Origin, Ethnobotany and Agricultural Potential of the Winged Bean—*Psophocarpus tetragonolobus*[1]

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According to Roberts (62) about 20 species of grain legumes are used in appreciable quantities in the human diet. These grain legumes are excellent sources of dietary protein and are expected to play a vital role in meeting the food needs of future generations of man. The top six grain legume crops in terms of production are the soybean, peanut, dry bean, chickpea, pigeon pea, and cowpea. In addition to the major grain legumes there are numerous minor grain legumes which have thus far received scant attention from the scientific community. Among these minor grain legumes is *Psophocarpus tetragonolobus* (L.) DC, or the winged bean.

This paper will attempt to present the evidence as to the possible origin of the winged bean and to evaluate the agricultural potential of the species by bringing together the limited ethnobotanical, historical, and agronomic literature.

THE GENUS *PSOPHOCARPUS*

Psophocarpus Necker (47) is a genus of about six species. All of the species, except perhaps *P. tetragonolobus*, appear to be indigenous to Africa. To date, no monograph has been published on the genus.

The species *P. tetragonolobus* (Fig. 1) is a twinning, perennial herb grown as an annual having tuberous roots and pods with longitudinal wings. The pod lengths average about 30 cm (57). Ramirez (61) reported that the $2n$ chromosome number is 26.

The exact ecological requirements of the winged bean have not been established. It is certain that it is confined to the humid tropics. At least 150 cm of precipitation is needed by the crop, and it may benefit from up to 250 cm (40).

The winged bean is most widely distributed in Asia. It has been reported in India (27, 37, 63, 64, 65), Burma (20, 66), Malaya (10, 41), Thailand (14, 22), the Philippines (23, 45, 46, 48), Indo-china (33), China (35), Ceylon (29, 43, 51, 67), Indonesia (10, 32, 69, 72), Papua and New Guinea (25, 68, 79) and in several South Pacific islands (6, 52, 53). In addition, the cultigen has been introduced into several African (5, 8, 15, 16, 31) and tropical American countries (30, 34, 70).

The species *Psophocarpus palustris* Desv. (Fig. 2) is a twining, perennial herb having tuberous roots and winged pods 12 to 20 cm long. It is generally considered to be a native of Africa (28). Recently, Verdcourt (77) divided *P. palustris* into two species, *P. palustris* and *Psophocarpus scandens* (Endl.) Verd., the latter being generally distributed in East Africa and cultivated in Indonesia, Brazil, Jamaica, Ceylon, India, and Burma (54, 67, 77) and the former having a West African distribution. Pods of *P. palustris* and *P. scandens* are commonly eaten but are not as popular as the winged bean. In Senegal, *P. palustris* is known as *niamadi soso* (1).

Cytologically, there is some confusion as to the chromosome number of *P. palustris*. Frahm-Leliveld (24) reported that $2n = 20$, while Miege (50) observed that $2n = 22$.

The species *Psophocarpus lancifolius* Harms (Fig. 3) is characterized by lanceolate leaves and is found in swampy grassland and forest edges from 1,100 to 2,500 m above sea level. The species has been reported in Uganda, Kenya, Tanzania, Malawi, Zambia, Congo, and Nigeria (59, 78).

Little is known about *Psophocarpus monophyllus* (Fig. 4). It has been collected from Sudan, Ivory Coast, and Portuguese

