VELVETBEAN: A "NEW" PLANT WITH A HISTORY[1]

DANIEL BUCKLES

Buckles, D. *(CIMMYT, Lisboa 27, Colonia Juárez, Apdo. Postal 6-641, 06600 México, D. F., México).* VELVETBEAN: A "NEW" PLANT WITH A HISTORY. *Economic Botany 49(1):13–25. 1995. Velvetbean* (Mucuna *spp.*), *a vigorous climbing legume of Asian origin, is prominent among the plants currently promoted for use as a green manure and cover crop in the humid tropics. What is not so well known, however, is that the development and diffusion of cropping systems using velvetbean is the result of experimentation by numerous farmers and scientists spanning four centuries and at least eight countries. This article traces the movement of velvetbean and knowledge of its uses, with a view to identifying some of the conditions under which the crop has waxed and waned in the United States and Mesoamerica. Climatic factors, land and labor constraints, and market forces are discussed. The velvetbean story shows that agricultural innovation is neither static nor the purview of a privileged class of innovators. It also suggests that sustainable cropping practices such as green manuring should not be promoted as static models but rather as dynamic systems responsive to the changing conditions of farmers and the broader environment.*

El Frijol de abono: Una planta nueva con una historia. *El frijol de abono* (Mucuna *spp.*), *una vigorosa leguminosa trepadora de origen asiatico, sobresale entre las plantas que en la actualidad estan siendo promovidas para usarse como abonos verdes o cultivos de cobertura en el tropico húmedo. Lo que no es de conocimiento tan común es que el desarrollo y la difusión de los sistemas de cultivo que utilizan frijol de abono son el resultado de la experimentación realizada por numerosos campesinos y científicos en el transcurso de cuatro siglos y en al menos ocho países. Este artículo rastrea el movimiento de la leguminosa y del conocimiento de sus usos, con miras a identificar las condiciones en las que se ha popularizado o ha caído en desuso en los Estados Unidos y Mesoamerica. Se examinan, ademas, los factores climáticos, los factores limitantes de tierra y mano de obra, y las fuerzas del mercado. La historia del frijol de abono demuestra que la innovación en la agricultura no es ni estática ni exclusiva de una clase privilegiada de innovadores. Asimismo, sugiere que las prácticas agronómicas "sostenibles", como los abonos verdes, no deben promoverse como modelos estáticos, sino como sistemas dinámicos que responden a las condiciones cambiantes de los agricultores y del medio ambiente en general.*

Key Words: green manure; *Mucuna*; sustainable agriculture; agricultural innovation.

In recent years, the ancient practice of green manuring has received considerable attention from scientists and development workers concerned with the productivity and sustainability of agricultural systems in the developing world. Empirical evidence and theoretical considerations strongly suggest that green manures can help intensify tropical agricultural systems while conserving the natural resource base (Giller and Wilson 1991; Hargrove 1991; IRRI 1988; Lathwell 1990; Sarrantonio 1991; Smyth, Cravo, and Melgar 1991). These crops can be efficient sources of nitrogen (N), improve soil properties, increase biological activity in the soil, help control pests and weeds, and provide a number of additional uses such as food, feed and fuel.

Velvetbean is prominent among the plants currently being promoted in the tropics for use as green manure. Rural development projects in Mexico, Central America and West Africa have made velvetbean seed available to thousands of farmers, encouraging them to grow it as green manure or as a smother crop (Buckles and Arteaga 1993; Bunch 1990; Flores 1993; Holt-Giménez 1993; Sasakawa Africa Association and Global 2000, 1992). Many researchers are currently experimenting with velvetbean in maize (*Zea mays* L.) and other crops with a view to determining the potential impact of various management practices on the productivity and sustainability of a wide range of cropping systems

[1] Received 24 February 1994; accepted 27 June 1994.

Economic Botany 49(1) pp. 13–25. 1995

(Barreto et al. 1994; Camas Gómez 1991; Chávez 1993; Derpsch and Florentín 1992; Durón et al. 1989; Lobo Burle et al. 1992; Quiroga Madrigal et al. 1991; Smyth, Cravo, and Melgar 1991; Versteeg and Koudokpon 1993; Zea 1992). In Central America and Mexico alone, no fewer than 50 non-governmental organizations and research institutions feature this genus among the plants they research or promote. It is without doubt one of the most popular green manure crops currently known for the tropics, and a featured example of green manure contributions to sustainable agricultural systems (cf. Reijntjes, Haverkort, and Waters-Bayer 1993). What is not so well known, however, is that velvetbean was heralded 75 years ago as "one of the most important crops of recent introduction" (Tracy and Coe 1918:3). Velvetbean was cultivated extensively in the United States during the early part of this century, and was included at that time in numerous research programs in Africa, Asia and Latin America, with mixed success. It has also been grown for over 40 years by indigenous farmers in Mesoamerica. This article traces the movement of velvetbean and knowledge of its uses, with a view to identifying some of the environmental and socioeconomic conditions under which this crop has waxed and waned in various parts of the globe. Understanding these conditions may help us to identify old constraints and new opportunities for use of this not-so-new plant.

