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RESEARCH PAPER

A Comprehensive Review of Multipurpose Underutilized Potential Legume NEH Region of India: Rice Bean

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ABSTRACT

Rice bean is a crop having numerous benefits and high nutritional values. The crop is nutritionally rich and genetically diverse agricultural crop, having potential to withstand extreme environmental condition, shows resistance to various diverse biotic and abiotic stress factors. Every part of rice bean plant is edible and used for cooking. Due high protein content and use of every plant part it can contribute to the agricultural sector as well as economy of the country is yet to be exploited. However, it is a significantly neglected crop often grown on marginal lands without proper cultivation practices. This has led to the little knowledge about the crop and its benefits. Considering all these properties of the rice bean crop, it is the need of the hour to create more awareness about how it can be used for the development of the crop, its varieties, and to encourage more technological advances as an input towards the crop.

HIGHLIGHTS

- Rice bean is a highly nutritious underutilized legume crop used as human and animal consumption.
- Rice bean has the capacity to withstand extreme environmental condition, shows resistance to various diverse biotic and abiotic stress factors**.**
- It improves nutrient content and biological health of soils.

Keywords: Rice bean, nutritional value

Rice bean, *Vigna umbellate* (2*n* = 22), belonging to Leguminocea family is a warm-season self-pollinated annual vine legume crop. It is commonly called rice bean or rice bean, red bean, oriental bean and climbing mountain bean. To date, it is little known, little researched and little exploited (*Dahiphale, et al.* 2017). 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.. As a crop, rice bean is suited to areas with annual rainfall ranging from 1000 to 1500 mm but it is fairly tolerant to drought. In Japan, rice bean was earlier grown in the south western part (Noda, 1951) but its cultivation has almost disappeared now. It grows better in areas where temperature ranges from 18 to 30 °C. Although rice bean can tolerate 10–40 °C, it is highly susceptible to frost. There is no specific record of its trade. In India, Myanmar, Nepal and Thailand, rice bean is sold in the local markets in an unorganized trade It is mainly grown as dried pulse, it is also important as a fodder, a green manure and a vegetable. In the past it used to be 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. It establishes rapidly and has the potential to produce large

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amounts of nutritious animal fodder and high quality grain. It is also a source of genes for biotic and abiotic stress tolerance including drought, soil acidity and storage pest (Pattanaik *et al.* 2018). Most of the research conducted in the past focused on its high level of resistance to grain storage pest bruchid beetles (*Callosobruchus* spp.) (Tomooka *et al.* 2000; Kashiwaba *et al.* 2003) although resistance to yellow mosaic virus, Cercospora and bacterial leaf spot (Arora *et al.* 1980) and mung bean yellow mosaic virus (Pandiyan *et al.* 2008) has been reported in this crop. Despite the recognition that rice bean has a current private value for people living in the vulnerable agricultural systems, and it is a source of many valuable agronomic and nutritional traits, the potential value of the crop is underestimated.

Origin and Distribution

Rice bean is considered to be of South and Southwest Asian origin (Bisht and Singh 2013). It was probably domesticated in the Indo China region (Doi *et al.* 2002). Wild forms of the species (*V. umbellata var. gracilis*) with which it exists as a complex are found in the Himalayas and Central China to Malaysia (Seehalak *et al.* 2006). It is believed that rice bean was domesticated from these wild forms. These wild forms occur in natural or disturbed habitats and are intermediate with twining plant types, freely branching, photoperiod sensitive with small seeds. Many intermediate land races are cultivated in northeast India (Iangrai *et al.* 2017). Inter- and intraspecifc genetic diversity and inter-species relationships of Vigna species from Thailand and neighbouring region have been assessed using AFLP analysis (Seehalak *et al.* 2006). These studies suggested that *V. umbellata* and *V. mungo* evolved from wild relatives in a single domestication event. The cultivated type and wild and weedy relatives of *V. umbellata* are poorly differentiated as compared to *V. mungo*. The study also suggested Thailand and neighbouring Shan state in Myanmar as the probable centres of domestication for *V. umbellate.*

