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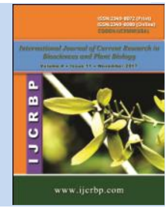

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Diversity of Potential Orphan Plants in Health Management and Climate Change Mitigation from Bahraich (Uttar Pradesh), India

T. P. Mall*

Postgraduate Department of Botany, Kisan PG College, Bahraich-Uttar Pradesh, India

Corresponding author.

Abstract

Crop species which are adapted to hot and dry climates will become increasingly important as the world worms. The Krikhouse Trust* supporting research and education in the biological Sciences is devoted for agricultural crop improvement for the relief of poverty, with a focus on legumes. The trust has supported research on legumes because of their importance in providing high quality protein in the diets of resource-poor farmers. Among these crops are many stress tolerant legume species found in India and Africa, which are relatively minor and neglected crops. A new programme called "Stress Tolerant Orphan Legumes" (STOL) for KT aims to support systematic studies of their potential to address the loss of agricultural productivity in areas of the globe that are suffering the greatest climate stresses. There are clear signs that climate change is already having severe effects on the agriculture where several crops are failing as result of the changed climate. In addition to direct effects of heat and drought on crops, the country is suffering soil loss due to increase in desert area per year. Over grazing, intensive cultivation, removal of tree cover, poor water management have all been as a reasons for this loss which cannot be compensated by any means. One more versatile fact remains that large tracts of land are being taken out of production for different types of constructions by the governments for the people as well as by the people for their settlements in urban areas. There are three possible ways to mitigate this looming disaster. First one is the adoption of stress tolerant legume species which may help farmers to fight the ravages of climate stress: production of grain to feed the family and also provide income; fodder and forage to livestock; ground cover as remedy for soil degradation. For this reason there should be a diversity of species where some crops may prove to be multipurpose, providing grain and fodder, forage and other crops may be specialized for other function such as soil remediation. In this study, only twelve orphan legumes are taken, *viz., Cajanus cajan, Lablab purpureus, Macrotyloma uniflorum, Phaseolus acutifolius, Phaseolus lunatus, Phaseolus vulgaris, Tylosema esculentum, Vigna aconitifolia, Vigna radiata, Vigna subterranean, Vigna umbillata, Vigna unguiculata* for their potential of climate stress mitigation, ethno-botanical and ethno-medicinal uses.

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Introduction

Legumes, broadly defined by their unusual flower structure, podded fruit, and the ability of 88% of the species examined to date to form nodules with rhizobia (de Faria et al., 1989), are second only to the Poaceae in their importance to humans. The 670 to 750 genera and 18,000 to 19,000 species of legumes (Polhill et al., 1981) include important grain, pasture, and agroforestry species. Cohen, 1977 and Bryan, 2000 reported domestication of lentils (*Lens esculenta*) at a site in Iran dating to 9,500 to 8,000 BP; Roosevelt et al. (1996) noted the use of *Hymenaea* as a food source in Amazonian prehistory. Bean (*Phaseolus vulgaris*) and soybean (*Glycine max*), staple crops in the Americas and Asia, respectively, were each domesticated more than 3,000 years ago (Hymowitz and Singh, 1987 and Kaplan and Lynch, 1999). Use of legumes in pastures and for soil improvement dates back to the Romans, with Varro 37 BC; (Fred et al., 1932) noting "Legumes should be planted in light soils, not so much for their own crops as for the good they do to subsequent crops."

Grain and forage legumes are grown on some 180 million ha, or 12% to 15% of the Earth's arable surface. They account for 27% of the world's primary crop production, with grain legumes alone contributing 33% of the dietary protein nitrogen (N) needs of humans (Vance et al., 2000). Under subsistence conditions, the percentage of legume protein N in the diet can reach twice this figure. In rank order, bean, pea (*Pisum sativum*), chickpea (*Cicer arietinum)*, broad bean (*Vicia faba*), pigeon pea (*Cajanus cajan*), cowpea (*Vigna unguiculata*), and lentil constitute the primary dietary legumes (National Academy of Science, 1994). Legumes (predominantly soybean and peanut *Arachis hypogeae*) provide more than 35% of the world's processed vegetable oil, and soybean and peanut are also rich sources of dietary protein for the chicken and pork industries. The potential of legume crops is evident in the huge increase in soybean production in Brazil, with national mean yields increased from 1,166 kg/ha in 1968 to 1969 to 2,567 kg/ ha in 2001 to 2002.This followed selection for later maturity, aluminum tolerance, and calcium-use efficiency (Smil, 1999). Unfortunately, improvement in legume crop yields has not kept pace with those of cereals. Jeuffroy and Ney (1997) note that wheat (*Triticum aestivum*) yields in France increased 120 kg/ha per year between 1981 and 1996; those for pea increased only 75 kg/ha/year over the same period. The situation is worse in the developing countries where Oram and Agcaoili (1992) note that pea yields are only 45%, and faba bean and chickpea are only 75%, of those achieved in developed countries. In part, this difference is due to the unfavorable environmental conditions under which many legume species are grown. Legumes are often grown after corn or rice and are seeded toward the end of the growing season. They may have short growing seasons and may be subject to intermittent or terminal drought. Progressive soil chemical and physical degradation and acid soil conditions may also limit their productivity. Drought problems for legumes are likely to worsen with the projected rapid expansion of water-stressed areas of the world from 28 to 30 countries today to 50 countries encompassing 3 billion people by 2030 (Postel, 2000). There is a crucial need to increase drought tolerance in legumes; increasing salinity tolerance is a parallel requirement in many areas. The more drought-tolerant legumes, such as cowpea, are deeply rooted and may have reduced leaf size with thickened cuticles to reduce water loss. Less tolerant legumes such as beans can be selected for early maturity, efficiency in the partitioning of nutrients toward reproductive structures and phenotypic plasticity (Beaver et al., 2003). Legume seeds generally contain 20% to 30% protein and are Lycine rich, complementing the nutritional profiles of cereals and tubers in the diet (Duranti and Gius, 1997). However, legumes are limited in sulfur amino acids, contain antinutritional factors including lectins and flatulence factors and are commonly hard to cook. Preference for particular grain types or seed color also affects marketability. Forage legumes have been the foundation for dairy and meat production for centuries (Russelle, 2001). When properly managed, they are rich sources of protein, fiber and energy. Even in intensive animal and milk production, where grain crops are major feed sources, forage legumes are required to maintain animal health (Wattiaux and Howard, 2001). Meat and dairy production in developing countries is almost solely dependent upon forage legumes and grasses. Alfalfa (*Medicago sativa*) is the prevalent forage legume in temperate climates (Russelle, 2001) with more than 72 million Mg of alfalfa worth $7 billion produced annually in the U.S. alone. Alfalfa is the third or fourth most valuable crop in the United States.

Presently underutilized crop and pasture legumes could still emerge. Ladizinsky and Smartt (2000) address opportunities for improved adaptation via further domestication. More exotic examples include marama bean (*Tylosema esculentum*; Dakora et al., 1999), sword beans (*Canavalia gladiata*; Ekanayake et al., 2000), and *Desmanthus illinoensis* among grain crops, and annual medics and *Biserrula pelecinus* among pasture species (Howieson et al., 1995, 2000).

Sprent and Parsons (2000) discuss the importance of woody tree legumes in forestry. Important genera include *Acacia*, *Anadenathera*, *Calliandra*, *Dalbergia*, *Erythrina*, *Gliricidia*, *Melanoxylon*, *Parkea*, *Prosopis*, *Pterocarpus*, and *Samanea*. Values for the percentage of plant N derived from fixation in such species listed by Giller (2001) range from 2% to 100%.

In tree fallows, *Sesbania* spp., *Leucaena* spp., *Tephrosia* spp., *Crotalaria* spp., *Glyricidia* spp., *or Cajanus* spp. are inter-planted into corn and allowed to grow as dry-season or longer-term fallows. The wood is harvested, and the N-rich leaves, pods and green stem material are hoed into the soil just before the rainy season (Sanchez, 1999). Gathumbi et al. (2002) reported aboveground biomass production in a 6-month period of 8 to 15 mg/ha with total N accumulation of 100 to 178 kg/ha. Significant crop yield increases in the season after tree fallow have been reported. Legume tree fodder with high levels of crude protein and minerals and in some cases, good digestibility is readily accepted by livestock.

In addition to traditional food and forage uses, legumes can be milled into flour, used to make bread, doughnuts, tortillas, chips, spreads and extruded snacks or used in liquid form to produce milks, yogurt, and infant formula (Garcia et al., 1998). Pop beans (Popenoe et al., 1989), licorice (*Glycyrrhiza glabra*; Kindscher, 1992) and soybean candy (Genta et al., 2002) provide novel uses for specific legumes. Legumes have been used industrially to prepare biodegradable plastics (Paetau et al., 1994), oils, gums, dyes and inks (Morris, 1997). Galactomannan gums derived from *Cyamopsis* spp. and *Sesbania* spp. are used in sizing textiles and paper, as a thickener, and in pill formulation. Graham and Vance 874 Plant Physiol. Vol. 131, 2003 Many legumes have been used in folk medicine (Duke, 1992 and Kindscher, 1992). Iso-flavones from soybeans and other legumes have more recently been suggested both to reduce the risks of cancer and to lower serum cholesterol (Kennedy, 1995 and Molteni et al., 1995). Soybean and soyfood phyto-estrogens have been suggested as possible alternatives to hormone replacement therapy for post-menopausal women.

A hallmark trait of legumes is their ability to develop root nodules and to fix atmospheric nitrogen in symbiosis with compatible rhizobia. This is often a critical factor in their suitability for the uses. Formation of symbiotically effective root nodules involves signaling between host and micro-symbionts. Flavonoids and/or iso-flavonoids released from the root of the legume host induce transcription of nodulation genes in compatible rhizobia, leading to the formation of lipochitooligosaccharide molecules that, in turn, signal the host plant to begin nodule formation (Long, 1996). Numerous changes occur in host and bacterial gene expression during infection, nodule development and function (Vance, 2002), with approximately 100 host legume and rhizobial genes involved. Some 40 to 60 million metric tons of nitrogen is being fixed by agriculturally important legumes annually, with another 3 to 5 million mt fixed by legumes in natural ecosystems (Smil, 1999). This is amazing efficiency given the miniscule quantities of nitrogenase enzyme involved (Delwiche, 1970).

Climate

In this study we are taking only twelve orphan legumes *viz., Cajanus cajan, Lablab purpureus, Macrotyloma uniflorum, Phaseolus acutifolius, Phaseolus lunatus, Phaseolus vulgaris, Tylosema esculentum, Vigna aconitifolia, Vigna radiata, Vigna subterranean, Vigna umbillata* and *Vigna unguiculata* for their potential of climate stress mitigation, ethno-botanical and ethno-medicinal uses.

***Cajanus cajan* (Linn.) Millsp.** Pigeon pea, Dhal, Gandul, Red gram, Congo pea, Gungo pea, No eye pea (Fabaceae):

Synonyms: *Cajanus indicus* Spreng. *Cajanus flavus* DC., *Cytisus cajanus* Linn.

Perennial woody shrub, mostly grown as an annual for the legume; stems strong, woody, to 4 m tall, freely branching; root system deep and extensive, to about 2 m, with a taproot. Leaves alternate, pinnately trifoliolate, stipulate; stipels small, subulate; leaflets lanceolate to elliptic, entire, acute apically and basally, penninerved, resinous on lower surface and pubescent, to 15 cm long and 6 cm wide. Inflorescence in terminal or axillary racemes in the upper branches of the bush. Flowers multi-colored with yellow predominant, red, purple, orange occur in streaks or fully cover the dorsal side of the flag, zygomorphic. Pods compressed, 2–9-seeded, not shattering in the field. Seeds lenticular to ovoid, to 8 mm in diameter, about 10 seeds per gram, separated from each other in the pod by slight depressions. Germination cryptocotylar. (Duke, 1981a).

Cajanus cajan grows in forests in its native range. It can be found in warmer, dryer regions of the tropics and subtropics as well as more temperate regions.

Adaptation

Cajanus cajan is adapted to a wide range of soil types. It grows best in well-drained soils and will not survive waterlogged conditions. It can be grown in a pH range of 4.5–8.4 (Cook et al., 2005). It grows best under hot conditions (65–86°F) and can grow in temperatures greater than 95°F (Cook et al., 2005). Mullen et al. (2003) found that a soil temperature of 64°F or greater is required at time of planting, as lower temperatures will lengthen the period of establishment. Nevertheless, it is a hardy plant that can grow at temperatures as low as 41°F (Phatak et al., 1993) and has been successfully grown in warmer temperate regions such as North Carolina (Duke, 1983). Frost will defoliate the plant.

*Cajanus cajan*is drought resistant and can survive under very dry conditions because of its deep root system. It has been found to grow throughout a six month dry season (Cook et al., 2005); however, flowering will be delayed and seed yields will decrease under long periods of drought (Mullen et al., 2003). It is less adapted to humid, wet conditions.

Management

*Cajanus cajan*can be managed as an annual shrub or a perennial plant. As a perennial plant it has been successfully used in alley cropping systems with cerealsand legumes. Under good management, the plant can live up to five years. As the plant ages, the stem will become woodier, and leaf regeneration will decline. Harvesting should be done after first frost, as leaf drop will make harvesting easier. Harvesting methods are similar to those for soybean and can be done with a combine. The plant will not survive heavy, continuous grazing or heavy cutting, but may be pruned. Weeds can be cultivated in the inter-rows. It cannot survive fire. Pigeon pea can be used in rotation with cowpea and it is resistant to root lesion nematodes (*Pratylenchus* spp.) that affect cowpea (Mullen et al., 2003).

Germplasm

Many cvs differ in height, habit of growth, color of flower, time of maturity, color, and shape of pods, and color, size, and shape of seed. Perennial types assume a tree-like appearance, yield well the first year but poorer in later years; suitable for forage, cover purposes, shade and for hedge plants. Annual (weak perennial) types are small plants grown as field crops, mainly cultivated for seed purposes, with very good quality white-seeded cvs ('Gujerat' in Ceylon) and red-seeded cvs (common in areas south of Bombay). Also in India and Ceylon the cvs 'Tur 5' and 'Tenkasi' are extensively grown. High-yield, short-duration Indian cvs include 'Co-l', 'Kanke 3', 'Kanke 9', 'Makta', 'Pusa ageta', 'Sharda', 'T-21', and 'UPAS-120'. In Florida day-neutral 'Amarillo' can be sown and harvested at different times throughout the year. Other good cvs are 'Morgan Congo', 'Cuban Congo' and 'No-eye Pea'. Of the better yielding cvs in trials in Uganda 'CIVE1', 'UC948', 'UC2288', 'UC3035' and 'UC16' are "spray types" where secondary branches are almost as long as the main stem, and there are few tertiaries; 'UC1377' and 'UC959' are "bush types". Assigned to the Hindustani and African Centers of Diversity, pigeon pea or cvs thereof is reported to exhibit tolerance to disease, drought, frost, high pil, laterite, low pH, nematodes, photoperiod, Salt, sand, virus, waterlogging, weed, wilt, and wind. ($2n$ = 22, 44, 66) (Duke, 1981a).

Cultivars, improved, and selected materials

There are many cultivars of pigeonpea from Africa and India (Sheahan, 2012). The variety ‘Flavus’ is yellow-flowered and early maturing. The variety ‘Bicolor’ may be red, purple, or streaked, perennial, and late-maturing. Both varieties may cross. There is a day-neutral cultivar from Florida called ‘Amarillo’ that can be sown and harvested throughout the year (Duke, 1983). Other varieties include ‘Hunt’, ‘Quantum’, and ‘Quest’ (Mullen et al., 2003).