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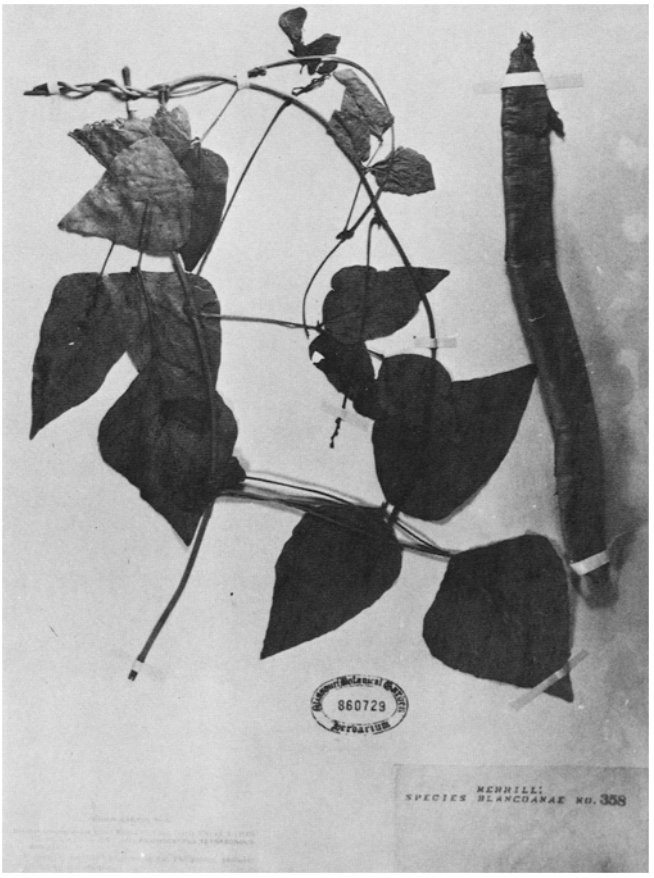

Fig. 1. *Psophocarpus tetragonolobus* (L.) DC. All photographs were taken of specimens in the Missouri Botanical Gardens.

Guinea (12). The species *Psophocarpus grandiflorus* has been reported in Uganda, Congo, and Ethiopia. It is found in upland bushland, forest, and grassland from 1,800 to 2,100 m above sea level (78). The chromosome numbers of *P. monophyllus, P. grandiflorus*, and *P. lancifolius* have not been reported in the literature.

SYNONYMY (47)

Psophocarpus Necker (Retained name, Vienna Code: *Botor* Adansis is older (1763)).

Psophocarpus tetragonolobus (L.) DC. Podr. 2 (1825) 403.

Dolichos tetragonolobus L. Stickman Herb. Amb. (1754) 23, Amoen. Acad. 4 (1759) 132, Syst. ed 10 (1759) 1162, Sp. Pl. ed. 2 (1763) 1020.

Botor tetragonoloba Kuntze Rev. Gen. Pl. 1 (1891) 162.

Lotus quadrangularis Rumph. Herb. Amb. 5:374, t. 133.

VERNACULAR NAMES

The use of vernacular names to trace the origin of the *P. tetragonolobus* is at best precarious. Rumphius, who lived on the Island of Amboina from 1653 to 1702, first wrote of *P. tetragonolobus* (47). Rumphius believed that the cultigen had been brought to the Moluccas from elsewhere, probably from Bali or Java and that the vernacular name given to the plant, *botor*, was an Arabic word (10). According to Hilu (personal communication, Khidir W. Hilu), the word *botor* does not exist in the Arabic language. Heyne,

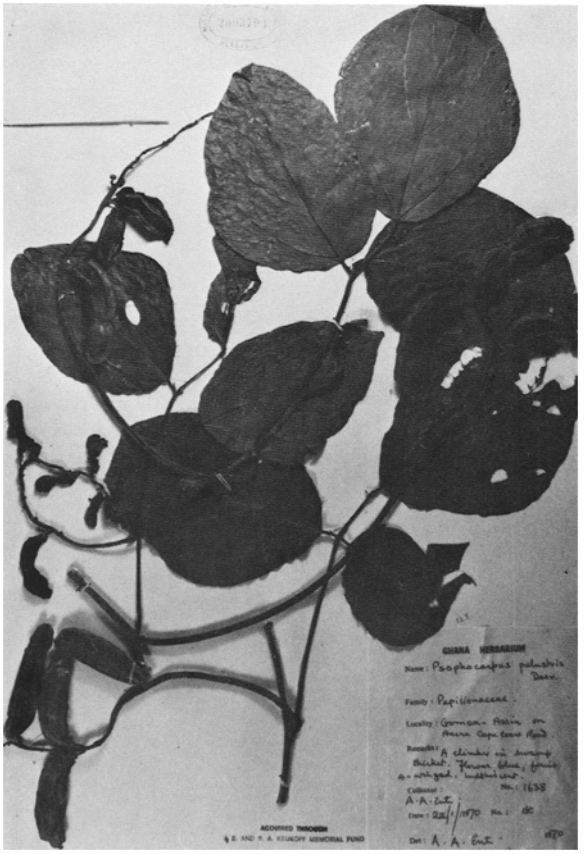

Fig. 2. *Psophocarpus palustris* Desv.