Rice bean is a traditional crop of South, Southeast and East Asia (Seehalak *et al.* 2006; Tomooka *et al.* 2002a). *V. umbellata var. gracilis* from which rice bean is believed to have originated is conspecific with the cultivated *V. umbellata* and widespread in distribution in South and Southeast Asia (Bisht *et al.* 2005; Seehalak *et al.* 2006; Tomooka *et al.* 1991, 2002a). It is mainly grown in Bhutan, India, Myanmar, Northern Thailand, Southern China, Laos, Vietnam, Indonesia and East Timor (Tian *et al.* 2013; Iangrai *et al.* 2017; Pattanayak *et al.* 2018). The crop was introduced as a garden and cover crop in Fiji, Sri Lanka, Ghana, Jamaica, Mexico and Haiti. It is also cultivated to a limited extent in West Indies, Americas, Australia and tropical Africa (Khadka and Acharya 2009). Although rice bean possesses an ability to thrive in diverse climatic conditions, its cultivation is limited to areas with moderate to high rainfall and temperature (the crop does not tolerate frost). Furthermore, it appears that being a highly photosensitive but indeterminate crop, it lost ground to other pulses such as black and green gram, lentil, field pea, pigeon pea and chickpea from the economic yield point of view. The crop duration creates a problem for planting of subsequent crops. Ironically, the tastier varieties are late. Also, the crop so far is not amenable to a mechanized cultivation system. Its harvest index is low (25.8–27.3) (Sarma *et al.* 1995) compared to other economically important pulses such as soybean, field pea and lentil (36.6–44.6) (Jayasundara, 2015). Because of seed coat type, rice bean cannot be split into two halves easily, and remains relatively intact even after boiling. It is possible that these factors caused its little use as a pulse for daily consumption leading to limited spread.

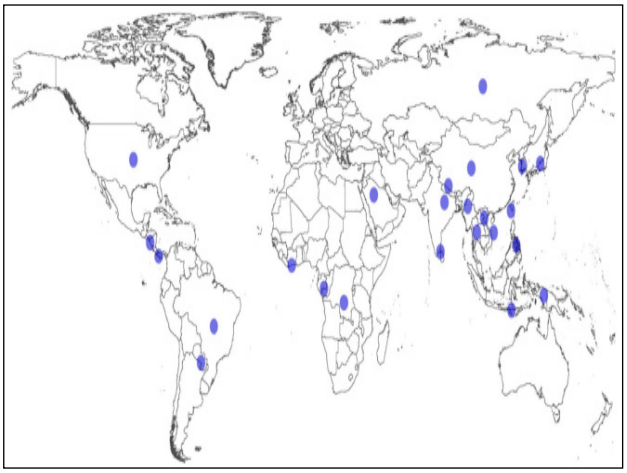

Fig. 1: World distribution of rice bean (Pattanayak *et al.* 2018)

In India, as a cultigen its distribution is mainly confined to the tribal regions of North Eastern hills and hilly tracts of Western and Eastern Ghats. In the North Eastern Hill Region of India

(Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura) rice bean is grown predominantly under rain fed conditions in a mixed farming system, under shifting cultivation or in kitchen gardens and backyards. It is grown on a limited scale in the eastern and western peninsular tracts of India.

Table 1: States reported to be growing rice bean in India

Spread of the crop	States with the crop reported
High	Assam, Meghalaya, Manipur, Nagaland, Mizorum, parts of Arunachal Pradesh, hill regions of North Bengal, Sikkim and Orissa
Medium	Himachal Pradesh, Uttranchal, Chattisgarh, Jharkhand, Madhya Pradesh
Low	Kerala, Tamil Nadu, Gujrat, Punjab, Maharashtra, Haryana, Jammu & Kashmir , Karnataka , Andhra Pradesh, Andaman and Nicobar Islands

