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New Opportunities in *Vigna*

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INTRODUCTION

The genus *Vigna* Fabaceae, formerly Leguminosae, is composed of more than 200 species that are native to the warm regions of both the old world and new world. *Vigna* is closely related to *Phaseolus*, which is composed of more than 20 species that are native to warm or tropical regions of the New World. A number of species previously placed in *Phaseolus* are now placed in *Vigna*. The genus *Vigna* contains several species that are of considerable economic importance in many developing countries. Cowpeas [*V. unguiculata* (L.) Walp.], mung beans [*V. radiata* (L.) Wilczek], and urd beans [*V. mungo* (L.) Hepper] are key dietary staples for many millions of people. Additionally, adzuki beans [*V. angularis* (Willd.) Ohwi & Ohashi], bambara groundnuts [*V. subterranea* (L.) Verdn.], mat beans [*V. aconitifolia* (Jacq.) Marechal], and rice beans [*V. umbellata* (Thunb.) Ohwi & Ohashi] are important in the diets of many societies. Many of these *Vigna* species are also valued as forage, cover, and green manure crops in many parts of the world. Annual worldwide production of the various *Vigna* species likely approaches 20 million hectares, and virtually all of this production is in developing countries.

The economic *Vigna* species exhibit a number of attributes that make them particularly valuable for inclusion in many types of cropping systems. They can be grown successfully in extreme environments (e.g., high temperatures, low rain fall, and poor soils) with few economic inputs. Many of these species produce multiple edible products, and these products provide subsistence farmers with a food supply throughout the growing season as well as dry seeds that are easy to store and transport. For example, tender shoot tips and leaves of cowpeas can be consumed as soon as the plants reach the seeding stage and immature pods and immature seeds can be consumed during the fruiting stage. Harvested dry seed of all of the *Vigna* crops can be consumed directly, and seeds of several of the crops are commonly used to make flour or produce sprouts. Plant residues can be used as fodder for farm animals. *Vigna* food products exhibit many excellent nutritional attributes and these products provide a needed complement in diets comprised mainly of roots, tubers, or cereals.

VIGNA RESEARCH AND GERMPLASM COLLECTIONS

Except for cowpeas, which were heavily researched in the US early in the 20th century, there has been little research on any of the *Vigna* species until recent decades. Although there are appreciable efforts in the international research arena at present directed towards cowpeas and mung beans, most of the *Vigna* species are still largely ignored by the scientific community. For example, a search of the National Agricultural Library's AGRICOLA (AGRIcultural OnLine Acess) bibliographic database demonstrates how few scientific resources have been directed to research on several of the *Vigna* species. This extensive database (www.nal.usda.gov/ag98) includes most of the prime scientific agricultural literature published since 1970, and a search made during September 2001 resulted in the following numbers of citations: cowpea, 2,796; mung bean, 1,878; urd bean, 636; adzuki bean, 201; bambara groundnut, 72; mat bean, 127; and rice bean, 68. By comparison, this search identified the following numbers of publications for selected major crops: maize (*Zea mays* L., Gramineae), 24,027; soybean [*Glycine max* (L.) Merrill, Fabaceae], 14,947; common bean (*Phaseolus vulgaris* L., Fabaceae), 9,349; garden pea (*Pisum sativum* L., Fabaceae), 8,005; peanut (*Arachis hypogaea* L., Fabaceae), 3,906; lettuce (*Lactuca sativa* L, Compositae), 2089; and pepper (*Capsicum annuum* L., Solanaceae), 2,400.

The centers of origin of all of the economic *Vigna* species are in the Old World (Smartt and Hymowitz 1985). Cowpea and Bambara groundnut likely originated in Africa and mung bean, urd bean, adzuki bean, mat bean, and rice bean are likely of Asiatic origin. Plant explorers and the plant germplasm preservation community long ago recognized the potential importance of these species. Plant explorers have done a commendable job of collecting and preserving *Vigna* germplasm, and appreciable collections of *Vigna* germplasm are held by various national and international agencies (IBPGR Ad Hoc Working Group on Vigna species

1982). For example, the US Department of Agriculture holds extensive collections of *Vigna* germplasm at its Plant Genetic Resources Conservation Unit, Griffin, Georgia; the International Institute of Tropical Agriculture, Ibadan, Nigeria, holds a very comprehensive collection of cowpea germplasm; the Asian Vegetable Research and Development Center, Shantua Tainan, Taiwan, holds a comprehensive collection of mung bean germplasm; the National Board of Plant Genetic Resources in New Delhi, India, holds large collections of cowpea, mung bean, urd bean, and rice bean germplasm; and the Chinese Academy of Agricultural Sciences hold a large collection of adzuki bean germplasm.

