CP 403

Origin, Distribution, and Taxonomy of *Arachis* and Sources of Resistance to Groundnut Rust (*Puccinia arachidis* Speg.)

V. Ramanatha Rao[1]

Abstract

The natural occurrence of the genus Arachis *is limited to five countries, i.e., Argentina, Bolivia, Brazil, Paraguay, and Uruguay. The headwaters of the Paraguay river in the region of Mato Grosso is considered to be the center of origin of the genus. The taxonomy of the genus is not well delineated and the grouping of species into seven sections is only tentative, there may be as many as 70 species in the genus* Arachis. *The cultivated groundnut,* Arachis hypogaea *L., originated in an area of southern Bolivia and northwestern Argentina on the eastern slopes of the Andes. This species is subdivided into subspecies and botanical varieties that have been found to have a specific geographic distribution in South America. Groundnut rust, caused by* Puccinia arachidis *Speg., is one of the major diseases of groundnut. It probably originated in South America and evolved along with the host species.*

Most of the 39 groundnut accessions identified as rust-resistant at ICRISAT belong to the ribbed valencia type and originated in Peru. So it is concluded that resistance to rust in the cultivated groundnut may have also originated in Peru. Hence there is a need for pointed collection in Peru to enrich and broaden the available gene pool. Wild Arachis *species belonging to different sections have been found to be either resistant or immune to rust. Efforts are under way to utilize such resistance for groundnut improvement. Observations in the native habitat have indicated that wild* Arachis *might be infected by rust and other diseases to a greater extent than expected. More research is required in South America to investigate possible pathogenic variation and resistance to rust in wild* Arachis *species.*

Résumé

Origine, distribution et taxonomie du genre Arachis et sources de résistance à la rouille de l'arachide (Puccinia arachidis Speg.) : *Le genre* Arachis *sous forme de végétation naturelle n'existe que dans cinq pays du monde : Argentine, Bolivie, Brésil, Paraguay et Uruguay. Le centre d'origine du genre serait dans la région de Mato Grosso où se trouve la source du fleuve Paraguay. La taxonomie du genre n'est pas bien délimitée, le groupement de ses quelques 70 espèces en sept sections étant encore provisoire. L'arachide cultivée,* Arachis hypogaea *L., est originaire de la zone recouvrant le sud de la Bolivie et le nord-est de l'Argentine sur le versant est des Andes. A hypogaea est divisée en sous espèces et variétés botaniques ayant une distribution géographique spécifique en Amérique du Sud. La rouille de l'arachide due à* Puccinia arachidis *Speg. est une maladie importante attaquant cette culture. Elle serait également originaire de l'Amérique du Sud où elle a évolué avec sa plante-hôte.*

La plupart des 39 accessions ayant montré une résistance à la rouille appartiennent au type Valencia strié en provenance du Pérou. D'où la conclusion que la résistance à la rouille serait également originaire du Pérou. Il faut donc lancer un programme de collection bien défini au Pérou, en vue d'améliorer et d'élargir le pool génique existant. Certaines espèces sauvages d' Arachis *appartenant à différentes sections ont fait preuve d'une résistance ou même une immunité à la rouille. Les travaux en cours tentent d'incorporer cette résistance afin d'améliorer la culture d'arachide. L'étude de son habitat naturel indique que l'* Arachis

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1 Botanist, Genetic Resources Unit, International Crops Research Institute for the Semi-Arid Tropics, Patancheru A P 502 324, India

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sauvage serait plus exposé à l'attaque de la rouille et d'autres maladies qu'on aurait supposé Des recherches approfondies effectuées en Amérique du Sud sont indispensables pour etudier la variation éventuelle du pathogène ainsi que la résistance à la rouille chez les espèces sauvages d' Arachis

The Genus *Arachis*

Origin and distribution

The natural occurrence of the genus *Arachis* is confined to that area of South America that is bounded by the Amazon river to the north, the la Plata river to the south, the Atlantic to the east, and by the foothills of the Andes to the west (Krapovickas 1969, Gregory et al 1980) (Fig 1a and b) However, plant explorations have yet to be made in many areas, and the distribution of the genus may eventually be found to be much wider (Simpson 1982, Valls 1983, Valls et al 1985)

The geocarpic habit has largely determined the evolution of the genus The aerially fruited genera of the subtribe *Stylosanthineae* are more widely distributed than *Arachis* (Gregory et al 1973) Specific and supraspecific differentiation in *Arachis* follows the drainage basins and river beds of the continent, while the greatest diversity occurs in the headwaters of the Paraguay river in the region of Mato Grosso, Brazil This region is considered to be the center of origin of the genus, the oldest forms occurring on the highlands of the Brazilian shield (Gregory et al 1980)

The natural occurrence of *Arachis* species is restricted to Argentina, Bolivia, Brazil, Paraguay, and Uruguay Species belonging to all sections of the genus *Arachis* occur in Brazil, and four sections, *Ambinervosae, Caulorhizae, Extranervosae*, and *Triseminalae*, are known to occur only in Brazil

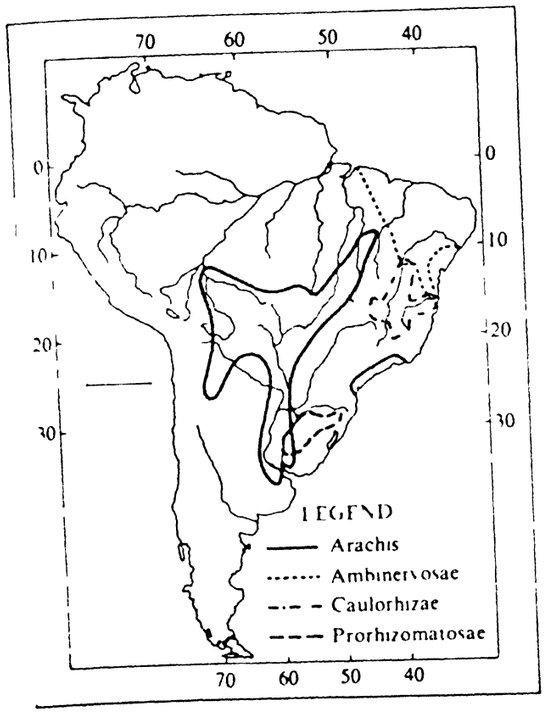

Figure 1a. Geographic distribution of *Arachis* in South America (group a) (after Valls et al. 1985).

