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Rice Bean - A Multipurpose, Underutilized, Potential Nutritive Fodder Legume - A Review

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Rice bean *(Vigna umbellata)* is a neglected legume regarded as a minor food and fodder crop in Nepal and northern India, and grown in a range of cropping systems with maize during summer, as a sole crop in the uplands, on rice bunds or in home gardens. It is mainly grown for human consumption, though it is also used for fodder and green manure. There has been very little research or development support for this crop and farmers mainly grow landraces. There is relatively very less published literature on rice bean regarding its area coverage, production, productivity, utilisation and marketing. It is grown by subsistence farmers in a very limited scale and most of the produce is consumed at home although, there is a limited market for a short period each year. The crop contributes to household food security as several food items are prepared from rice bean and also it is culturally important and is thought to have important nutritional values. Rice bean foliage and dry straw are valuable livestock feed and when used as a green manure it improves soil fertility. Thus, rice bean is a vibrant potential fodder legume crop which has capacity to provide balance diet to the livestock and to sustain under wide range of climatic condition. But, there is need to focus on the crop for more popularity as a potential legume crop.

Keywords: Rice bean, fodder, landraces, upland, legume.

Like other Vigna species, ricebean (*Vigna umbellata*) is a warm-season annual. Grown mainly as a dried pulse, it is also important as a fodder and as a green manure. The dried seeds are highly nutritious and as the protein is high in lysine they make an excellent addition to a cereal-based diet. The seeds are also high in mineral content and in vitamins including thiamine, riboflavin, niacin and ascorbic acid.

The presumed centre of domestication is Indo-China. It is thought to be derived from the wild form *V. umbellata* var. *gracilis* with which it is cross-fertile and which is distributed from Southern China through the north of Vietnam, Laos and Thailand into Burma and India (Lawn, 1995; Tomooka *et al*., 1991). 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.

Rice bean is a neglected crop, cultivated on small areas by subsistence farmers in hill areas of Nepal, northern India and parts of SE 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,

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ancient alluvial river fans). It is mainly grown between 700 and 1300 m from mean sea level, although in home gardens it is found from 200 up to 2000 m. There is almost no published literature on rice bean with relevant information on its area and distribution and the potential of the crop is lacking. Most of the crop currently grown in Nepal is used for human nutrition, with a smaller proportion used for fodder and green manuring. Generally, rice bean 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 rice bean sowing extends from April-May to June.

The crop receives almost no inputs and is grown on residual fertility and moisture and in marginal and exhausted soils. Anecdotal evidences indicate that the area and production of rice bean is declining due to the introduction of high yielding maize varieties and increasing use of chemical fertilizers, while consumption is decreasing due to increased availability of more preferred pulses in the local markets. No modern plant breeding has been done and only landraces which have low yield potential are grown. These have to compete with other summer legumes such as soybean (*Glycine max*), black gram (*Vigna mungo*), cowpea (*V. unguiculata*), common beans (*Phaseolus vulgaris*) and horse gram (*Mactotyloma uniflorum*). Other production constraints that limit the production of ricebean include small and fragmented land holdings and declining productivity.

There is no institutional support either from research or from the extension services for the development and promotion of this crop. Despite this, as a legume ricebean should have an important contribution to make to mixed subsistence farming systems, it is important culturally, and is thought to possess important nutritional characteristics which could give it a major role in improved diets and food security in the areas where it is currently grown and elsewhere.

Morphology

Vigna umbellata is a short-lived perennial legume usually grown as an annual. It has a very variable habit as it is erect, semi-erect or twining. It is usually 30-100 cm in height, but can grow up to 200 cm (Ecoport, 2014). It has an extensive root system with a taproot that can go as deep as 100-150 cm. The stems are branched and finely haired. The leaves are trifoliate with entire, 6-9 cm long leaflets. The flowers born on 5-10 cm long axillary racemes, are papillonaceous and bright yellow. The fruits are cylindrical, 7.5-12.5 cm long pods that contain 6-10 oblong, 6-8 mm seeds with a concave hilum. Rice bean seeds are very variable in colour, from greenish-yellow to black through yellow, brown. Yellow-brownish types are reported to be the most nutritious. The red type gives its common name to the grain in several languages, for example in Chinese-red small bean, (Ecoport, 2014).