as reported by Burkhill (10), suggested that *botor* is a Sundanese name for the pod. According to the Indonesian language dictionary edited by Poerwadarminta (56), *botor* is a plant which fruits like a bean, *Psophocarpus tetragonolobus* (tumbuhan jg buahnja sebagai katjang, *Psophocarpus tetragonolobus*). If Heyne is correct, perhaps the winged bean was originally from western Java or first brought to western Java from elsewhere. A list of vernacular names of *P. tetragonolobus*, the language, and/or geographical site is presented in Table 1.

Merrill (49) observed that the number of specific local plant names in the Malaysian, Melanesian, Micronesian, and Polynesian regions is very great. He believed that this was due to the over 500 different languages and dialects spoken by the native peoples of the regions. Many of the indigenous, as well as introduced, cultivated, and naturalized species have vernacular names that are specific to a particular geographical region, while others refer to a general class of plants. For example, in Table 1, *katjang* or *kachang* are general terms for beans. Specifically, *katjang botor* refers to *P. tetragonolobus*. However, very often this system of vernacular nomenclature can be misleading. For example, the peanut in Indonesia has been called *katjang manilla*. In this case, reference is given to the place of origin of an early introduction into the country. Similarly, the vernacular names Goa bean, Manila bean, or Mauritius bean for *P. tetragonolobus* probably refer to the place of introduction of the species as it moved about from one country to another.

Attempts to relate the origin of a domesticate to the number of vernacular names in a country or region can be misleading. Very often the number of vernacular names for a

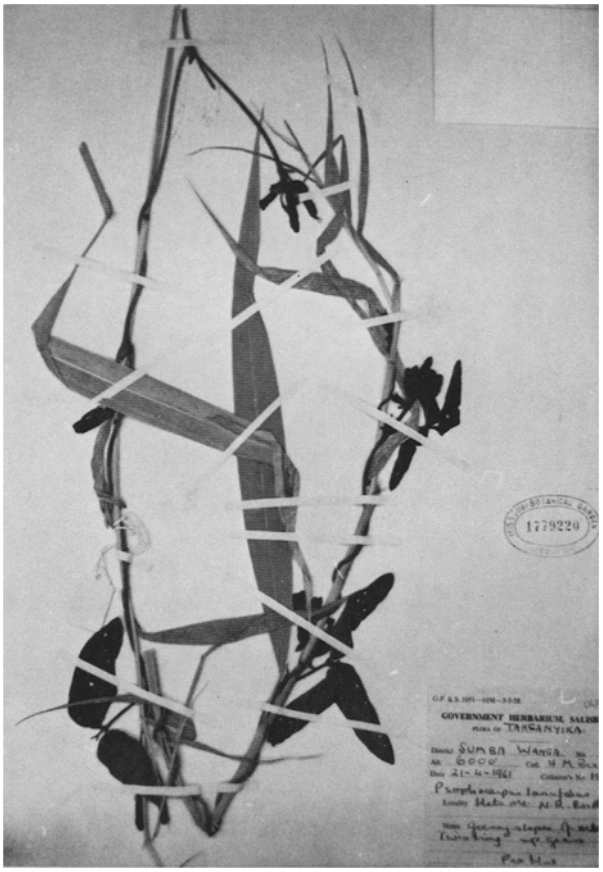

Fig. 3. *Psophocarpus lancifolius* Harms.

domesticate is a function of the number and special interests of botanists in the region. Hence, Burkhill (10) and Merrill (48) were able to cite large numbers of vernacular names of *P. tetragonolobus* in Malaya and the Philippines. Yet, according to Barrau (6, 7), while *P. tetragonolobus* is widely grown in Papua and New Guinea, only a few vernacular names of the domesticate from the region have been reported in the literature.