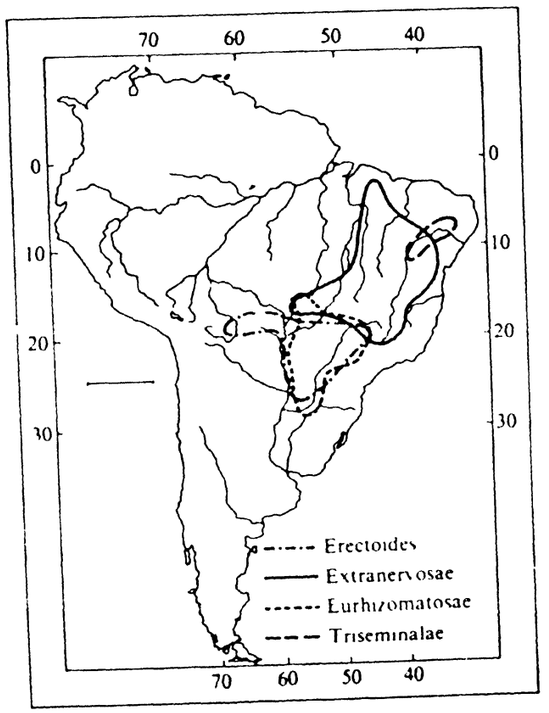

Figure 1b. Geographic distribution of *Arachis* in South America (group b) (after Valls et al. 1985).

Species in sections *Arachis* and *Rhizomatosae* occur in all five countries, but section *Erectoides* is not known to occur in Uruguay (Valls et al 1985)

Taxonomy

Arachis hypogaea was first described as a species by Linnaeus (1753) Bentham (1841) associated *Arachis* for the first time with the genera *Stylosanthes* and *Chapmannia* in the tribe *Hedysareae* of the family *Leguminosae* Taubert (1894) separated the tribe *Hedysareae* into six subtribes and *Arachis* was placed in the subtribe *Stylosanthineae* Three genera of the subtribe *Stylosanthineae* i e , *Chapmannia, Stylosanthes*, and *Arachis* have a distinct tubular hypanthium, pinnate leaves and a straight embryo The genus *Arachis* differs from *Stylosanthes* and *Chapmannia* by having a geocarpic peg an underground fruiting habit, and by producing most of its flowers at the lower nodes (Taubert 1894, Burkart 1939, Hoehne 1940) *Arachis* is now placed in the tribe *Aeschynomeneae* (Benth) Hutch , formerly considered to be one of the subtribes of *Hedysareae* (Rudd 1981) The taxonomy of the genus is not well delineated and new and unidentified taxa are regularly reported.

The wild species show marked interspecific variation for various morphological features Both annual and perennial forms occur and in some cases this character is difficult to ascertain The genus is further subdivided into sections and series (Krapovickas 1969, 1973, Gregory et al 1973), which are, however, invalid according to the International Code of Botanical Nomenclature (Resslar 1980) Nevertheless, the section and series groupings have been used extensively in the literature and most groundnut workers are familiar with this system of grouping The key (Table 1) to the seven sections in the genus *Arachis* is a tentative attempt to highlight certain morphological characters that have been used in the subdivision of the genus into sections and series Before 1839 only one species of *Arachis* was described the cultivated groundnut, *Arachis hypogaea* Bentham (1841) described five species, and Chevalier (1934-35) recognized six In the early taxonomic treatments by Chevalier (1934-35), Hoehne (1940), and Hermann (1954), only the above-ground parts were considered Gregory et al (1973) and Krapovickas (1973) recognized and emphasized the importance of underground parts of stem, root, and reproductive structures in the classification of *Arachis* At present, there are 22 described species assigned informally to groups (sections and series) based on morphological structures and the cross-compatibility and fertility of hybrids (Table 2) Apart from validly published names, 12 specific names have been used in the literature (Resslar 1980) The use of invalid *Arachis* epithets has created much confusion Therefore, until authentic descriptions of various species become available, it is convenient to refer to the genotypes/accessions by their collector numbers These, as well as more recently collected species, are expected to be formally described in the near future The genus *Arachis* is likely to have 70 species (A Krapovickas, IBONE, personal communication 1984) This number may be exceeded as more collections are made in South America

Arachis hypogaea L.

Origin and distribution

The center of origin of the cultivated groundnut, *Arachis hypogaea*, has been discussed many times Brazil was considered to be the center of origin by Bentham (1859) Mendes (1947) believed that the groundnut originated in the state of Mato Grosso, Brazil, which is generally recognized as a major center of diversity for the genus However, Krapovickas (1969), who collected extensively in South America, postulated that *A hypogaea* probably originated in Bolivia and northwest Argentina on the eastern slopes of the Andes This area is a very important center of variation for *A hypogaea* subsp *hypogaea A monticola*, another tetraploid species in section *Arachis*, also occurs in this region *A monticola*, which is fully cross-compatible with *A hypogaea*, can be considered to be the closest wild relative of the cultivated form This species resembles the cultivated groundnut closely and differs mainly in characters such as catenate pods (the segments of fruit are separated by a length of isthmus), and longer pegs, which enable it to survive in the wild Krapovickas (1969) also considered ethnobotanical evidence, such as the diversity of the uses of groundnut in this region Cardenas (1969) supported the Bolivian origin of groundnut and an independent origin in Brazil is unlikely (Gregory et al 1981) In addition, six secondary centers of diversity are recognized, and a brief description of the genocenters is given below, following Krapovickas (1969) and Gregory et al (1973)

Table 1. Key to ... of *Arachis* L. (after Krapovickas 1973, Gregory et al. 1973, Smartt and Stalker 1982, and A. Krapovickas, personal communication).