Origins and Early Uses of Velvetbean

Velvetbean is a vigorous annual climbing legume originally from China, Malaysia, or India, where it was at one time widely cultivated as a green vegetable crop (Burkill 1966; CSIR 1962; Duke 1981; Wilmot-Dear 1984). The genus *Mucuna* Adans is used to describe various species of annual and perennial legumes belonging to the Fabaceae family, including the annual velvetbean. The genus *Stizolobium* was used by Bort (1909) to distinguish velvetbean from perennial *Mucuna* species but this distinction was not maintained by Burkill (1966) or Bailey (1947: 744, 1076).

Mucuna is self pollinating, hence natural outcrossing is rare (Duke 1981). The dozen or so cultivated *Mucuna* species found in the tropics probably represent a fragmentation from the Asian cultigen and there are numerous crosses and hybrids (Bailey 1947; Bailey and Bailey 1976; Burkill 1966; Piper and Tracy 1910). The most commonly cited species include *M. deeringiana, M. utilis, M. pruriens, M. cochichinensis, M. nivea, M. capitata, M. hassjoo, M. diabolica, and M. aterrima* (Duke 1981; IIA 1936; Tanaka 1976). However, the taxonomy of these species is confused and some designations may be synonymous.

The main differences among cultivated species are in the character of the pubescence on the pod, seed color and the number of days to harvest of the pod. "Cowitch" or "cowhage" are the common English names of *Mucuna* types with abundant, long stinging hairs on the pod. Contact results in an intense itchy dermatitis caused by mucunain (Infante et al. 1990). The non-stinging types, known as velvetbean, have appressed, silky hairs. Cowitch may be the original type of the genus (Bailey 1947:3244). Seed colors include shiny black, beige, brown and mottled. Life cycles range from 100 to 290 days to harvest of the pod (Bailey 1947; Tracy and Coe 1918). A non-vining variety with low forage yields is also reported under the name "bunch velvetbean" (Duke 1981; Watson 1922).

Velvetbean thrives best under warm, moist conditions in areas where rainfall is plentiful. Under favorable conditions, the vines attain a length of 10–14 m and produce up to 23 t/ha of green forage and 9 t/ha of dry matter, including more than 1 t/ha of dried roots (Camas Gómez 1991; Chávez 1993; Duggar 1899; Ferris 1917). The plant does not have deep taproots, but it produces an abundance of surface roots (Tracy and Coe 1918). Most *Mucuna* species exhibit reasonable tolerance to drought and poor, sandy or laterite soils, although they are sensitive to frost and do not grow well on cold, wet soils (Duke 1981; Lobo Burle et al. 1992). Photoperiod response is unknown, although flowering is stimulated by cooler night temperatures (21°C) (Duke 1981).

Like most legumes, velvetbean has the potential to fix atmospheric nitrogen through a symbiotic relationship with soil microorganisms. Inoculation of soil with *Rhizobium* bacterial cultures may help stimulate nodulation, especially in the tropics (Burkill 1966:1526; CSIR 1962: 56; Duke 1981:172).

Few insect problems have been reported in velvetbean and it is immune to wilt and root-knot caused by nematodes (IIA 1936; Scott 1910). Damage to maize caused by soil-borne pathogens harbored in velvetbean, such as *Macrophomina phaseolina,* has been reported (Bell and Jeffers 1992; Berner et al. 1992).

The seeds of *Mucuna* species contain levodopa and N-dimethyltryptamine (DMT) (CSIR 1962; Infante et al. 1990). Levodopa is used in the treatment of Parkinson's disease but can produce a toxic confusional state in humans (Infante et al. 1990). The hallucinogenic properties of DMT are well documented.

Mucuna species have been grown as a soil-improving crop, a "smother" crop to control weeds, a forage plant, and as a minor food crop. Some species have also been used as an ornamental, an aphrodisiac, an emetic and as a poison (Duke 1981; Watt 1883).

Burkill (1966) notes that *Mucuna* was cultivated in Java, Bali and Sumatra in the seventeenth century to recover worn-out ground, its first reported use as a green manure. Species of this genus were also grown widely in the foothills and lower hills of the eastern Himalayas and in Mauritius as a green vegetable during the eighteenth and nineteenth centuries (CSIR 1962; Piper and Tracy 1910; Watt 1883). Both the green pods and the mature beans were boiled and eaten. Burkill (1966) and Watt (1883) suggest that *Mucuna* was eventually replaced as a vegetable in Asia by the introduction of more palatable legumes, although it is still used as a famine food in India (CSIR 1962).

A survey of the use of legumes in tropical countries conducted by the International Institute of Agriculture in the 1930s (IIA 1936) documented the use of *Mucuna pruriens* as a cover crop in the Punjab of India and on the island of Madagascar as fodder for cattle and a soil improver preceding sugarcane, cassava and lemon grass. The same species was reportedly used in Zanzibar to prevent the growth of *Imperata cylindrica* and as a green manure for maize, cassava and sorghum. *Mucuna aterrima* was used as a green manure for maize and tobacco in Malawi and as a cover crop in Sierra Leone, whereas *Mucuna deeringiana* was used as a cover crop in citrus and banana estates in Puerto Rico and Jamaica as early as 1906.