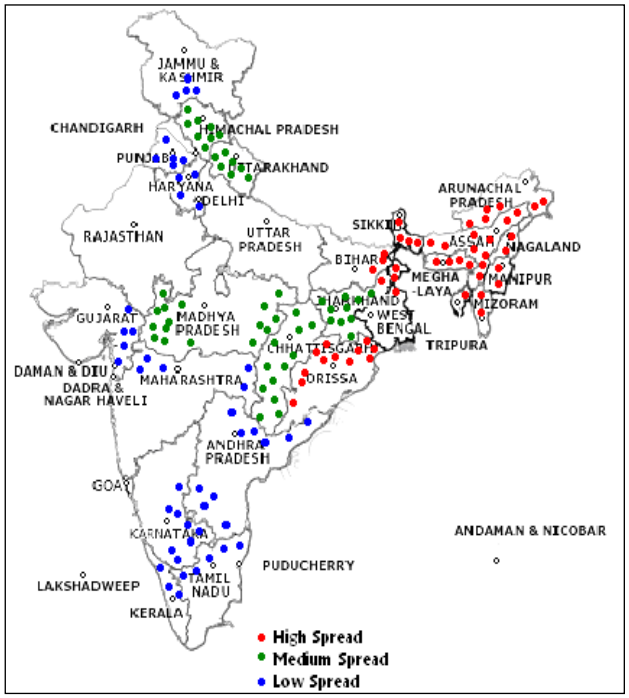

Fig. 2: Rice bean distribution in India (Buergelt *et al.* 2010)

In India ricebean mainly cultivated in the North Eastern Hill (NEH) Region, northern Himalayan states (Himachal Pradesh and Uttarakhand), Central India (Madhya Pradesh and Chhattisgarh) and a limited area in India's western peninsular region (Arora *et al.* 1980). The landraces of this crop is widely cultivated in Manipur, Mizoram, Meghalaya and Nagaland in by tribal farmers.

Climate

It is well suited to well drained, loamy to sandy loam textured soil. The plant shows moderate growth in poor or light fertile soil. Rice bean is highly susceptible to saline-alkaline soil or waterlogged soils, so growing in such soils can drastically affect yield and thus should be avoided. Light soils should be avoided as it causes root-knot nematode problem. Rice bean is an annual crop requiring warm temperature for its growth. Optimum temperature ranges from 18°-37°C. It requires sowing temperature of 30°-35°C and harvesting temperature of 35°-40°C. Annual rainfall of 60-150 cm and relative humidity of 80% is favorable. The seed yield of rice bean is about 225 kg/ha worldwide. It can, however, vary from 200-300 kg/ha in West Bengal to 1300-2750 kg/ha in Zambia, Brazil and India (*Chandel et al.* 1988; Chatterjee *et al.* 1977). As a result of its high fodder production potential (up to 35 t ha^{-1}), rice bean is now attracting attention as a leguminous fodder crop in Kerala, Orissa and West Bengal.

Taxonomy and diversity Diversity

Phylogenetic analysis based on DNA sequences from the ITS and atpB–rbcL regions showed a close relationship between *V. umbellata*, both cultivated and wild forms, with species of section Angulares such as *V. hirtella, V. exilis, V. tenuicaulis, V. napalensis, V. minima, V. nakashimae* and *V. ruikiuensis* (Doi *et al.* 2002). These fndings were supported by a recent study using seventy-one Vigna accessions, consisting of 28 species and three subgenera (Ceratotropis, Plectrotropis, and Vigna) conserved at the National Institute of Agrobiological Sciences, Japan (Takahashi *et al.* 2016). Sequence data from four intergenic spacer regions of chloroplast DNA of 18 species of the subgenera Ceratopteris were analysed using Bayesian and parsimony methods (Javadi *et al.* 2011). Two major geographical clades, the East Asia–SE Asian clade and the Indian subcontinent clade, were identifed within 18 species. This study further classified major clades into eco-geographical groups: temperate and subtropical (the East Asia–SE Asian clade) and tropical (the Indian subcontinent clade). *V. umbellata* clustered

under V. *hirtella–V. exilis–V. umbellata* subgroup within the subtropical group which also included the *V. nakashimae–V. riukinensis–V. minima* subgroup. The genetic relationship of different species within Ceratotropic subgenus is given in Fig. 3, as adapted from three different studies (Doi *et al.* 2002; Javadi *et al.* 2011; Takahashi *et al.* 2016).