1 Plant with ...	Section *Rhizomatosae* Krap et Greg *nom nud.*
2 Rhizome ... 2x = 20	Series *Prorhizomatosae* Krap. et Greg *nom nud.*
2' Rhizome ... deep. 2n = 2x = 40	Series *Eurhizomatosae* Krap et Greg *nom nud.*
1' Plants with... ...nate	Section *Trierectoides* Krap *nom. nud* (= Ser *Trifoliolatae* Krap. et Greg. *nom nud.* under sect *Erectoides* Krap. et Greg *nom. nud.*)
3 Plants ... ...nate ...al ...gs without any roots ... at nodes common, mostly ...ow stems	Section *Caulorhizae* Krap et Greg. *nom nud.*
3' Plants ... ...any rooting at nodes, mostly ...al stems	
4 Per... ... purple markings on both the ... the standard, 2n = 2x = 20	Section *Ambinervosae* Krap et Greg *nom nud*
...out any prominent markings ... back of the standard	Section *Arachis nom nud*
... plants annual or perennial, ... = 2x = 20	
... Usually annual, flowers smaller	Series *Annuae* Krap et Greg. *nom nud.*
... Usually perennial, flowers larger	Series *Perennes* Krap et Greg *nom nud*
Plants annual or less than annual, short-lived, 2n = 2x = 40	Series *Amphiploides* Krap. et Greg *nom. nud.*
...adventitious roots thickened, ... with roots, red or purple ...ings on the back of the standard	Section *Extranervosae* Krap. et Greg. *nom. nud*
5 ... horizontal ... with prominent purple color ... on the front face of the ...	
4' ... flowers small, fruits ... pigmented	Section *Triseminalae* Krap. et. Greg. *nom. nud.*
... markings on the front face ... standard, flowers larger ... prostrate, tap-rooted, ... any root thickenings	Section *Procumbensae* Krap et. Greg *nom. nud* (= Ser. *Procumbensae* Krap. et Greg. *nom nud.* under sect *Erectoides* Krap. et. Greg. *nom. nud.*)
... prostrate or erect, tap ... thickened or not, sometimes ... tuberiform hypocotyl	Section *Tetraerectoides* Krap. et. Greg. *nom. nud.* (= Ser. *Tetrafoliolatae* Krap. et Greg. *nom. nud.* under sect *Erectoides* Krap. et Greg. *nom. nud.*)

Table 2. Valid *Arachis* epithets[1].

Section[2]	Series	Species ploidy level	Author citation
Arachis Annuae	*A batizocoi* Krap. et Greg	20	in Krapovickas et al 1974
Perennes	*A villosa* Benth.	20	Bentham 1841
	A diogoi Hoehne	20	Hoehne 1919
	A helodes Mart ex Krap et Rig	20	Krapovickas and Rigoni 1957
Amphiploides	*A hypogaea* L.	40	Linnaeus 1753
	A monticola Krap. et Rig	40	Krapovickas and Rigoni 1957
Caulorhizae	*A repens* Handro	20	Handro 1958
Erectoides Trifoliolatae	*A tuberosa* Benth	20	Bentham 1841
	A gauaranitica Chod. et Hassl.	20	Chodat and Hassler 1904
Tetrafoliolatae	*A paraguariensis* Chod et Hassl.	20	Chodat and Hassler 1904
	A benthamii Handro	20	Handro 1958
	A martii Handro	20	Handro 1958
Procumbensae	*A rigonii* Krap et Greg	20	Krapovickas and Gregory 1960
Extranervosae	*A prostrata* Benth	20	Bentham 1841
	A marginata Gard	20	Gardner 1842
	A villosulicarpa Hoehne	20	Heohne 1944
	A lutescens Krap. et Rig.	20	Krapovickas and Rigoni 1957
Rhizomatosae			
Prorhizomatosae	*A. burkartii* Handro	20	Handro 1958
Eurhizomatosae	*A. glabrata* Benth.	40	Bentham 1841
	A. hagenbeckii Harms.	40	in Kuntze 1898
Triseminalae	*A. pusilla* Benth.	20	Bentham 1841

1. After Krapovickas 1973, Gregory et al 1973
2. No species have been described in section *Ambinervosae*, though germplasm is available

1. The ...

This regi... Paraguay ... Argentina ... Grosso an... extending ... ...ge part of the river basins of ... (bordering northeastern ...guay, and southern Mato ... Paulo in Brazil), probably ... Grande do Sul, Brazil. This region is rich in subsp *fastigiata*; var *fastigiata* forms are more common than var *vulagaris* forms. A few subsp *hypogaea* forms also occur. There could have been some introgression within the subsp *fastigiata*, since some intermediate forms have been found. Both valencia and spanish forms could have evolved in this region.

2. Southeastern Brazil (Goias and Minas Gerais)

This includes the river basins of Tocantins and Sao Franscisco. A predominance of subsp *fastigiata* forms was observed with an increasing frequency of spanish types.

3. West Brazil (Rondonia and northeastern Mato Grosso)

This region still needs to be explored properly. The so-called *A. nambyquarae*, which is now considered a form of *hypogaea* with variegated seed coat, and a few *fastigiata* forms with yellow seed coat, occur in this region. *A. villosulicarpa*, a diploid wild species with fairly large fruits, was found to be cultivated by natives of Juruena and Diamantino (Hoehne 1944, C.E. Simpson, personal communication 1985).

4. Bolivia (Eastern slopes of the Andes)

Var *hypogaea* forms predominate here, featuring extensive variability for various morphological characters. A few valencias have been found, and even fewer spanish forms. In this region, a great range of ecologically distinct groundnut-growing areas have been found at altitudes of up to 2000 m. There may have been significant introgression between subsp *hypogaea* and subsp *fastigiata* in this area.

5. Peru

Mostly primitive valencias (var *fastigiata*), characterized by constricted fruits with prominent beaks and highly reticulated, thick shells, occur in this region. Similar forms were observed in many pre-Columbian archaeological remains in coastal Peru, indicating that this type of groundnut was grown in the ancient agricultural system of Peru. Subsp *hypogaea* (both var *hypogaea* and var *hirsuta*) forms are also found and may still be cultivated on the Pacific coast. A few typical virginia runner forms were also found in this region but they may be later introductions from North America. Spanish (*vulgaris*) landraces have not been recorded.

6. Northeastern Brazil

Considerable variability exists in this region especially in the subsp *fastigiata*. Spanish forms predominate, some of which are typically large-seeded. A few *hypogaea* forms also occur in this region.