COWPEA

The cowpea is a predominately hot weather crop. It is more tolerant to drought, waterlogging, infertile soils, and acid stress than the common bean. Cowpea can be grown quite successfully under conditions that are totally unsuitable for the common bean. However, cowpeas are much less tolerant to cold soils than common bean. Smartt and Hymowitz (1985) noted that "the cowpea can be regarded very much as the Old World counterpart of the *Phaseolus* beans. Its products, seeds and fruits, can be utilized in precisely similar ways." Smartt and Hymowitz (1985) also noted that the similarity between cowpea and common bean probably explains the ready acceptance of cowpea in the New World and common bean in the Old World. The cowpea is one of the mandated crops addressed by the International Institute of Tropical Agriculture, Ibadan, Nigeria.

Cowpea Taxonomy

Most taxonomists agree that cowpeas belong to the botanical species *Vigna unguiculata* (L.) Walp. However, classification and nomenclature of taxa at the intraspecific level are still debated. Verdcourt (1970) subdivided the species into 3 subspecies, i.e., cowpea (subspecies *unguiculata*, catjang (subspecies *catjang*), and yardlong bean (subspecies *sesquipedalis*). However, Marechal et al. (1978) reclassified the subspecies *unguiculata*, *catjang*, and *sesquipedalis* as cultigroups Unguiculata, Biflora, and Sesquipedalis, respectively, and lumped these cultigroups under *V. unguiculata* subsp. *unguiculata*. Most cowpea breeders seem to have adopted Marechal et al.'s (1978) cultigroup scheme for classification of cultivated *V. unguiculata* taxa.

World Cowpea Production

Subsistence farmers in the semi-arid and subhumid regions of Africa are the major producers and consumers of cowpeas. These farmers not only grow cowpeas for dry seed for human consumption and fodder for animal feed, but also utilize the leaves and fruits for vegetables. Cowpeas are widely grown in eastern Africa and southeast Asia primarily as a leafy vegetable. Steele et al. (1985) noted that the protein content of the leafy cowpea parts consumed annually in Africa and Asia is equivalent of 5 million tonnes (t) of dry cowpea seeds and that this represents as much as 30% of the total food legume production in the lowland tropics.

Quin (1997) estimated the annual world cowpea crop at 12.5 million ha, and the total grain production at 3 million t. West and central Africa is the leading cowpea producing region in the world; this region produces 64% of the estimated 3 million t of cowpea seed produced annually (Quin 1997). Nigeria is the world's leading cowpea producing country. Other countries in Africa, e.g., Ghana, Niger, Senegal, and Cameroon, are significant producers. Outside Africa, the major production areas are Asia and Central and South America. Brazil is the world's second leading producer of cowpea seed, producing 600,000 t annually (Guazzelli 1988).

Cowpea Production in the United States

Cowpea was a major agronomic crop in the US during the early part of the 20th century, with production peaking at 2.4 million ha in 1937 (Fery 1990). However, the introduction of newer types of forage crops and the availability of mechanized harvesting equipment for these newer crops resulted in cowpea production dropping to 0.9 million ha in 1964. By the early 1980s, annual cowpea production in the US was estimated at 80,000 ha (Fery 1981). The cowpea has long been valued in the southern US as a vegetable crop, and an extensive industry currently exists to supply fresh, canned, frozen, and dry-pack products that are marketed nationwide. Additionally, the cowpea has long been a popular item with home gardeners throughout the south. There is a broad range in the characteristics of cowpea cultivars that are grown for horticultural use in the US

(Fery 1990). Most American cultivars grown for seed can be classified as blackeye, crowder (large, irregular, distorted, or globular shaped peas crowded together in the pod), cream, or field types (old agronomic cultivars). Each type produces a seed with a distinctive appearance and flavor and appeals to a unique market segment. Additionally, two other types, yardlong beans and cowpea cultivars developed for production of edible pods, are grown to a limited extent in the US. The blackeye pea (often called blackeye bean) is the most common type of cowpea grown in the US. The pinkeye pea, a variant of the blackeye, is the leading horticultural class of cowpea grown in the US.

Yardlong Bean

The yardlong bean is an intensely cultured, trellised vegetable crop that is grown widely in southeast Asia. Other commonly used names include asparagus bean, sitao, bodi bean, and snake bean. The pod length can vary from 45 to 75 cm (Lorz and Halsey 1964). The yardlong bean is considered to be one of the most important vegetable crops in parts of Indonesia, Thailand, Philippines, Taiwan, and China (Rachie 1985). Rubatzky and Yamaguchi (1997) estimated that yardlong bean production in China alone exceeds 250,000 ha annually.

MUNG BEAN AND URD BEAN

In his review of *Vigna* genetics, Fery (1980) observed that there is some confusion in the literature with respect to mung bean and urd bean. Fery (1980) noted that some authorities consider the mung bean and the urd bean to be variants of the same species while others conclude that there is ample evidence to justify keeping distinct identities for mung bean and urd bean. Fery (1980) noted that the US Department of Agriculture recognizes *V. radiata* and *V. mungo* as separate species. Most published estimates of mung bean production include estimates of urd bean production; combined mung bean/urd bean estimates run as high as 5.8 million hectares (Lawn and Ahn 1985). About 70% of the world production of mung bean and urd bean is in India, and two these crops account for 12% of the total pulse production in that country (Lawn and Ahn 1985).

