Nota de Investigación

Collection of *Arachis* germplasm in Paraguay for forage crop improvement: Phase I

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Introduction

The worldwide economic importance of the peanut or groundnut (*Arachis hypogeae* L.) has led to extensive germplasm collection and preservation efforts. This work has emphasized collecting material to better understand the complex taxonomy of this genus and that might be useful in plant breeding efforts to improve adaptation, disease resistance, and seed yield. In the past two decades, this genus has come to the attention of agronomists in the tropical and subtropical areas of the world as a source of desirable forage plants. Perennial members of this genus (e.g., *A. glabrata, A. pintoi*, *A. repens*, and *A. sylvestris*) are now know to form stable associations with tropical grasses (e.g., *Brachiaria* spp. and *Paspalum* spp.) in wild (Pizarro, 2001) and cultivated (Williams et al., 1991; Pizarro, 2001) situations. These associations have the characteristics of high dry matter (DM) yield, good nutritive value (protein and digestibility), and persistence under grazing.

Rhizoma perennial peanut (*A. glabrata*) was introduced to Florida, USA in the 1930s. Much of the initial evaluation work of this material for forage production and as a conservation crop was done by the USDA, Soil Conservation Service (now Natural Resources Conservation Service) at their Plant Materials Centers in Arcadia and Brooksville, Florida. Selections 'Arb' (PI 118457) and 'Arblick' (PI 262839) trace back to this program, but their use as forage or conservation species was very limited due to problems with slow establishment and low productivity. It was not until the release of Florigraze (PI 421707) and Arbrook (PI 262817) rhizoma peanut (Prine et al., 1981; 1986) by the University of Florida that this species was commercially accepted. Although still slow to establish (Williams et al., 1997), these cultivars have much higher DM production potential than previously available material. Studies have indicated that these cultivars are adapted throughout much of the Gulf Coast region of the US (French et al., 1994; Venuto et al., 2000) and these cultivars have proved useful for commercial hay production, pasture, creep grazing, and living mulch (French and Prine, 1998). It is now estimated that about 8,000 ha (Quesenberry, 1999) of these cultivars have been planted with the majority occurring in Florida and Georgia. The latest development of the rhizoma peanut germplasm evaluation and selection program the University of Florida is Ecoturf (PI 262840), an *A. glabrata* introduction that is gaining wide spread acceptance as a low maintenance turf or ornamental selection.

Current work is focused on genotypes for wetter sites. Following extensive

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evaluation of essentially all of the previously untested *A. glabrata* collection in the National Plant Germplasm System (NPGS) (Freire et al., 2000), three elite forage lines have been selected and are under regional evaluation for such factors as rate of establishment and spread, compatibility with associated grasses, flooding tolerance, and DM production (M.J. Williams et al., unpublished).

This work clearly demonstrates the importance of perennial *Arachis* for forage, conservation cover, and turf situations in the subtropical US. Significant further progress with *Arachis* in the US as a forage, ornamental, or conservation crop is hindered by lack of adequate tolerance of available germplasm to such factors as high water table and cold temperatures and a need for less photoperiod sensitivity. The relatively limited seed production observed in existing plant introductions precludes the chance of much progress being made by traditional plant breeding.

In 2002, a collection expedition funded through the USDA, Agricultural Research Service, Plant Exchange Office (PEO) and in collaboration with the Minsterio de Agricultura y Ganadería (MAG), Asunción, Paraguay, was conducted with the emphasis specifically on perennial *Arachis* spp. for forage, ornamental, and turf. In Paraguay, collection in the region from 23 S, 55 W to 23 S, 58 W was emphasized because this area is the least explored (C. Simpson, 2001, personal communication).