Utilisation

Rice bean is a multipurpose legume, sometimes considered as neglected and underutilised (Joshi et al., 2008). However, though less important than cowpea (*Vigna unguiculata*), adzuki bean (*Vigna angularis*) and mung bean (*Vigna radiata*), rice bean is a locally important contributor to human nutrition in parts of India and South-East Asia (Joshi *et al.*, 2008; Tomooka *et al.*, 2011). All parts of the rice bean plant are edible and used in culinary preparations. The dry seeds can be boiled and eaten with rice or they can replace rice in stews or soups. In Madagascar, these are grounded to make nutritive flour included in the food for children. Unlike other pulses, rice beans are not easily processed into dhal, due to their fibrous mucilage that prevents hulling and separation of the cotyledons (Rajerison, 2006; Ecoport, 2014; van Oers, 1989). Young pods, leaves and sprouted seeds are boiled and eaten as vegetables. Young pods are sometimes eaten raw (Rajerison, 2006).

Rice bean is useful for livestock feeding. The vegetative parts can be fed fresh or made into hay and the seeds are used as fodder. Rice bean straw indudes the stems, leafy portions, empty pods, and some seeds . Before feeding, the woody portions and soiled or mildewed parts of the straw should be removed (Göhl, 1982). In the marginal hills, farmers consider rice bean both as a grain and fodder legume and look for dual-purpose landraces (Khanal *et al.*, 2009). Rice bean is also grown for green manure, as a cover crop, and used

as a living fence or biological barrier (Ecoport, 2014).

Distribution

Rice bean originated from Indochina and was probably domesticated in Thailand and neighbouring regions (Tomooka *et al.*, 2011). It is found naturally in India, central China and in the Indochinese Peninsula. It was introduced to Egypt, to the East Coast of Africa and to the islands of the Indian Ocean. It is now cultivated in tropical Asia, Fiji, Australia, tropical Africa, the Indian Ocean Islands as well as in the Americas (USA, Honduras, Brazil and Mexico) (Rajerison, 2006; van Oers, 1989; Khadka *et al.*, 2009). In the middle hills of Nepal, rice bean is cultivated along rice bunds and terrace-margins (Khadka *et al.*, 2009). Though it can thrive in the same conditions as cowpea and can better tolerate harsh conditions (including drought, waterlogging and acid soils), rice bean remains an underutilised legume and there is no breeding programme to improve this crop. Farmers must rely on landraces rather than on cultivars (Joshi *et al.*, 2008).

Rice bean is a fast summer-growing legume found from sea level up to altitudes of 1500 m in Assam and 2000 m in the hills of the Himalayas (Khadka *et al.*, 2009). Rice bean requires a short day length to produce seeds. It is grown on a wide range of soils including shallow, infertile or degraded soils. High soil fertility may hinder pod formation and reduce seed yield (Khadka *et al., 2009*). *Vigna umbellata* is a versatile legume that can grow in humid subtropical to warm and cool temperate climates. It is suited to areas with annual rainfall ranging from 1000 to 1500 mm but it is also fairly tolerant of drought. It does better in areas where average temperatures range from 18 to 30°C, tolerates 10-40°C but does not withstand frost (Rajerison, 2006; Ecoport, 2014). It prefers full light and its growth can be hampered if it is intercropped with a tall companion crop that overshadows it, such as maize (Khadka *et al.*, 2009).