Distribution

Probably native to India, pigeon pea was brought millennia ago to Africa where different strains developed. These were brought to the new world in Post-Columbian times. Truly wild *Cajanus* has never been found; they exist mostly as remnants of cultivations. In several places *Cajanus* persists in the forest. The closest wild relative, *Atylosia cajanifolia*

Haines, has been found in some localities in East India. Most other *Atylosias* are found scattered throughout India, while in North Australia a group of endemic *Atylosia* species grow. In Africa the tree fallows, *Sesbania* spp., *Leucaena* spp., *Tephrosia* spp., *Crotalaria* spp., *Glyricidia* spp., or *Cajanus* spp. are interplanted into corn, and allowed to grow as dry-season or longer-term fallows. The wood is harvested, and the N-rich leaves, pods, and green stem material are hoed into the soil just before the rainy season (Sanchez, 1999). Gathumbi et al. (2002) reported aboveg round biomass production in a 6-month period of 8 to 15 mg/ha, with total N accumulation of 100 to 178 kg/ha significant crop yield increases in the season after tree fallow have been reported. Legume tree fodder with high levels of crude protein and minerals, and in some cases, good digestibility is readily accepted by livestock. *Cajanus kerstingii* grows in the drier belts of Senegal, Ghana, Togo, and Nigeria. Pigeon peas occur throughout the tropical and subtropical regions, as well as the warmer temperate regions (as North Carolina) from 30°N to 30°S (Duke, 1981a).

Ecology

Pigeon pea is remarkably drought resistant, tolerating dry areas with less than 65 cm annual rainfall, even producing seed profusely under dry zone conditions, as the crop matures early and the incidence of pest damage is low. Pigeon pea is more or less photoperiod-sensitive; short days decrease time to flowering. Under humid conditions pigeon pea tends to produce luxuriant vegetative growth, rain during the time of flowering causes defective fertilization and permits attack by pod-caterpillars. Annual precipitation of 6–10 dm is most suitable, with moist conditions for the first two growing months, drier conditions for flowering and harvest. Growing best under temperatures of 18–29°C, some cultibers will tolerate 10°C under dry conditions and 35°C under moist conditions. The plant is sensitive to waterlogging and frost. It will grow in all types of soils, varying from sand to heavy clay loams, well-drained medium heavy loams being best. Some cultivars tolerate 6–12 mmhos/cm salinity. Ranging from Warm Temperate Moist to Wet through Tropical Desert to Wet Forest Life Zones, pigeon pea has been reported to tolerate annual precipitation of 5.3–40.3 dm (mean of 60 cases 14.5 dm), annual mean temperature of 15.8–27.8°C (mean of 60 cases = 24.4°C), and pH of 4.5 to 8.4 (mean of 44 cases = 6.4). (Duke, 1981a).

Chemical composition

Analysis of dal (without husk) gave the following values: moisture, 15.2; protein, 22.3; fat (ether extract), 1.7; mineral matter, 3.6; carbohydrate, 57.2; Ca, 9.1; and P, 0.26%; carotene evaluated as vitamin A, 220 IU and vitamin B_1, 150 IU per 100 g.

Sun-dried seeds of *Cajanus cajan* are reported to contain (per 100 g) 345 calories, 9.9% moisture, 19.5 g protein, 1.3 g fat, 65.5 g carbohydrate, 1.3 g fiber, 3.8 g ash, 161 mg Ca, 285 mg P, 15.0 mg Fe, 55 g carotene equivalent, 0.72 mg thiamine, 0.14 mg riboflavin, and 2.9 mg niacin.

Immature seeds of *Cajanus cajan* are reported to contain per 100 g, 117 calories, 69.5% moisture, 7.2 g protein, 0.6 g fat, 21.3 g total carbohydrate, 3.3 g fiber, 1.4 g ash, 29 mg Ca, 135 mg P, 1.3 mg Fe, 5 mg Na, 563 mg K, 145 g carotene equivalent, 0.40 mg thiamine, 0.25 mg riboflavin, 2.4 mg niacin, and 26 mg ascorbic acid/100 g.

Among the total amino acids, 6.7% is arginine, 1.2% cystine, 3.4% histidine, 3.8% isoleucine, 7.6% leucine, 7.0% lysine, 1.5% methionine, 8.7% phenylalanine, 3.4% threonine, 2.2% tyrosine, 5.0% valine, 9.8 aspartic acid, 19.2% glutamic acid, 6.4% alanine, 3.6% glycine, 4.4% proline, 5.0% serine with 0 values for canavanine, citrulline and homoserine. Methionine, cystine, and tryptophane are the main limiting amino acids. However, in combination with cereals, as pigeon peas are always eaten, this legume contributes to a nutritionally balanced human food.

The oil of the seeds contains 5.7% linolenic acid, 51.4% linoleic, 6.3% oleic, and 36.6% saturated fatty acids. Seeds are reported to contain trypsin inhibitors and chymotrypsin inhibitors. Fresh green forage contains 70.4% moisture, 7.1 crude protein, 10.7 crude fiber, 7.9 N-free extract, 1.6 fat, 2.3 ash. The whole plant, dried and ground contains 11.2% moisture, 14.8 crude protein, 28.9 crude fiber, 39.9 N-free extract, 1.7 fat and 3.5 ash (Duke, 1981a).

- **Ethno-botanical potential:**

  - **Commercial crop:** *Cajanus cajan* is grown as a pulse crop (crop harvested for dry seed) or eaten green as a vegetable. The grain is popularly consumed in India, Asia, and Africa. India is the largest importer and producer, where seed is sold as dal (dry split pea). Unprocessed seed should not be consumed by humans or livestock. The seed contains tannin and trypsin inhibitors (trypsin inhibitors are removed through cooking). The protein content in split seeds is similar to soybean and ranges from 21–28% (Phatak et al., 1993). It is also widely used as a good source of dietary vitamins and minerals.

- **Forage:** *Cajanus cajan* makes an excellent, high-protein forage for livestock. Crude protein ranges from 28–36% (Phatak et al., 1993). In Florida, plants yielded 3.1 short tons/acre of biomass (Duke, 1983). Livestock may browse foliage, but damage to the branches may result, so continuous grazing has to be avoided. Palatability has been reported to increase with age of the plant (Cook et al., 2005). *Cajanus cajan* can be grown as a forage intercropped with sorghum and/or millet. The deep tap root of *Cajanus cajan* draws water from deeper soil depths than most legumes, so will not interfere with the water uptake of other crops and grasses. It is not generally seeded as forage with other legumes like cowpea (*Vigna unguiculata*), but mainly with grasses (Cook et al., 2005). A nutritious feed for sheep can be made from the seedpod hulls and threshed waste of harvested plants.
- **Cover crop/green manure:** *Cajanus cajan* competes poorly with weeds and can be slow to establish if soils are not at least 64°F (Mullen et al., 2003). As a green manure it can fix about 62 lb N/acre up to the time when pods are produced (Phatak et al., 1993).
- **Wildlife:** *Cajanus cajan* has been used as a trap crop for *Heliothis* spp. (moth pests), in affected cotton (Mullen et al., 2003). A trap crop is a form of companion planting used to attract pests away from nearby crops. Plantings are also used as live fences and windbreaks in many regions. Woody stems have been used for thatched roofs, baskets, and charcoal (Allen and Allen, 1981).
- Pigeon peas are popular food in developing tropical countries.
- Nutritious and wholesome, the green seeds (and pods) serve as vegetable.
- Ripe seeds are a source of flour, used split (dhal) in soups or eaten with rice.
- Dhal contains as much as 22% protein, depending on cv and location.
- Tender leaves are rarely used as a potherb. Ripe seeds may be germinated and eaten as sprouts. Plants produce forage quickly and can be used as a perennial forage crop or used for green manure.
- Often grown as a shade crop for tree crops or vanilla, a cover crop, or occasionally as a windbreak hedge.
- In Thailand and North Bengal, pigeon pea serves as host for the scale insect which produces lac or sticklac.
- In Malagasy the leaves are used as food for the silkworm.
- Dried stalks serve for fuel, thatch and basketry (Duke, 1981a).

➢ Ethno-medicinal potential:

- In India and Java, the young leaves are applied to sores.
- Indochinese claim that powdered leaves help expel bladderstones.
- Salted leaf juice is taken for jaundice.
- In Argentina the leaf decoction is prized for genital and other skin irritations, especially in females (Morton, 1976).
- Floral decoctions are used for bronchitis, coughs, and pneumonia.
- Chinese shops sell dried roots as an alexeritic, anthelminthic, expectorant, sedative, and vulnerary.
- Leaves are also used for toothache, mouthwash, sore gums, child-delivery and dysentery. Scorched seed, added to coffee, are said to alleviate headache and vertigo.
- Fresh seeds are said to help incontinence of urine in males, while immature fruits are believed of use in liver and kidney ailments. (Duke, 1981a).
- Decoctions of leaf and stem have been used as a diuretic, laxative, and to treat sore throat (Allen and Allen, 1981).
- *Cajanus cajan*seedsreduces the serum glucose levels (Jeeva and Sheebha, 2014).
- *Cajanuscajan*and *Vigna mungo* (Burm. f.) Walp.: The pulse obtained from the seeds of these plants is cooked and is recommended to diabetics (Ahmad et al., 2009).
- Several cultures have used decoctions for skin irritations and sores. Floral decoctions have

been used to treat bronchitis, coughs, and pneumonia. Some Chinese use the dried roots to evacuate intestinal worms, as an expectorant, sedative, and a remedy for wounds (Duke, 1983).

***Lablab purpureus* (Linn.) Sweet.;** Hyacinth-beans, Lablab-bean, Bonavist bean/pea, Dolichos bean, Seim bean, Egyptian kidney bean, Indian bean, Bataw bean, Australian pea,Tonga bean, Papaya bean, Poor man bean,Bounavista pea, and Butter bean:

Synonyms: *Dolichos lablab* Linn., *Dolichos purpureus* Linn., *Dolichos lignosus* Linn., *Lablab niger* Medikus, *Lablab lablab* (Linn.) Lyons, *Lablab vulgaris* (Linn.) Savi, *Dolichos benghalensis* Jacq., *Vigna aristata* Piper

Lablab purpureus is a species of bean in the family Fabaceae. It is native to Africa and it is cultivated throughout the tropics for food. It is the only species in the monotypic genus *Lablab*. *Lablab purpureus* is an herbaceous, climbing, warm-season annual or short-lived perennial with a vigorous taproot. It has a thick, herbaceous stem that can grow up to 3 feet, and the climbing vines stretching up to 25 ft from the plant (Valenzuela and Smith, 2002). The wild species is perennial. The thick stems can reach six meters in length It has trifoliate, long-stemmed leaves. Each egg-shaped leaflet widens in the middle and is 3–6 in. (7.5–15 cm) long. The surface of the leaflet is smooth above and short-haired below.

The inflorescence is made up of racemes of many flowers. The flowers grow in clusters on an unbranched inflorescence in the angle between the leaf and the main stem. It may have white, blue, or purple flowers depending on its variety.

Seedpods are 2 in. (4–5 cm) (Cook et al., 2005) to 4 in. (10 cm) long (Venezuela and Smith, 2002), smooth, flat, pointed, and contain 2 to 4 seeds. Seeds can be white, cream, pale brown, dark brown, red, black, or mottled depending on variety. The seed is about a centimeter long. Wild plants have mottled seeds..

Distribution

L. purpureus is an old world food crop that is thought to have originated in Africa (Cook et al., 2005) or India (Murphy and Colucci, 1999). It has been successfully grown in the Southern United States, Texas, Florida, Georgia, Puerto Rico, and as far north as the Great Lakes and Canada. It grows from sea level up to 6,500 ft. (FAO, 2012).

Habitat

It grows best in the tropics and subtropics.

Lablab purpureus can grow in a variety of soils, from sand to clay, in a pH range of 4.5–7.5 (Cook et al., 2005). It does not grow well in saline or poorly-drained soils, but it grows better than most legumes under acidic conditions (Valenzuela and Smith, 2002). It can continue to grow in drought or shady conditions, and will grow in areas with an average annual rainfall is 25–120 in. (Cook et al., 2005). It is more drought resistant than other similar legumes like common beans (*Phaseolus vulgaris*) and cowpea Maass et al., 2010), and can access soil water 6 feet deep (Cook et al., 2005).

It grows best where average daily temperatures are between 64 to 86°F; but it can grow at 37°F for short periods (Cook et al., 2005) and can tolerate light frosts. It is better adapted to cold than other warm-season forages such as velvet bean (*Mucuna pruriens*) or cowpea.

Establishment

The seed should be inoculated with a cowpea-type, *Bradyrhizobium* strain as it does not easily nodulate with native rhizobia (FAO, 2012). If grown in the same area, inoculant is not needed in subsequent years, since rhizobia bacteria will be in the soil. The seeds do not need to be scarified, but studies have shown that the seedbed should be adequately prepped either through chemical preparation or cultivation (Murtagh, 1972). Natural pastures must be cultivated for successful establishment (FAO, 2012).

The seed should be sown 1 to 4 in. deep at 11–18 lb/acre on rows 2.5 ft wide with roughly 1 to 1.5 ft between plants (Cook et al., 2005). When planting with grasses, reduce the seeding rate by half. Planting dates should coincide with other warm-season legumes. No additional fertilizer is necessary (FAO, 2012).

Management

Lablab purpureus can be used in rotations with cereals to add nitrogen to the soil. It is often used as an intercrop species with maize, but should be sown roughly 30 days later than maize so as to limit competition. It can also be sown as a monoculture.

In green manure applications, the crop should be terminated before flowering to return maximum amounts of N to the soil. The plant can be mowed almost to ground level and will regrow, but regrowth will be slowed by the cutting (Valenzuela and Smith, 2002). Fire will kill the plant.

Lablab purpureus should not be heavily grazed. Grazing can begin 10 weeks from the date of planting and animals can be grazed 2 to 3 times per season if the plant is not eaten below 10 in. (25 cm) (FAO, 2012). Cutting the plant lower will result in delayed regrowth. To avoid bloat, supplement the animal's diet with grasses. *Lablab purpureus* is a weak perennial and is not likely to spread (FAO, 2012). In some cases, the climbing variety of *Lablab purpureus* has shown some invasive tendencies in old fields (Valenzuela and Smith, 2002).

Seeds and plant production

Lablab purpureus is a short-day annual, flowering in response to longer nights in late-summer and fall. It is mainly self-fertilizing, and will set seed within the first year after planting. Flowering and seedpod production is sporadic. Cook et al. (2005) observed that plants will produceroughly 900–2,000 lb of seed/acre, but FAO (2012) observed cases in South America where significantly less seed (450–900 lb/acre) was produced. There are roughly 1,500–1,950 seeds per pound (FAO, 2012). It will produce seed in the Southern United States, including Texas, Georgia, and Florida.

Cultivars, improved, and selected materials

Lablab purpureus is well known and valued for its physiological diversity, and can exhibit both bush and twining growth habits, as well as early-flowering and late-flowering characteristics. More than 3,000 accessions of germplasm have been collected worldwide (Maass et al., 2010). Yet despite its morphological diversity, the two varieties Rongai and Highworth (both forage varieties) seem to be most popular in the United States. Rongai (late-flowering) grows upright and has white flowers that bloom when there is less than 11 hours of daylight (FAO, 2012). Highworth (early-flowering) is a twining variety that has purple blooms. There is also an earlier flowering variety from East Texas called Rio Verde that flowers after 55 days.