The progenitors of *A. hypogaea* are yet to be identified. On the basis of cytogenetic evidence, Husted (1936) suggested that *A. hypogaea* had an amphidiploid origin. Mendes (1947) concluded that it arose through spontaneous chromosome doubling of a diploid form. Krapovickas and Rigoni (1957), and Smartt and Gregory (1967) suggested that the derivation was directly from a wild allotetraploid. However, the wild amphidiploid could also have evolved from a hybrid between annual and perennial species within the section *Arachis* (Gregory and Gregory 1976) and the parents could have been similar to *A. cardenasii* Krap. et Greg. *nom. nud.* and *A. duranensis* Krap. et Greg. *nom. nud.* On the basis of karyotype studies, Smartt et al. (1978) suggested that *A. batizocoi* Krap. et Greg. *nom. nud.* and *A. cardenasii* Krap. et Greg. *nom. nud.* could be the probable ancestors. Singh and Moss (1982) also suggested that *A. cardenasii* Krap. et Greg. *nom. nud.* could be one of the parents for the tetraploid species. However, as Stalker (1980) indicated, many species have still to be collected and more basic information is required before the question of the putative parents of the cultivated groundnut can be resolved.

Though the cultivated groundnut originated in South America, it is now cultivated in many countries across the world, between latitudes 40°N and 40°S. In Peru, groundnut has been cultivated since 3000-2000 B.C. (Johnson 1964, D.J. Banks, OSU, personal communication 1985), but no form of wild *Arachis* has been reported from Peru. Cultivation of groundnut above the subsistence level of agriculture could be attributed only to the then level of civilization (Krapovickas 1969).

Groundnut could have spread to the old world only after the Spanish and Portugese colonization of South America. There is no credible evidence for any pre-Columbian spread of groundnut to Africa or Asia. Africa, where a considerable amount of variation exists, especially for var *hypogaea* types, has been tentatively described as a secondary center of diversity (Gibbons et al. 1972). However, the diversity in African germplasm is much less than that in South American germplasm, and hence it can be only a tertiary center of diversity.

Taxonomy

As in the case of interspecific taxonomy of the genus *Arachis*, intraspecific classification of *A. hypogaea* has received much attention by various workers. Most of the early systems were based on growth habit, presence or absence of dormancy, and maturity (Bouffil 1947). However, later attempts were based on branching pattern and location of fruiting branches. Gregory et al. (1951) presented a comprehensive study in which *A. hypogaea* was divided into two large botanical groups, i.e., virginia and spanish-valencia, on the basis of the branching pattern described by Richter (1899). The presence or absence of reproductive nodes on the main axis and the arrangement of reproductive and vegetative nodes on the laterals (alternate or sequential) were considered the most important criteria in this classification.

The subspecific classification of *A. hypogaea* is given below (after Krapovickas 1969).

A. hypogaea L. subsp *hypogaea* Krapovickas et Rigoni

1. var *hypogaea* Virginia type (western Brazil and Bolivia)

2. var *hirsuta* Kohler (Peru) subsp *fastigiata* Waldron

1. var *fastigiata* Valencia type (Guaranian, southeastern Brazil and Peru)

2. var *vulgaris* Harz Spanish type (Guaranian, southeastern Brazil, and northeast Brazil)

A few attempts have been made to relate the classification of the cultivated groundnut by Bunting (1955, 1958), extended by Smartt (1961), with the taxonomic treatment of Krapovickas and Rigoni (1960) and Krapovickas (1969). Gibbons et al. (1972) described four cultivar groups in var *hypogaea*, one in var *fastigiata* and three in var *vulgaris*. Each of these cultivar groups was subdivided into a number of cultivar clusters based on various morphological characters such as plant habit, and pod and seed characters. This classification was based on a study of the material available in Africa. From the extent of variation, they considered that Africa was a secondary center of diversity. A somewhat similar classification was given by Varisai Muhammad et al. (1973a,b), in which they classified the available material into 45 different varietal groups. However, these classification systems fail to explain the extent of diversity in much larger collections. Moreover, considering the number of intermediate forms now available in the germplasm collection at ICRISAT, any agronomic classification will be cumbersome and one may end up with too many classes to be of any value.

Sources of Rust Resistance

Groundnut rust (*Puccinia arachidis*) is an important foliar disease causing substantial yield loss to groundnut in many countries (Subrahmanyam and McDonald 1983). Rust, in combination with leaf spots, can cause yield losses exceeding 50% (Gibbons 1980), and losses of over 70% have been recorded at ICRISAT Center (Subrahmanyam et al. 1980a,b and 1984). Although the disease can be controlled by fungicides, this approach is too expensive for many developing countries.

Screening for resistance to rust has been successfully carried out by numerous workers (Mixon et al. 1983). At ICRISAT a large collection of cultivated groundnut and its wild relatives has been assembled by the Genetic Resources Unit (Rao 1980, Rao and Sadasivan 1983). Intensive screening of the available germplasm for all the major groundnut pests and diseases was conducted in order to identify sources of resistance for incorporating genetic resistance into high-yielding cultivars. Screening of germplasm for resistance against rust and late leaf spot was carried out during 1977-84 under natural disease pressure in the field and several sources of resistance to rust and/or late leaf spot have been reported by Subrahmanyam et al. (1980a,b). Subrahmanyam et al. (1983), and Subrahmanyam and McDonald (these proceedings). Cultivated groundnut and wild *Arachis* species accessions with resistance to rust are listed in Tables 3 and 4 with details of their identity, origin, and botanical type.

Resistance in *A. hypogaea*

Out of about 9000 groundnut accessions screened so far, 39 have shown resistance to groundnut rust, but some appear to be duplicates (Hammons, these proceedings). However, various morphological characters indicate that they are not duplicates in the real sense (Reddy et al., these proceedings). Most of the resistant accessions belong to the botanical variety *fastigiata*, while less than 10% belong to var *hypogaea*, and none to var *vulgaris* (Table 3). It is not surprising that var *vulgaris* does not include rust-resistant types since spanish type landraces are not known from Peru (Krapovickas 1969). Among the *hypogaea* resistant types, two accessions from Honduras (ICG 7899 and 7900) originated from a cross with a resistant Tarapoto line (var *fastigiata*) from Peru as per the available germplasm records. These *fastigiata* types differ from normal valencia types in having a thick and highly reticulated shell and pods, which are constricted, prominently ridged and conspicuously beaked. The seeds of most of the resistant accessions are either purple or are variegated with splashes of purple, red, or tan. They generally have a long maturation period. Most of the rust-resistant accessions are poor yielders, and have other undesirable agronomic characters (Subrahmanyam et al. 1980a, Subrahmanyam and McDonald 1983).

