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Cluster bean [*cyamopsis tetragonoloba* (L.) Taub.], an important industrial arid legume: A review

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ABSTRACT

Cluster bean is an important legume cultivated mostly on marginal and sub marginal lands of arid and semi-arid regions. Overall, India produces around 80% of global cluster bean production. It is cultivated on more than 4 m ha in India, Rajasthan alone accounts for around 80% of the area and production. Owing to its demand in the international market, it has been introduced in the non-traditional growing areas like Andhra Pradesh, Tamil Nadu, Karnataka, Maharashtra and Chhattisgarh. Further, its cultivation is also being taken up under irrigated conditions during summer. Cluster bean seed (endosperm) is a source of a natural hydrocolloid (galactomannan/'guar gum'). The gum has unique abilities with multiple commercial applications like textile, printing, paper, cosmetics, mining, pharmaceutical, petroleum, natural gas, well drilling and oil industries. Green pods are nutritionally rich and are routinely consumed as vegetable especially in northern and western parts of India. Additionally, cluster bean has been reported to have beneficial effects when cultivated as an intercrop. Cluster bean meal (high protein content) obtained from seed coat and germ cell is an excellent feed for monogastric animals. Cluster bean cultivars with high gum content (>32%) and viscosity (4000-5000 cps) are more preferred for export. The value of cluster bean exports from India has increased from Rs 242 crores (1994) to Rs 2100 crores (2012-13). This review presents the various aspects of cluster bean cultivation and its emergence as an important industrial crop.

Key words: Applications, Cluster bean, Cultivation, Galactomannan, Markets, Processing.

[Cluster bean *Cyamopsis tetragonoloba* (L.)] is an annual legume crop mostly grown under resource constrained conditions in arid and semi-arid regions (Kumar, 2005). Cluster bean is a deep rooted plant of *Leguminosae* (*Fabaceae*) family known for drought and high temperature tolerance (Kumar and Rodge, 2012). The major cluster bean cultivating countries are India, Pakistan, USA, Italy, Morocco, Germany, and Spain (Punia *et al.*, 2009). India produces about 80% of the world cluster bean production (Tripathy and Das, 2013). Cluster bean is grown especially in the arid regions of India (Rajasthan, Haryana, Gujarat and Punjab) for gum purpose, whereas it is grown for vegetable purpose in other parts of India (Rai and Dharmatti, 2013). Cluster bean can be used for multiple purposes (vegetable, cattle feed/fodder or green manure). It is a good source of nutrition and its tender green pods are also a cheap source of nutrients. Further cluster bean meal and seed are used as high protein cattle feed (Rai and Dharmatti, 2013). Cluster bean gum is a naturally occurring hydrocolloid present in the endosperm of seed (also known as 'Guaran'). It has emerged as the most important biologically produced non-toxic, eco-friendly and safe agro-chemical. The gum is produced primarily from ground endosperm after dehusking the seed (Sabahelkheir *et al.*, 2012). Owing to its varied uses, cluster bean has emerged as a new industrial crop with high foreign exchange earning potential.

Area, production and productivity: In India, Rajasthan is the major cluster bean producing state followed by Haryana, Gujarat, Uttar Pradesh, Punjab and Madhya Pradesh (USDA, 2014). Based on 2011-12 statistics, Rajasthan and Haryana together contribute about 95% of the total cluster bean production in India; Rajasthan alone accounts for ~80% of the cluster bean production in the country. During 2012-13, the cluster bean area, production and productivity in India was ~2.46 million tons (MT; USDA, 2014), 5.15 million hectare (m ha) and 478 kg/ha respectively. But estimated area, production and yield for 2013-2014 are 5.6 m ha, 2.7 MT and 485 kg/ha respectively. Cluster bean production in India has fluctuated from 0.2 MT (2002-03) to 2.7 MT (2013-14) mainly due to the differences in rainfall pattern. In spite of certain fluctuations in area and production an increasing trend has been observed in the acreage during the last decade in India (Table 1a). The production of cluster bean crop in India is increasing probably due to increase in its area. But, the productivity of cluster bean does not show any specific trend and fluctuates probably owing to climatic conditions. The production statistics of leading producers in India are presented in Table 1b.