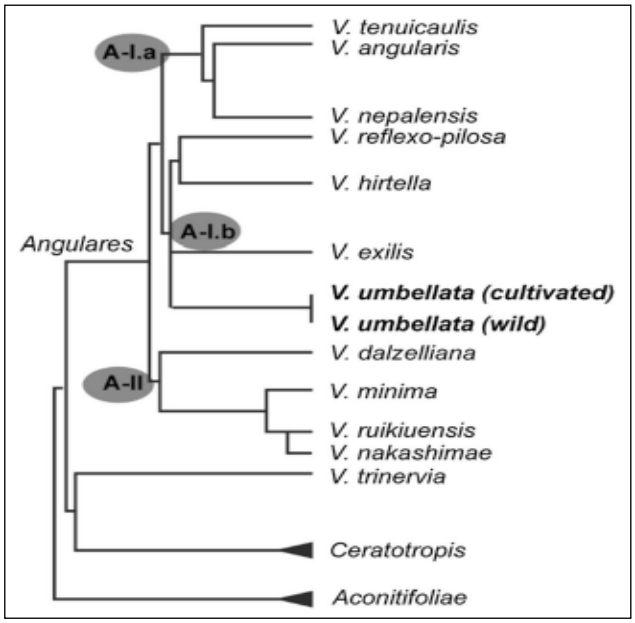

Fig. 3: Relationship of rice bean with other *Vigna* spp. (Pattanayak *et al.* 2018)

There are five distinct botanical varieties of rice bean viz., *Vigna umbellate var major*, *Vigna umbellate varglabra*, *Vigna umbellate varrumbaiya* and *Vigna umbellate varmacrocarpa*have been identified. (Chandel *et al.* 1988). Huge amount of variation was observed in rice bean germplasm available in North Eastern region of India (Fig. 4) indicating opportunities for improvement of this crop utilizing natural variability present among them.

Importance of crop in current scenario

Ricebean is a non-conventional underutilized crop which has apotential to generate livelihood for the underprivileged sections of the population particularly in South and South East Asia. Ricebean is nutritionally rich and genetically diverse agricultural crop, having potential to withstand extreme environmental condition. It shows resistance to various diverse biotic and abiotic stress factors. Every part of ricebean plant is edible and used for cooking. Ricebean seeds are consumed by boiling and eating dry seeds with rice or substituting the rice in stew or soup. In Madagascar, the seeds are grounded to produce nutrient flour as food for children.

Fig. 4: Variability in seed morphology from Northeast India (Pattanayak *et al.* 2018)

Moreover, boiled leaves, young pods and sprouted seeds are eaten as vegetables, while as young pods can be eaten raw. For livestock feeding, ricebean is veryuseful, as the vegetative parts of the plant can be fed freshly as well as made into hay, while as the stems, empty pods, leafy portions, and some seeds are used as ricebean straw. In addition, plants of ricebean are grown as green manure, cover crop, as well as a living fence or biological barrier. Therefore, ricebean can be considered both as a grain and a fodder legume.

Taxonomic classification

Kingdom	: Plantae
Phylum	: Spermatophyta
Subphylum	: Angiospermae
Class	: Dicotyledonae
Order	: Fabales
Family	: Fabaceae
Subfamily	: Faboideae
Genus	: Vigna
Scientific Name	: *Vigna umbellata*

Chromosome no: 2*n* = 22

Morphological characteristics

The plant can grow up to an average height of 30-100cm. However, the varieties found in Manipur can grow upto a height of 270 cm, while the landraces found in Mizoram and Meghalaya can grow upto the height of 110 cm and 165 cm respectively. The growth habit is indeterminate. Staking needs to be provided to give support for its twinning habit and to avoid intertwining among plants. Rice bean is featured by extensive root system with a deep taproot of approximately 100-150 cm long. Stems are branched and finely haired. Leaves are trifoliate with 6-9 cm long leaflets. Flowers are superior, zygomorphic, bisexual and self-pollinated. They and bright yellow, papillonaceous and born on 5-10cm long axillary racemes. The flower share a pentamerous ground plan with 5 sepals, 5 petals, 2 whorls of 5 stamens each (diadelphous: 9+1) and a single carpel, 21 organs in all. The floral apicalmeristem is determinate. There is a single carpel at the centre.

Fig. 5: Flowers, green and mature pods of rice bean

The inflorescence proceeds in acropetal succession. Each flower has three petal forms: a single standard petal (vexillum), two wing petals and two keel petals which look alike throughout much of their development and only differentiate late in ontogeny. Some cultivated species of the genus Vigna has shown male sterility. Fruits are cylindrical in shape and generally contains 7.5-12.5 cm long pods that shows the presence of 6-10 oblong, 6-8 mm seeds with concave hilum. Seeds of ricebean are found to be diverse colors ranging from red, brown, grey to black, mosaic. Seed size ranges from 0.6 mm - 1.3 cm in length and 0.4-0.8 mm in diameter. The varieties in Manipur are late flowering and takes 150 days for complete maturity while those found in Mizoram matures in about 120 DAS and those in Meghalaya matures in 140 DAS (Philanim *et al.* 2020).