Mucuna species were grown in the 1920s on several experiment stations in Nigeria as an improved fallow and as a relay crop with maize and cassava with a view to intensifying small-scale shifting agricultural systems (IIA 1936). No adoption of the practice was reported, however. The authors of the IIA study argued that there was no pressing need for green manuring in west Africa, as forest land was abundant and traditional shifting cultivation practices required less labor for clearing land than permanent cultivation would require. In West Africa during the 1920s, fallowing and slash and burn techniques effectively controlled weeds and provided optimum land preparation for planting. Under these circumstances, farmers were not willing to invest additional labor to establish green manure crops. Recent reports indicate, however, that *Mucuna* species did gain acceptance among small-scale farmers as a minor food crop in Nigeria (Ezueh 1977), Ghana (Osei-Bonsu and Buckles 1993) and Mozambique (Infante et al. 1990).

VELVETBEAN IN THE UNITED STATES

Velvetbean came into its own in the southern United States at the turn of the century, where it was used widely as an animal fodder and green manure. It was probably taken to the Caribbean by Asian Indians (Burkill 1966) and from there reached Florida in the 1870s, where it drew the interest of farmers and researchers. One farmer, Mr. Newheart of Ocoee, Florida provided "Seed of a pea" to O. Clute of the Florida Agricultural Experiment Station in 1895, noting that "the abundance of foliage and vine, so completely covering the ground after the frost, suggested the idea of planting them in the orange grove as a manure, instead of buying commercial fertilizer" (Clute 1896:342). By 1897 some 300 Florida orange growers were planting velvetbean in orchards to improve soil fertility (Bort 1909; Miller 1902).

The long frost-free season required to produce velvetbean seed (190 days) initially limited its use outside of Florida and the southern half of the Gulf States (Duggar 1899; McClelland 1919; Piper and Tracy 1910). This limitation was partially overcome, however, when another farmer, Mr. Clyde Chapman of Sumner, Georgia collected beans from early-maturing plants of the Florida velvetbean. Seed from these plants was distributed after 1914 throughout the South as the "Georgia velvetbean" (Coe 1918). Seed was produced by these varieties in approximately 100 days.

Use of early maturing velvetbean as a soil-improving crop quickly extended to the northern limits of the cotton belt (Fig. 1). From an esti-

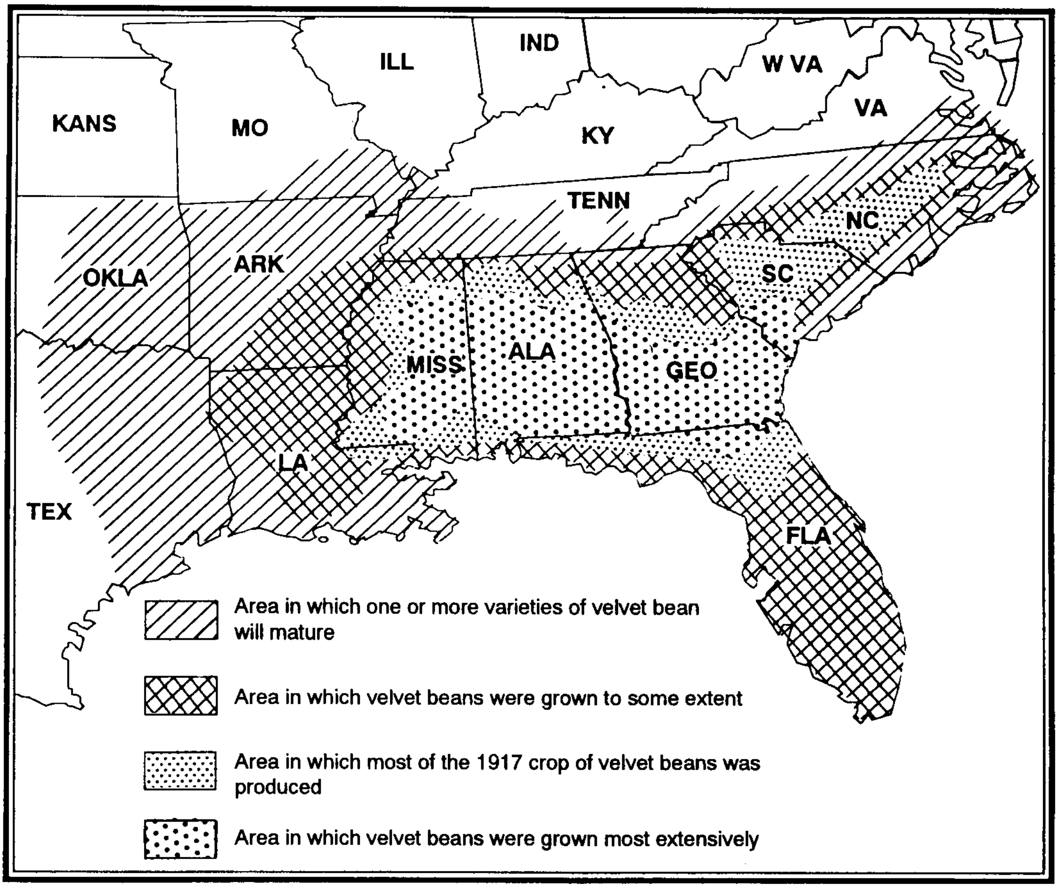

Fig. 1. The southern United States, showing the distribution of velvetbean, 1917. Adapted from Tracy and Coe (1918).

mated 9293 ha in 1908 (Scott 1910:45), the area in velvetbean grew to over 400 000 ha in 1915 and 2 000 000 ha in 1917 (Coe 1918). The Georgia and another early maturing variety called the "Alabama" velvetbean accounted for some 80% of the velvetbean area in 1917 (Tracy and Coe 1918).

