes in interspecific crosses with the cultivated groundnut.

Peanut stunt virus (PSV)

Hebert and Stalker (1981) tested 90 collections of wild *Arachis* species by mechanical inoculation, and those that were not infected were further tested by graft inoculation. Forty-eight collections from four sections were highly resistant and several of these are presented in Table 4. The resistance of these selected lines was confirmed by ELISA and by assays on *V. unguiculata*. The selected lines were also tested for susceptibility to PSV in a field where the disease pressure was adequate and they still remained free from PSV infection.

Nematode Diseases

Banks (1969) evaluated some 33 accessions of wild *Arachis* species for resistance to the northern root knot nematode (*Meloidogyne hapla* Chitwood). Only one species from section *Rhizomatosae*, PI 262286, had a moderate level of resistance. Castillo et al. (1973) tested 12 accessions for resistance to northern root knot nematode. Four accessions of section *Rhizomatosae*, PI 262286, PI 262841, PI 262814, and PI 262844, had fewer galls than the control *A. hypogaea* cv Spantex. The number of egg-laying females was also reduced. At present no information is available on utilization of these species in breeding for resistance to *M. hapla*.

Table 4. Wild *Arachis* species resistant to peanut stunt virus[1].

Species or collector number	Section	PI number
9571	*Rhizomatosae*	262818
9806	*Rhizomatosae*	262792
9921	*Rhizomatosae*	262296
A.glabrata B1	*Rhizomatosae*	—
10596	*Rhizomatosae*	276233
7988	*Arachis*	—
10598	*Arachis*	276234
9764	*Erectoides*	262859
10573	*Erectoides*	276225
A.repens	*Caulorhizae*	—

1. After Hebert and Stalker (1981)

References

Abdou, Y. A-M., Gregory, W.C., and Cooper, W.E. 1974. Sources and nature of resistance to *Cercospora arachidicola* Hori and *Cercosporidium personatum* (Berk et Curtis) Deighton in *Arachis* species. Peanut Science 1: 6-11.

Banks, D.J. 1969. Breeding for northern root knot nematode, *Meloidogyne hapla* resistance in peanuts. Journal of American Peanut Research and Education Association 1: 23-28.

Bromfield, K.R. 1971. Peanut rust: a review of literature. Journal of American Peanut Research and Education Association 3: 111-121.

Bromfield,K.R. and **Cevario, S.J.** 1970. Greenhouse screening of peanut (*Arachis hypogaea*) for resistance to peanut rust (*Puccinia arachidis*). Plant Disease Reporter 54: 381-383.

Castillo, M.B., Morrison, L.S., Russel, C.C., and **Banks, D.J.** 1973. Resistance to *Meloidogyne hapla* peanuts. Journal of Nematology 5: 281-285.

Company, M., Stalker, H.T., and **Wynne, J.C.** 1982. Cytology and leafspot resistance in *Arachis hypogaea* x wild species hybrids. Euphytica 31: 885-893.

Demski, J.W., and **Sowell, G., Jr.** 1981. Resistance to peanut mottle virus in *Arachis* spp. Peanut Science 8: 43-44.

Foster, D.J., Stalker, H.T., Wynne, J.C., and **Beute, M.K.** 1981. Resistance of *Arachis hypogaea* L. and wild relatives to *Cercospora arachidicola* Hori. Oléagineux 36: 139-143.

Ghanekar, A.M. 1980. Groundnut virus research at ICRISAT. Pages 211-216 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Gibbons, R.W. 1969. Groundnut rosette research in Malawi. Pages 1-8 *in* Proceedings of the Third Eastern

African Cereals Research Conference, Zambia and Malawi, Mar 1969

Gibbons, R.W. 1980 Groundnut improvement research technology for the semi-arid tropics. Pages 27-37 *in* Proceedings of the International Symposium on Development and Transfer of Technology for Rainfed Agriculture and the SAT Farmer, 28 Aug-1 Sept 1979, ICRISAT Center, India. Patancheru, A P 502 324, India: International Crops Research Institute for the Semi-Arid Tropics

Gibbons, R.W. 1982 Sources of resistance to some important diseases in the genus *Arachis*. Presented at the International Symposium on Production, World Oilseeds Market and Intra-African Trade in Groundnuts and Groundnut Products, 7-11 June 1982, Banjul, Gambia. Patancheru, A P 502 324, India: International Crops Research Institute for the Semi-Arid Tropics (Limited distribution.)