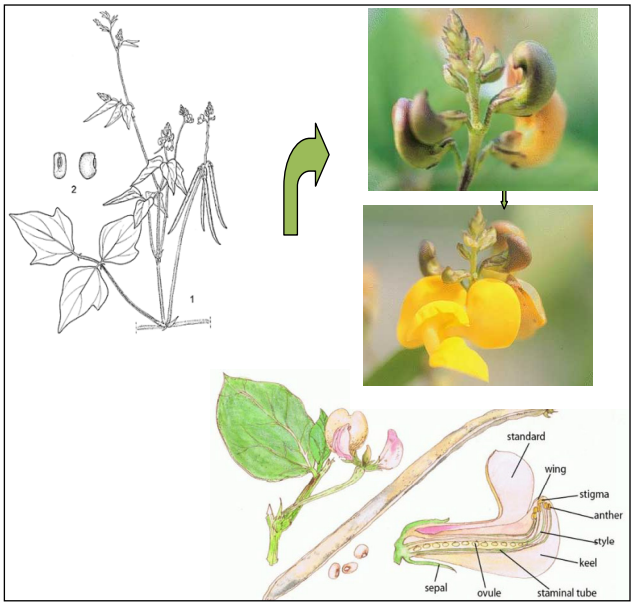

Fig. 6: Inflorescence

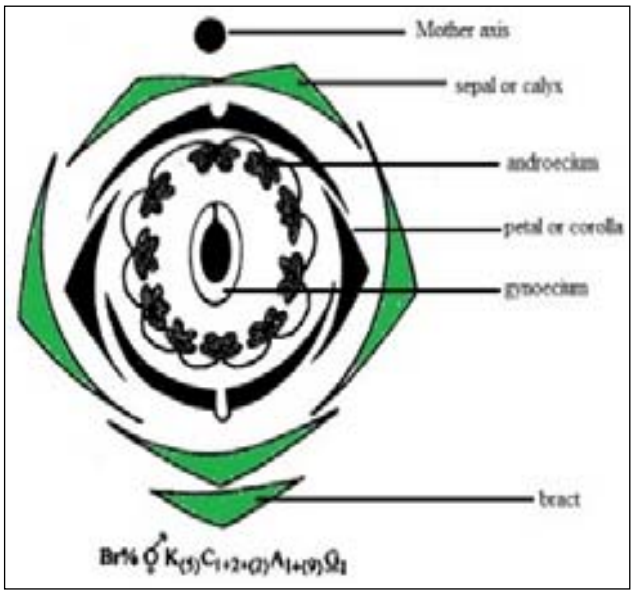

Fig. 7: Floral Formula

Nutritional aspects

Rice bean plays an important role in human, animal and soil health improvement. All varieties seem to be good sources of protein (25%), essential amino acids, essential fatty acid and minerals, and the dried seeds make an excellent addition to a cereal-based diet. Rice bean has a comparatively higher

Table 2: Comparative biochemical constituents of ricebean (seed) and other pulses

Crop	Crude protein%	Ash%	Fiber %	Fat%	CHO%	Soluble EE%	Ca mg/100g	Fe mg/100g	P mg/100g
Rice bean	25.0	4.3	4.8	0.6	—	1.6	450	6.0	393
Mungbean	23.6	4.0	3.3	1.2	58.2	3.0	199	7.5	313
Urdbean	23.4	4.8	3.8	1.0	57.3	—	—	—	—
Frenchbean	22.1	3.6	4.0	1.6	57.8	2.1	175	6.9	328
Broadbean	23.4	3.2	7.1	1.5	48.5	—	—	—	—
Chickpea	20.1	2.7	3.9	5.3	61.2	5.3	283	10.3	43
Cowpea	23.4	3.6	3.9	1.3	56.8	2.1	243	6.9	459
Lentil	24.2	3.3	3.7	1.0	55.8	3.1	140	7.3	263
Pea	22.5	3.0	4.4	1.0	58.5	3.2	259	5.2	286
Pigeon pea	20.9	3.8	3.1	1.5	57.3	3.8	296	6.7	366

Source: *Singh et al. 2020.*

content of proteins than other cereal crops. Its favourable protein content ensures high digestibility and therefore makes it as fit food for little children, women and older people with weak digestion. Rice bean retains high nutritional value than most of the pulses although there is considerable variation.