Velvetbean was typically intercropped between rows of maize to improve soil fertility in maize and cotton rotations in the South. According to many researchers, as a soil improver it had no equal (Braunton 1918; Cauthen 1921; Ferris 1917; Miller 1902; Pieters 1928; Piper and Tracy 1910). Its most important use, however, was as feed for cattle and hogs (Ferris 1917; Lamaster and Jones 1923; Scott 1919; Templeton, Ferguson, and Gibbens 1917). When first introduced in the South, velvetbean was grown in maize and grazed by animals in the fall and winter after the removal of the maize. The remaining residue was then plowed under and a new crop cycle initiated. As experience with velvetbean increased, more of the beans were picked after the crop was killed by a heavy frost and either fed to animals on the farm or put on the market as beans in the hull (Ferris 1917; Lamaster and Jones 1923; Scott 1919; Templeton, Ferguson, and Gibbens 1917:109; Tracy and Coe 1918). Velvetbean pods were taken to mills and crushed or ground with the hull for cattle, horse and mule feed, largely replacing cottonseed meal as the protein component in animal feed used in the South (Ferris 1917; Willet 1918). Raw velvetbean contains approximately 27% protein (de la Vega, Giral, and Sotelo 1981; Olaboro 1993).

Velvetbean was very popular in the cotton belt of the United States on account of its extreme vigor and large quantity of pods (Scott 1910, 1919). Growth greatly exceeded that of cowpeas, a common alternative green manure crop, and it was not attacked by nematodes, a parasite that could be spread in cotton plantations by cowpea. When killed by frost, velvetbean leaves and vines would go down on the ground together, forming a close-knit mat that stayed in place until plowed under. Bean yields in the pod of 2–3 t/ha were attained easily. The feed value of velvetbean produced on the farm for beef and milk production was comparable to purchased alternatives such as cottonseed meal, at less than 20% of the cost (Cauthen 1921; Scott 1919).

Although velvetbean was appreciated mainly as a forage crop, its soil-improving effects were also well documented (Cauthen 1921; Duggar 1899; Ferris 1917; McClelland 1919; Miller 1902; Stubbs 1899). An estimated 155–200 kg/ha of nitrogen was contained in the leaves, pods and roots of well-grown velvetbean sole crops, without mineral fertilization. When velvetbean was intercropped with maize at 30 days after maize planting, maize yields were reduced by up to 10%, but these losses were more than compensated by subsequent crops (Ferris 1917; Tracy and Coe 1918). Maize yield increases of 60–80% following velvetbean use are consistently reported in the early literature, prompting one researcher of that period to note that "velvetbeans are a cheaper source of nitrogen than is any nitrogenous material which may be bought as commercial fertilizer" (Duggar 1902:176). Experiments conducted at various experiment stations with maize, sorghum, wheat, cotton and oats showed that velvetbean was superior to cowpea or soybean for improving yield (Coe 1918; Duggar 1899; Ferris 1917; McClelland 1919; Miller 1902; Stubbs 1899). Even when grazed by cattle, soil fertility was maintained for succeeding crops (Scott 1910:53).

Expansion of the area dedicated to velvetbean was given a boost by the invasion of the boll weevil and a decline in the cotton industry of the South (McClelland 1919:97). Lands left relatively idle by the cotton crisis were brought back into production with velvetbean, which rapidly became one of the most important crops in the South for feed and as a soil improver. One researcher noted that "the story of the velvet bean [sic] might be called an agricultural romance" (Scott 1919:216). Velvetbean was hailed by scientists and farmers alike as the savior of southern agriculture, as the large quantity of feed produced by the crop at a low cost stimulated the production of livestock (Coe 1918:179; Ferris 1917:19; Scott 1919:216). The net cash value of velvetbean produced as an intercrop in maize in 1917 was estimated by Scott (1919) at more than US$ 20 000 000.

Velvetbean use declined somewhat at the beginning of the 1920s but the crop continued to be important in the South until the mid-1940s, when velvetbean area declined (Fig. 2). By 1965, velvetbean had disappeared from United States agricultural statistics.

The decline of velvetbean in the South was probably due to sharp decreases in mineral fertilizer prices and to the increasing popularity of soybean as a commercial crop (Fig. 2). Both velvetbean and soybean could be intercropped with maize to improve soil fertility and grazed by cattle and pigs or the seed harvested for use in the preparation of animal feed. Soybean, however, was a more versatile crop, garnering a much higher price as a grain crop. According to USDA statistics, the production value of velvetbean grain in 1944, the year velvetbean area began to decline sharply, was US$ 29/ha compared to US$ 91/ha for soybeans. Soybean area in the United States began to increase sharply as velvetbean area declined, reflecting the substitution of one crop for the other. This shift in production was accompanied by a drop in the real price of commercial fertilizers during the mid-1940s, further contributing to the decline of velvetbean and other soil-improving crops such as cowpea in the United States.