Mung Bean

The mung bean is best known in the US as the bean used for production of bean sprouts. The mung bean is commonly known in Asia as the green gram. Other common names include golden gram, moong, and chop suey bean. Seed color is usually a dark olive green or yellow, but some cultivars produce brown or black seed (Rubatzky and Yamaguchi 1997). The mung bean is the most important grain legume in Thailand and Philippines, and it ranks second in Sri Lanka and third in India, Burma, Bangladesh, and Indonesia (Lawn and Ahn 1985). Each kilogram of mung bean seed produces 6–10 kg of sprouts. Approximately 10 million kg of mung beans are consumed annually in the US, but only about 25% this annually requirement is produced in the US (Cupka 1987). Bhardwaj et al. (1999) estimated that the annual mung bean production in the US at 50,000 ha, and observed that 90% of this production is in Oklahoma, California, and Texas. The mung bean is one of the mandated crops addressed by the Asian Vegetable Research and Development Center, Shantua Tainan, Taiwan.

Urd Bean

The urd bean is also commonly known as black gram. Most urd bean cultivars produce black-colored seeds. The urd bean is a staple crop in India, Burma, Bangladesh, Pakistan, and Thailand (Lawn and Ahn 1985; Rubatzky and Yamaguchi 1997). Lawn and Ahn (1985) noted that the urd bean thought to be of more recent derivation than the mung bean. The urd bean is favored for production of bean sprouts in Japan, and it valued for its high digestibility and freedom from the flatulence effect. The urd bean is important in the vegetarian diets of high caste Hindus (Rachie and Roberts 1974).

ADZUKI BEAN

The adzuki bean is a small bean that has an inherently sweet, nutty taste, and it is one of the 12 most important grain legume crops in the world (McGill 1995). Most popular adzuki bean cultivars produce red- or maroon-colored seeds, but other seed colors include black, green, gray, yellow, white, and mottled combina-

tions of various colors (Rubatzky and Yamaguchi 1997). Adzuki bean is reportedly the sixth largest crop grown in Japan (Sacks 1977). Rubatzky and Yamaguchi (1997) estimated annual adzuki bean production in China, Japan, Korean peninsula, and Taiwan at 670,000, 120,000, 30,000, and 20,000 ha, respectively. In Japan, adzuki is often cooked with a sweetener and made into sweet soups, deserts, and various confectionary products. Except for color, the adzuki bean seeds resemble mung bean seeds. There is limited adzuki bean production in the US; the crop has been grown to limited extent in the states of Michigan and Washington to produce dry seeds for export to Japan.

BAMBARA GROUNDNUT

The bambara groundnut is grown for its underground seed, and its outward appearance is similar to peanut. It is extensively cultivated in western Africa where 1/3 million t of dry seed are produced on 400,000 ha annually (Rachie and Roberts 1974). The major producers of bambara groundnuts are Nigeria, Niger, and Ghana, where it is third in importance only to cowpea and peanuts (Howell 1994). Howell (1994) noted that the bambara groundnut is the most widely grown native grain legume south of the Sahara where it is second only to the peanut. Typical fruits are rounded, 2 cm in diameter, and yield 1 or 2 seeds each. The seeds are round (typically 1.5 centimeters in diameter), and often have a patterned seed coat (sometimes with an eye).

MAT BEAN

The mat bean, commonly known as the moth bean in some parts of the world, is native to India, Pakistan, and Burma (Rachie and Roberts 1974). The mat bean has a short, compact plant habit, and it is extensively grown for food in the arid and semi-arid regions of India. It is also an important pulse crop in semi-arid regions adjoining tropical deserts (Rachie and Roberts 1974). Rubatzky and Yamaguchi (1997) noted that green immature mat bean pods are a popular vegetable in India. The mat bean has been used to limited extent in the southwestern US for pasture, fodder, and green manure.

RICE BEAN

The rice bean is cultivated to limited extent in India, Burma, Malaysia, China, Fiji, Mauritius, and Philippines (Fery 1980). The beans are frequently cooked with rice (hence the name rice bean). There are many types and varieties of rice bean; the seed color ranges from ivory to greenish ivory, red, violet, and black (Chatterjee and Dana 1997). The seeds are small to medium sized.

CONCLUSIONS

All of the economic *Vigna* species have potential for introduction or increased production in the US. The introduction or expansion of the culture of *Vigna* species in the US would create new opportunities and provide alternative crops for American farmers, give American consumers access to new and novel foods, and increase the bio-diversity of crops used in American agriculture. All of the economic *Vigna* species have great potential as a supplemental or alternate source of legume protein for the nation's food supply. These species are suited for production in many areas with heat and drought stresses too extreme for the successful production of other table legume crops.

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