The study also revealed that about 90% of the resistant genotypes are landraces from South America, or in some way related to such material, originating from Peru, which is a secondary center of diversity for the subsp *hypogaea* var *fastigiata* (Gregory et al. 1973). The origins of lines ICG 2716 (from Uganda) and ICG 6022 (from Sudan) are uncertain but plant and pod characters suggest that they were introductions from South America, probably from Peru. Even in the large collection at the Instituto Nacional de Tecnologia Agropecuaria (INTA), Manfredi, Argentina, the var *fastigiata* forms with characteristics of the resistant accessions described here come only from Peru, and may be separated taxonomically as var *peruviana* Krap. et Greg. *nom. nud.* (A. Krapovickas, IBONE, Personal communication 1984). So it is logical to assume that most of the rust resistant lines originate from Peru. Of all the cultivated germplasm accessions screened so far, only about 62 originate from Peru; about 50% of these are resistant to rust. The collection data indicate that almost all of these accessions could be traced to the Tarapoto region of Peru. Thus the existing evidence suggests that the resistance to rust in the cultivated groundnut has evolved in or around

Table 3. Rust-resistant cultivated groundnut accessions (after Subrahmayam et al. 1980a,b).

ICG Number	Identity	Origin	Botanical variety	Seed color	Rust reaction
1697	NC Ac 17090	Peru	*fastigiata*	Light tan	MR
1703	NC Ac 17127	Peru	*fastigiata* stripes	Tan/purple	MR
1704	NC Ac 17129	Peru	*fastigiata*	Light tan	MR
1705	NC Ac 17130	Peru	*fastigiata*	Tan	MR
1707	NC Ac 17132	Peru	*fastigiata*	Purple	MR
1710	NC Ac 17135	Peru	*fastigiata*	Purple	MR
1712	NC Ac 17142	Brazil	*fastigiata*	Tan	MR
2716	EC 76446(292)	Uganda[1]	*fastigiata*	Purple	R
3527	USA 63	-	*fastigiata*	Purple	R
3580	C. No 45-23	-	*fastigiata*	Tan	MR
4683	U 4-7-7	-	*fastigiata*	Tan	MR
4746	PI 298115	Israel, USA[2]	*hypogaea*	Off white	MR
4747	PI 259747	Peru	*fastigiata*	Purple	HR
4790	Krap. st.16	Argentina	*fastigiata*	Purple	R
4995	NC Ac 17506	Pereu	*fastigiata*	Purple	MR
6022	NC Ac 927	Sudan	*fastigiata*	Purple	MR
6280	NC Ac 17124	Peru	*fastigiata* stripes	Tan/purple	MR
6330	PI 270806	Zimbabwe	*fastigiata*	Purple	R
6340	PI 350680	Honduras[3]	*fastigiata*	Purple	R
7013	NC Ac 17133RF[4]	Peru	*fastigiata*	Purple	R
7881	PI 215696	Peru	*fastigiata*	Purple	R
7882	PI 314817	Peru	*fastigiata*	Light tan	R
7883	PI 315608	Israel/USA[2]	*hypogaea*	Purple	MR
7884	PI 341879	Peru	*fastigiata*	Purple	R
7885	PI 381622	Honduras[3]	*fastigiata*	Purple	R
7886	PI 390593	Peru	*fastigiata*	Light tan	R
7887	PI 390595	Peru	*fastigiata*	Purple	R
7888	PI 393516	Peru	*fastigiata*	White/red	R
7889	PI 393517	Peru	*fastigiata*	Off white	R
7890	PI 393526	Peru	*hypogaea*	Red	M
7892	PI 393527 B	Peru	*fastigiata* stripes	Tan/purple	R
7893	PI 393531	Peru	*fastigiata* stripes	L. tan/purple	R
7894	PI 393641	Peru	*fastigiata* stripes	L. tan/purple	R
7895	PI 393643	Peru	*fastigiata*	Tan	R
7896	PI 393646	Peru	*fastigiata*	Purple	R
7897	PI 405132	Ecuador/ Venezuela[5]	*fastigiata*	Tan	MR
7898	PI 407454	Ecuador[5]	*fastigiata*	Tan	MR
7899	PI 414331	Honduras[6]	*hypogaea*	Tan	R
7900	PI 414332	Honduras[6]	*hypogaea*	Tan	MR

1. Given origins in Uganda and Sudan, respectively, uncertain, may be from Peru due to pod and plant characters.
2. Selection in Israel in material from USA. Exact origin not known.
3. Mazzani, origin not specified, sample source is Honduras.
4. Red flower selection at ICRISAT original population from Peru.
5. Origin uncertain, may be from Peru since it is also known as Tarapoto line.
6. Bred in Honduras, parents Florispan runner × Tarapoto (probably PI 259747 from Peru).

Table 4. Rust-resistant wild *Arachis* species/accessions (Subrahmanyam et al. 1983).