Velvetbean Use in Mesoamerica

Enthusiasm for velvetbean in the United States stimulated diffusion of seed for experimentation to many countries in the tropics during the early part of this century. Initially it was sold by seed companies in the United States under the name "banana field bean" (Bort 1909:26; Duggar 1899) and later distributed as velvetbean throughout the tropics by the United States Department of Agriculture (Piper and Tracy 1910). Velvetbean and knowledge of its uses in Mesoamerica can be linked to management practices developed by farmers in the southern United States. The plant was probably introduced into Mesoamerica in the 1920s as a forage crop by the United Fruit Company, a banana producer with extensive tracts of land along the Atlantic coast of Central America. Elderly banana plantation workers in Morales and Puerto Barrios, Guatemala report

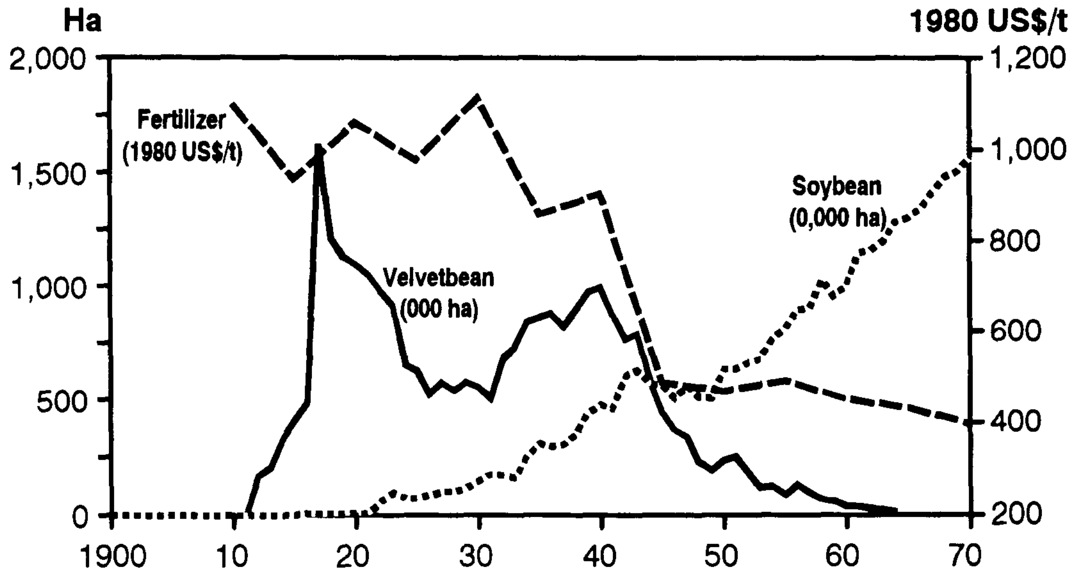

Fig. 2. Area of velvetbean and soybean, and the real price of fertilizer, United States, 1900–1970. Source: USDA Statistics (various years); Hayami and Ruttan (1985: Table c-2). Note: Current farm expenses for fertilizer divided by quantity of principal plant nutrients (N, P, K).

that velvetbean was intercropped in wet season maize grown by plantation workers on company land and grazed by mules used to transport bananas from the plantations to the railway depots.

Use of velvetbean as a forage crop by the banana companies faded as mules were replaced by tractors during the 1930s, but the plant retained the name "mule bean" or *quenk mula* among the Ketchi Indians of Guatemala. The Ketchi, originally from the densely populated highland area of Verapaz, were employed on banana plantations in Guatemala and may have become familiar with velvetbean on these estates. Carter (1969) reported that Ketchi migrating to the lowland valley of Polochic in the Department of Izabel, Guatemala had planted velvetbean in rotation with maize since their arrival in the 1950s. Commercial farmers also settling in the valley during the 1950s used velvetbean as a dual-purpose soil improver for maize and forage crop for cattle. According to recent interviews with elderly residents by the author, the crop was first introduced into the valley during the 1930s by a Jamaican banana plantation owner financed by the United Fruit Company (see also Carter 1969:116).

The velvetbean management strategy employed by commercial farmers and Ketchi in the Polochic Valley differed from that employed by United States farmers. Whereas velvetbean was intercropped in summer maize in the United States, in Guatemala a rotation strategy with dry season maize was developed. The rotation takes advantage of warm temperatures and high annual rainfall (>2500 mm/yr) in a bimodal distribution characteristic of the Atlantic coast of Central America. These climatic conditions permit a wide range of cropping patterns, including two maize cycles per year. Velvetbean was managed by farmers in Polochic as an 8-month sole crop during the main rainy season, followed by maize during the relatively dry period of the year. The mature velvetbean crop was slashed with a machete and a few weeks later maize was stick planted into the layer of decomposing leaves and vines. The field was not burned, nor was the legume incorporated into the soil. After the maize harvest, the velvetbean crop was reestablished by natural reseeding or replanted by the farmer, thereby continuing the rotation indefinitely. Maize was also grown by these farmers during the main wet season on a different field using traditional techniques of slash and burn cultivation (Carter 1969).

Use of *Mucuna* by commercial farmers in Polochic declined sharply during the 1970s when much of the land used for maize production was diverted to pasture for cattle. The increased area

Fig. 3. Areas with spontaneous adoption of velvetbean-maize rotations.

of pasture in turn reduced requirements for *Mucuna* as a forage crop. These changes occurred before commercial fertilizers became widely available in the valley. In fact, the few remaining large-scale maize producers in the valley continue to grow dry season maize in rotation with *Mucuna,* reportedly with better yields and higher net returns than gained from maize production practices based on commercial fertilization (Chávez 1993).