Gibbons, R.W., and Bailey, B.E. 1967 Resistance to *Cercospora arachidicola* in some species of *Arachis*. Rhodesia, Zambia, and Malawi Journal of Agricultural Research 5: 57-59

Herbert, T.T., and Stalker, H.T. 1981 Resistance to peanut stunt virus in cultivated and wild *Arachis* species. Peanut Science 8: 45-47

Jackson, C.R., and Bell, D.K. 1969 Diseases of peanut (groundnut) caused by fungus. Research Bulletin no. 56, Georgia Agriculture Experiment Stations 137 pp

Klesser, P.J. 1967 *Arachis* species and their reaction to virus infections. South African Journal of Agricultural Science 10: 919-927

Kolawole, K.B. 1976 A short progress report on transfer of *Cercospora* resistant traits to the cultivated *Arachis hypogaea* L. Samaru Agricultural Newsletter 18: 40-43

Kuhn, C.W., and Demski, J.W. 1975 The relationship of peanut mottle virus to peanut production. Research Report 213, Georgia Agriculture Experiment Stations 19 pp

Melouk, H.A., and Banks, D.J. 1978 A method of screening peanut genotypes for resistance to *Cercospora* leafspot. Peanut Science 5: 112-114

Moss, J.P. 1980 Wild species in the improvement of groundnuts. Pages 525-535 *in* Advances in legume science: proceedings of the International Legume Conference, 24-29 July 1978, Kew, Surrey, UK (Summerfield, R.J., and Bunting, A.H., eds.). Vol 2. Kew, Surrey, UK: Royal Botanic Gardens

Nevill, D.J. 1979 An investigation of the disease reaction to *Cercosporidium personatum* in *Arachis hypogaea*. Tropical Grain Legume Bulletin 15: 18-22

Porter, D.M., Smith, D.H., and Rodriguez-Kabana, R. 1982. Peanut plant diseases. Pages 326-410 *in* Peanut Science and Technology (Pattee, H.E., and Young, C.T., eds.) Yoakum, Texas, USA: American Peanut Research and Education Society

Reddy, D.V.R. 1980 International aspects of groundnut virus research. Pages 203-210 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A P 502 324, India: International Crops Research Institute for the Semi-Arid Tropics

Reddy, D.V.R., Iizuka, N., Ghanekar, A.M., Murthy, V.R., Kuhn, C.W., Gibbons, R.W., and Chohan, J.S. 1978 The occurrence of peanut mottle virus in India. Plant Disease Reporter 62: 978-982

Sharief, Y., Rawlings, J.O., and Gregory, W.C. 1978 Estimates of leafspot resistance in three interspecific hybrids of *Arachis*. Euphytica 27: 741-751

Singh, A.K., Sastri, D.C., and Moss, J.P. 1980 Utilization of wild *Arachis* species at ICRISAT. Pages 82-90 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A P 502 324, India: International Crops Research Institute for the Semi-Arid Tropics

Singh, A.K., Subrahmanyam, P., and Moss, J.P. 1984 A note on dominant nature of resistance to *Puccinia arachidis* in wild *Arachis* species. Oléagineux 39: 535-537

Stalker, H.T. 1980 Cytogenetic investigations in the genus *Arachis*. Pages 73-81 *in* Proceedings of the International workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A P 502 324, India: International Crops Research Institute for the Semi-Arid Tropics

Subrahmanyam, P., McDonald, D., Gibbons, R.W., Nigam, S.N., and Nevill, D.J. 1982 Resistance to rust and late leafspot diseases in some genotypes of *Arachis hypogaea*. Peanut Science 9: 6-10

Subrahmanyam, P., Mehan, V.K., Nevill, D.J., and McDonald, D. 1980 Research on fungal diseases of groundnut at ICRISAT. Pages 193-198 *in* Proceedings of the International Workshop on Groundnuts, 13-17 Oct 1980, ICRISAT Center, India. Patancheru, A P 502 324, India: International Crops Research Institute for the Semi-Arid Tropics

Subrahmanyam, P., Moss, J.P., and Rao, V.R. 1983 Resistance to peanut rust in wild *Arachis* species. Plant Disease 67: 209-212

Subrahmanyam, P., Williams, J.H., McDonald, D., and Gibbons, R.W. 1984 The influence of foliar diseases and their control by selective fungicides on a range of groundnut (*Arachis hypogaea* L.) genotypes. Annals of Applied Biology 104: 467-476

Wynne, J.C., and Gregory, W.C. 1981 Peanut Breeding. Pages 39-72 *in* Advances in agronomy, Vol 34. New York, USA: Academic Press, Inc