ICG Number	Name	Synonym[2]	Section[3]/ series[4]	Collection State	Area/ Country[5]	Rust reaction[6]
8124	*A. batizocoi*	K 9484	AR/AN	Corrientes	ARG	I
8123	*A. duranensis*[1]	K 7988	AR/AN	Salta	ARG	I
8138	*Arachis* sp	GKP 10038	AR/AN	-	ARG	I
8190	*Arachis* sp	GK 30006	AR/AN	Mato Grosso	BRA	I
8193	*Arachis* sp	GK 30011	AR/AN	Mato Grosso	BRA	I
8216	*A. cardenasii*[1]	GKP 10017	AR/PE	Robore	BOL	I
4983	*A. chacoensis*[1]	GKP 10602	AR/PE	Puerto Casado	PRY	I
4985	*A. correntina*[1]	GKP 9548	AR/PE	Corrientes	ARG	I
8132	*A. correntina*[1]	GKP 9530	AR/PE	Corrientes	ARG	I
8134	*A. correntina*[1]	K 7897	AR/PE	Corrientes	ARG	I
8140	*A. correntina*[1]	K 9530-1	AR/PE	Corrientes	ARG	I
8125	*A. stenosperma*[1]	HLK 408	AR/PE	Parana	BRA	HR
8126	*A. stenosperma*[1]	HLK 411	AR/PE	Parana	BRA	HR
8137	*A. stenosperma*[1]	HLK 409	AR/PE	Parana	BRA	HR
8144	*A. villosa*	PI 210554	AR/PE	-	BRA	I
8952	*A. helodes*	GK 30031	AR/PE	Mato Grosso	BRA	HR
8918	*Arachis* sp	Manfredi-5	AR/PE	-	-	I
8954	*Arachis* sp	GK 30035	AR/PE	Mato Grosso	BRA	HR
8130	*A. paraguariensis*	KCF 11462	ER/TE	Cordillera	PRY	I
8127	*A. appresipila*[1]	GKP 9990	ER/PR	Mato Grosso	BRA	I
8128	*A. papresipila*[1]	GKP 9993	ER/PR	Mato Grosso	BRA	I
8129	*A. appresipila*[1]	GKP 10002	ER/PR	Mato Grosso	BRA	I
8142	*A. villosulicarpa*		EX	-	BRA	I
8149	*A. glabrata*	HLKHe 552	RZ/EZ	S Mato Grosso	BRA	I
8150	*A. glabrata*	HLKHe 553	RZ/EZ	S Mato Grosso	BRA	I
8153	*A. glabrata*	HLKHe 560	RZ/EZ	S Mato Grosso	BRA	I
8155	*A. glabrata*	GKP 9566	RZ/EZ	Trinidad	ARG	I
8167	*A. glabrata*	GKP 9806	RZ/EZ	S Mato Grosso	BRA	I
8168	*A. glabrata*	GKP 9813	RZ/EZ	S Mato Grosso	BRA	I
8902	*A. glabrata*	-	RZ/EZ	-	-	I
8908	*A. glabrata*	A 3990	RZ/EZ	S Mato Grosso	BRA	I
8933	*A. glabrata*	GKP 9797	RZ/EZ	S Mato Grosso	BRA	I
8935	*A. glabrata*	GKP 9827	RZ/EZ	S Mato Grosso	BRA	I
8936	*A. glabrata*	GKP 9830	RZ/EZ	S Mato Grosso	BRA	I
8941	*A. glabrata*	GKP 9935-p49	RZ/EZ	Mato Grosso	BRA	I
8165	*a. glabrata*	GKP 9649	RZ/EZ		BRA	I
8170	*A. glabrata*	GKP 9834	RZ/EZ	S Mato Grosso	BRA	I
8171	*A. glabrata*	GKP 9882	RZ/EZ	S Mato Grosso	BRA	I
8938	*A. glabrata*	GKP 9893(a)	RZ/EZ	Mato Grosso	BRA	I
8146	*A. hagenbeckii*	HL 486	RZ/EZ	Campinas	BRA	I
8911	*A. hagenbeckii*	A44 11	RZ/EZ	-	-	I
8922	*A. hagenbeckii*	HLKO 349	RZ/EZ	Corrientes	ARG	I
8145	*Arachis* sp	HLO 333	RZ/EZ	Corrientes	ARG	I
8154	*Arachis* sp	K 7934	RZ/EZ	Misiones	PRY	I
8156	*Arachis* sp	GKP 9567	RZ/EZ	Trinidad	PRY	I
8158	*Arachis* sp	GKP 9580	RZ/EZ	Asuncion	PRY	I
8159	*Arachis* sp	GKP 9592	RZ/EZ	Asuncion	PRY	I

Continued

Table 4. [illegible]

ICG Number	Name	Synonym[2]	Section[3]/ series[4]	Collection State	Area/ Country[5]	Rust reaction[6]
8160	*Arachis* sp	GKP 9618	RZ/EZ	Itobati	PRY	I
8161	*Arachis* sp	GKP 9634	RZ/EZ	S Mato Grosso	PRY/BRA	I
8162	*Arachis* sp	GKP 9645	RZ/EZ	S Mato Grosso	BRA	I
8166	*Arachis* sp	GKP 9667	RZ/EZ	S Mato Grosso	BRA	I
8172	*Arachis* sp	1960 No.100	RZ/EZ	-	-	I
8916	*Arachis* sp	2AS 301	RZ/EZ	-	-	I
8925	*Arachis* sp	GKP 9553	RZ/EZ	Corrientes	ARG	I
8929	*Arachis* sp	GKP 9591	RZ/EZ	Asuncion	PRY	I
8937	*Arachis* sp	GKP 9893(p1)	RZ/EZ	Mato Grosso	BRA	I
8959	*Arachis* sp	GKBSPScZ30085	RZ/EZ	Portacheulo	BOL	I
8131	*A.* [illegible]	GKP 12922	TR	Bahia	BRA	I

1. [illegible]
2. [illegible] C = Cristobal; G = Gregory; H = Hammons; He = Hemsy; K = Krapovickas; L = Langford; O = Ojeda; P = Pietrarelli; [illegible] Z = Zurita
3. [illegible] ER = *Erectoides*; EX = *Extranervosae*; RZ = *Rhizomatosae*; TR = *Triseminalae*.
4. [illegible] PE = *Perennes*; TE = *Tetrafoliolatae* PR = *Procumbensae*; EZ = *Eurhizomatosae*.
5. [illegible] = Argentina; BOL = Bolivia; BRA = Brazil; PRY = Paraguay.
6. [illegible] resistant; I = immunity.

Peru and [illegible] such cultivars are probably distinct from other groundnuts.

More recent collections from Peru are arriving at ICRISAT and preliminary observations indicate that some of the accessions have resistance to rust.

Resistance in wild *Arachis* species

Most of the accessions tested in the section *Arachis* were either immune or highly resistant to rust (Table 4). The probable ancestral species, *A. batizocoi* [illegible], *A. cardenasii nom. nud.*, and *A. chacoense nom. nud.* were immune to the disease. However, *A. monticola*, probably the closest relative to *A. hypogaea* was susceptible. The species from sections *Erectoides*, *Extranervosae*, *Rhizomatosae*, and *Triseminalae* that were tested were immune to rust although the number of accessions tested in sections *Erectoides*, *Extranervosae*, and *Triseminalae* were very few (Subrahmanyam et al. 1983). Several herbarium specimens at CENARGEN/EMBRAPA, Brasilia, Brazil were examined by the author and rust pustules were observed on several specimens of species in sections *Arachis*, *Erectoides*, *Extranervosae*, and *Rhizomatosae*. No pustules were observed on specimens belonging to the sections *Ambinervosae*, *Caulorhizae*, and *Triseminalae*. A number of specimens of *A. glabrata* had rust pustules. A similar situation was reported for specimens of *A. glabrata* collected by W.A. Archer and A. Ghert (Bromfield 1971).