➢ **Ethno-botanical potential:**

- The hyacinth bean is an old domesticated pulse and multi-purpose crop.
- Due to seed availability of one forage cultivar (cv. Rongai), it is often grown as forage for livestock and as an ornamental plant.
- It is cited both as a medicinal plant and a poisonous plant.
- The fruit and beans are edible if boiled well with several changes of the water. Otherwise, they are toxic due to the presence of cyanogenic glycosides, glycosides that are converted to hydrogen cyanide when consumed. Signs of poisoning include weakness, vomiting, dyspnea, twitching, stupor, and convulsions. It has been shown that there is a wide range of cyanogenic potential among the varieties.
- The leaves are eaten raw or cooked like spinach. The flowers can be eaten raw or steamed.
- The root can be boiled or baked for food.
- The seeds are used to make tofu and tempeh.
- In Maharashtra, dry preparations with green masala are often made out of these green beans mostly found at the end of monsoon during fasting festivals of Shravan month.
- In Karnataka, the hyacinth bean is made into curry, salad, added to upma, and as a flavoring to Akki rotti.
- Sometimes the outer peel of the seed is taken out and the inner soft part is used for a variety of dishes. This form is called which means "pressed hyancinth bean, and a curry known as Hitikida Avarekaalu Saaru is made out of this deskinned beans.
- In Telangana, the bean pods are cut into small pieces and cooked as spicy curry in Pongal festival season, along with bajra bread; it has been a very special delicacy for centuries
- In Huế, Vietnam, hyacinth beans are the main ingredient of the dish Hyacinth Bean Sweet Soup.
- In Kenya, the bean called 'Njahe' is popular among several communities, especially the Kikuyu tribe.
- It is thought to encourage lactation and has historically been the main dish for breastfeeding

mothers. Beans are boiled and mashed with ripe and/or semi-ripe bananas, giving the dish a sweet taste.

- Today the production is in decline in eastern Africa. This is partly attributed to the fact that under colonial rule in Kenya, farmers were forced to give up their local bean in order to produce common beans (*Phaseolus vulgaris*) for export.
- It ia a dual purpose legume and can be used with cereals in smallholder systems.
- It can be sown with summer grass crops to provide a mixed forage crop system.
- It has high forage quality.
- As a green manure crop restores soil fertility.
- Drought tolerant once established.
- It has high grain yields.
- It has better root disease resistance than cowpeas.
- The most common use of *Lablab purpureus* in the United States is as an ornamental crop in the cut flower industry (Stevens, 2012). It is valued for its late summer flowers and colorful, purple peapods. Depending on the weather in late summer, harvest yields can be up to 55 cut stems per plant (Anderson et al., 1996).

➢ **Ethno-medicinal potential:**

- *Lablab purpureus* has been used in the Philippines and China as a stimulant.
- To reduce fever, flatulence.
- It stimulates digestion.
- It is also used as an antispasmodic (Stuart, 2011).
- In Namibia, the root has been used to treat heart conditions (Pennacchio et al., 2010).

***Macrotyloma uniflorum* Lam.,** Horse gram, Gaheth:

Synonym: *Dolichos uniflorum*

Macrotyloma uniflorum is an erect, sub-erect or trailing, densely hairy annual herb. Leaves compound, alternate, trifoliolate, stipules lanceolate petiole 1-7 cm. long leaflet ovate elliptical apex rounded to acute base rounded lateral leaflets a symmetric hairy to glabrescent on both surfaces.

Flowers short only 6-12 mm. long. The flower is cream - yellow with purple spot in auxiliary racemes with 2 appendages at base. Flower zygomorphic, bisexual, Fruit is a linear oblong pod 3-8 cm.x4-8 mm. up curved towards apex acuminate, densely hairy. When young later marsparsely so margins glabrous smooth or warty dehiscent 5-10 seeds.

Seed size ranges 6-8 mm long and 3-4 mm broad smooth of which 100 seed weight is recorded 4 gm. Seed trapezoidal oblong or somewhat rounded. Pale to dark reddish brown speckled or mottled with black and orange brown or all black (Mehra and Upadhyaya, 2013).

Macrotyloma comprises about 25 species. Most of which are restricted to Africa. Four varieties have been distinguished *viz.*, *Macrotyloma uniflorum, M. stenocarpum, M. verrucosum* and *M. benadirianum.*

In India it is the most extensively grown pulse in south India, the maximum area being in Andhra Parades, Karnataka and Tamil Nadu. It is grown mainly to furnish feed and fodder for cattle and horse. It makes excellent hay and is suitable as green manure (Seasonal Crop Madras, 1948 and Hyderabad, 1949). In Uttarakhand it is grown in large extent both region of Kumaun and Gadhwal. It is cultivated as major pulse crop in villages of Almora, Bageshwar, Nainital, Pithoragarh and Chamoli.

Rapid summer growth, high seed yield, draught tolerance, adapted to a wide range of soils from sand, gravels to clay, loam except highly alkaline type is the strength. Prey or near neutral soil but will grow down to 5.5 and up to about 8.0 tolerant of low to moderate salinity. It is draught resistant but cannot withstand water logging. Tropic and subtropical climate is ideal for its growth. In Uttarakhand it is widely distributed up to 1200m sea level.

Annual rainfall requirement is 200-1000 mm. It can easily be grown as a dry crop under moderate rainfall not exceeding 87 cm. Best growth is produce dully hot moist weather with temperatures between 25-350^{o}F common in the drier areas the growth rate declining markedly below 200^{o}F. It is completely intolerant of frost.

In India horse gram is usually sown as a sole crop, but sometime it is intercropped with maize, ground nut or castor. In Kumaun it is grown as a kharif crop mixed with maize or finger millet. It is also a valuable green fodder crop light grazing by sheep is permitted in the yield and green trimming are fed to cattle and sheep in some area's, Horse gram is grown with fodder and mixed crop and used as green feed. The crop comes into bearing in 4-6 months after sowing the leaves begin to dry and drop out the plant are uprooted dried and the seed threshed out by treading of bullocks and with the help of a stone roller. The seed are cleaned by winnowing and sifting. The average yield is 150-300 lb per acre a yield as high as 600 lb per acre has been obtained under favorable condition when grown for fodder as in north India. It is harvested about 6 week after sowing.

Nutritional value (per 100 g)

Nutrient Amount Units: Carbohydrates 57.3 g, moisture 11.8 g, fat 0.5 g, crude protein 22.0 g, calories 321 calories, fiber 5.3 g, mineral matter 3.1 mg, iron 7.6 mg, calcium- 0.28 mg, nicotinic acid 1.5 mg, carotene 11.9 IU, phosphorus 0.39 mg, vitamin B 0.42 IU. The globulins of Horse gram account for nearly 80% of Nitrogen. They contain arginine (6-7.1%), tryosian (6.68%), Lysine (7.64%) but are deficient in Cystine and Tryptophan. at 10% level of protein intake the biological value and digestibility coefficient are 66 and 73 respectively.

➢ **Ethno-botanical potential:**

- *Macrotyloma* is a nutritious food legume.
- It is cultivated for its seed and mostly eaten as a dal.
- It is rich in protein iron, calcium and polyphenols.
- Green plant of horse gram valuable green manure horse gram that fail to meet food grade standard can be used as livestock feed, because of their high protein content and lack of digestive inhibitors.
- Husk, dried leaves, stems and residues can be valuable feed to livestock.
- The fodder being rich in protein; it is widely used as a feed to animals and horses (Prakash et al., 2008).
- Horse gram is a valuable protein supplement.

➢ **Ethno-medicinal Potential:**

- It helps in eliminating kidney stones.
- Horse gram also helps in lowering cholesterol levels.
- Horse gram is famous for its medicinal uses because different parts of the plant are used for the treatment of Asthma, Urinary disorder and kidney stones.
- *Macrotyloma uniflorum* could play a role in antioxidation (Mehra and Upadhyaya, 2013).
- *Macrotyloma* has the greatest potential for further utilization as nutra-ceuticals forage and food for malnourished and drought prone areas of the world.
- It is famous for its medicinal use because different part of the plants are used for the treatment of heart disease , asthma, bronchitis, urinary discharges and for treatment of kidney stones.(Ghani, 2003).

***Phaseolus acutifolius* A Gray.,** Tepary bean, Pawi, Pavi, Tepari, Escomite, Yori mui, Yorimuni and Yori muni:

Synonyms: *Phaseolus acutifolius* var. *tenuifolius* A.Gray, *Phaseolus tenuifolius* (A. Gray) Wooton & Stand., *Vigna aconitifolia* (Jack.) Marehal.

Phaseolus acutifolius, the Tepary bean, is native to the south-western United States and Mexico and has been grown there by the native peoples since pre-Columbian times. It is more drought-resistant than the common bean (*Phaseolus vulgaris*) and is grown in desert and semi-desert conditions from Arizona through Mexico to Costa Rica. The water requirements are low and the crop grows in areas where annual rainfall is less than 400 mm (16 in).

The tepary bean is an annual and can be climbing, trailing, or erect with stems up to 4 m (13 ft) long. A narrow leafed, variety *tenuifolius*, and a broader leafed, variety *latifolius*, are known. Domestic varieties are derived from *latifolius*. In the Sonora desert, "the flowers appear with the summer rains, first appearing in late August, with the pods ripening early in the fall dry season, most of them in October." The beans can be of nearly any color. There are many local landraces. Beans vary in size but tend to be small. They mature 60 to 120 days after planting.

The name tepary may derive from the Tohono O'odham phrase t'pawi or "It's a bean". It should be noted that the name for a small bean was recorded in the 17th century, in the now extinct Eudeve language of northern Mexico, as tépar (accusative case, tépari). Names that contain yori in them typically refer to non-native species of beans since those names mean 'non-Indian person's bean'.

Tepary beans are the most drought tolerant legume. Germination, however, requires wet soil although the plants will flourish in dry conditions thereafter. too much water inhibits bean production. Cultivated beans have been found dating to 5,000 BCE in the Tehuacán Valley in Mexico. They were cultivated by various methods, most commonly after an infrequent rain insert or after flood waters along a river or ephemeral stream had subsided. The tepary bean is relatively disease free, except under conditions of high humidity.

The tepary bean was a major food staple of natives in the South-western United States and Northern Mexico. In addition to being grown in floodplains, it was often grown alongside squash and corn. Growing these plants together, known as Three Sisters agriculture, both enhances their growth and provides more balanced nutrition.

In the United States, the tepary bean was introduced to Anglo farmers in the 19th century by Tohono O'Odham (Papago) farmers. The Indian method of planting in the American Southwest was to plant three to five seeds in hills six to eight feet apart. Beans were planted in arroyos that had been recently flooded by summer rain.

Cultivation of tepary beans is possible under the most extreme conditions. The Sand Papago (Hia C-eḍ O'odham) were mainly hunter-gatherers but cultivated tepary beans and other crops when moisture made it possible for them to do so. In 1912, ethnographer Carl Lumholtz found small cultivated fields primarily of tepary beans in the Pinacate Peaks area of Sonora. In the Pinacate, with an average annual precipitation of 75 mm (3.0 in) and temperatures up to 48°C (118°F), Papago and Mexican farmers utilized runoff from sparse rains to grow crops. In the 1980s author Gary Paul Nabhan visited this area, and found one farm family taking advantage of the firstlarge rain in six years, planting seeds in the wet ground and harvesting a crop two months later. The most successful crops were tepary beans and a drought-adapted squash. Nabhan calculated that the cultivation in the Pinacate was the most arid area in the world where rain-fed agriculture is practiced.

➢ **Ethno-botanical potential:**

- North-western Mexico is the primary area of production for tepary beans. The tepary is also cultivated in many countries in Africa, Australia, and Asia. In India, tepary beans are an ingredient in the snacks 'bhujia' and Punjabi Tadka by Haldiram's.
- The tepary bean was a major food staple of natives in the Southwestern United States and northern Mexico.
- In addition to being grown in floodplains, it was often grown alongside squash and corn. Growing these plants together, known as Three Sisters agriculture, both enhances their growth and provides more balanced nutrition. The International Center for Tropical Agriculture in Colombia since 2015 is testing crossbreeds of the tepary bean and common bean, in order to impart the tepary's drought and heat resistance. The latter could be especially helpful given climate change's effects on agriculture.

➢ **Ethno-medicinal potential:**

- Research in the United States and Mexico suggest that lectin toxins and other compounds from tepary beans may be useful in chemotherapy for treating cancer.

Phaseolus lunatus **Linn., Sem,** Lima bean, Butter bean, Burma bean, Rangoon bean, Duffin bean, Madagascar bean:

Synonyms: *Phaseolus inamoenus* L., *Phaseolus limensis* Macfad

It is native to Tropical America and now widely cultivated throughout the tropics of the world, including India and Pakistan. Two varieties are found as large-seeded Potato Lima and small-seeded Baby Lima which is half of the size of the large variety.

Lima bean is an annual to perennial climbing plant producing twining stems generally up to 4 metres long, though sometimes as much as eight metre long, from a perennial rootstock. The stems scramble over the ground or twine into the surrounding vegetation or any provided supports. Plants generally grow well in lowland tropical areas at elevations up to 1,500 metres. An annual rainfall in the range 900 - 1,500 mm is adequate but once established the crop tolerates as little as 500 - 600 mm of rainfall. Plants are generally tolerant of heavy rainfall during the growing period, though heavy rain when they are flowering can adversely affect fertilization.

➢ **Ethnobotanical potential:**

- Lima bean is a very popular food crop, being used mainly for its seeds and immature seedpods. There are many different varieties of the plant, producing a wide range of beans, including the large, white 'butter bean'. The plant was already widely cultivated in the Americas before the arrival of the Europeans, who then spread it thoughout Africa, Asia etc. It is widely cultivated nowaday for its edible seed and seedpods in many tropical to warm temperate areas of the world.
- The raw mature seed is poisonous. The toxic principle is hydrocyanic acid and this is destroyed by thoroughly cooking the seed.
- It is claimed, if the green pods are chewed in ones mouth and applied to any place bitten by a horse, it will help.
- Bean pods are effective in lowing blood sugar levels and can be used (with the concurrence of a doctor) for mild cases of diabetes. A bean pod diet for this purpose would mean eating 9-16 lb. of pods per week (they can be cooked like vegetables).
- The pods are most effective before the beans are ripe, and fresh pods are more effective than dried. Dried pods are particularly to be used in conjunction or rotation with other efficacious herbs, such as bilberry, milfoil, dandelion, and juniper. These can be taken alone or mixed, as a tea.
- Bean pod tea is useful for dropsy, sciatica, chronic rheumatism, kidney and bladder problems, uric acid accumulations, and loss of albumin in the urine during pregnancy. Externally, promotes healing of ulcers and sores.
- Prolonged use of the decoction made from the beans is recommended for difficult cases of acne. Bean meal can also be applied directly to the skin for moist eczema, eruptions, and itching. Wash the skin every 2-3 hours with German chamomile tea and apply new meal. Use anywhere from 2 tbsp. to 3 handfuls of dried small-cut pods with 1 qt. water. Boil for 3 hours. Take 1/2 to 3/4 qt. per day.
- Immature seedpods - raw or cooked. The green pods are commonly used as a vegetable, they have a mild flavour and should only be cooked for a short time. When growing the plant for its seedpods, be sure to pick them whilst they are still small and tender. This will ensure the continued production of more pods by the plant. Flowering is reduced once the seeds begin to form inside the pods. The immature seeds are boiled or steamed and used as a vegetable.
- The mature seeds are dried and stored for future use. They must be thoroughly cooked before being eaten and are best soaked in water for about 12 hours prior to this. They can be boiled, baked, pureed, ground into a powder or fermented into "tempeh" etc.
- The powdered seed makes a protein-enriching additive to flour, it can also be used in soups etc.
- The seed can also be sprouted and used in salads or cooked. The roasted seeds have been used as a coffee substitute.
- Young leaves - raw or cooked as a potherb. The very young laves are sometimes eaten as a salad, the older leaves are cooked.

➢ **Ethnomedicinal potential:**

- The green pods are mildly diuretic and contain a substance that reduces the blood sugar level.
- The dried mature pod is used according to another report.
- It is used in the treatment of diabetes. The seed is diuretic, hypoglycaemic and hypotensive.
- Ground into a flour, it is used externally in the treatment of ulcers.
- The seed is also used in the treatment of cancer of the blood. When bruised and boiled with garlic they have cured intractable coughs.
- The root is dangerously narcotic.
- A homeopathic remedy is made from the entire fresh herb. It is used in the treatment of rheumatism and arthritis, plus disorders of the urinary tract.