Forage management

Establishment and harvest

In India, rice bean is sown in February and March for harvest during summer and in July and August for harvest in December (Khanal *et al.*, 2009; Oommen *et al.*, 2002). It can be sown alone in small fields or along bunds of rice terraces. Rice bean benefits from being sown between rows of a tall cereal such as maize or sorghum that it can use for climbing. Rice bean is a hardy plant that is resistant to many pests and diseases, and it does not require fertilizer or special care during growth. Farmers clip the tips of the plant to promote pod formation. Rice bean usually matures in 120-150 days after sowing but may need more time at higher altitudes. Seeds are harvested when 75% of the pods turn brown. Harvesting is best done in the morning or late afternoon to reduce the risk of heat-induced shattering. After the harvest, the vines and pods remain on the ground for 2-3 days after which the plants are threshed. The crop residues can then be used as fodder (Khanal *et al.*, 2009).

In India, late maturing and photo-sensitive landraces of rice bean are cultivated as a fodder crop. They are sown during long-day periods in order to prevent the plant from flowering (*Oommen et al*., 2002). Dual-purpose varieties may be cut when the pods are half-grown, but the hay should be handled as little as possible because the leaves drop easily (Göhl, 1982).

Yields potential of rice bean

The seed yi eld of rice bean is about 225 kg ha^{-1} worldwide (Duke, 1981). It can however, vary from 200-300 kg ha^{-1} in West Bengal to 1300-2750 kg ha^{-1} in Zambia, Brazil and India (*Chandel et al.*, 1988; Chatterjee *et al.*,1977).

In Bengal (India), fodder yields were reported to range from 5-7 t DM ha^{-1} in May and June, to 8-9 t DM ha^{-1} in November and December (Chatterjee *et al.*, 1977). Lower values have been reported, 5-6 t DM ha^{-1} in Myanmar (Tin Maung Aye, 2001), and 2.9 t DM ha^{-1} in the sub-humid Pothwar plateau of Pakistan (Qamar *et al.*, 2014). In India, rice bean grown with Nigeria grass (*Pennisetum pedicellatum*) yielded 7.6 t DM ha^{-1} after the application of 20 kg N ha^{-1} (Chatterjee *et al.*, 1977). In Pakistan, rice bean grown with sorghum (50:50 mix) yielded up to 12 t DM ha^{-1} (Ayub *et al.*, 2004).

Rice bean is an N-fixing legume that improves the N status of the soil, thus providing N to the following crop. Its taproot has a beneficial effect on soil structure and, when ploughed in, returns organic matter and N to the soil. Rice bean grown before or after a rice or maize crop is beneficial. In Thailand, it is profitably sown between the rows of maize once the crop has reached

maturity but before harvest so that rice bean covers enough soil at harvest. It is then possible to harvest the rice bean, thresh to obtain the seeds and bring the dry plants back to the field where they provide soil cover for the dry season (Echo AIC, 2012). In the Thai highlands, rice bean is a valuable green manure which outcompetes other legumes such as *Canavalia ensiformis*, *Lablab purpureus* and *Mimosa diplotricha* in their ability to improve rice yields (Chaiwong *et al*., 2012). In China, rice bean used as green manure in tangerine orchards resulted in higher fruit yields than soybean (*Glycine max*), mung bean (*Vigna radiata*) and cowpea (*Vigna unguiculata*) (Wen MingXia *et al.,* 2011).

Rice bean forage

Data on the composition of rice bean forage is scarce. Like other legume forages, fresh rice bean forage is relatively rich in protein, though its concentration is extremely variable (17-23% DM). Rice bean hay and straw are slightly less nutritious (16 and 14% protein in the DM, respectively). Rice bean forage is also rich in minerals (10% of the DM in the fresh forage) and particularly in calcium (up to 2% in the fresh forage). Rice bean straw contains large amounts of mineral matter (more than 20% of DM) though it is highly variable. Rice bean forage contains variable amounts of condensed tannins (0.1-2.8% DM) (Wanapat *et al.,* 2012; Chanthakhoun *et al.,* 2010).