Mild to very severe rust symptoms were observed by the author on species belonging to sections *Arachis*, *Erectoides*, and *Rhizomatosae* when on a collection expedition during April 1984 in the state of Matto Grosso do Sul, Brazil. Rust was also observed on a few plants of *A. glabrata* in a screen house.

Very little information is available on the occurrence of pests and diseases of wild *Arachis* in their natural habitats. Observations on herbarium material and on live plants by the author (both on plants in the screen house and on natural populations during collection expeditions) indicate that *Arachis* species may be infected, to a greater degree than expected, by a number of pathogens including rust. Hence it may be necessary to gather more information on such natural occurrence of pathogens and their pathogenicity. Differential reactions were also observed in *A. monticola* (Bromfield and Cevario 1970, Hammons 1977). These differences could be due to variation in the pathogen, host-pathogen-environment interactions, or even to confusion in the identification or to intraspecific variation (Subrahmanyam et al. 1983). As *A. monticola* is highly variable and it is difficult to maintain its genetic identity since it introgresses easily with the cultivated groundnut (Gregory et al. 1973), the variation in rust reaction in this species is probably due to variability in the host. In any case a number of wild species of *Arachis* are presently available with varying degrees of resistance to groundnut rust.

Conclusions

Much has still to be done to elucidate the origin and taxonomy of the genus *Arachis*. The authentic description of several species is an immediate need. A proper understanding of the taxonomic level of material available is essential for the exploitation of the genus. The origin of *Arachis* was probably in the planaltine region of South America. The cultivated groundnut probably originated in south Bolivia and northwestern Argentina on the eastern slopes of the Andes. More information is needed to understand the intrasectional relationships in *Arachis* and the ancestry of the cultivated groundnut.

Resistance to rust in the cultivated groundnut appears to have originated in Peru. The evidence available indicates that the genes for rust resistance in *A. hypogaea* are nonrandomly distributed in the region of Peru. These sources of rust resistance in *A. hypogaea* are already being exploited at ICRISAT and elsewhere. More recent collections from Peru are presently becoming available at ICRISAT, and preliminary observations in the quarantine nurseries indicate that a number of them may possess rust resistance. Pointed collections should be carried out in Peru and in surrounding areas to find more germplasm having resistance to rust. Such a search may also result in obtaining accessions with yields beyond the postulated yield/resistance barrier (Subrahmanyam et al. 1984) as some introgression may have occurred in this secondary center of diversity.

A number of *Arachis* species/accessions are immune or highly resistant to groundnut rust. More species/accessions, especially in sections other than *Arachis* and *Rhizomatosae*, are presently becoming available and should be screened for rust resistance. Attempts are being made to transfer this character from wild relatives to the cultivated groundnut. Wild species may have different mechanisms of resistance and so provide the possibility of combining rust resistance of wild and cultivated, to give more effective and stable resistance. More input to understand the possible variation in the pathogen, specially in the wild, in South America, is essential. This has significance not only in groundnut improvement, but also in the context of international exchange of germplasm, specially the non- or poor seed producing species that need to be transferred in the form of cuttings or live plants.

References

Bentham, G., 1841. On the structure and affinities of *Arachis* and *Voandzeia*. Transactions of the Linnean Society of London 18:155-162.

Bentham, G., 1859. *Papilionaceae*. Flora Brasiliensis 15:85-88.

Bouffil, F. 1947. Biologie, écologie et selection de l'arachide au Sénégal. (In Fr.) Bulletin Scientifique, Ministère des Colonies de la France d'Outre Mer, Section Technique d'Agriculture Tropicale 1:1-112.

Bromfield, K.R. 1971. Peanut rust: a review of literature. Journal, 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.

Bunting, A.H. 1955. A classification of cultivated groundnuts. Empire Journal of Experimental Agriculture 23:158-170.

Bunting, A.H. 1958. A further note on the classification of cultivated groundnuts. Empire Journal of Experimental Agriculture 26:254-258.

Burkart, A. 1939. Estudios sistematicos sobre las Leguminosas Hedisareas de la Republica Argentina y regiones adyacentes. (In Es.) Darwiniana 3:117-302.

Cardenas, M., 1969. El mani. (In Es.) Pages 130-136 *in* Manual de plantes economicas de Bolivia. Cochabamba, Bolivia:Imprenta Ichthus.

Chevalier, A. 1934-35. Monographie de l'arachide. (In Fr.) Revue de Botanique Appliquée et d'Agriculture Tropicale 13:689-789, 14:562-632, 709-755, 834-864, 16:673-871.

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 Sep 1979, ICRISAT Center, India. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Gibbons, R.W., Bunting, A.H., and **Smartt, J.** 1972. The classification of varieties of groundnuts (*Arachis hypogaea* L.). Euphytica 21:78-85.

Gregory, W.C., Gregory, M.P., Krapovickas, A., Smith, B.W., and **Yarbrough, J.A.** 1973. Structure and genetic resources of peanuts. Pages 47-134 *in* Peanuts—culture and uses (Wilson, C.T., ed.). Stillwater, Oklahoma, USA: American Peanut Research and Education Association.

Gregory, W.C., and **2Gregory , M.P.** 1976. Groundnut, *Arachis hypogaea*. Pages 151-154 *in* Evolution of crop plants (Simmonds, N.W., ed.). London, UK: Longman.

Gregory, W.C., Hammons, R.O., Bunting, A.H., Lynch, R.L., Norden, A.J., Simpson, C.E., Smith, D.H., Smith, O.D., Wynne, J.C., and Young, C.T. 1981 *Arachis hypogea* L. Pages 18-22 *in* Handbook of legumes of world economic importance (Duke, J.A., ed.) New York, USA: Plenum Press.

Gregory, W.C., Krapovickas, A., and Gregory, M.P. 1980 Structure, variation, and evolution and classification in *Arachis*. Pages 469-481 *in* Advances in legume science. Volume I of the International Legume Conference, 31 Jul-4 Aug 1978, Kew, Surrey, UK (Summerfield, R.J., and Bunting, A.H., eds.) Kew, Surrey, UK: Royal Botanic Gardens.

Gregory, W.C., Smith, B.W., and Yarbrough, J.A. 1951 Morphology, genetics and breeding. Pages 28-88 *in* The peanut—the unpredictable legume. Washington, D.C., USA: National Fertilizer Association.