Velvetbean is still used by Ketchi in the valley of Polochic, the northern coastal mountains near Livingstone, the Peten and border areas in Belize. The crop has also been used in a similar fashion since the 1950s in Mexico by Mames of southwestern Chiapas (Gonzalo Tsuzuki A., pers. comm.), Chontales of Tabasco (Quiroga Madrigal et al. 1991) and Nahua and Popoluca of southern Veracruz (Buckles and Arteaga 1993). The practice was adopted more recently by Chinantecos and Mixes in southeastern Oaxaca (Arévalo Ramírez and Jiménez Osornio 1988) and some 30 000 mestizo farmers in Atlantic Honduras (Buckles et al. 1994) (Fig. 3).

No strong evidence has been found to explain how velvetbean was diffused among these populations. It is clear, however, that the technology moved from farmer to farmer, without the intervention of formal agricultural extension services. Migration patterns and trade links among indigenous people in Guatemala, Chiapas and Tabasco may have played a role. For decades the Ketchi have been displaced by population growth and political forces from their homeland, migrating throughout Guatemala, Belize and into Mexico. Velvetbean seed produced in the Guatemalan lowlands is marketed as a coffee substitute among Indian groups in the highlands and in parts of southern Mexico where it is known as nescafé. The person credited with introducing velvetbean to the Nahua of southern Veracruz migrated to the area from a Nahua enclave in Tabasco (author's field notes).

Numerous interviews and a formal survey in Atlantic Honduras indicate that velvetbean was introduced to the region by farmers from Guatemala and diffused from farmer to farmer (Buckles et al. 1994). Two Guatemalan Indians are credited with bringing velvetbean to Planes de Hicaque near Tela, Atlantida in the early 1970s, from where it diffused to various nearby villages. Some use of velvetbean during the mid-1970s is reported from all municipalities in the area (although by less than 10% of the farming population). Velvetbean use increased significantly during the 1980s, growing at a rate of approximately 5% per year and peaking at almost two-thirds of all hillside farmers in Atlantic Honduras by the early 1990s (Fig. 4). The survey indicated that virtually all of the farmers using

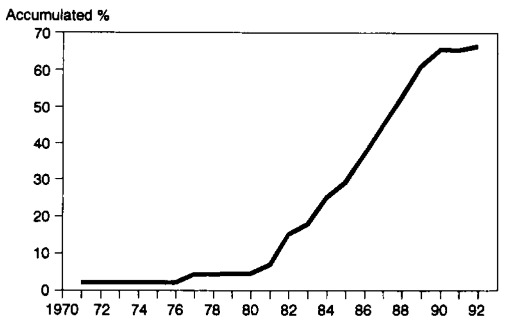

Fig. 4. Accumulated percentage of farmers adopting velvetbean, Atlantic Honduras. Source: Buckles et al. (1994).

the technology in 1992 learned about it from family members or other farmers, either in the same or a nearby community. Researchers took note of this development during the 1980s but only recently have governmental and non-governmental organizations begun to support diffusion of velvetbean in the region.

Farmers in different regions have developed variations on the basic velvetbean-maize rotation. In the Polochic and Atlantic Honduras, where some rain falls during most of the year, the velvetbean crop germinates in the maize field during the relatively dry season and farmers must control the crop until the risk of competition with maize is past (40–55 days after planting maize). These farmers can rely, however, on natural reseeding of the velvetbean crop to maintain the rotation. In the Sierra de Santa Marta in Veracruz, and in Tabasco, where the dry season is more pronounced, the velvetbean crop germinates during the onset of the main rainy season. Annual replanting of the green manure crop is usually required to ensure adequate plant populations. These differences have implications for the timing and amount of labor needed to maintain the rotation.

Land types under the rotation also vary between regions. In Tabasco and Oaxaca velvetbean-maize rotations are established on low-lying land where residual moisture helps support the development of the maize crop. In the other areas mentioned, the rotation is more commonly practiced on sloping land. The distribution of dry season rainfall and the different land types themselves seem to determine these variations.

While in most regions velvetbean has been used exclusively as a rotation with dry season maize, in some areas distinct velvetbean associations have developed. Among the Chontales in Tabasco, squash (*Cucurbita pepo* L.) is intercropped in dry season maize followed by the velvetbean sole crop, a more intensive cropping pattern than that employed by farmers in other regions (Quiroga Madrigal et al. 1991). In the Sierra de Santa Marta, farmers broadcast velvetbean seed into abandoned maize fields where it is left for two years as an improved fallow, a less intensive management strategy. Some farmers in the Sierra de Santa Marta and the Polochic Valley relay velvetbean into wet season maize, where the green manure develops as a sole crop during the relatively dry season.

In recent years, velvetbean associations with wet season maize have been developed and promoted by researchers and development workers and adopted by thousands of farmers throughout the region (cf. Bunch 1990; Buckles and Arteaga 1993; Holt-Giménez 1993). Velvetbean is intercropped into wet season maize from as early as 15 days after maize sowing in some areas to as late as 55 days in others. This variability results mainly from differences in climatic conditions, cropping patterns and the availability of labor. Early velvetbean intercropping strategies in maize have been adopted by farmers where labor is available to prune the velvetbean crop that would otherwise compete severely with the maize crop (Bunch 1990). Later intercrops and relay crops with velvetbean reduce the risk of competition with maize but the potential benefits of these strategies are subject to other constraints. Farmers employ these strategies only in areas where rainfall does not limit the full development of the velvetbean crop and where it does not compete directly for land dedicated to other crops such as beans or dry season maize. Where more intensive cropping patterns exist, the land opportunity costs of including velvetbean in the system may constrain farmer adoption (Buckles and Barreto 1994).