USES

The primary use of the winged bean is for human consumption. The entire plant is utilized in several different ways. The young tender pods prepared in the manner of French beans are the most popular part of the plant (23, 40, 57). The immature pods also are eaten raw (80). In some areas the young leaves and shoots are eaten both raw and cooked. The unripe seeds are used in soups and curries (43, 57). The mature seeds may be roasted and eaten like peanuts (4, 17, 57). In Java, the ripe seeds are parched before eating. Burkhill (10) reports that in Mauritius after mature seeds are dried and cooked, they are eaten with difficulty. The use of the tuberous roots for food appears to be restricted to Burma (26) and the South Pacific Islands. The tuberous roots are slightly sweet, firm like an apple (10), and eaten both raw and cooked (21, 52).

In Java, the plant is parasitized by a fungus, *Woroninella psophocarpi*. The young parts swell, become turgid, and are prized as a delicacy when steamed (17). The flowers are both eaten and used to color dishes for the table (23, 60).

Medicinally, the leaves of the winged bean have been used in the treatment of smallpox

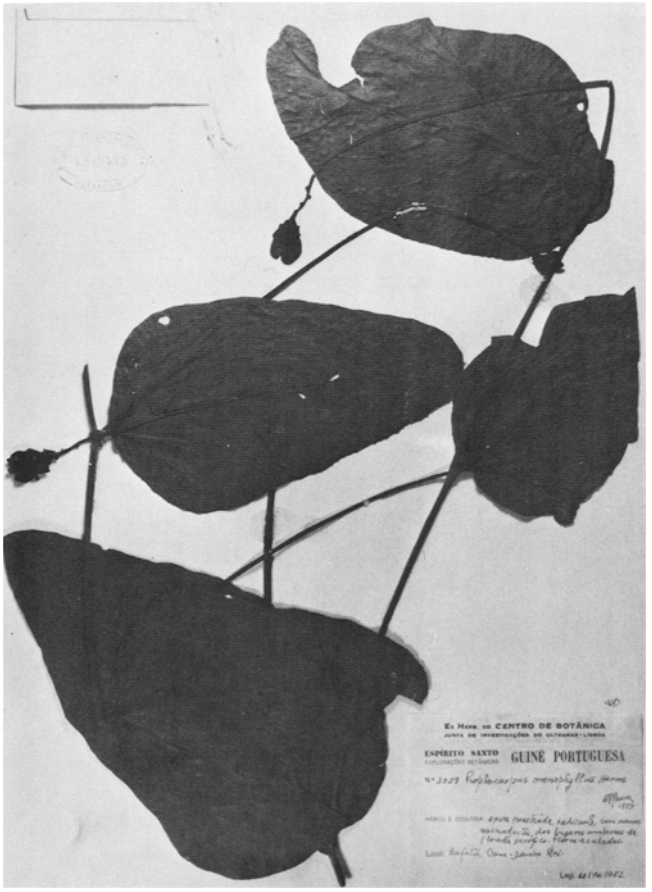

Fig. 4. *Psophocarpus monophyllus* Harms.

(41). The roots have been used in Malaya as a poultice to cure vertigo (41).

Hyland (29) noted that in Sri Lanka wing bean plants generally are used for forage. The winged bean has shown promise as a green manure, cover, and fallow restorative crop (57).

NUTRITIONAL AND AGRICULTURAL POTENTIALS

Currently, *P. tetragonolobus* principally is grown as a garden vegetable. The main consumption areas are Southeast Asia, Indonesia-New Guinea region, with limited use in West Africa. Unfortunately, the dietary value of the winged bean has not been fully recognized. The nonrecognition of the winged bean as an important nutritional source exists in spite of the fact that its protein content has been known since 1929 (2). It would be difficult to find another high rainfall-adapted tropical legume crop with as many desirable characteristics as *P. tetragonolobus*. Virtually all parts of the plant are suitable for human consumption. Analysis of the seeds has shown them to contain around 37% protein and 18% oil (2, 57). The protein and oil contents are nearly equal to the values obtained in soybeans (11). The seeds contain a high content of unsaturated fatty acids and the seed oil contains a high content of alpha and beta tocopherols (57). Defatted winged bean meal contains all of the essential amino acids. However, like most of the grain legumes, the limiting amino acid in the winged bean is methionine. Pospisil et al. (57) laud the winged bean for not having the urease enzyme and "any poisonous sub-

Table 1. Language and geographical site for vernacular names of *Psophocarpus tetragonolobus*.