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Table 1a: Area, production and yield of cluster bean in India

Year	Area ('000 ha)	Production ('000 tons)	Yield (kg/ha)
2005-06	2956	1059	358
2006-07	3344	1169	350
2007-08	3472	1789	515
2008-09	3863	1936	501
2009-10	2996	595	199
2010-11	3382	1965	581
2011-12	3444	2218	644
2012-13	5152	2461	478
2013-14±	5603	2715	485

Source: Ministry of Agriculture, GOI;±Estimated figures, adopted from USDA 2014

Origin and botany: The genus *Cyamopsis* belongs to Leguminaceae family and Papilionoideae sub-family with four species: *C. dentata, C. senegalensis, C. serrata,* and *C. tetragonoloba* (Dwivedi and Bhatnagar, 2002; Chevalier, 1939). *Cyamopsis* was emphasized to be a separate genus with Africa as its probable center of origin (Gillett, 1958). Vavilov (1951) suggested India to be the center of variability for cluster bean. Trans-domestication process was proposed to explain the origin of cluster bean (Hymowitz, 1972) and it is reported that the cultivated cluster bean plant, *C. tetragonoloba,* developed from a drought tolerant wild African species *C.* senegalensis (Mudgil *et al.*, 2014).

Cluster bean is a self-pollinated crop with a chromosome number of 2n=14 (Hymowitz and Upadhya, 1963). It is an annual crop with well-developed long tap root system. It is about 50-100 cm tall bearing 4-10 branches. Stem is mostly hairy and elongated oval in shape. Leaves (pointed and saw-toothed) and flowers are borne in alternate trifoliate pattern. The inflorescence is a raceme, ~9-13 cm (in branched types) and ~15-20 cm in erect (non/sparsely branched type; Stafford and Hymowitz, 1980). Usually 40-60 and 50-70 flowers are present in the inflorescence of branched and erect types respectively. Flowers (white, pink or bluish) are small, bisexual, ~9 mm long, sessile, and papilionaceous in nature. Cleistogamous nature of flowers restricts out crossing but, it does occur on a small scale (0.5-7.9%; Saini *et al.*, 1981; Chaudhary and Singh, 1986). Flowers contain five unequal sepals (calyx), while corolla has the standard, wing, long/broad keel petals (Kumar and Singh, 2002). Pistil consists of a single carpel; ovary is linear with 6-10 ovules. Cluster bean flower has diadelphous stamens, short style and head shaped stigma (Chandersekharan and Ramakrishnan, 1928; Sindhu *et al.*, 1982). Uniform anthers with spherical shaped pollen grains are found in cluster bean (Menon, 1973). Pod length is usually 5-12 cm with ~5-12 seeds of variable shape (Poats, 1961) and color. Usually mature seed color varies from grey to whitish grey and sometimes due to excess moisture the color changes to black.

Genetic resources : The 'National Bureau of Plant Genetic Resources (NBPGR)', New Delhi and the 'Central Arid Zone Research Institute', Jodhpur, have evaluated 4869 germplasm lines and identified early maturing and high yielding genotypes (ex. IC 116804, IC 116868, IC 116869 HGI 1/ P8-80 and others; Dabas *et al.*, 1982). Collection and evaluation of indigenous (731) and exotic lines (20) at Hisar center have yielded lines maturing in <90 days1. Large numbers of germplasm accessions have been put under medium term storage (Mishra *et al.*, 2009) and also for ex-situ conservation. At S K Nagar, Gujarat several promising lines with enhanced disease resistance against bacterial leaf blight (GAUG 9406, GG 1, RGC 1027), *Alternaria* blight (GAUG 9406, GAUG 9005, GAUG 9003 and GC 1) and root rot (GAUG 9406, GG 1 and HGS 844) have been identified (Kumar, 2005). Some cluster bean lines have been released for grain (ex. Suvidha, Naveen, Sona, PLG-85, PLG-850, RGC-471) and vegetable (Pusa Navbahar, Pusa Sadabahar and Sharad Bahar) purpose (Kumar and Rodge, 2012). Further, two wild species viz., *C. serrata* and *C. senegalensis* have been introduced from USA. Efforts for transferring earliness trait from these two wild species into the cultivated species (C. *tetragonoloba*) using conventional methods were not successful (Kumar and Rodge, 2012).

Table 1b: Area, production and yield of cluster bean in Rajasthan, Haryana and Gujarat

Year	Area ('000 ha)			Production ('000 tons)			Yield (kg/ha)		
	R*	H*	G*	R	H	G	R	H	G
2005-06	2445	270	188	566	289	108	231	1070	575
2006-07	2808	295	205	658	334	83	234	1132	404
2007-08	2842	341	196	1244	395	130	438	1200	662
2008-09	3316	370	150	1261	602	53	380	1627	353
2009-10	2581	252	133	201	329	45	78	1305	337
2010-11	3001	256	125	1546	333	73	515	1300	586
2011-12	3000	215	37	1847	290	33	616	1350	892
2012-13	4526	-	-	2023	-	-	447	-	-
2013-14±	4924	-	-	2201	-	-	512		-