Collection procedure

The field expedition was conducted from 8-27 May 2002. The dates of the collection were selected based on the usual end of summer rainy season when plants are most visible and seed, if present, would be available. A database of herbarium and genebank accessions compiled during a USDA/La Dirección General de Protección y Conservación de la Biodiversidad - Secretaría del Ambiente (DGPCB - SEAM) Inventory of the Wild Crop Relatives of Paraguay contains over 200 entries of specific locations where wild *Arachis* has been found in Paraguay. This database was used to help target exact locations where germplasm could be collected. Maps made using FloraMap Geographical Information System software (Jones and Gladkov, 1999; Figures 1 - 3) were generated for *A. glabrata* var. *glabrata*, *A. glabrata* var. *hagenbeckii*, and *A. paraguaríensis* by the USDA, ARS, PEO using data from the wild crop relative inventory project. These maps are based on climate information (average monthly temperature, rainfall, and diurnal temperature) where each taxon was found and indicate locations with similar environmental descriptors. The dark areas have the climate most similar to that where specimens have been found. Additionally use was made of FloraMaps supplied by Dr. A. Jarvis, Internat. Plant Genetic Res. Institute, Cali, Colombia, that identified priority collection areas based on the specific objective of finding flooding and cold-tolerant germplasm. Within the collection areas, a collection protocol was followed of stopping every 5 km (10 km in areas of high *Arachis* density) or whenever *Arachis* flowers were seen.

Latitude, longitude, and elevation were determined using a Global Positioning System (GPS) at each stop whether *Arachis* was collected or not. When *Arachis* was collected, plants were checked for the presence of seed and suitable vegetative material was collected for herbarium specimens and germplasm preservation. Additionally at each collection site with *Arachis* present, soil samples were taken for determination of pH (Hellige-Truogg Soil Reaction/pH Test Kit, Forestry Suppliers, Inc., Jackson, MS, USA) and soil texture (LaMotte Soil Texture Unit, Forestry Suppliers, Inc., Jackson, MS, USA).

The collected germplasm was divided and a portion of each accession was retained by the Paraguayan team member, Ing. Agron. Pedro Juan Caballero of the Ministerio de Agricultura y Ganadería. Subsequent to the germplasm arrival in the USA, portions of the herbarium materials were sent to Dr. A.

Krapovickas, IBONE, Corrientes, Argentina, for taxonomic verification.

Results and discussion

Over 5000 km was covered in nine departments in central and south central Paraguay. Little mature seed was found; seed production may have been delayed due to the severe drought that occurred that previous summer (P.J. Caballero, 2002, personal observation). As a consequence, vegetative material was collected for each accession of the wild *Arachis*. A total of sixty-four accessions of wild and domesticated *Arachis*, representing six described and one undescribed species, were collected (Table 1). Members of the sections Rhizomatosae (*A. glabrata*), members of the sections Erectoides (*A. paraguaríensis*), Procombentes (*A. lignosa*), and Arachis (*A. hypogaea*, *A. microsperma*) were found. Most of this material is under-represented in the USDA, National Plant Germplasm System.

Although *Arachis* was found at about half of the collection sites (64 accessions out of 123 sites, data not reported), the material was not uniformly distributed throughout the area covered. We traveled extensively through the central and eastern portions of the department of Caaguazú and the northern portions of Guaira and Caazapá. Although this region was predicted to be a priority area for material that had adaptation characteristics of particular interest (e.g., adaptation to cold temperatures) and because of species richness, extensive areas of the native vegetation of the eastern portions of these Departments have been cleared for row crop production and dairy pastures. It is unknown whether failure to find material in this area was because *Arachis* was not originally abundant in the region (see Figures 1-3) or whether it has been destroyed due to recent extensive agricultural development. Also, little material was found in northern and central San Pedro Department and extreme southeastern Concepción Department which has extensive areas of brachiaria grass pastures and field

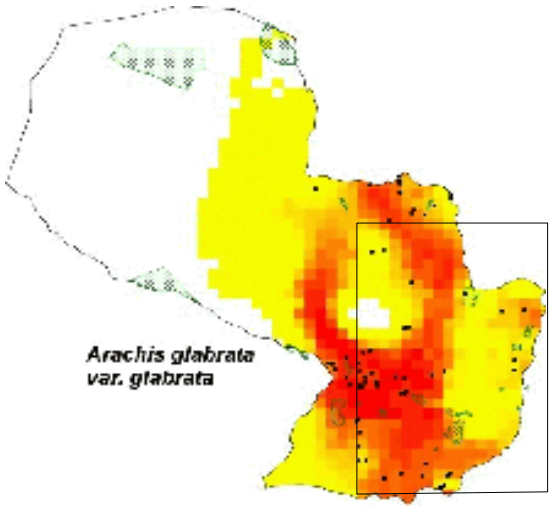

Figure 1. Floramap analysis map for *Arachis glabrata* var. glabrata based on USDA/DGPCB - SEAM Inventory of the Wild Crop Relatives of Paraguay. Box outlines approximate collection area.