Phaseolus vulgaris **Linn.;** Common bean, Doufuto fu (bean curd), Green bean, Kidney bean, Navy bean, Pinto bean, Snap bean, String bean, Wax bean:

The Kidney bean is an annual, twining plant; the leaves are alternate, each leaf consisting of 3 broad-ovate to rhombic-ovate, entire, pointed leaflets. The white, yellow or purplish flowers grow in sparse, axillary clusters. The fruit is a green or yellow pod; the color of the seeds, or beans, depends on the variety. Diverse as they are, all the beans named above are varieties of the kidney bean. The dry beans are picked when mature, the others at various stages of maturity.

Probably originated in South America and is still the predominant bean cultivated in the Americas.

Phaseolus vulgaris (kidney bean) is indigenous to the Americas, being unknown to the rest of the world before Columbus. This species includes the common green bean as well as wax beans, and various dried beans such as red kidney, pinto, and navy. These beans were extensively cultivated and used as trade goods by Native American tribes from Canada to South America, with each tribe having its own names and folklore for the beans.

Before the discovery of the New World, Europeans did have other bean species with various traditions associated with them. On 3 days of the year, the Roman head of the household went through a ritual ceremony of spitting beans out of his mouth to rid his home of evil spirits. This custom carried over to the Middle Ages, where spitting a mouthful of beans in a witch's face was considered to negate her powers. Perhaps beans were thought to be a potent deterrent against evil because as a seed they have stored within them the positive life force of all living and growing things.

➢ Ethnobotanical potential:

- Since 200 BC, tofu (bean curd) has been cooked to prepare soup to treat colds; the Chinese version of chicken soup. Tofu can be stored up to 5 days in the refrigerator. To preserve freshness, immerse tofu in water and change the water daily. It is both low in calories and highly nutritious: 6 oz. portion is a mere 100 calories and contains about 6% protein.
- It is claimed, if the green pods are chewed in ones a month and applied to any place bitten by a horse, it will help.
- Dried pods are particularly to be used in conjunction or rotation with other efficacious herbs, such as bilberry, milfoil, dandelion, and juniper.
- Immature seed pods are used raw or cooked.
- The green pods are commonly used as a vegetable, they have a mild flavour and should only be cooked for a short time.
- When growing the plant for its seedpods, it should be pickedwhen they are still small and tender. This will ensure the continued production of more pods by the plan
- Flowering is reduced once the seeds begin to form inside the pods.
- The immature seeds are boiled or steamed and used as a vegetable.
- The mature seeds are dried and stored for future use.
- The mature and dried seeds must be thoroughly cooked before being eaten and it is better tosoake in water for about twelve hours prior to this.
- The mature and dry seeds can be boiled, baked, pureed, ground into a powder or fermented into "tempeh" etc.
- The powdered seed makes a protein-enriching additive to flour, it can also be used in soups etc.
- The seed can also be sprouted and used in salads or cooked.
- The roasted seeds have been used as a coffee substitute.
- Young leaves - raw or cooked as a potherb. The very young laves are sometimes eaten as a salad where as the older leaves are cooked.

➢ Ethno-medicinal Potential:

- Bean pods are effective in lowing blood sugar levels and can be used for mild cases of diabetes. A bean pod diet for this purpose would mean eating 9-16 lb. of pods per week (they can be cooked like vegetables). The pods are most effective before the beans are ripe, and fresh pods are more effective than dried.
- Dry pods can be taken alone or mixed, as a tea. Bean pod tea is useful for dropsy, sciatica, chronic rheumatism, kidney and bladder problems, uric acid accumulations, and loss of albumin in the urine during pregnancy.
- Externally, promotes healing of ulcers and sores.
- Prolonged use of the decoction made from the beans is recommended for difficult cases of acne.
- Bean meal can also be applied directly to the skin for moist eczema, eruptions, and itching.

For this the skin should be washed every 2-3 hours with German chamomile tea and apply new meal.

- It can be used anywhere from 2 tbsp. to 3 handfuls of dried small-cut pods with 1 qt. water. It should be boiled for 3 hours and taken 1/2 to 3/4 qt. per day.
- The green pods are mildly diuretic and contain a substance that reduces the blood sugar level. The dried mature pod is used according to another report. It is used in the treatment of diabetes.
- The seed is diuretic, hypoglycaemic and hypotensive.
- The grounded flour is used externally in the treatment of ulcers.
- The seed is also used in the treatment of the blood cancer.
- When bruised and boiled with garlic they have cured intractable coughs.
- The root is dangerously narcotic.
- A homeopathic remedy is made from the entire fresh herb. It is used in the treatment of rheumatism and arthritis, plus disorders of the urinary tract.

***Tylosema esculentum* (Burch.) A.Schreib.,** Marama bean, Gemsbok bean:

Synonyms: *Bauhinia bainesii* Schinz, *Bauhinia esculenta* Burch.

It is a long-lived perennial legume native to arid areas of southern Africa. Stems grow at least three mt, in a prostrate or trailing form, with forked tendrils that facilitate climbing. A raceme up to twenty five mm long, containing many yellow-orange flowers, ultimately produces an ovate to circular pod, with large brownish-black seeds. Summer growth is typically prodigious, particularly in plants older than one year - due in part to its large underground tuber. The plant is dormant over winter in its native home - South Africa, Namibia and Botswana - but might possibly remain evergreen in less harsh environments. The seeds develop in typical legume pods, albeit large and squat in shape - with typically one or two seeds per pod.

The marama bean is adapted to its native region of Southern Africa and therefore, grows in dry and low-moisture soils. Its drought tolerance is accordingly high. The fact that the marama bean is adapted to harsh environments offers potential to extend the agricultural activity into regions which are dry or unproductive at the moment. Nevertheless, it needs to be investigated whether it can grow on different soil types.

Propagation

The seed's hard outer shell means that scarification is necessary in order to ensure satisfactory germination rates (Travlos et al., 2007). As for most legumes, a pH neutral soil is preferred. The plant typically grows in very sandy loam, where water logging would not be a problem. Despite much global interest in this plant, propagation rates are still fairly low.

The greatest impediment to producing a crop of seeds is the long maturation time for the seed pods - which is right up to the first hard freeze of the year. Water logging is indeed an issue - leading to root rot - and a well drained sandy loam is preferred, but not essential. Curiously, this and the other three members of the genus *Tylosema* are possibly unique within the family Fabaceae in the fact they exhibit heterostyly (Heartley et al., 2002).

It is known that two fungi are co-infecting the pods of marama beans leading to necrotic lesions. The fungi were revealed to be *Alternaria tenuissima* and *Phoma* spp. Insect pests could have been observed causing seed damage (Jackson et al., 2010). This reduces propagation potential, and obviously reduces seed production rates for cropping.

Nutritional value

The nutritional value of the marama bean is astonishingly very high for an unimproved legume. The tubers have a high protein content of 9.0% and also have a high amino acid content. The tubers of cassava, for example, only have a protein content of 1-3%, while yam has one of 7%.

Also the grain is relatively high in protein with a share of 30-39%. The concentration of sulphur-containing amino acids is high as well (with a lysine content of 5.0% and a methionine content of 0.7%). This shows that the protein content of the seeds is comparable to the one of commercial soybeans, which have a content of 38-40%. Therefore, the potential of the marama bean is high to replace the soybean as a protein source, once there have been genetical improvements.

The tuber can grow very large - at least 10 kg, perhaps much larger. In Botswana a tuber of 277 kg has been found.

Scarification and seed germination

Tylosema esculentum have hard seed coats, which lead to many ecological benefits such as an accumulation of seed banks in soils and a higher percentage of germinating, establishing, and completing a successful life cycle. In order to optimize germination and growth of this perennial legume and increase its importance in the food market, germination behavior of untreated *Tylosema esculentum* seeds compared to seeds undergoing various dormancy-breaking treatments was investigated. The results indicated that seed germination was greatest when scratching and cracking of the seed coat with sandpaper, also known as mechanical scarification, was applied (Travlos et al., 2007). Other types of scarification include immersion of seed in water or acid.

Another experiment in Greece discovered that the seed germination of *Tylosema esculentum* increases significantly in speed and emergence when the seeds are immersed in hot water for two to four minutes or dry heating for five minutes at 100 to 150^{0}C. Soil is also an important factor to consider when growing this perennial legume plant. *Tylosema esculentum* grows best in a sandy soil texture, instead of a clay loam soil texture, because a sandy soil has optimal physical properties that allow the Marama bean to germinate quickly (Travlos, 2007).

Chemical and nutritional composition

The marama bean has a very low moisture content as the dry matter content ranges from 93.4% to 98.7%. The moisture content may also vary due to external factors (Bower et al., 1988; Holse et al., 2010; Wehemeyer et al., 1969).

- It was reported that the content of lipids ranges between 24% and 42%. This high amount of lipids is an advantage, especially in Southern Africa where it helps improving the status of the undernourished people (Jackson et al., 2010). The lipid content of the marama beans can be compared to sunflower seeds (22-36 %) and rapeseed (22-49 %) and almost reaching the amount that is found in peanuts (45-55 %) (Belitz et al., 2004 and Salunkle and Kadam, 1989). The amount of lipids is twice as high as found in soybeans (17-20 %) (Belitz et al., 2004 and Street and Opik, 1975).
- The protein range of marama beans ranges from 29% to 39% on a dry matter basis. Thus, it is comparable or slightly higher to most other legumes. This amount of protein makes the marama bean a great nutritive food but can be also used as a protein-rich ingredient for supplementing other products (Jackson et al., 2010).
- ➢ Sixteen samples of *Tylosema esculentum* from Botswana, Namibia, and South Africa were tested, and the plant's chemical composition was analyzed. The results showed that the Marama bean seeds contained high lipid and protein levels (29-38% protein content, 32-42% lipid content, and 19-27% dietary fiber content), which are higher in value than other legumes (Holse et al., 2010).

➢ <u>Ethno-botanical potential:</u>

- The plant is a significant food-source for the people of the Kalahari because of the high protein and oil content of its large seeds (20-30gm each).
- The seeds are usually roasted, imbuing them with a more palatable flavour - comparable to cashew or chestnut.
- The seeds can also be ground or boiled. The beans keep well, due to their hard outer shell.
- The tuber is also edible, but needs to be harvested from young plants (one or two years old) - after this age the tuber becomes astringent and fibrous.
- Another interesting marama bean product is its flour. The flour of *Tylosema esculentum*, prepared from heated or unheated marama beans, has a potential as a functional food ingredient. However although studies about its nutritional and physicochemical properties are lacking, the flour is protein-rich.
- Protein-based ingredients of marama bean are similar to those commercially available from soybean. Therefore, the flour of *Tylosema esculentum* has the potential to be used as a protein supplements in composite flours with cereals to improve the protein quality (Maruatona et al., 2010).

- The milk of the marama bean is a creamy white water extract very similar to dairy milk or soymilk. The milk can be consumed in the form of a refreshing and nutritious beverage just like dairy milk or soymilk. Though it is not available commercially (Jackson et al., 2010).
- The milk of the marama bean has high levels of sodium (47.9 mg/100 g) and iron (3.7 mg/100 g) compared to soymilk and dairy milk, with much a lower calcium content (6.8 mg/100 g). In order to get marama milk several processing steps are involved: Thermal treatment (blanching and roasting of the beans), cracking, milling, suspending in water, boiling and filtration to obtain a milk-like phase (Jackson et al., 2010).
- It is most common to eat the marama beans as mature beans when the seeds are surrounded by a hard and woody seed coat, which has a reddish to brownish color. But the beans can also be eaten when they are still immature green beans (Jackson et al., 2010).
- *Tylosema esculentum*, also known as the Marama bean, is a perennial legume that grows in arid Southern African environments. Indigenous natural food sources, such as this specific perennial legume, are essential for rural livelihoods, especially for communities living in extremely harsh environmental conditions where there is little to no rainfall. The plant's ability to be cultivated in harsh and arid environments is due to its large tuber structure that stores high amount of water and soil nutrients, making *Tylosema esculentum* a drought tolerant crop. Many families of Southern African regions grow the Marama bean locally, but are unaware of its high nutritional value.
- *Tylosema esculentum* can also be used for other nutritional sources such as for oil, milk, and flour. After learning more about the benefits of nutrition of this perennial legume, many families hope to have the Marama bean as part of the commercial market in order to stabilize food security and improve food diversity.

Forage

The potential uses of the marama bean go beyond the role of only being a food plant. The foliage of the plant serves as forage for livestock and wildlife in Southern Africa because the leaves are highly palatable. Since the marama bean is used to grow in harsh environments it could be used as a feed crop in the drier parts of Africa. While using it as forage one does also protect the soil by conserving its moisture and preventing from soil erosion by wind and water. Furthermore, there would be a build-up in organic matter, which would be beneficial for soils which are poor in nutrients (Dakora, 2013).

Heterostylous and its evolutionary significance

Tylosema esculentum is heterostylous, meaning that two or three morphological types of flowers exist in the population. For this specific legume, its pistil and anthers show reciprocal heights in two morphological types. Experiments involving *in vivo* fertilization (naturally occurring crosses of living organisms) and in vitro fertilization (crosses done in a laboratory setting) indicated that a two-allele self-incompatibility system exists in *Tylosema esculentum.* Having a successful self-incompatibility system evolutionarily benefits this plant because it promotes more out-crossing and in turn creates more diversity within a population. Diversity in a population is important and beneficial because the population has a stronger defense against a lethal or harmful virus or bacteria infecting the entire population. The evolutionary significance of *Tylosema esculentum* is that the discovery of the function heterostylous plant was the first in the Fabaceae family (Heartley et al., 2002).

Vigna aconitifolia **(Jacq.) Maréchal;** Moth bean, Moth gram, Mat bean, Dew bean, Dew gram, Haricot mat, Mat, Haricot papillon:

Synonym: *Phaseolus aconitifolius* Jack. (1768)

Moth bean is native to India, Pakistan and Myanmar where it grows both wild and cultivated. It is also grown in other parts of Asia, Africa, the United States and Cuba. As a pulse it is mostly grown in India and Thailand; elsewhere it is mostly a forage, green manure or cover crop. In tropical Africa it has been recorded from Sudan, Eritrea, Somalia, Kenya and Botswana (Kay,1979; Thulin,1983; Hanelt, 2001 and Nimkar et al., 2005).

Annual, slender, hairy herb with short, angular, erect stem up to 40 cm tall and many prostrate branches up to 150 cm long. Leaves alternate, 3-foliolate; stipules lanceolate, c. 12 mm long, peltate; petiole 5–10 cm long, grooved; stipels small; leaflets 5–12 cm long, deeply divided into 3–5 narrow lobes. Inflorescence an axillary, head-like, dense false raceme; peduncle 5–10 cm long. Flowers bisexual, papilionaceous; pedicel 5–8 mm long; calyx campanulate, c. 2.5 mm long; corolla yellow, standard orbicular, up to 8 mm long, wings c. 6 mm long, keel sickle-shaped, c. 7 mm long; stamens 10, 9 united and 1 free; ovary superior, sessile, c. 4 mm long, style incurved. Fruit a cylindrical pod 2.5–5 cm × 0.5 cm, brown, covered with short stiff hairs, 4–9-seeded. Seeds rectangular to cylindrical, 3–5 mm × 1.5–2.5 mm, whitish green, yellow to brown, often mottled with black; hilum white, linear. Seedling with epigeal germination. *Vigna* comprises about eighty species and occurs throughout the tropics. *Vigna aconitifolia* belongs to subgenus *Ceratotropis*, which also includes *Vigna radiata* (L.) R.Wilczek (mung bean), *Vigna umbellata* (Thunb.) Ohwi & H.Ohashi (rice bean), *Vigna mungo* (L.) Hepper (black gram) and *Vigna angularis* (Willd.) Ohwi & H.Ohashi (adzuki bean). In India numerous landraces and cultivars of moth bean exist.

For germination of moth bean a temperature of 25–27°C is optimal. Vegetative development starts slowly. Moth bean is predominantly self-pollinated and takes 75–90 days after sowing to mature. It effectively nodulates with *Bradyrhizobium* strains from the cowpea cross-inoculation group.