*Sources: Department of Agriculture, Rajasthan; Department of Agriculture, Haryana; Department of Agriculture, Gujara*t R* - Rajasthan, H* - Haryana, G* - Gujarat;± - *second advanced estimates*

Genetic parameters of different traits: High level of variability was observed in different characters like days to maturity [112 – 127 days], pods per cluster [3.7 – 10.4], pods per plant [12.0 – 85.0] and pod length [41.0 – 65.0 cm] (Sultan *et al.*, 2012). But, variability was low for days to flower initiation [63-69 days], pod width [5.0 - 7.0 cm] and pod thickness [3.3 – 5.5]. Rai *et al.,* (2012) reported a wide variability for plant height [32.1 – 100.8 cm], pods per plant [75.5 – 185.0] and yield per plant [57.7 – 222.3 g]. Interestingly, Satyavathi *et al.*, (2014) have observed variability in total biomass [21-103 g/plant] and seed yield [4.8-16.9 g/plant]. Wide range of variability was recorded for dry matter yield [262-1020 g/plot], leaf stem ratio [0.6-1.0], crude protein [17.6-20.8%], acid detergent fiber [31.9-36.6%], neutral detergent fiber [43.0-47.8%], *in-vitro* dry matter digestibility [59.0-63.6%], green fodder yield [3117-12033 g/plot] (Kapoor and Bajaj, 2014).

Seed yield is found to be positively associated with 100 seed weight and pod length. A significant negative correlation of days to flower initiation, days to 50% flowering, and days to maturity with seed yield per plant was observed (Sultan *et al.*, 2012). Rai (2010) found a significant positive correlation of yield with plant height, pods per plant, pod yield per plant and pods per cluster. Green fodder yield recorded a positive association with plant height, leaf length, leaf width, number of leaves and dry matter yield (Kapoor and Bajaj, 2014). Quality traits like crude protein exhibited positive correlations with number of leaves and stem girth; acid detergent fiber with plant height, leaf length, and leaf width; neutral detergent fiber with leaf width. On the contrary, *in-vitro* dry matter digestibility exhibited only significant negative association with plant height, leaf length, leaf width, acid detergent fiber and neutral detergent fiber (Kapoor and Bajaj, 2014).

High heritability estimates [>85%] for plant height, clusters per plant, number of branches, pods per plant and seed yield per plant was recorded by Rai et al., (2012). But, Kapoor and Bajaj (2014) reported a moderate heritability for plant height [64.3%], and leaf width [52.4%]; low values for leaf length [35.8%], crude protein [38.5%], acid detergent fiber [11.8%]; and negative values for neutral detergent fiber [-5.7%] and IVDMD [-15.9%]. High heritability [>85%] coupled with high genetic advance as percent of mean [GAM; 31-69%] was detected in several characters [plant height, number of branches, days to 50% flowering, pods per plant and yield per plant] (Rai *et al.*, 2012). Branching pattern in cluster bean exhibited a complimentary gene effect (Hooda *et al.,* 1990). But, a monogenic inheritance pattern was observed for branching behavior. Additive type variances were reported to be more important for seed yield/seed weight (Arora *et al.*, 1996; Stafford, 1982) and pod length (Poats, 1961; Jukanti *et al.*, 2015).

Breeding in cluster bean: Multiple approaches are being attempted in cluster bean to identify better lines suited for drought conditions: (i) germplasm collection from dry regions (ii) summer screening to identify tolerant genotypes (iii) crossing high yielders with drought tolerant lines and (iv) hybridization between two early lines. Cluster bean varieties maturing in about 80-90 days are now available [HG-365, RGC-936, RGC-563] (Dass *et al*., 1973). Gum content has a positive correlation with seed yield (Lal and Gupta, 1977; Jhorar *et al.*, 1988) and negative correlation with seed weight. Gum content and endosperm showed negative correlation with protein content (Singh *et al.*, 1995). Both additive and non-additive gene effects determine the gum content in cluster bean (AICRPAL, 2013). There is a need to isolate entries with high gum content [>32%] and higher viscosity profile [4000 cP] (Kumar, 2005). NBPGR has evaluated and identified lines with high gum content: 34 lines [>40%], 98 lines [30-39.9%] and 31 [19.2-29.9%] (Kumar, 2005), similarly HGS 870 showed high gum content [31.78%] and higher viscosity profile [5116 cP] (Gandhi *et al.*, 1978).