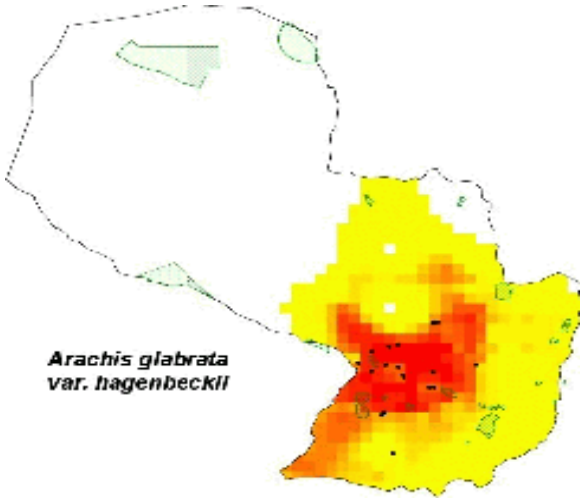

Figure 2. Floramap analysis map for *Arachis glabrata* var. Hagenbeckii based on USDA/DGPCB - SEAM Inventory of the Wild Crop Relatives of Paraguay.

Table 1. Accessions of wild and domesticated *Arachis*, representing six known species and one undescribed species, collected in Paraguay.

Collection CbWlPmPz[1] (no.)	Identification	Latitude-S		Longitude W		Altitude (m.a.s.n.)	pH	Texture (%)		
								Sand	Silt	Clay
901	*A. glabrata* var. *glabrata**	25	1.090	55	57.052	361	<5.0	40	15	45
902	*A. glabrata* var. *Hagenbeckii**	25	14.705	55	58.848	326	<5.0	40	15	45
903	*A. hypogaea*[2]	25	28.666	56	0.937	321	-	-	-	-
904	*A. hypogaea*	25	28.666	56	0.937	321	-	-	-	-
905	*A. hypogaea*	25	28.666	56	0.937	321	-	-	-	-
906	*A. hypogaea*	25	28.666	56	0.937	321	-	-	-	-
907	*A. glabrata* var. *Hagenbeckii**	25	0.623	55	49.648	282	-	80	15	5
908	*A. hypogaea*	25	30.569	56	46.837	150	-	-	-	-
909	*A. hypogaea*	25	30.569	56	46.837	150	-	-	-	-
910	*A. glabrata* var. *glabrata**	25	27.698	56	53.186	140	4.5-5.0	67	10	23
911	*A. repens**[3]	25	27.348	56	53.758	148	8.0	57	23	20
912	*A. glabrata* var. *Hagenbeckii**	25	27.468	56	55.999	221	6.5	53	12	35
913	*A. glabrata* var. *Hagenbeckii**	25	27.557	56	56.363	231	4.5-5.0	67	13	20
914	*A. glabrata* var. *Hagenbeckii**	25	32.091	57	0.657	232	5.0	73	12	15
915	*A. glabrata* var. *Hagenbeckii**	26	3.127	57	17.506	223	4.5	63	8	29
916	*A. glabrata* var. *glabrata**	26	0.283	57	23.461	123	4.5	73	17	10
917	*A. glabrata* var. *glabrata**	26	0.283	57	23.461	123	5.5-6.0	63	27	10
918	*A. glabrata* var. *Hagenbeckii**	26	0.128	57	23.609	126	5.5	60	33	7
919	*A. glabrata* var. *Hagenbeckii**	26	0.128	57	23.609	126	5.5	60	33	7
921	*A. glabrata* var. *glabrata**	26	43.548	57	17.248	111	5.5	83	5	12
922	*A. glabrata* var. *glabrata**	26	54.754	57	20.142	84	7.0	80	7	13
923	*A. glabrata* var. *glabrata**	26	54.754	57	20.142	84	7.0	80	7	13
924	*A. glabrata* var. *Hagenbeckii**	26	52.312	57	6.634	156	6.0	60	5	35
925	*A. glabrata* var. *Hagenbeckii**	26	15.792	57	0.796	87	5.5	73	20	7
926	*A. glabrata* var. *Hagenbeckii**	26	11.701	56	52.133	129	5.5	67	13	20
927	*Arachis* sp.	26	11.701	56	52.133	129	5.5	67	13	20
928	*Arachis* sp.	26	11.701	56	52.133	129	5.0	53	7	40