The wide range of velvetbean management practices currently used by farmers in Mesoamerica is the result of farmer adaptation to varied environmental and socio-economic conditions and, more recently, to the introduction of practices promoted by researchers and development workers. The use of velvetbean by Mesoamerican farmers differs dramatically from traditional forms of shifting cultivation in that a green manure crop (velvetbean) is grown specifically to provide nutrients and other management benefits. This strategy and its numerous adaptations indicate that agricultural innovation is neither static nor the purview of a privileged class of innovators.

Farmers, agronomists and transnational corporations are all linked in a fortuitous and complex chain of events that confound both conventional and radical notions of technology generation and transfer. The various velvetbean management practices employed by farmers did not proceed in a linear fashion from agricultural research stations to farmers fields. Nor did they simply arise from unadulterated indigenous technical knowledge. Rather, the technologies are the result of numerous groups borrowing and adapting foreign species and practices. Farmers using velvetbean in Mesoamerica readily identify their reasons for doing so. The decaying leaves, stems and roots of velvetbean crops partially compensate for reduced fallow periods and corresponding declines in soil fertility. On-farm trials with *Mucuna*-maize rotations in Polochic produced dry-season maize yields of 4–5 t/ha, similar to yields obtained under recommended levels of mineral fertilization and twice those of continuously cultivated fields without fertilization (Chávez 1993). Maize yield benefits of velvetbean associations are reported for other humid regions in Mexico and Central America (Barreto et al. 1994; Camas Gómez 1991; Granados Alvarez 1989; Miranda Medrano 1985; Quiroga Madrigal et al. 1991; Zea 1992).

Worsening problems of weed invasion and resulting declines in the productivity of labor have also stimulated adoption of velvetbean associations. Farmers report that land preparations for dry season maize are greatly facilitated by velvetbean rotations as the aggressive legume smothers virtually all competing weeds and is very easy to cut. Allelopathic effects of *Mucuna* rotations on weed germination have also been demonstrated (Gliessman 1983).

While velvetbean-maize associations can respond to a number of constraints on cropping systems, institutional factors and broader socioeconomic considerations also affect the relative advantages of the technology. For example, few farmers on the Atlantic coast of Honduras grew dry season maize before the 1980s because wet season maize met regional demand, and farmers were relatively isolated from the national maize market. Improvements in transportation and strong seasonal variations in the national price of maize favoring dry season production stimulated a shift in production patterns. During the last 10 years, dry season maize has overtaken wet-season maize as a proportion of total maize production in the region (Buckles et al. 1994). This corresponds to a period of rapid adoption of velvetbean rotations, a technology well suited to dry season maize production.

In the same region, survey data confirm the importance of land ownership to adoption of velvetbean rotations; land owners were significantly more likely to use the technology than farmers dependent upon rented land. Nevertheless, long term security of land ownership did not prove to be a condition for adoption. Farmers with squatters rights were equally disposed to adopt velvetbean.

The rotation of velvetbean and maize depends in part on farmers' access to additional land for the cultivation of wet season maize and other crops. Survey data from Atlantic Honduras indicate that adoption increases with farm size. Nevertheless, the minimum farm size for adoption of the technology in Atlantida is quite low, as little as 1.6 ha. Adoption rates are still relatively high (56%) among farmers who have less than 2 ha of land (Buckles et al. 1994).

These findings suggest that farm size is not an absolute limit on adoption of velvetbean management practices. One must take into consideration, however, the relative abundance of fallow land in Atlantic Honduras and the well-developed land rental market. The landless and farmers with very small farms can rent land under bush-fallow, especially for summer maize, at low cost from large land holders interested in converting fallow land into pasture. They are consequently free to dedicate their own small parcels to the velvetbean-maize rotation. In short, while land pressures can limit the adoption of relatively land-extensive technologies such as green manure rotations, this constraint can be moderated by broader land rental markets.

Conclusions

The development and diffusion of velvetbean-maize associations is the result of experimentation by numerous farmers and scientists spanning four centuries and at least eight countries. The links to the past and across continents are strong, yet the ecological and economic conditions influencing the success and failure of the crop in specific situations have been quite varied.

Five broad generalizations concerning these conditions can be made.

First, use of velvetbean as a green manure is best suited to areas with high total annual rainfall in a bimodal distribution. Under these climatic conditions, velvetbean can develop fully as a rotation prior to a food crop or as a relay crop.

Second, velvetbean cover crops and green manure imply less intensive cropping patterns than continuous cultivation of food crops and consequently require relatively abundant land. In all areas where stable *Mucuna*-maize cropping associations have developed, farmers have had access to the land needed for economic crops during the period when velvetbean is growing. Farmers have either had relatively large landholdings (for example, the commercial farmers in Polochic) or have made inexpensive land rental arrangements (as in Atlantic Honduras). Both of these situations share conditions that give farmers access to land during the main growing season.