In India moth bean is the most drought-resistant pulse crop and particularly cultivated in hot, arid to semi-arid regions (Narain et al., 2000). For optimum production it requires an average temperature of 24–32°C, but it withstands daytime temperatures up to 45°C (Narain et al., 2000). In India moth bean is grown from sea-level up to an altitude of 1300 m. Moth bean thrives with a well-distributed annual rainfall of 500–750 mm, but it is also grown successfully in areas with as low as 200–300 mm annual rainfall. Even with as little as 50–60 mm in 3–4 showers during the growing period, some yield can be obtained. Moth bean is a quantitative short-day plant, but day-neutral types are also known. It grows on many soil types but is particularly suitable for dry light sandy soils. It does not tolerate waterlogging. Some degree of salinity and a wide pH range (3.5–10) are tolerated. Moth bean is propagated by seed; the 1000-seed weight is 10–35 g. It should be sown on a well-prepared seedbed. Moth bean is usually broadcast, at a seed rate of 10–20 kg/ha when grown for seed as a sole crop and 7–34 kg/ha when grown for forage. When sown in rows the seed rate is 2–5 kg/ha for pure stands; it is sown in rows 30–90 cm apart at a depth of 2.5–4 cm. When grown as a rainfed crop in arid regions best results were obtained in India by planting equal amounts of early and late types in alternate rows. Moth bean is frequently sown towards the end of the rainy season and grown on residual soil moisture.

Weed control is important until a full canopy has developed. Irrigation and fertilizer applications are rare. The most important diseases of moth bean are mung bean yellow mosaic virus (MYMV) transmitted by white fly (*Bemisia tabaci*), and root rot and seedling blight caused by *Macrophomina phaseolina*, which is soil- and seed-borne. Cultivars resistant to yellow mosaic are available; some cultivars are moderately resistant to *Macrophomina phaseolina*. Moth bean is also affected by nematodes, especially *Meloidoigyne incognita*. It is parasitized by several *Striga* species. Bruchids (*Callosobruchus* spp.) feed on the seed during storage. Plants are difficult to harvest with a mower because of the prostrate branches. They are usually cut with a sickle, left to dry for one week, then threshed and winnowed. Average seed yields of moth bean are only 70–270 kg/ha, although in the United States and Australia experimental seed yields of up to 2600 kg/ha have been obtained. Yield of green matter for forage is 37–50 t/ha and of hay 7.5–10 t/ha.

Nutritional and chemical constituents

- Mature, raw moth bean seeds contain per hundred g edible portion: water 9.7 g, energy 1435 kJ (343 kcal), protein 22.9 g, fat 1.6 g, carbohydrate 61.5 g, Ca 150 mg, Mg 381 mg, P 489 mg, Fe 10.9 mg, Zn 1.9 mg, vitamin A 32 IU, thiamin 0.56 mg, riboflavin 0.09 mg, niacin 2.8 mg, vitamin B_6 0.37 mg, folate 649 μg and ascorbic acid 4.0 mg.
- The essential amino-acid composition per hundred g edible portion is: tryptophan 147 mg, lysine 1248 mg, methionine 220 mg, phenylalanine 1028 mg, valine 734 mg, leucine 1541 mg and isoleucine 1138 mg.
- The principal fatty acids are per 100 g edible portion: linoleic acid 485 mg, palmitic acid 313 mg, linolenic acid 265 mg, oleic acid 129 mg and stearic acid 51 mg (USDA, 2005).
- The protein has a lower digestibility than that of mung bean (*Vigna radiata* (L.) R.Wilczek). The digestibility of the starch and protein is

considerably improved by processing treatments such as soaking, removal of the seed coat, germination and pressure cooking (Negi et al., 2001).

Genetic resources

The largest germplasm collection of moth bean is at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, India, where more than 1000 accessions are held. Smaller collections are available in the United States (USDA Southern Regional Plant Introduction Station, Griffin, Georgia, 56 accessions), Kenya (National Genebank of Kenya, Crop Plant Genetic Resources Centre, Kikuyu, 47 accessions) (van Ores, 1989) and the Russian Federation (N.I. Vavilov All-Russian Scientific Research Institute of Plant Industry, St. Petersburg, 56 accessions). Increased efforts in germplasm collection, characterization, evaluation and preservation are recommended (Brink and Jansen, 2001). Improved moth bean cultivars have been developed and released in India, e.g. 'RMO-40', 'RMO-225', 'RMO-257', 'RMO-435' and 'Jwala' (Kathju et al., 2003; Khatri et al., 2004 and Rathore, 2001). Genetic transformation of moth bean has been achieved using particle bombardment or *Agrobacterium* -mediated transfer (Kamble et al., 2003).

Prospects

Moth bean is considered to be one of the most drought-tolerant pulse crops, but its spreading habit, which makes harvesting difficult, and the lack of information on its potential and on appropriate management practices limits its spread and use. Although recorded from various countries, it has not become important in tropical Africa (NAS, 1979). It could, however, increase production of food and forage in arid and semi-arid regions, and protect the soil against erosion. The ecological limits, optimal cultivation practices and most appropriate cultivars should be investigated. Priorities for breeding include the development of erect, early maturing types, resistance to diseases and high nutritional quality of the seed.

➢ **Ethno-botanical potential:**

- The ripe whole or split seeds of moth bean are eaten cooked or fried.
- Sprouted and cooked seeds are preferred as breakfast items in India whereas fried splits are consumed in the form of a ready to eat product.
- The seeds are sometimes ground into flour, which is mixed with other flours to make unleavened bread.
- The immature pods are sometimes eaten boiled as a vegetable.
- In India the pod walls and residues left after the preparation of dal are fed to animals.
- Moth bean is also grown for green manure, forage and hay and as a cover crop.
- In India moth bean is grown as a sole crop or inter cropped with pearl millet, sorghum or other cereals, occasionally with pulses. It is grown as a green manure in rotation with cotton.

➢ **Ethno-medicinal potential:**

- Seeds are used medicinally in diets to treat fevers; roots are said to be narcotic.

➢ **Production and international trade:**

- In India moth bean is grown on 1.5 million ha producing annually about 0.4 million t of seed which is traded and consumed within the country. Worldwide moth bean is grown on about two million ha.

Vigna radiata **(Linn.) R. Wiliz.,** Green gram, Mudga, Mung, Pesalu, Thua khieo, Balatonge: Wild Moong, Mung bean, Wild black gram, Ban Urad, Golden gram, Greed gram:

Synonyms: *Phaseolus radiates* Linn., *Phaseolusaureus* Roxb., *Phaseolusmungo* var *radiates* (Linn) Baker

It is a trailing or twining annual herb. Leaves trifoliate. Flowers yellow. Pods cylindrical. Commonly cultivated crop, rarely found as an escape. Phenology- February-March.

➢ **Ethno-botanical potential:**

- Used as a pulse; soup is given as a diet to patients of enlarged liver and spleen, and after recovery from acute illness.
- A poultice of it is used for checking secretion of milk and reducing distention of the mammary glands [Indian Medicinal Plants an Illustrated Dictionary].

- Being low in antinutritional factors it is a good source of minerals, proteins, provitamin A and vitamin B complex.
- The clinical evidences suggest that plant-derived foods have various potential health benefits and as a result the consumption has been growing at a rate of 5%-10% per year (Tham et al., 1998).
- Moreover, many worldwide health organizations have recommended an increase in the intake of plant-derived foods to improve health status and prevent chronic diseases (Espin et al., 2007).
- The mung bean (*Vigna radiata*) has been consumed as a common food in China for more than 2,000 years. It is well known for its detoxification activities and is used to refresh mentality, alleviate heat stroke, and reduce swelling in the summer.
- In the book Ben Cao Qiu Zhen, the mung bean was recorded to be beneficial in the regulation of gastrointestinal upset and to moisturize the skin (Min, 2001).
- The seeds and sprouts of mung beans are also widely used as a fresh salad vegetable or common food in India, Bangladesh, South East Asia, and western countries (Fery, 1990).
- As a food, mung beans contain balanced nutrients, including protein and dietary fiber, and significant amounts of bioactive phytochemicals. High levels of proteins, amino acids, oligosaccharides, and polyphenols in mung beans are thought to be the main contributors to the antioxidant, antimicrobial, anti-inflammatory, and antitumor activities of this food and are involved in the regulation of lipid metabolism (Kanatt et al., 2011; Randhir et al., 2004; Vanamala et al., 2006 and Anjum et al., 2011).
- In recent years, studies have shown that the sprouts of mung beans after germination have more obvious biological activities and more plentiful secondary metabolites since relevant biosynthetic enzymes are activated during the initial stages of germination. Thus, germination is thought to improve the nutritional and medicinal qualities of mung beans (El-Adawy et al., 2003).
- Highly efficient use of mung beans according to evidence demonstrated from scientific experiments will be beneficial to the application of mung beans as a health food, medicine, and cosmetic (Golob, 1999).
- The knowledge about the nutritional value, chemical constituents, and metabolite changes during the sprouting process, as well as pharmacological activities, and clinical applications of mung beans, will provide a better understanding of the potential applications of this common food.

➢ **Nutritional value of mung beans as a common food:**

- Mung beans are a pulse or food legume crop used primarily as dried seeds and occasionally as forage or green pods and seeds for vegetables (Tomooko, 2002).
- Dried seeds may be eaten whole or split, cooked, fermented, or milled and ground into flour.
- Mung beans can also be made into products like soups, porridge, confections, curries, and alcoholic beverages. In western cultures, mung bean sprouts are popularly used as a fresh salad vegetable (Lambrides, 2007).
- Importantly, mung beans are composed of about 20%–24% protein. Globulin and albumin are the main storage proteins found in mung bean seeds and make up over 60% and 25% of the total mung bean protein, respectively. Therefore, due to its high protein content and digestibility, consumption of mung beans in combination with cereals can significantly increase the quality of protein in a meal (Wang et al., 2004 and Kuare et al., 2013).
- Mung bean protein is rich in essential amino acids, such as total aromatic amino acids, leucine, isoleucine, and valine, as compared with the FAO/WHO (1973) reference. However, compared with the reference pattern, mung bean protein is slightly deficient in threonine, total sulfur amino acids, lysine, and tryptophan (Mubarak, 2004). Moreover, the proteolytic cleavage of proteins during sprouting leads to a significant increase in the levels of amino acids.
- Mung beans have much greater carbohydrate content (50%–60%) than soybeans, and starch is the predominant carbohydrate in the legume. Due to its high starch content, mung beans have typically been used for the production of starchy noodles, also called muk in Korea. Oligosaccharides, including raffinose, stachyose, and verbascose, in raw or poorly processed legumes are associated with flatulence in the

human diet. While these oligosaccharides are present in mung beans, they are soluble in water and can be eliminated by adequate presoaking, germination, or fermentation. The energy offered by mung beans and sprouts is lower than that of other cereals, which is beneficial for individuals with obesity and diabetes (Zheng, 1999). In addition, trypsin inhibitors, hemagglutinin, tannins, and phytic acid found in the mung bean have also been reported to have biological functions, promoting digestion and eliminating toxins (Lin and Li, 1997).

- In addition to high protein and low energy content, mung beans also contain various enzymes and plentiful microelements. For example, superoxide dismutase (SOD) extracted from the mung bean can be chemically modified and made into an SOD oral liquid. This chemically modified SOD can avoid destruction by gastric acid and pepsin, thereby extending its half-life, making it suitable for human oral absorption (Lin and Li, 1997).
- Overall, regular consumption of mung beans could regulate the flora of enterobacteria, decrease the absorption of toxic substances, reduce the risk of hypercholesterolemia and coronary heart disease, and prevent cancer (Kruawan et al., 2012).

➢ **Ethnomedicinal potential:**

- Used in Ayurveda, Unani and Sidha.
- Seeds used for paralysis, rheumatism, coughs, fevers and liver ailments.
- Veterinary medicine, seed paste mixed with turmeric powder applied to treat dislocated bone of cattle. [CRC World Dictionary of Medicinal and Poisonous Plants]

➢ **Chemical constituents:**

- During the past few decades, flavonoids, phenolic acids, organic acids and lipids have been identified from the seeds and sprouts of mung beans and have been shown to contribute to its pharmaceutical activities

➢ **Flavonoids:**

- Flavone, isoflavone, flavonoids, and isoflavonoidsare the important metabolites found in the mung bean (Prokudina et al., 2012 and Wang et al., 2008).
- Most flavonoids have polyhydroxy substitutions and can be classified as polyphenols with obvious antioxidant activity. Vitexin (apigenin-8-C-β-glucopyranoside) and isovitexin (apigenin-6-C-β-glucopyranoside) have been reported to be present in mung bean seeds at about 51.1 and 51.7 mg g^{-1}, respectively (Li et al., 2012; Dong et al., 2008).
- Flavonoids are involved in stress protection (i.e., oxidative and temperature stress), early plant development, signaling (i.e., legume nodulation), and protection from insect and mammalian herbivores (Koes et al., 1994).

➢ **Chemical constituents identified from mung bean seeds and sprouts:**

- **Phenolic acids:**

- Phenolic acids are secondary metabolites primarily synthesized through the pentose phosphate pathway (PPP) and shikimate and phenylpropanoid pathways (Randhir et al., 2004).
- Phenolic acids are major bioactive phytochemicals, and their presence in wild plants has facilitated the trend toward the increasing use of wild plants as foods (Estomba et al., 2006 and Singh et al., 2009).
- Twelve phenolic acids have been identified from mung bean seeds and sprouts (Sosulski and Dabrowski, 1984 and Sawa et al., 1999). Based on high levels of total phenolics and total flavonoids, mung beans show the benefits of 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging activities, tyrosinase inhibition, and antiproliferative and alcohol dehydrogenase activities, which allow it to be used as a substitution for proper prescription drugs and as a preventative or therapeutic agent for the treatment of human diseases (Kim et al., 2012).

- **Others:**

- Organic acids and lipids have also been found in mung beans and sprouts. Twenty-one organic acids, including phosphoric and citric acid, and 16 lipids, including γ-tocopherol, were reported to be the major components of mung beans by gas chromatography/mass spectrometry (GC/MS) (Bowles, !990).