929	*A. glabrata* var. *Hagenbeckii**	26	11.822	56	52.820	111	4.5	74	13	13
930	*Arachis* sp.*	25	56.951	56	29.293	123	4.5	60	20	20
931	*A. glabrata* var. *glabrata**	25	51.710	56	25.040	165	5.5	80	10	10
932	*A. glabrata* var. *Hagenbeckii**	25	51.102	56	25.022	165	6.5-7.0	97	1.5	1.5
933	*A. hypogaea*	24	39.907	56	26.172	-	-	-	-	-
934	*A. glabrata* var. *Hagenbeckii**	24	28.418	56	53.673	120	6.0	67	5	28
935	*A. hypogaea*	24	29.021	56	57.722	120	-	-	-	-
936	*A. glabrata* var. *glabrata**	24	27.592	56	54.088	153	7.0	80	5	15
937	*A. glabrata* var. *Hagenbeckii**	24	27.592	56	54.088	153	5.0	80	18	2
938	*A. glabrata* var. *Hagenbeckii**	23	51.394	56	30.782	126	-	94	3	3
939	*A. hypogaea*	23	24.667	57	26.375	75	-	-	-	-
940	*A. hypogaea*	23	24.667	57	26.375	75	-	-	-	-
941	*A. glabrata* var. *glabrata**	23	27.785	57	17.536	84	6.5	67	30	3
942	*Arachis* sp.	23	31.442	57	13.988	83	7.5-8.0	60	40	<1
943	*Arachis* sp.	23	31.442	57	13.988	83	7.5-8.0	60	40	<1
944	*Arachis* sp.	23	33.773	57	14.872	96	6.0	73	7	20
945	*A. glabrata*	22	38.603	56	18.160	252	7.5-8.0	80	7	13
946	*Arachis* sp.	22	21.130	56	19.895	252	5.5-6.0	93	7	<1
947	*A. glabrata* var. *glabrata**	22	21.130	56	19.895	252	5.5-6.0	93	7	<1
948	*A. glabrata* var. *glabrata**	23	21.130	56	19.895	252	5.5-6.0	64	7	29
949	*A. lignosa**	23	23.868	57	26.092	78	5.0-5.5	60	10	30
950	*A. nov.* Valls et al.	23	23.479	57	25.267	78	8.0	80	13	7
951	*A. lignosa**	23	23.413	57	25.162	78	5.5-6.0	50	27	23
952	*A. paraguariensis* *	23	16.505	57	20.820	93	5.0-5.5	73	20	7
953	*A. lignosa**	23	4.487	57	6.976	102	5.5-6.0	80	7	3
954	*A. lignosa**	23	4.487	57	6.976	102	5.5-6.0	80	7	3
955	*A. microsperma**	23	2.499	57	6.491	99	5.0			100
956	*Arachis* sp.	23	2.232	57	2.546	136	5.0	73	20	7
957	*A. glabrata* var. *glabrata**	23	2.216	57	2.514	111	5.0	73	20	7
958	*A. glabrata* var. *glabrata**	23	2.200	57	1.234	111	5.0	67	17	16
959	*A. glabrata* var. *glabrata**	23	2.200	57	1.234	111	5.0	67	17	16
960	*Arachis* sp.	23	2.200	57	1.234	111	5.0	67	17	16
961	*A. glabrata* var. *glabrata**	22	34.007	57	33.881	171	8.0	80	14	6
962	*A. microsperma**	22	55.571	57	21.997	111	4.5	77	6	17
963	*A. lignosa**	23	27.604	57	26.233	87	6.5	53	15	32
964	*A. hypogaea*	25	36.940	57	10.223	180	-	-	-	-
965	*A. hypogaea*	25	36.940	57	10.223	180	-	-	-	-