Name	Language	Geographical site	Reference
Aglmong	Metlba	New Guinea	73
Amale	Ibanag	Philippines	48
Asparagus bean	English		48
Asparagus pea	English		4
Batang-baimbing	Sulu	Philippines	48
Beyed	Bontok	Philippines	48
Borbai Krui	Brous	Cambodia	42
Buligan	Ifugao, Bontok	Philippines	48
Calamismis	Tagalog	Philippines	2
Calongcan		Bali	10
Charkoni-sem	Hindi	India	37
Chaud haari-phali	Hindi	India	37
Cigarillas	Tagalog, Pangasinan	Philippines	48
Culebet		Banda	10
Dara-dhambala	Singhalese	Sri Lanka	44
Four-angled bean	English		60
Goa bean	English		20
Haricot de la foret	French		25
Haricot dragon	French		42
Jaat	Sundanese	Indonesia	10
Kachang belimbing		Malaya	10
Kachang belingbing		Sumatra	10
Kachang embing		Sumatra	10
Kachang kelisah		Malaya	10
Kadjang-outan		New Guinea	25
Kamaluson	Bisaya	Philippines	48
Katjang botor	Sundanese	Indonesia	56
Ketjeper		Indonesia	49
Ksang borong		Sumatra	69
Manila bean	English		44
Mauritius bean	English		10
Mpir	Buang	New Guinea	25
Pai-myeet		Burma	55
Pallang	Iloko	Philippines	2
Parupagulung	Bikol	Philippines	48
Pois carre	French		36
Prabaiy	Khmer	Cambodia	42
Princess bean	English		44
Seguidilla	Tagalog	Philippines	2
Tua-pu	Thai	Thailand	14
Winged bean	English		19
Winged pea	English		4

stances." Contrarily, Sohonie and Bhandarkar (71) found trypsin inhibitor in winged beans, and Toms and Western (75) reported that seeds of *P. tetragonolobus* contain phytohaemagglutinins, which cause nonspecific haemagglutination.

The roots are a potential source of both protein and carbohydrates. Hooper, as reported by Burkhill (10), found that dried winged bean tubers contain 24% protein and 56% carbohydrates. Unfortunately, no additional data on the chemical composition of dried winged bean tubers have been seen in the literature in order to confirm or refute the values obtained by Hooper.

Yields of 1,400 kg of seeds per hectare have been obtained in Ghana (57). Tuber yields of 2.8 to 6.7 tons per hectare have been reported from Burma (3). These yields most probably could be improved upon by plant breeders and crop production agronomists. Taking root and seed harvests in combination, the winged bean potentially could outyield any other grain legume adapted to the high rainfall regions of the tropics.

Much research needs to be conducted to

evaluate the oil and protein content of the winged bean and its ability to replace the more conventional plant sources. Domestic science investigations into methods of preparation and preservation also are sorely needed.

Aside from human consumption, several other uses for *P. tetragonolobus* have been suggested. The nodulation capacity of the winged bean makes it a potential restorative intercrop (38, 39). In Malaya, the nodulation capacity of the winged bean was compared to other food legumes. On a soil with a high water table, *P. tetragonolobus* nodulated more heavily than soybeans, cowpeas, peanuts, and yam beans. Thus, the winged bean appears to have value as a short-term regenerative crop. Purseglove (60) noted that sugarcane gave one-half greater yields following *P. tetragonolobus*. The effect of root harvest on the restorative capacity of the crop is not known.

The dry stalks of the winged bean left after harvest have been fed to livestock with some success (40).

As a cover crop, *P. tetragonolobus* is not as good as its smaller relative *P. palustris*. The major deterrent for its use as a green manure is the difficulty of incorporating the large mass of material into the soil.