- **Dynamic changes in metabolites:**

- Under biotic and abiotic stress, plant physiology dramatically changes. The induction of defense systems, such as those involving proteinase inhibitors, produces a response that protects the plant from these types of stresses (Jom et al., 2011). As a part of this response, accumulation of secondary metabolites with various health benefits has been observed (Bowles, 1990 and Kessler and Baldwin, 2002). However, in the absence of stress, healthy plants can also be stimulated by stress inducers to artificially produce secondary metabolites.
- Targeted analyses have demonstrated that the germination of mung beans is accompanied by a spectrum of significant changes in metabolite contents, such as decreased antinutrient concentrations (Katoria et al., 1989) and increased levels of free amino acids (Mubarak, 2004; Katoria et al., 1989; Kavas and Sedaf, 1991; Abdel Rahman et al., 2007 and Kirchhoff, 2002).
- Germination significantly reduces the levels of reducing sugars and starches by 36.1% and 8.78%, respectively (Mubarak, 2004). Interestingly, until 60 h of incubation, levels of the monosaccharides fructose and glucose increase dramatically in the germinating material. However, significant reductions in the levels of both sugars have been observed during the final germination stage from 60 to 75 h. The concentration of the disaccharide sucrose increases within the first 24 h, but rapidly declines after the initial germination phase (El-Adawy et al., 2003; Mubarak, 2004 and Bowles, 1990). Moreover, raffinose and stachyose are completely eliminated during germination. The decline of sucrose in the latter stages of sprouting may be due to the lack of raffinose, resulting in the hydrolysis of sucrose for the energy supply (Mubarak, 2004).
- Compared to cereals, mung beans contain higher amounts of protein (Kirchhoff, 2002). As described earlier, proteolytic cleavage of proteins during sprouting leads to a significant increase in the levels of most amino acids. Additionally, increased levels of free amino acids in germinated mung beans and lentils have been observed via targeted analysis (Kavas and Sedaf, 1991 and Chau and Cheung, 1997).
- Gentistic acid, cinnamic acid, and *p*-hydroxybenzoic acid are the major phenolic acids of metabolites that are found throughout the sprouting process (Amarowicz et al., 2009). Within the first day of incubation, the levels of caffeic acid, ferulic acid, and shikimic acid are relatively low in mung bean seeds. However, after the initial soaking and early germination phase, mung bean samples exhibit significantly increasing amounts of these compounds (Singh et al., 2009). Moreover, the levels of gallic acid, chlorogenic acid, and coumarin increase dramatically in the germination material until day 3 or 4, and catechin levels increase during the final stage of mung bean sprout development (i.e., on the eighth day of incubation) (Sosulski and Dabrowski, 1984).
- The overall levels of organic acids also increase during sprouting. Phosphoric and citric acid are 2 of the major organic acid metabolites. A distinct and continuous increase in lactic acid is observed, while malic acid and citric acid peak after only 24 h of incubation (Bowles, 1990).
- Fatty acid methyl esters (FAMEs) are formed mainly from transesterification of the crude lipid extract and reflect the presence of mung bean triglycerides. Within the first 24 h of incubation, changes in the levels of most FAMEs are relatively minimal. However, after the initial soaking and early germination phase, mung bean samples exhibit significant decreases in the levels of FAMEs. In contrast, the levels of *γ*-aminobutyric acid in mung bean sprouts are enhanced throughout sprout development and may be of special interest for human nutrition because of its health-promoting effects (Bowles, 1990 and Moumita et al., 2010).
- Protease inhibitors are proteins or peptides capable of inhibiting catalytic activities of proteolytic enzymes that play essential roles in biological systems, regulating proteolytic processes, and participate in defense mechanisms against a large number of insects, fungi, and other pathogenic microorganisms (Lawrence and Kounddal, 2002). During the first 5 days of germination, there is a gradual decrease in the levels of extractable trypsin inhibitors in mung bean seeds (Lorensen et al.,

1981). The hemagglutinin activity of mung bean seeds has also been reported to decrease by about 84.4% after 3 days of germination (Messina, 1999).

Ethno-medicinal potential:

- In ancient books, mung beans were well known for their detoxification activities.
- Mung bean protein, tannin, and other polyphenols are thought to combine with organophosphorus pesticides, mercury, arsenic, and other heavy metals, promoting the excretion of sediments from the body (Zhang, 1988).
- Mung beans have been shown to possess antioxidant, antimicrobial, and anti-inflammatory activities.
- Mung beans have antidiabetic, antihypertensive, lipid metabolism accommodation, antihypertensive, and antitumor effects, among others. These various properties of this functional legume are as below:

Biological activities and compounds of mung beans:

Antioxidant effects:

- The proteins, polypeptides, polysaccharides, and polyphenols from the seeds, sprouts, and hulls of mung beans all show potential antioxidant activity. The antioxidant capacities of mung bean protein hydrolysate (MPH) have been reported as 0.67 and 0.46 µmol Trolox equivalent (TE)/mg protein, as measured by oxygen radical absorbance capacity-fluorescein ($ORAC_{FL}$) and Trolox equivalent antioxidant capacity (TEAC) assays, respectively. Freeze-drying in lactose excipient reduces the antioxidant capacity of MPH to 0.48 µmol TE/mg protein in the $ORAC_{FL}$ assay, but does not alter the results of the TEAC assay (Wongekalak et al., 2011).
- MP1 and MP2, isolated from the water extract of mung beans, are 2 acid heteropolysaccharides with 9.9% and 36.4% uronic acid content, respectively. The main composition of MP1 (molecular weight: 83 kDa) is mannose, whereas MP2 (molecular weight: 45 kDa) consists of rhamnose and galactose. MP2 exhibits higher hydroxyl radical-scavenging activity, while MP1 has higher reducing power and stronger scavenging capacity for superoxide and DPPH radicals, as well as greater inhibition of the self-oxidation of 1,2,3-phentriol than MP2 (Lai et al., 2010).
- The mung bean extracts possess significantly higher radical scavenging activities, greater reducing power, and higher levels of polyphenols than soy bean extracts, suggesting that they are superior functional foods. Indeed, the radical scavenging activities of DPPH and 2,2′-azino-di-(3-ethyl-2,3-dihydrobenzthiazoline −6-sulfonate) (ABTS) isolated from mung bean extracts were found to be 11.33 ± 0.24 and 36.65 ± 0.63 µmol/g, respectively, and the ferric reducing antioxidant power (FRAP) of mung bean extracts was 31.85 ± 3.03 µmol/g. Mung bean extracts reduce the rate of pyrogallol autoxidation by 85% compared to the control and possess SOD-like activity of $83.48\% \pm 0.88\%$ (Lee et al., 2011).
- During the sprouting process, sprout extracts show higher amounts of total phenolics, total flavonoids, and DPPH radical scavenging activity than seed extracts (Kim et al., 2012). Additionally, the antioxidant activity of mung bean sprouts is the highest on day 1 or 2, depending on the analysis method used (i.e., *β*-carotene assay or DPPH assay, respectively) (Randhir et al., 2004).
- The DPPH scavenging activity (SA) of mung bean soup (MBS; 20 mg/mL) is approximately 145% that of tea soup (5 mg/mL) and 195% that of vitamin C solution (0.15 mg/mL), indicating that the DPPH-SA of 100 g mung bean is equivalent to that of 36.3 g dried green tea and 1462 mg vitamin C. Vitexin and isovitexin are the major antioxidant components in mung beans (Cao et al., 2011). Vitexin inhibits DPPH radicals by approximately 60% at 100 µg/mL and effectively prevents UV-induced skin cell death (Kim et al., 2005).

Antimicrobial activity:

- The use of phytochemicals as natural antimicrobial agents, commonly called ‘biocides’ is gaining popularity. Enzymes, peptides, and polyphenols extracted from mung beans have been shown to possess both antimicrobial and antifungal activities. Assays for antifungal activity are usually executed using the method of inhibition crescents, while assays for antimicrobial activity are performed using the deferred plate method or the agar-diffusion method (Wang et al., 2009a and 2009b).

- A nonspecific lipid transfer peptide (nsLTP; molecular weight: 9.03 kDa) with antimicrobial and antifungal activity was isolated from mung bean seeds. Interestingly, nsLTP exerts antifungal effects on *Fusarium solani*, *F. oxysporum*, *Pythium aphanidermatum*, and *Sclerotium rolfsii* and antibacterial effects on *Staphylococcus aureus* but not *Salmonella typhimurium*(Wang et al., 2004).
- Mungin, a novel cyclophilin-like antifungal protein isolated from mung bean seeds, possesses activity against the fungi *Rhizoctonia solani*, *Coprinus comatus*, *Mycosphaerella arachidicola*, *Botrytis cinerea*, and *F. oxysporum*. Mungin also exerts inhibitory activity against α- and β-glucosidases, suppressing thymidine in corporation by mouse splenocytes (Ye and Ng, 2000).
- In 2005, a chitinase (30.8 kDa) with antifungal activity was isolated from mung bean seeds. The protein has a pI of 6.3, as determined by isoelectric focusing, and an estimated specific activity of 3.81 U/mg. The enzyme exhibits optimal activity at pH 5.4 and is stable from 40 to 50°C. Importantly, chitinase exerts antifungal activity on *R. solani*, *F. oxysporum*, *M. arachidicola*, *P. aphanidermatum*, and *S. rolfsii*(Wang et al., 2004).
- In addition to the above antimicrobial and antifungal effects, polyphenol extracts from mung bean sprouts have also been shown to have activity against *Helicobacter pylori*, one of the most common bacterial infections in human beings causing gastro-duodenal disease (Randhir et al., 2004).

- **Anti-inflammatory activity:**

- In Asia, mung beans have been used in various cuisines and in folk remedies to treat toxic poisoning, heat stroke associated with thirst, irritability, and fever; these beneficial effects of mung beans are thought to be related to the inflammatory response (Lee et al., 2011).
- Researchers have analyzed the anti-inflammatory effects of mung bean ethanol extracts on lipopolysaccharide (LPS)-stimulated macrophages. The extract mainly included polyphenols, gallic acid, vitexin, and isovitexin and markedly reduced the activity of murine macrophages through the prevention of pro-inflammatory gene expression without cytotoxicity (Yeap et al., 2012). Moreover, a study demonstrated that all pro-inflammatory cytokines, including interleukin (IL)-1β, IL-6, IL-12β, tumor necrosis factor (TNF)-α, and inducible NO synthase (iNOS), were dramatically down regulated in cells treated with 3.7 mg/mL polyphenols. These results suggested that the ethanol extract had great potential to improve the clinical symptoms of inflammation-associated diseases, such as allergies and diabetes (Bellik et al., 2012).
- The immune modulatory activities of mung bean water extracts and monomers on human peripheral blood mononuclear cells (PBMCs) have also been evaluated by BrdU immunoassay, secretion of interferon-gamma (IFN-γ) and IL-10, and elucidation of the responding cells by flow cytometry. The results demonstrated that 20 µg/mL genistein, phytic acid, and syringic acid induce a Th1-predominant immune response through significant suppression of IL-10 secretion and promotion of IFN-γ secretion. The study concluded that several non-nutritional ingredients of mung beans, such as flavonoids, acids, and plant hormones, are most likely to be important in the modulation of human immunity (Cherng et al., 2007).

- **Antidiabetic effects:**

- Studies have also investigated the antidiabetic effects of mung bean extracts. In a study conducted in 2008, the antidiabetic effects of mung bean sprout extracts and mung bean seed coat extracts were investigated in type 2 diabetic mice (male KK-A^y mice and C57BL/6 mice). These extracts were orally administered to KK-A^y mice for 5 weeks, and mung bean sprout extracts (2 g/kg) and mung bean seed coat extracts (3 g/kg) lowered blood glucose, plasma C-peptide, glucagon, total cholesterol, triglycerides, and blood urea nitrogen (BUN) levels. At the same time, both treatments markedly improved glucose tolerance and increased insulin immunoreactive levels (Yao et al., 2008).

- Phenolic antioxidants and levo-dihydroxy phenylalanine (L-DOPA) can be enriched in mung bean extracts through solid-state bioconversion (SSB) by *R. oligosporus*, with the goal of enhancing health-linked functionality. *α*-Amylase is responsible for cleaving starch during the digestive process, which is important in the management of postprandial blood glucose levels. A study in 2007 by Randir and Shetty investigated the inhibition of *α*-amylase and *H. pylori* in bioprocessed extracts and linked these effects to diabetes management and peptic ulcer management, respectively. The *α*-amylase inhibition potential of the tested sprouts extract was moderately high during early stages (days 0–2) and was higher during days 4–10, which correlated with higher phenolic content (Randhir and Shetty, 2007).

- **Lipid metabolism accommodation:**

- The modulation of lipid metabolism by mung bean has been well established. In an early study, rabbits with hyperlipidemia were fed a 70% mixture of mung bean meal and mung bean sprout powder. The mixtures affected the total cholesterol and *β*-lipoprotein content, alleviating symptoms of coronary artery diseases (Li, 1981). Additionally, in more recent studies, normal mice and rats were fed mung bean extracts for 7 days, and total cholesterol was significantly decreased in both types of rodents. This effect was thought to arise from the phytosterol content of mung beans, which was similar to blood cholesterol, facilitating the prevention of cholesterol biosynthesis and absorption (Zhang and Cai, 1995).

- **Antihypertensive effects:**

- High doses (600 mg peptide/kg body weight) of raw sprout extracts, dried sprout extracts, and enzyme-digested sprout extracts have been shown to significantly reduce systolic blood pressure (SBP) in rats after administration for 6–9, 3–6, or 3–9 h, respectively. Similar changes were found in the plasma angiotensin I-converting enzyme (ACE) activity of these mung bean extracts. A long-term (1-month) intervention study that included treatment with fresh sprout powder, dried sprout powder, and concentrated extracts of the sprouts was carried out. The results indicated that the sprout powders were not as efficacious as concentrated sprout extracts. The SBPs of rats treated with concentrated extracts of fresh and dried sprouts were significantly reduced during the intervention period from weeks 1–4 and weeks 2–4, respectively (Hsu et al., 2011).

- **Antitumor effects:**

- Mung beans have been shown to exert antitumor effects through several different mechanisms. The recombinant plant nucleases R-TBN1 and R-HBN1, similar to nucleases derived from pine pollen and mung beans, were found to be effective against melanoma tumors and were about 10-times more potent than bovine seminal ribonuclease (RNase). Due to their relatively low cytotoxicity and high efficiency, these recombinant plant nucleases appear to be stable biochemical agents that can be targeted as potential antitumor cytostatics (Matousck et al., 2009).
- In addition, mung beans have been shown to exert antiproliferative effects, as examined by MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] assay using an *in vitro* cell culture system. Mung beans exhibit dose-dependent antiproliferative effects against the tongue squamous cell carcinoma cell line CAL27 and several other cancer cell lines tested (i.e., DU145, SK-OV-3, MCF-7, and HL-60 cells) (Xu and Chang, 2012).
- Another study evaluated the effects of trypsin inhibitors from mung beans (i.e., LysGP33) on the metastasis and proliferation of human colon cancer cells (SW480 cells). In this study, the effects of the purified GST-LysGP33 active fragment on the migration of SW480 cells were detected using wound healing assays. The results showed that 10 μmol/L GST-LysGP33 active fragment affected cell migration beginning at the 24-h time point. After 72 h, cells treated with GST-LysGP33 exhibited an approximate 50% reduction in wound healing compared to the control group (Zhao et al., 2012).

- **Antisepsis effects:**

- The aqueous extract from mung bean coat (MBC) is protective against sepsis *in vitro* and *in vivo*. The effect was achieved by the inhibition of high mobility group box 1 (HMGB1), a nucleosomal protein that has recently been established as a late mediator of lethal systemic inflammation with a relatively wider therapeutic window for pharmacological interventions. It was found that MBC dose-dependently attenuated the LPS-induced release of HMGB1 and several chemokines in macrophage cultures. The animal survival rates after oral administration of MBC were significantly increased from 29.4% (in the saline group, N = 17 mice) to 70% (in the experimental MBC extract group, N = 17 mice, $P < 0.05$) (Zhu et al., 2012). Chlorogenic acid (56) has also been shown to be protective against lethal sepsis by inhibiting late mediators of sepsis. Chlorogenic acid suppresses endotoxin-induced HMGB1 release in a concentration-dependent manner in murine peritoneal macrophages. Additionally, administrations of chlorogenic acid attenuate systemic HMGB1 accumulation *in vivo* and prevented mortality induced by endotoxemia and polymicrobial sepsis (Lee et al., 2012).

The mung bean [*Vigna radiata* (L.) Wilczek] is one of the most important short-season, summer-growing legumes and is grown widely throughout tropic and subtropic regions. Mung beans have wide applications in agriculture, health food, pharmaceutical, and cosmetics industries. Mung bean seeds and sprouts are excellent examples of functional foods that lower the risk of various diseases. Moreover, the seeds and sprouts have health-promoting effects in addition to their nutritive value.

During the germination process of the mung bean, its chemical constituents undergo a series of biochemical reactions. One such reaction is the synthesis of small active compounds from macromolecular substances, promoting absorption and utilization.

Another change observed during germination is the formation and accumulation of many types of active substances, such as polyphenols, saponins, vitamin C, etc. Therefore, we believes that these changes in the chemical composition of mung beans during germination will lead to substantial and important changes in the pharmacological activities of mung beans as well.

Research into the chemical constituents and biological activities of mung bean seeds and sprouts have a solid theoretical basis for the development and utilization of mung beans. Combined with analysis of the metabolites of these chemical constituents, research investigating the physiological functions of these compounds is required for further advancement of this field. Thus, future studies may focus on the extraction and purification of new physiologically active substances in agriculture, health foods, cosmetics, and pharmaceutical applications.