1. Cb - Caballero, WL - Williams, Pm - Pittman, Pz -Pizzaro.
2. All *A. hypogaea* accessions collected represent domesticated material.
3. Material introduced from Brazil.

* Taxonomy verified by Dr. A. Krapovickas, IBONE, Corrientes, Argentina.

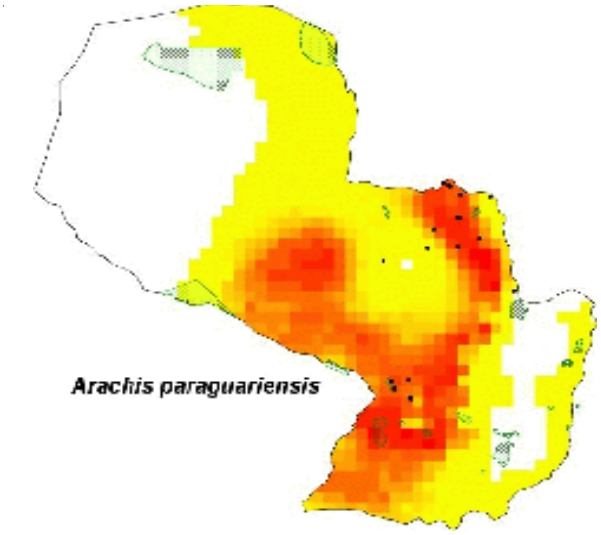

Figure 3. Floramap analysis map for *Arachis paraguariensis* based on USDA/DGPCB - SEAM Inventory of the Wild Crop Relatives of Paraguay.

crops. Jarvis et al. (2003) used a value of 30% cropland cover as the maximum level of disturbance before *Arachis* populations would expected to be impacted.

Not surprisingly over half of the accessions collected during the entire trip were *A. glabrata*. The geographic distribution of the section Rhizomatosae series Rhizomatosae (*A. psuedovillosa*, *A. glabrata* var. *glabrata*, and *A. glabrata* var. *Hagenbeckii*) extends from the states of Mato Grosso and São Paulo in Brazil south through eastern Paraguay and into the northern states of Corrientes and Misiones in Argentina (Krapovickas and Gregory, 1994). Paraguay is the portion of its range that encompasses what is perceived, for adaptation to US conditions, the critical tropical/subtropical environments.

Because one of our main objectives was to find *A. glabrata* with better flooding tolerance we traveled through in the southern areas of Paraguarí Department and into northern Misiones and western Guairá Departments. Large portions of these departments are dominated by hydromorphic soils (Ferreira-H., 2000). South of the city of Paraguarí, we traveled west to Lago Ypoá. The majority of area leading over to the lake is a rolling alluvial plain that can have a high water table. We found three *A. glabrata* plants (915, 916, and 919) in this area. Preliminary field evaluations indicate that accession 915 is performing well under the high water table conditions found in the Spodosols of south Florida (M.J. Williams, personal observation, 2003).

North of the city of Concepción on the road to Puerto Vallemi we relocated two major areas of *Arachis* that had been previously found on collection trips (E. Pizarro, personal observation, 2001) that had made with Brazilian and Paraguayan cooperators. Both of these populations, an *A. glabrata* (961) and an A. *microsperma* (962), are major components of their respective ecosystems and occur, by conservative estimate, in areas in excess of several hundred hectares. The *A. glabrata* material is found on the top the small mountain range called Serranía de San Luis west of the Reserva Ecológica Serranía San Luis. We measured a distance of over 10 km were we easily observed *A. glabrata* associated with *Aristida* sp. and small trees. The soil is very shallow heavy calcareous clay interspersed with large rocks and outcrops of boulders. It was not unusual to observe the *A. glabrata* growing in the cracks in the boulder surfaces. The *A. microsperma* occurred in a natural wetland savanna north of the Río Aquidabán. The savanna appeared to be periodically flooded for short periods of time, but drained rather quickly in most spots due to a gravel layer underneath the top soil. The *A. microsperma* was being actively grazed by large herds of cattle and horses on this ranch.