Doku (18) summarized the problems of the traditional bush fallow system and enumerated the criteria for an ideal crop to be put into the system. Pospisil et al. (57) noted that except for drought tolerance, *P. tetragonolobus* met all of these requirements. Whether *P. tetragonolobus* will have a future place in the bush fallow fertility system remains to be explored by management system investigators.

ORIGIN

Evidence to indicate the origin of *P. tetragonolobus* is sketchy at best. The very early history of the winged bean essentially is lost. In the following paragraphs an attempt will be made to piece together what information is available and finally provide a personal hypothesis as to the geographical origin of the winged bean.

The earliest referral to winged bean was noted by Pickering (55). He cites the travelogue of a Portuguese sailing captain, a Vicente Cadamosto, who sailed down the coast of West Africa to the Gambia River in 1455. Pickering asserted that *P. tetragonolobus* was a native of equatorial Africa, using the description furnished by Cadamosto as his only evidence. Pickering's speculation must be refuted for several reasons, the most important being that *P. tetragonolobus* has never been found wild in West Africa (80). Another reason is that the rainfall in the area visited by Cadamosto averages about 122 cm per year, well below the required growth for the winged bean. Most likely, Captain Cadamosto saw *P. palustris* in West Africa. Many of the floras of the area (3, 9, 15, 19, 28, 74) include *P. palustris*, while only a few authors (9, 19, 28) have reported the subspontaneous occurrence of *P. tetragonolobus* in West Africa.

Burkhill (10) subscribes to an East African origin and Purseglove (60) tends to agree, though neither cite East Africa unequivocally. The species is not included in the East African floras and is listed as subspontaneous in Mauritius (5).

Cobely (13) and Vavilov (76) claim an Indian center of origin. The likelihood of an Indian origin is so remote that it does not merit much discussion. It was certainly introduced to India (27, 35, 58, 80). One of the more accurate statements concerning the origin of the winged bean was stated by Roxburgh (64) in his *Flora Indica*, "where indigenous I cannot say."

Widely grown in Southeast Asia, the winged bean is considered to be introduced there from elsewhere (14, 33).

Rumphius, who lived on Amboina in the Moluccas from 1653–1702, included the winged bean in his Herbarium Amboinense (47). Rumphius believed that the winged bean had been brought to Amboina from elsewhere, possibly Bali or Java, by the Arabs. Barrau (7) observed that "*Dolichos lablab* and *P. tetragonolobus* seem to be the only two legumes established in early times in Melanesia." Although the winged bean is found throughout Melanesia, Barrau maintains that it does not seem to have been present for a long time except in New Guinea. In New Guinea it is widely grown in certain areas of the Central Highlands, in the Markham and Sepik valleys, and in the coastal

areas of the Morobe District. In these areas the warm and humid climate with rainfall in excess of 250 cm is favorable to the winged bean. In New Guinea, *P. tetragonolobus* is cultivated for its pod, grain, flowers, leaves, and tuberous roots (25). Ryan (68) ventures that New Guinea may well be the origin of the winged bean and that the domesticate is of some antiquity in the region.

Although the data presented are by no means conclusive, the meager evidence available points to Papua and New Guinea as the most likely center of geographical origin, or at the minimum a center of germplasm diversity, for *P. tetragonolobus*.

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of Australia, the only distribution maps given are those for Victoria (about 3% of the area of the continent); distribution of aquatics outside that state is given in the text.

Ms. Aston is a senior botanist at the National Herbarium of Victoria. Among her published papers is a study of *Villarsia* (Menyanthaceae) in Australia. After 9 years of studying aquatic plants in Victoria, Ms. Aston remarks that "many expanses of standing water and miles of waterways in the state remain unexamined, and a number of plant groups still require more detailed study" and that "Coverage of the 97 per cent of Australia which lies outside Victoria is even less complete, as it has never been systematically investigated for aquatics." Certainly *Aquatic Plants of Australia* will be a stimulus to such exploration.

The review copy of the book was not received until late 1976. *Aquatic Plants of Australia* may be obtained, in the United States, from ISBS, Inc., P.O. Box 555, Forest Grove, OR 97116.

J.W.T.

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