***Vigna subterranea* (Linn.) Verdc.** Bambara groundnut:

Bambara groundnut*Vigna subterranea* is a leafy, annual, creeping legume with glabrous (hairless) leaves supported by a petiole 5-30 cm long. Each leaf is composed of three leaflets (trifoliolate) and can be up to 11 cm long. Yellow flowers are clustered 1-3 on an unbranched axis, known as a raceme. They are papilionaceous, typical of species belonging to the subfamily Papilionoideae, and resemble, for example, the pea flower. The peduncle (the stalk supporting the raceme) is up to 3 cm long, hairy and after flowering it expands and bends downwards so that the fruits develop underground.

The ovary, which develops into the seed pod, contains 1-4 ovules. Once mature the seeds, which can be of various colours, are almost spherical and are 8-15 mm in diameter. Bambara groundnut has a deep taproot surrounded by lateral roots bearing nitrogen-fixing nodules. Bambara groundnut grows best in dry areas with sandy soils.

It is found in Cameroon, Central African Repu, Chad, Nigeria, Sudan and it is introduced in Angola, Benin, Burkina, Dominican Republic, Ethiopia, Gambia, Ghana, Guinea, Guinea-Bissau, India, Ivory Coast, Jawa, Kenya, Madagascar, Mali, Mozambique, Namibia, New Guinea, Senegal, Sierra Leone, Swaziland, Tanzania, Togo, Uganda, Zambia, Zaïre.

Bambara groundnut (*Vigna subterranea*) is an important grain legume which grows in the semi-arid regions of Africa. Its ability to fix nitrogen and its resistance to high temperatures and drought makes it a valuable crop in areas where soils are too poor for other leguminous crops to grow. By burying its fruits in the soil it protects them from insect damage which can devastate other crops such as cowpea, common bean and soybean, whose tastiest parts are above ground.

Since it is common in the wild and in cultivation so it is not globally threatened.

Bambara groundnut most likely originated in north-eastern Nigeria and northern Cameroon, where it can still be found growing wild today. It is cultivated throughout tropical Africa and to a lesser extent in the tropical parts of the Americas, Asia and Australia.

- **Ethnobotanical potential:**

- Bambara groundnut is very nutritious, boasting a 65% carbohydrate content and an 18% protein content, making it an important addition to the diets of people who cannot afford expensive animal protein. It is considered to be a complete food and people can survive exclusively on bambara groundnut for all of their nutritional needs.
- Bambara groundnut is a lifesaver during the hungry season, the period that exists when the old crops have been eaten and the new crops have not yet been harvested.
- Despite all of these benefits it is a much underutilised and has the potential to be more than just a subsistence crop. Part of the problem is its stigma as a 'poor person’s crop'.
- Bambara groundnut is cultivated mainly for its seeds which can be boiled, roasted or fried to make a delicious snack or mixed in with maize or plantains to serve as a meal.
- The seeds can be ground into flour after roasting and used to prepare porridge or they can be soaked, boiled and ground into a paste and used in fried or steamed dishes popularly eaten in Nigeria.
- The flour can also be used as a thickener in soups and stews and in Zambia it is commonly made into bread.
- Milk can be made from the seeds and fermented products similar to tempeh and dawadawa can be prepared.Besides being a food crop, the seeds and leafy shoots of bambara groundnut, which are rich in protein and phosphorus make good fodder for pigs and poultry.
- The Millennium Seed Bank and the Global Crop Diversity Trust are engaged in a ten-year project, called 'Adapting Agriculture to Climate Change'. The project aims to protect, collect and prepare the wild relatives of 29 key food crops, including bambara groundnut, so that they are available to pre-breeders for the development of new varieties that are more resilient to the effects of climate change.
- Its ability to fix nitrogen and its resistance to high temperatures and drought makes bambara groundnut a valuable crop with enormous potential to be grown on a larger scale, providing food security for many more people.
- The Millennium Seed Bank Partnership aims to save plants worldwide, focusing on those plants which are under threat and those which are of most use in the future. Once seeds have been collected they are dried, packaged and stored at -20°C in Kew’s Millennium Seed Bank vault.
- It is being used as food, fodder and as medicine.

- **Ethnomedicinal potential:**

- Bambara groundnut also has a number of medicinal uses.
- In Senegal leaf preparations are applied as a poultice for infected wounds and abscesses.
- The leaf sap is applied to the eyes as a treatment for epilepsy.
- The pounded seeds mixed with water are used to treat cataracts.
- The roots of the plant can be taken as an aphrodisiac.
- Evidence suggests that high fibre foods such as bambara groundnut can reduce the incidence of heart disease and help to prevent colon cancer.
- Bambara groundnut improves the quality of the soil because of its ability to fix nitrogen from the air. It is therefore a good companion in crop rotations.

***Vigna umbillata* (Thunb.) Ohwi & H.Ohash,** Rice bean

Synonym: *Phaseolus calcaratus* Linn.

Rice bean, a less known and underutilized legume, has emerged as a potential legume because of its nutritional potential. The nutritional quality of rice bean is higher as compared to many other legumes of Vigna family.

Practical application

Vigna umbellata (Thunb.) Ohwi and Ohashi is a warm-season annual vine legume with yellow flowers and small edible beans. To date, it is little known, little researched and little exploited. It is regarded as a minor food and fodder crop and is often grown as intercrop or mixed crop with maize (*Zea mays*), sorghum (*Sorghum bicolor*) or cowpea (*Vigna. unguiculata*), as well as a sole crop in the uplands, on a very limited area. Like the other Asiatic *Vigna* species, rice bean is a fairly short-lived warm-season annual. Grown mainly for dried pulse, it is also important as a fodder, a green manure and a vegetable. Rice bean is most widely grown as an intercrop, particularly of maize, throughout Indo-China and extending into southern China, India, Nepal and Bangladesh. In the past it was widely grown as lowland crop on residual soil water after the harvest of long-season rice, but it has been displaced to a great extent where shorter duration rice varieties are grown. Ricebean grows well on a range of soils. It establishes rapidly and has the potential to produce large amounts of nutritious animal fodder and high quality grain. The cultivated Asiatic Vigna species belong to the sub-genus *Ceratotropis*, a fairly distinct and homogeneous group, largely restricted to Asia, which has a chromosome number of 2n = 22 (except *V. glabrescens*, 2n = 44). There are seven cultivated species within the sub-genus, including mung bean or green gram (*V. radiata*), black gram or urad bean (*V. mungo*), adzuki bean (*V. angularis*) and moth bean (*V. aconitifolia*) as well as a number of wild species. Artificial crosses have been made between *V. mungo* and *V. umbellata* to produce improved mung bean varieties (Singh et al., 2006). There are three more or less secondary gene pools within the group: ricebean is closer to *V. angularis* than to the other species, being in the Angulares group (Tomooka et al., 2003). Rachie and Roberts (1974) classed ricebean as adapted to subhumid regions with 1000–1500 mm precipitation, although they noted that other factors were also involved in adaptation, for example rainfall pattern, moisture distribution, temperature, cloud cover and relative humidity, soil characteristics, pests and diseases. They noted the importance of human needs in assessing adaptation – for example taste, the need for a particular use, or market price. Average yields were between 200 and 300 kg ha^{-1}, although with the potential for 1200 kg ha^{-1}, the crop would grow on a range of soils, and was resistant to pests and diseases. It would mature in as little as 60 days, and although performing well under humid conditions, was also tolerant to drought (NAS 1979) and high temperatures. It is tolerant to some degree of water logging, although the youngplants appear to be susceptible (de Carvallho & Veira, 1996). Ricebean is also known to be tolerant to acid soils (Dwivedi, 1996). Shattering is a problem in comparison with other grain legumes, and can be particularly serious under conditions of frequent wetting and drying.

Sixteen diverse rice bean genotypes were evaluated for major nutritional constituents viz; protein content, total lipids, dietary fiber, total carbohydrates, vitamins, minerals, protein fractions, amino acid, and fatty acid profile (Katoch, 2013). The protein content to the extent of 25.57% was observed in the genotype BRS-2 with in vitro digestibility of 54.23%. The fatty acid profile revealed the higher percentage of unsaturated fatty viz., linoleic and linolenic acid, which are nutritionally desirable in the diet. Albumins (6.13% to 7.47%) and globulins (13.11% to 15.56%) constituted the major portion of proteins. Anti-nutritional factors were in the range of: total phenolics (1.63% to 1.82%), total tannins (1.37% to 1.55%), condensed tannins (0.75% to 0.80%), hydrolysable tannins (0.56% to 0.79%), trypsin inhibitor (24.55 to 37.23 mg/g), phytic acid (7.32 to 8.17 mg/g), lipoxygenase activity (703 to 950 units/mg), and saponin content (1.2 to 3.1 mg/100 g). The oligosaccharides associated with the production of flatulence viz., raffinose, stachyose, and verbascose were in the limits of 1.66% to 2.58%, 0.94% to 1.88%, and 0.85% to 1.23%, respectively. In vitro protein digestibility up to 55.57% was observed in rice bean genotypes. The study of Katoch (2013) has revealed that rice bean is a nutritionally rich legume as compared to many other legumes of the category. Among different genotypes BRS-2 was observed superior and could be advocated for consumption as well as for inclusion in crop improvement programs.

Ricebean is a neglected crop, cultivated on small areas by subsistence farmers in hill areas of Nepal, Northern and Northeastern India, and parts of Southeast Asia. It can be grown in diverse conditions and is well known among farmers for its wide adaptation and production even in marginal lands, drought-prone sloping areas, and flat rainfed tars (unirrigated, ancient alluvial river fans). It is mainly grown between 700 and 1300 m above sea lavel, although in home gardens it is found from 200 up to 2000 m. Most of the crop currently grown in Nepal is used as food for humans, with a smaller proportion used for fodder and green manuring.

Generally, ricebean is grown as an intercrop with maize, on rice bunds or on the terrace risers, as a sole crop on the uplands or as a mixed crop with maize in the **khet** (bunded parcels of lands where transplanted rice is grown) land. Under mixed cropping with maize it is usually broadcast sometime between sowing maize and that crop's first and second earthing up, so ricebean sowing extends from April–May to June.

Wild forms are typically fine-stemmed, freely-branching and small-leaved, with a twining habit, photoperiod sensitivity and indeterminate growth (Lawn, 1995). Flowering is asynchronous, and there is a tendency to hard seeds. In many areas, landraces which retain many of these characteristics persist, in particular with regard to daylight sensitivity, growth habit and hard seeds. Seed colour is variable, but commonly red or yellow. The red type is commonly named in Chinese, literally meaning 'red small bean'. It's considered an herb in Traditional Chinese Medicine.

➢ **Ethno-botanical potential:**

- Ricebean plays an important role in human, animal and soil health improvement. All varieties seem to be good sources of protein, essential amino acids, essential fatty acids and minerals (Mohan and Janardhanan, 1994), and the dried seeds make an excellent addition to a cereal-based diet.
- Rice bean is nutritionally rich legume, but despite its nutritional excellence, it has been put in underutilized category. Because of this and several other reasons the people are not aware of its nutritional benefits. Moreover, the complete nutritional details are also not available on this pulse. The study of Katoch (2013) provides vivid description of nutritional attributes of this legume for making people aware of its nutritional excellence and provoking improved work in rice bean.
- Ricebean is most often served as a dal, either soaked overnight and boiled with a few spices, or cooked in a pressure cooker.
- Apart from various recipes for dal soups and sauces, pulses are also used in a number of other ways, either whole, cooked or roasted, as flour, or ground to make various deep fried dishes or snacks. Some recipes are specific to particular pulses, but many are open to substitution.
- The consumption of green pods as a vegetable has been recorded but is not widespread, although the indeterminate growth habit of many varieties is beneficial in providing a steady supply of green pods over long periods of the year.
- The raw protein content of ricebean is lower than that of most pulses, although there is considerable variation. Gopinathan *et al.* (1987) note that the protein content of related wild species (e.g. *Vigna minima*) tends to be higher than of cultivated lines, so there may be potential to breed for improved protein content. However, the amino acid composition is reported by several authors to be well balanced for human consumption (e.g. Chandel et al., 1978; Mohan and Janardhan, 1994; de Carvalho and Vieira, 1996).
- As in other pulses, an important problem is that ricebean contains various antinutrients, notably phytic acid or phytate, polyphenols and fibres that reduce micronutrient uptake, in particular iron and zinc. Breeding for low phytate seeds is possible, but there are conflicting opinions about its desirability because phytate is also a human nutrient, and also plays various roles in the life cycle of the plant.
- Special concern for flatulence-producing substances is important when a pulse is promoted for human consumption (Smil, 1997). Revilleza et al. (1990) tested the content of known flatulence-producing oligosaccharides in common legumes from the Philippines and ranked them on their flatulence-producing potential: Sam-samping (*Clitoria ternatea*) > hyacinth bean (*Lablab purpureus*, syn. *Dolichos lablab* L.) > Lima bean (*Phaseolus lunatus*) > swordbean (*Canavalia gladiata*) > ricebean > jack bean (*Canavalia ensiformis*). Two different varieties of ricebean contained 2.25 and 2.55% oligosaccharides. Kaur and Kawatra (2002) measured the effect of soaking, open pan cooking, pressure cooking, sprouting and combinations of these. All led to a significant reduction of the content of flatus-producing sugars, although the most effective was a combination of sprouting and pressure

cooking.

- While most legumes contain one or several enzyme inhibitors and similar antinutritive or toxic factors (Smil, 1997), the content of such substances appears to be low in ricebean.
- Ricebean is valuable as a high class fodder which is known to increase milk production in livestock (Baek et al., 2011).

➢ **Ethno-medicinal potential:**

- No information is available regarding any "folk medicine" use in Nepal or India.

In South Asia, the idea of a division of foods into hot, cold and neutral is very common. This has an important bearing on dietary choices, as this perception not only promotes a balance between hot and cold food stuffs in daily nutrition, but also encourages or discourages the consumption of various items according to season, and during sickness. An account of the perception of a number of food items in Nepal has been published by Gittelsohn et al. (1997). Their data shows that there is hardly any "scientific" basis for the division into hot and cold foods. For instance, yogurt is cold while goat milk is hot, buffalo meat is cold while fish and chicken is hot, and black gram is cold while red gram (cowpea) is hot. It should be noted that this perception tends to be location-specific, so these findings cannot be generalised all over Nepal (or South Asia!). In Nepal, ricebean tends to be categorised as a cold food (e.g. in Gulmi, Kailali, Syangja, Dang, Gorkha districts) and it is said to cool people in the summer. However, it is also said to make people warm during the winter. In Ilam District in Eastern Nepal, ricebean is considered hot, and there it is advised that old and sick people should not eat it during the hot season, as it is not easily digested and weak people would get stomach problems from eating it.

Another account from Ilam stated that ricebean, although creating some stomach unrest, was milder and more digestible than other pulses, and therefore often served to people who suffer from indigestion. Whether hot or cold, the major share of ricebean is consumed soon after harvest, so the crop will only indirectly impact on food security during the lean season in the pre- and early monsoon period.

Some oral evidence from Nepal says that ricebean does not have a particular ceremonial role. This is in contrast to black gram which is used for ceremonial purposes among high caste Hindus, and also for instance among Rai people in the Arun Valley. In addition, black gram is considered tastier and fetches a higher market price, so will tend to replace ricebean if the farmer has to make a choice.

Quantee (or kwati in Newari) is a mixed bean sprout soup served at the Janai Purnima or Raksha Bhandan festival. Ricebean is one of nine beans prescribed for this recipe. The festival marks the end of the monsoon where people by traditional perception (and probably also in reality) have been weak, undernourished and subject to diseases. In this respect, *quantee* is said "to make one strong" and to purify the stomach as the mixed bean sprouts are hard to digest and so cleans the stomach. In addition, eating *quantee* is said to kill a certain type of mosquito (Löwdin, 1998).