Rice bean seeds

Rice bean seeds are rich in protein (18-26% DM), though generally less than pea (*Pisum sativum*) or cowpea (*Vigna unguiculata*). They contain limited amounts of fibre and fat (about 4 and 2%, respectively). The amino acid profile is comparable to that of other grain legumes. It is relatively rich in lysine (more than 6% of the protein) but poor in sulphur-containing amino acids. Rice beans have a high starch concentration with reported values ranging from 52 to 57% of the DM (Kaur *et al.,* 1990; Chavan *et al.,* 2009). The amylose content of the starch is extremely variable from 20 to 60% (Kaur *et al.,* 2013).

Rice bean as a potential resource as a fodder crop

Palatability

Rice bean forage at the pre-flowering stage is palatable to sheep (Chandel *et al.,* 1988). In Nepal, farmers have emphasized the softness and palatability of rice bean fodder for livestock (Joshi *et al.,* 2008). In an experiment with rice bean hay in India, bullocks consumed it hesitantly at first but within a few days the animals grew accustomed to it and DM consumption increased, indicating that the hay was palatable (Gupta *et al*., 1981). Rice bean straw was reported to be relished by cattle (Göhl, 1982).

Fresh rice bean forage

In India, 22 month-old calves fed a mixture of fresh Sudan grass (*Sorghum* × *drummondii*) and rice bean forage (54:46 fresh basis) for 64 days had a DM intake of 1.90 kg DM/100 kg LW and a daily weight gain of 456 g day^{-1} (Singh *et al*., 2000). In India, 22 month old calves fed a mixture of fresh Sudan grass (*Sorghum* × *drummondii*) and rice bean forage (54:46 fresh basis) for 64 days had a DM intake of 1.90 kg DM/100 kg LW and a daily weight gain of 456 g/d (Singh *et al.,* 2000).

Rice bean hay

Rice bean hay is generally used as a protein source to supplement poor quality roughage based diets in ruminants. Rice bean hay included at 600 g day^{-1} to supplement rice straw in diets for swamp buffalo increased DM intake, digestible protein and N retention. It had a positive effect on rumen microflora, resulting in increased VFA production and lower CH_4 emissions (Chanthakhoun *et al.,* 2011). Adding rice bean hay was reported to increase cellulolytic rumen bacteria thus improving the utilization of high fibrous feeds in buffalo diets (Chanthakhoun *et al.,* 2010).

In India, a trial with bulls showed that rice bean hay had a moderate OM digestibility (50%) but that it contained nitrogen, calcium and phosphorus in adequate amounts to meet the maintenance needs of adult cattle (Gupta *et al.,* 1981). In Vietnam, a mixture of cassava hay and rice bean hay (3:1 ratio) replaced 60% of concentrate in a forage-based diet (*Pennisetum purpureum* + urea-treated rice straw) offered to growing crossbred heifers, resulting in higher daily weight gain (609 g day^{-1}), better feed efficiency and reduced feed costs (Thang *et al.,* 2008).

In India, supplementing local goats fed grass with rice bean hay (15% of diet DM) did not increase grass intake but total DM intake and nutrient digestibility were increased. Increasing the level of rice bean level above 15% had no further effect on digestibility (Das, 2002).

Rice bean straw as a fodder

In India, a trial with bullocks showed that rice bean straw had a low OM digestibility (31-47%) and it was recommended to supplement a rice straw-based diet with energy-rich feed materials, such as cereal grains or bran (Chaudhuri *et al.*, 1981).

Rice bean seeds as a feed

In India, rice bean seeds are fed to buffalo calves and sheep to provide energy. Rice beans replaced half the cereals and half the deoiled cake present in the concentrate offered to buffalo calves (Ahuja *et al.*, 2001). In sheep, replacing 50% of the metabolizable energy from oat hay by rice bean seeds had no deleterious effect on sheep N balance, which remained positive (Krishna *et al.*, 1989).

CONCLUSION

From above review it can be concluded that rice bean is a vibrant potential fodder legume crop which has capacity to provide balance diet to the livestock and to sustain under wide range of climatic condition. Appropriate focus on the crop is needed for more popularity as a potential legume crop under the climate change situation.

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