Hammons, R.O. 1977 Groundnut rust in the United States and the Caribbean. PANS 23: 300-304.

Hermann, F.J. 1954 A synopsis of the genus *Arachis*. Agriculture Monograph no. 19. Washington, D.C., USA: United States Department of Agriculture.

Hoehne, F.C. 1940 Leguminosas—Papilionadas. Genero *Arachis*. Flora Brasilicas 25(II), 122: 1-20.

Hoehne, F.C. 1944 Duas novas especies de Leguminosas do Brasil. (In Pt.) Arquivos de Botanica do Estado de Sau Paulo 2: 15-18.

Husted, L. 1936 Cytological studies on peanut. II. Chromosome number, morphology and behaviour and their application to the problem of origin of the cultivated forms. Cytologia 7: 396-423.

Johnson, F.R. 1964 The peanut story. North Carolina, USA: Johnson Publishing Co.

Krapovickas, A. 1969 Origin, variability and distribution of groundnut (*Arachis hypogaea*). Pages 427-441 *in* The domestication and exploitation of plants and animals (Ucko, P.J., and Dimbleby, G., eds.) London, UK: Duckworth.

Krapovickas, A. 1973 Evolution of the genus *Arachis*. Pages 135-151 *in* Agricultural genetics selected topics (Moav, R., ed.) Jerusalem, Israel: National Council for Research and Development.

Krapovickas, A., and Rigoni, V.A. 1957 Nuevas especies de *Arachis* vinculados al problema del origin del mani (In Es.) Darwiniana 17: 431-455.

Krapovickas, A. and Rigoni, V.A. 1960 La nomenclatura de las subespecies y variabilidades de *Arachis hypogaea* L. (In Es.) Revista de Investigaciones Agricolas 14: 197-228.

Linnaeus, C. 1753 Species plantarum. Holmiae 2: 741.

Mendes, A.J.T. 1947 Cytological studies in the genus *Arachis*. Bragantia 7: 257-267.

Mixon, A.C., Hammons, R.O., and Branch, W.D. 1983 Germplasm for use in genetic enhancement of peanut genotype. Proceedings of American Peanut Research and Education Society 15: 15-38.

Rao, V.R. 1980 Groundnut genetic resources at ICRISAT. Pages 47-57 *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.

Rao, V.R., and Sadasivan, A.K. 1983 Wild *Arachis* genetic resources at ICRISAT. Pages 37-41 *in* Proceedings of the International Workshop on Cytogenetics of *Arachis*, 31 Oct-2 Nov 1983, ICRISAT Center, India: Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Resslar, P.M. 1980 A review of the nomenclature of the genus *Arachis* L. Euphytica 29: 813-817.

Richter, C.G. 1899 Beitrage zur Biologie von *Arachis hypogaea*. Inaug. Diss. Kgl. Botanisch Garten Berlin, Breslau (Schreiber, A., ed.) (cited from Gregory et al. 1973).

Rudd, V.E. 1981 *Aeschynomeneae*. Pages 347-354 *in* Advances in legume systematics. Vol. 2 of the International Legume Conference, 24-29 Jul 1978, Kew, Surrey, UK (Polhill, R.M. and Raven, P.H., eds.) Kew, Surrey, UK: Royal Botanic Gardens.

Simpson, C.E. 1982 Collection of *Arachis* germplasm (1976-1982). Plant Genetic Resources Newsletter 52: 10-12.

Singh, A.K., and Moss, J.P. 1982 Utilization of wild relatives in genetic improvement of *Arachis hypogaea* L. Part 2. Chromosome complements of species in section *Arachis*. Theoretical and Applied Genetics 61: 305-314.

Smartt, J. 1961 Groundnut varieties of northern Rhodesia and their classification. Empire Journal of Experimental Agriculture 29: 153-158.

Smartt, J., and Gregory, W.C. 1967 Interspecifc cross-compatibility between the cultivated peanut *Arachis hypogaea* L. and other members of the genus *Arachis*. Oleagineux 22: 455-459.

Smartt, J., Gregory, W.C., and Gregory, M.P. 1978 The genomes of *Arachis hypogaea* 1. Cytogenetic studies of putative genome donors. Euphytica 27: 665-675.

Smartt, J., and Stalker, H.T. 1982 Speciation and cytogenetics in *Arachis*. Pages 21-49 *in* Peanut science and technology (Pattee, H.E., and Young, C.T., eds.) Yoakum, Texas, USA: American Peanut Research and Education Society.

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., Gibbons, R.W., Nigam, S.N., and Rao, V.R. 1980a Screening methods and further sources of resistance to peanut rust. Peanut Science 7: 10-12.

Subrahmanyam, P., and McDonald, D. 1983 Rust disease of groundnut. (Summary in Fr.) Information Bulletin no. 13. Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics. 15pp.

Subrahmanyam, P., Mehan, V.K., Nevill, D.J., and McDonald, D. 1980b Research on fungal diseases of groundnut at ICRISAT. Pages 193-196 *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: 476-576.

Taubert, P. 1894 *Arachis*. Pages 322-325 *in* Die Naturlichen Pflanzenfamilien. III. Teil Abt. 3 (Engler, A., and Prantl, K., eds.) (Publisher not known).

Valls, J.F.M. 1983 Collection of *Arachis* germplasm in Brazil. Plant Genetic Resources Newsletter 53: 9-14.

Valls, J.F.M., Ramanatha Rao, V., Simpson, C.E., and Krapovickas, A. 1985 Current status of collection and conservation of South American groundnut germplasm with emphasis on wild species of *Arachis*. Pages 15-35 *in* Proceedings of the International Workshop on Cytogenetics of *Arachis*, 31 Oct-2 Nov 1983, ICRISAT Center, India: Patancheru, A.P. 502 324, India: International Crops Research Institute for the Semi-Arid Tropics.

Varisai Muhammad, S., Ramanathan, T., Ramachandran, M., and Mohanbabu, G. 1973a Classification of *Arachis hypogaea* L. var. *fastigiata*. Madras Agricultural Journal 60: 1399-1402.

Varisai Muhammad, S., Ramachandran, T., and Ramachandran, M. 1973b Classification of *Arachis hypogaea* L. var. *procumbens*. Madras Agricultural Journal 60: 1403-1408.