While ricebean in Nepal is to some extent perceived as a "poor man's food", it is not particularly stigmatised, so no ethnic or caste group actually has a rule against it. In Dang, ricebean is particularly enjoyed by Tharu (indigenous Terai) people, who have a version of *quantee* which requires ten different beans. One source mentioned that since ricebean is supposed to make you strong, people will often serve it to labourers, while also occasionally consuming it themselves in connection with tasks requiring hard work.

Potential

So far little has been done to exploit ricebean's potential: there are several features that need attention from breeders before it could be widely adopted. Most varieties are highly photoperiod sensitive, and so when grown in the subtropics are late flowering and show strong vegetative growth. Their twining habit makes them very suitable for use as intercrops with such species as maize, sorghum and possibly some of the minor millet species, which can provide support, but also makes them difficult to harvest.

Many of the current varieties are susceptible to shattering, and show high levels of hard seededness. Some crop improvement work has been carried out on ricebean in India, but not in Nepal. However, the use of ricebean as a green manure crop was studied in a series of field experiments in Nepal, and this revealed that it is one of the best legumes for the purpose due to high biomass production over a short period of time, is easy to incorporate into the soil, and decomposes rapidly.

Phytochemicals

Catechin-7-O-glucoside can be found in the seed of *V. umbellata*. *In vitro*, this compound has an antioxidant activity leading to a cytoprotective effect (Baek et al., 2011, Kim et al., 2011). Rice bean, a less known and underutilized legume, has emerged as a potential legume because of its nutritional potential. The nutritional quality of rice bean is higher as compared to many other legumes of Vigna family.Sixteen diverse rice bean genotypes were evaluated for major nutritional constituents viz; protein content, total lipids, dietary fiber, total carbohydrates, vitamins, minerals, protein fractions, amino acid, and fatty acid profile (Katoch, 2013) . The protein content to the extent of 25.57% was observed in the genotype BRS-2 with in vitro digestibility of 54.23%. The fatty acid profile revealed the higher percentage of unsaturated fatty viz., linoleic and linolenic acid, which are nutritionally desirable in the diet. Albumins (6.13% to 7.47%) and globulins (13.11% to 15.56%) constituted the major portion of proteins. Anti-nutritional factors were in the range of: total phenolics (1.63% to 1.82%), total tannins (1.37% to 1.55%), condensed tannins (0.75% to 0.80%), hydrolysable tannins (0.56% to 0.79%), trypsin inhibitor (24.55 to 37.23 mg/g), phytic acid (7.32 to 8.17 mg/g), lipoxygenase activity (703 to 950 units/mg), and saponin content (1.2 to 3.1 mg/100 g). The oligosaccharides associated with the production of flatulence viz., raffinose, stachyose, and verbascose were in the limits of 1.66% to 2.58%, 0.94% to 1.88%, and 0.85% to 1.23%, respectively. In vitro protein digestibility up to 55.57% was observed in rice bean genotypes. The present study has revealed that rice bean is a nutritionally rich legume as compared to many other legumes of the category. Among different genotypes BRS-2 was observed superior and could be advocated for consumption as well as for inclusion in crop improvement programs.

➢ **Ethno-botanical potential:**

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- It is regarded as a minor food and fodder crop and is often grown as intercrop or mixed crop with maize (*Zea mays*), sorghum (*Sorghum bicolor*) or cowpea (*V. unguiculata*), as well as a sole crop in the uplands, on a very limited area

***Vigna unguiculata* (Linn.) Walp. subsp. *cylindrica* (Linn.) van Zesltine,** Cow pea, Croder pea, Black eyed pea, Southern pea:

Synonyms: *Vigna catiang* (Burm. F.) Walp, *Vigna sisensis* (Linn.) Savi ex Hassk., *Vigna unquiculata* var**.** *cating* (Burm.F) Bertoni and *Phaseolus cylindricusm* Linn.

Annual herb, erect or suberect, spreading, to 80 cm or more tall, glabrous, taproot stout with laterals near soil surface, roots with large nodules, stems usually procumbent, often tinged with purple, first leaves above cotyledons are simple and opposite, subsequent trifoliolate leaves are alternate, the terminal leaflet often bigger and longer than the two asymmetrical laterals, petiole, stout, grooved, 5–15 cm long; leaflets ovoid-rhombic, entire or slightly lobed, apex acute, 6.5–16 cm long, 4–11 cm wide, lateral leaflets oblique; inflorescence axillary, 2–4-flowered, crowded, near tips on short curved peduncles 2.5–15 cm long; calyx campanulate with triangular teeth, the upper 2 teeth connate and longer than rest; corona dull white, yellow, or violet with standard 2–3 cm in diameter, keel truncate; stamens diadelphous, the anthers uniform; pods curved, straight or coiled; seeds 2–12 mm long, globular to reniform, smooth or wrinkled, red, black, brown, green buff or white, as dominant color; full colored, spotted, marbled, speckled, eyed, or blotched; (5–30 g/100 seeds, depending on the cv). Germination phanerocotylar. Fl. early summer. Fr. mid- and late summer, depending on the cv sensitivity tp; pca; photoperiod and tmperature conditions.

The most sensitive collection of germplasm (and literature) is at IITA (over 7,000 cv accessions in 1975). Cowpea cvs may be grouped in the following manner for the United States: 'Crowder peas': seeds black, speckled, brown, or brown-eyed, crowded in pods, seed usually globose; 'Brown Crowder' a good cv in Puerto Rico; 'Black-eyed': seeds white with black-eye around hilum, not crowded in pods. Extensively grown in California and southeastern United States and Puerto

Rico; 'Cream' cvs: seed cream-colored, not crowded in pods; intermediates between 'Crowder' and 'Black-eyed' types, as 'Purple Hill' with deep purple mature pods and buff or maroon eyed seed; forage cvs: as 'New Era,' useful also for dry seeds in other geographical locations, e.g. western Africa. Other standard cvs are: 'Block,' 'Brabham,' 'Early Bluff,' 'Iron,' 'Taylor,' and 'Victor.' 'Gub-gub' is an excellent table cv. Assigned to the African and Hindustani Centers of Diversity, cowpea or cvs thereof as reported to exhibit tolerance to aluminum, drought, high pH, heat, laterite, low pH, nematodes, poor soil, shade, slope, virus, weeds, and wilt (2*n* = 22.).

Distribution

Of ancient culture in Africa and Asia, and widespread in Africa, spreading by way of Egypt or Arabia to Asia and the Mediterranean. Now widely cultivated throughout the tropics and subtropics. Wild and cultivated forms readily cross. Steele (1972) and Sauer (1952) agree on a solely Ethiopian center of origin, followed by subsequent evolution predominantly In the ancient farming systems of the African Savanna.

Ecology

Thrives on many kinds of soil, from highly acid to neutral; less well adapted to alkaline. Crop grows and yields at relatively low fertility levels, but often responds to P fertilization, N applications rarely effective on well-nodulated plants. Can withstand considerable drought and a moderate amount of shade, but is less tolerant of waterlogging than soybean. Some plants are indeterminant in growth, and continue to grow until killed by frost. In the tropics, such indeterminate plants may be weak perennials and continue growing as long as conditions are favorable.

In some determinate types, the later flower initiation, the higher up the stem it is, the more flowers, and the greater the ultimate seed yield providing the growing season is sufficiently long. Dry matter production, seed yield, and root nodulation are reduced in photoperiods less than 12 hr, 13 min. Differences of as short as 12 min can affect flowering and seed yield. Cowpeas are short-day, warm-weather plants, sensitive to cold and killed by frost. They tolerate heat and relatively dry conditions and can be grown with less rainfall and under more adverse conditions than *Phaseolus vulgaris* or *P. lunatus*. Over a range of 21°C day/16°C night to 36°C day/ 31°C night dry matter production was greater at 27°C day/22°C night. Night temperatures strongly affect many phases of the life cycle and differences in day temperature during reproductive growth markedly affect crop duration and yield. Marked cv differences in environmental responses have been identified. Ranging from Warm Temperate Thorn to Moist through Tropical Thorn to Wet Forest Life Zones, cowpea is reported to tolerate anntial precipitation of 2.8–41.0 dm (mean of 54 cases = 14.2). Annual mean temperature of 12.5° - 27.8°C (mean of 54 cases = 22.1), and PH of 4.3–7.9 (mean of 46 cases = 6.2).

➢ Ethnobotanical potential:

- The plant is cultivated for the seeds (shelled green or dried).
- The pods and/or leaves that are consumed as green vegetables.
- The plant is also used for pasturage, hay, ensilage, and green manure.
- The tendency of indeterminate cvs to ripen fruits over a long time makes them more amenable to subsistence than to commercial farming. However, erect and determinate cvs, more suited to monocultural production systems, are now available. If cut back, many cvs continue to produce new leaves, that are eaten as a potherb.
- Leaves may be boiled, drained, sun-dried and then stored for later use.
- In the United States, green seeds are sometimes roasted like peanuts.
- The roots are eaten in Sudan and Ethiopia.
- Scorched seeds are occasionally used as a coffee substitute.
- Peduncles are retted for fiber in northern Nigeria.
- The crop used to some extent as pasture, especially for hogs, and may be used for silage, for which it is usually mixed with corn or sorghum.
- The crop is very useful as a green manure, and leafy prostrate cvs reduce soil erosion.
- *Vigna unguiculata* ssp. *unguiculata* (Linn.) Walp is a vinous plant widely cultivated in Bangladesh for its edible beans, which are cooked and consumed as vegetable. Various sub-species of *Vigna unguiculata* beans are consumed throughout the World including Bangladesh Tazin et al. (2014).

➢ **Folk medicine:**

- Cowpeas are sacred to Hausa and Yoruba tribes, and are prescribed for sacrifices to abate evil and to pacify the spirits of sickly children. Hausa and Edo tribes use cowpeas medicinally, 1 or 2 seeds ground and mixed with soil or oil to treat stubborn boils.

➢ **Ethno-medicinal potential:**

- The plant is considered to have ethnomedicinal importance (Tazin et al., 2014).
- Seeds of the plants are taken in Kerala, India, for menstrual disorders (Rajith et al., 2012).
- The seeds are also used for menstrual disoreders in Northern Telangana, India (Suther et al., 2014).
- The roots are used against syphilis, gonorrhea, and sexually transmited diseases in Nebbi district, Uganda (Anywar et al., 2014).

Chemistry

Raw mature seeds typically contain (per 100 g): ca. 11.4% moisture, 338 calories, 22.5g protein. 1.4 g fat, 61.0 g total carbohydrate, 5.4g fiber. 3.7 g ash, 104 mg Ca, 416 g P, 0.08 mg thiamine, 0.09 mg riboflavin, 4.0 mg niacin, and 2 mg ascorbic acid. In results at IITA, based on seveal thousand distinct cvs, protein averaged 23–25%, protein, ranged from 18 to 29%, with potential for perhaps 35%. The proteins consist of 90%, water-insoluble globulins and 10% water-soluble albumins. The reported amino acid content is (mg/g N): isoleucine, 239, leucine 440, lysine 427, methionine 73, cystine 68, phenylalanine 323, tyrosine 163, threonine 225, tryptophan 68, valine 283, arginine 400, histidine 204, alanine 257, aspartic acid 689, glutamic acid 1027, glycine 234, proline 244, and serine 268. Although much variation occurs, cowpeas are deficient in cystine, methionine, and tryptophan. Total sugars range from 13.7 to 19.7% and include: 1.5% sucrose, 0.4% raffinose, 2.0% stachyose, 3.1% verbascose. Starch may vary from 50.6 to 67.0% with 20.9–48.7%, amylose, 11.4–36.6% amylopectin. The fatty acid compostion of Pakistani seed oil is reported as: linolenic 12.3, linoleic 27.4, oleic 12.2, 1.1 lignoceric, 4.0 behenic, 0.9 arachidic, 7.1 stearic, 33,4 palmitic. Seeds also contain 0.025% stigmasterol. Immature pods also contain (per 100 g): 85.3% moisture, 47 calories, 3.6 g protein. 0.3 g fat, 10.0 g total carbohydrate, 1.8 g fiber, 0.8 ash, 45 mg Ca, 52 mg P, 1.2 mg Fe, 170 ug vitamin A, 0.13 mg thiamine, 0.10 mg riboflavin, 1.0 mg niacin, and 22 mg ascorbic acid. Raw immature seeds contain (per 100 g): 66.8% moisture, 127 calories, 9.0 g protein, 0.8 g fat, 21.8 g total carbohydrate, 1.8 g fiber, 1.6 mg ash, 27 mg Ca, 175 mg P, 2.3 mg Fe, 2 mg Na, 541 mg K, 370 IU vitamin A value, 0.43 mg thiamine, 0.13 mg riboflavin, 1.6 mg niacin, and 29 mg ascorbic acid. Tender shoot apices, raw, contain (per 100 g): 89% moisture, 30 calories, 4.8 g protein, 0.3g fat, 4.4 g total carbohydrate, 1.8 g ash, 73 mg Ca, 106 mg P, 2.2 mg Fe, 0.35 mg thiamine, 0.18 mg riboflavin, 1.1 mg niacin, and 36 mg ascorbic acid. The hay contains per 100 g: 9.6% moisture, 18.6 g crude protein, 23.3 g crude fiber, 2.6 g fat, 34.6 g N-free extract, and 11.3 g ash. Digestibility is improved by grinding the seeds into a fine powder. Seeds contain a trypsin inhibitor, a chymotrypsin inhibitor and a cyanogen in concentrations of ca. 2 mg/100 ml extract. Cooking improves the nutritive value, perhaps because the activity of trypsin inhibitors and/or the amount of other toxins are decreased by heat.

It is also a delicacy among other peoples in southern Africa the plant is regarded as having considerable potential as a crop for arid and semi-arid regions, and it is being investigated as a potential crop in several countries.

Conclusion

Many countries struggle with the consequences of unsustainable growth programmes, affecting the climate, people and natural resources. Local authorities and their inhabitants are faced with droughts, floods, air pollution, land degradation, deforestation and rising sea levels. By developing sustainable growth policies, local governments in partnership with the community, can improve the quality of life of citizens and contribute to protecting the global environment.

This course discusses how local authorities can respond and adapt to climate change, plan and implement solutions for environmental and natural resource challenges and promote more sustainable ways of development. Leading international experts and practitioners will share the latest insights on climate change adaptation and mitigation and the impact for local authorities. We will zoom in on the design and implementation of sustainable local development programmes that protect the environment and improve the quality of life of citizens. In addition, we will discuss tools to recognise local vulnerabilities and instruments to become more resilient.

Best practices from different parts of the world will be discussed and linkages will be made to the local challenges that the participants are faced with. Furthermore, we will visit innovative projects in European cities that aim to prevent environmental pollution with respect to air, water and land.study highlight the need for more effective transformation and regeneration protocols in the more recalcitrant legumes, including bean and cowpea. Progress in the study of nodulation and N2 fixation under drought or salinity stress has been minimal, largely because the legume and the process of nodulation are more susceptible to these constraints than is the microorganism.

Legumes play a critical role in natural ecosystems, agriculture, and agroforestry, where their ability to fix N in symbiosis makes them excellent colonizers of low-N environments, and economic and environmentally friendly crop, pasture, and tree species. Legume yields unfortunately continue to lag behind those of cereals. A research orientation that better balances the needs of third-world or sustainability oriented agriculture with the break through technologies of genomics and bioinformatics is needed. It requires stronger and more adventurous breeding programs, better use of marker-assisted technologies, and emphasis on disease resistance, enhanced N fixation, and tolerance to edaphic soil constraints. It also requires extension of existing low-cost technologies, such as rhizobial inoculation, to the small farmer.

To paraphrase a comment by Catroux et al. (2001) "we enter the era of biotechnology knowing more and more about the growth of legumes at the gene level, but except for some producers in developed countries, unable to effectively translate these into major gains in productivity".

Special attention will be given to Urban and Peri-urban Agriculture and Forestry (UPAF) which can play a strong role in enhancing food security for the urban poor, greening the city and improving the urban climate, while stimulating the productive reuse of urban organic wastes and reducing the urban energy footprint.

Conflict of interest statement

Author declares that there is no conflict of interest.

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