Conclusion

Much of the perennial *Arachis* collected appears to show good potential as ornamental or low maintenance turf species. In particular, the *A. lignosa* and *A. microsperma* collected in Concepción Department and the *A. glabrata* collected Paraguarí and Misiones Departments may hold potential as forage

material for wetter sites in the Tropics and Subtropics. This field work also represents the first widely reported occurrence of extensive (>200 ha) areas of both *A. glabrata* and *A. microsperma* in single contiguous naturally occurring populations under grazing. We also observed that, as with any rapidly developing country, considerable evidence that conversion of native vegetation to pasture and farmland were impacting natural *Arachis* populations.

Abstract

In 2002, a plant collection expedition funded through the USDA, Agricultural Research Service, Plant Exchange Office (PEO) and in collaboration with the Minsterio de Agricultura y Ganadería, Asunción, Paraguay, was conducted. Sixty-four accessions of wild and domesticated *Arachis*, which are thought to represent six known and one undescribed species, were collected. Over 5000 km was covered in parts of nine departments in central and south central Paraguay. Much of the perennial material appeared to show great potential as ornamental or low maintenance turf. The *A. lignosa* and *A. microsperma* collected in Concepción Department and the *A. glabrata* collected Paraguarí and Misiones Departments may hold potential as forage for wetter sites in the Tropics and Subtropics. This field work also represents the first widely reported occurrence of extensive (>200 ha) areas of both *A. glabrata* and *A. microsperma* in single contiguous naturally occurring populations under grazing. We found considerable evidence that conversion of native vegetation to pasture and farmland was impacting *Arachis* populations. The collection was divided, and a portion of the material remained in Paraguay under the control the host country collaborator, Pedro Juan Caballero, Ministerio de Agricultura y Ganadería (MAG). All the collection numbers and herbarium identification should be proceeded with these initials: CbWlPmPz. An illustrated version of the trip report can be found at: www.pasturasdeamerica.com/relatos/paraguay1.asp (verified 27 July 2004).

Resumen

En el primer semestre de 2002 se realizó en Paraguay una expedición de recolección de material silvestre y domesticado de *Arachis,* que fue financiada por USDA, Servicio de Investigación Agrícola y la Oficina de Intercambio de Plantas (OIP=PEO) en colaboración con el Ministerio de Agricultura y Ganadería del Paraguay (MAG). En un recorrido de 5000 km a través de las regiones central y sur del país se recolectaron en total 64 accesiones, que representan siete especies. La mayor parte del material perenne recolectado aparentemente posee gran potencial para uso ornamental o en pasturas bajo condiciones de manejo deficiente. Se destacan *A. lignosa* y *A. microsperma* recolectados en el departamento de Concepción, así como *A. glabrata*, en los departamentos de Paraguarí y Misiones, los cuales exhiben gran potencial como plantas forrajeras para regiones húmedas del trópico y subtrópico. En el trabajo de recolección fue identificada y registrada, por primera vez, la mayor área continua bajo pastoreo de *A. glabrata* y *A. microsperma* (> 200 ha). También se detectó una rápida conversión de la vegetación nativa en sistemas agrícolas, lo cual tiene un impacto visible en la población de plantas nativas del Paraguay. El material recolectado fue dividido y depositado bajo la custodia del Ing. Agr. Pedro Juan Caballero, miembro del Ministerio de Agricultura y Ganadería. Los números de recolección y la identificación del herbario están caracterizados por las siguientes iniciales: CbWlPmPz. Una versión ilustrada de la expedición puede ser consultada en: http://www.pasturasdeamerica.com/relatos/paraguay1.asp (verificada el 27 de julio, 2004.

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