Third, velvetbean can play a role in cropping systems where labor productivity is low and declining. Weed invasion and corresponding declines in labor productivity stimulated adoption of velvetbean rotations in a number of areas, and weed control is an important consideration for farmers using velvetbean as an intercrop and relay crop. Evidence from Benin (Versteeg and Koudokpon 1990, 1993) suggests that the ability of velvetbean to control *Imperata cylindrica,* a major constraint on maize productivity in this and other West African countries, may partially overcome limitations on the adoption of velvetbean associations imposed by land scarcity. The intensity of weed infestation and associated declines in labor productivity may be a good indicator of the potential of green manure rotations in many cropping systems.

Fourth, relative prices of external inputs and competing crops strongly influence the profitability of velvetbean. Sharply falling fertilizer prices in the southern United States contributed to the rapid decline of velvetbean intercrops, as did relative price increases for competing crops (soybeans). Seasonally high maize prices in Atlantic Honduras contributed to a shift toward dry season maize, a crop ideally suited to rotation with velvetbean. These broad market forces played a key role in the rise or decline of velvetbean-maize associations in several settings.

Finally, velvetbean may have the greatest potential under conditions where the crop can respond simultaneously to several serious constraints on system productivity. Farmers using velvetbean rotations in Mesoamerica report a wide range of benefits, including improved soil fertility, reduced weed and pest populations and improved soil properties. Farmers in the United States emphasized both the soil-improving and forage uses of velvetbean.

These generalizations are too broad to serve as the basis of a full evaluation of the potential of velvetbean in all farming systems. Further research in areas where velvetbean associations have been adopted by farmers would contribute to the development of more precise guidelines, such as the degree of weed infestation stimulating adoption of velvetbean cover crops or measures of relative input and output prices displacing the crop from a farming system. Nevertheless, farming system variability is such that interactions between factors may favor or limit use of the technology in unforeseen ways. This variability, and the uncertainty it engenders, point to the dynamic nature of agricultural systems. Sustainable cropping practices such as green manuring should not be promoted as static models to which all farming systems must adapt for once and for all. The changing conditions of farmers and their environment call for the continuous development of new cropping systems. The history of velvetbean's use in various settings suggests that although not all old technologies can become new again, changing conditions may provide fresh opportunities for building on older practices.

Acknowledgments

Helpful comments from Kelly Cassaday, Greg Edmeades, Larry Harrington, Miguel López-Pereira and Robert Tripp are gratefully acknowledged. Errors are the reponsibility of the author.

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BOOK REVIEW

In The Society of Nature. A Native Ecology in Amazonia. Descola, Philippe. 1994. Cambridge, Great Britain, Cambridge University Press and Editions de la Maison des Sciences de l'JHomme. xviii + 372 pp. (hardcover). Price not given. ISBN 0-521-41103-3.

"The present book is both a description and an analysis of the technical and symbolic relationships entertained by an Upper-Amazonian Indian tribe with its natural setting. The result is a degree of ambiguity, which the unsuspecting reader might ascribe to some awkwardness in the construction or vagueness in the conception of the theme expounded" (p. xii). I am not sure what that quote means, but at least two terms apply. *Society of Nature's* prose is awkward and vague, and the preface will deter all but the most determined. Much of the text suffers from pretentious jargon. This verbosity emanates, perhaps, from the book's origin as Descola's dissertation research, originally (1986) in French.

This book is not an ethnobotanical treatise. Descola, a student of Clalude Lévi-Strauss, is an anthropologist. Faithful to his mentor, Descola's discussion reflects his academic ancestry. He attempts to meld knowledge of the physical and biological world with Achuar cosmology and sporadically succeeds at the task.

Despite its bloated discourse, the patient reader will find a wealth of historical and ethnographical data on the Achuar. The first section of the book describes the Achuar's environment. This portion is a cultural ecology although Descola probably would reject that term. He writes, "One of my objects is to refute the reductionist theses of ecological anthropology." The second section analyzes environment domains of the Achuar and their material and conceptual relationship with these domains.

Economic botanists will be most interested in the plant data presented. Unfortunately, these data are the text's greatest weakness. In fairness, the author makes no claim to being an ethnobotanist. He writes, "All botanical identification of wild and cultivated species ... was done by us from personal observation and reasoned collation of documentary data ... we were unable to constitute a systematic collection, and the identifications we propose are subject to subsequent validation."

Though many Achuar names correspond with Shuar names (Bennett 1992; Bennett et al. in press), errors abound. Table 38 lists 52 Achuar forest plants that bear edible parts. The author identifies 25 to species; 18 to genera; the remaining nine are unidentified. Of the 25 specific names listed, eight are incorrect or synonyms. Therefore, he correctly names only 17 of 52 (32.7%) species.

The author also errs in describing the Achuar physical and biological environment. For example, inceptisols, not oxisols and ultisols, dominate the Achuar interfluve (González Artienda et al. 1986); terrestrial herbivores are *not* "particularly scarce"; the effects of drought can be significant.

Ethnobotanical assessments in Descola's text, like those of the analogous Shuar ethnology by Harner (1972), are inadequate. Nonetheless, the ethnographies are prerequisites for ethnobotanical study. *Society of Nature* will introduce the curious reader into the world of an important indigenous culture. The similarities and differences between the Achuar and Shuar are intriguing, and I hope this provocative ethnology inspires a definitive ethnobotanical study of the Achuar.

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BRADLEY C. BENNETT
DEPARTMENT OF BIOLOGICAL SCIENCES
FLORIDA INTERNATIONAL UNIVERSITY
MIAMI, FL 33199