Food items prepared from the crop

Ricebean has multiple usage and most parts of the crop are used for different purposes. Processed seed of this crop is consumed as a snack, for example with roasted maize, and is eaten with local alcoholic drinks. It also has cultural importance, being used in local feasts or social gatherings as curry and in the form of snacks. There are several traditional Manipuri dishes that are prepared from rice bean such as Singju (salad), Eronba (chutney), Champhut and Kangsoi (vegetable stew) (Athokpam *et al.* 2023).

Singju is a kind of vegetable salad made with many ingredients. There are a variety of singju according to the main ingredient used and the singju made from rice bean is called chakhwaisingju. The cooked seeds of ricebean are used for this purpose.

Eronba is also a vegetable chutney which is spicy and is used as a side dish in Manipuri cuisine. Along with other vegetables like potato, the cooked seeds of ricebean are used for making the chakhwaieromba.

Kangsoi is basically a vegetable stew and the young pods and leaves of ricebean are used with other ingredients like dried fish to add to the flavor of the stew. It is eaten as a main dish with rice.

Champhut is Vegetables of seasons are being boiled and served as a side dish. Chayote (Squash) or other vegetable like sweet pumpkin and rice bean are some of the major vegetables consumed by preparing this dish.

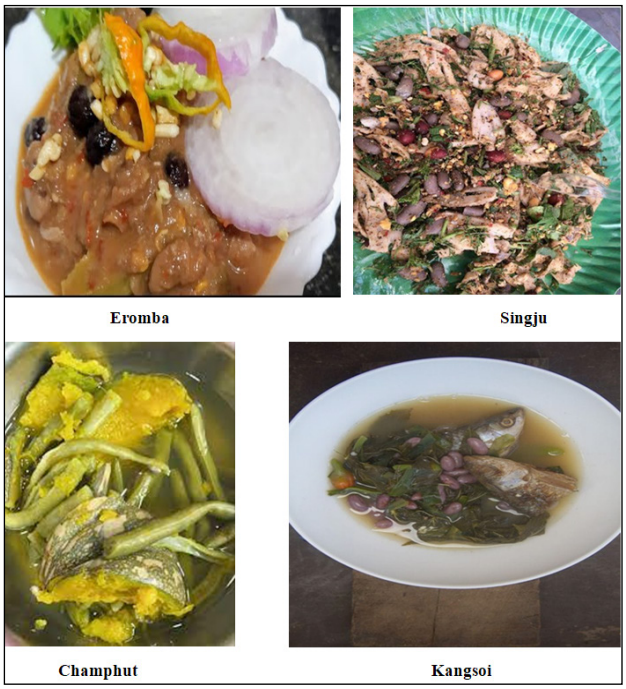

Fig. 8: Use of rice bean as ingredient in different food item (Athokpam *et al.* 2023)

Pharmaceutical properties

Beans play an important role in human nutrition, particularly among the low-income groups of people. They are good source of dietary fiber, slow digestible starch, minerals, vitamins and bioactive phytochemicals which have capability to control

or prevent various chronic and metabolic diseases especially diabetes mellitus, coronary heart diseases and colon cancer. It has a number of bioactivities which include antioxidant, hepato-protection, anti-inflammation, anti-cancer, anti-fungal, anti-diabetic, anti-hypertension immunity booster, inhibition of activities of HIV 1 and mutagenic activities.

CONCLUSION

Ricebean is a crop having numerous benefits and high nutritional values. It has high protein content and can serve as a crop for food security. All of its plant parts can be eaten or fed to livestock. Its overall potential to contribute to the agricultural sector as well as economy of the country is yet to be exploited. However, it is a significantly neglected crop often grown on marginal lands without proper cultivation practices. This has led to the little knowledge about the crop and its benefits. Considering all these properties of the ricebean crop, it is the need of the hour to create more awareness about how it can be used for the development of the crop, its varieties, and to encourage more technological advances as an input towards the crop.

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