Bacterial blight, alternaria leaf spot and powdery mildew are the important diseases that threaten guar production in several guar growing regions. Tolerant varieties with inbuilt resistance are the best option for combating these diseases thereby preventing heavy economic losses. Lodha (1984) reported that 'GAUG 63' had some tolerance to powdery mildew whereas HG75, G85, G102 and G225 were sources of bacterial leaf blight resistance (Kumar, 2005; Sharma *et al.*, 1999). Resistance to blight and leaf spot were reported to be dominant and recessive respectively [Singh *et al.*, 1995; Vig, 1965]. Further studies indicated the presence of additive, dominance and epistatic interactions governing the resistance of these two diseases. Phenol and peroxidase enzymes have been reported to confer resistance against these diseases.

Induced mutations through physical mutagens in cluster bean were used for the first time in India (Vig, 1969; Singh, 1972). Germination percentage, seedling survival and pollen fertility were greatly affected by increasing concentration of gamma rays [10-200 kR] (Chaudhary *et al.*, 1973). But, Chaudhary *et al.*, (1973) reported an increase in yield, protein and gum contents in M2 population irradiated with low doses [2-20kR] of gamma rays. High pods per plant and seed yield were observed in M3 progenies of RGC 197, exposed to different doses [10-80 kR] of gamma rays (Yadav *et al.*, 2004). Literature indicates that lower doses of different mutagens single or in combination induce higher variability than compared to higher doses (Kumar *et al*., 2013).

An unsuccessful attempt was made to transfer earliness from wild cluster bean (*C. serrata*) into cultivated species (*C. tetragonoloba*) by Sandhu (1988). Several other approaches including stigma amputation, organic solvents and bud pollination could not overcome the stigmatic incompatibility barrier. Techniques like protoplast hybridization, ovary/embryo rescue, and or recombinant DNA technology could be used in transferring agronomically important genes from wild species. Markers (RAPDs, SSRs, AFLPs and ISSR) are powerful tools to analyze the genetic diversity and relationships. RAPD markers have been utilized in cluster bean to a large extent to analyze the genetic diversity of varieties or cultivars (Punia *et al.,* 2009; Pathak et al., 2010).

Production technology: Cluster bean is mainly grown during rainy (*kharif*) season, but it can be grown during summer season under irrigation. Sowings can be taken up from 2^{nd} week of July to 1^{st} week of August and during summer from last week of February to 1^{st} week of March. Seed rate of 15-20 kg/ha is usually optimum. Sowing in paired rows (Kumar *et al.,* 2003) or solid rows is better compared to the broadcasting method. Better performance was observed at 60 cm inter-row spacing compared to 40 cm for early maturing varieties whereas closer spacing is recommended for late sown conditions (Faroda and Singh, 2003). An intra-row spacing of 10-15 cm was found to be optimum for both branched and unbranched types of cluster bean. Rao (1995) reported that cluster bean fixes around 30-70 kg/ha atmospheric nitrogen which had a residual effect of ~15-20 kg/ha. Its ability to fix nitrogen makes it a very good option for inclusion in different cropping systems. Singh et al., (2003) reported a 27.2% increase in cluster bean yield in intercropping of pearl millet [1 row] and paired rows of cluster bean as compared to solo stand in paired row. For kharif crop 1 or 2 additional irrigations are required at pod filling stage or under drought conditions.

Seed yield of cluster bean was significantly increased [25.2%] and better water use efficiency [21.7%] was recorded when the crop was supplied with 20 kg N and 40 kg P_2O_5/ha compared to control (Bhadoria *et al.,* 1997). But, supplying 60 kg P_2O_5/ha resulted in seed yield increase of 38.1% and 13.6% over control and 30 kg P_2O_5/ha respectively. A yield advantage of 44.9% [60 kg P_2O_5/ha] was realized over the control. Interestingly, this application also resulted in increased gum and protein content (Bhadoria et al., 1997). It has been shown that cluster bean responds to sulphur (S) supplementation at 40 kg/ha on S deficient soils (Kumar and Rodge, 2012). The first month after sowing is crucial for weed control and good control of weeds during this period result in better growth and higher yields (Yadav, 1998). Kumar *et al.,* (1996) have reported that mechanical weed control is better than chemical control in cluster bean. Pre-plant soil incorporation of fluchloralin at 1.0 kg a.i./ha was effective in reducing the weed population by 84% (Kumar *et al.,* 1996).

Seed yield, dry matter and nodule production in cluster bean is improved by seed treatment with either VAM fungi (Rao and Tarafdar, 1993) or arbuscular mycorrhizal fungus [AMF] + *Rhizobium* culture compared to the control. The impact of *Rhizobium* treatment on seed yield [varies from 8-15%] depended upon the rainfall distribution and intensity (Rao, 1995). Further, *Rhizobium* inoculation was reported to increase gum and protein content in the seed along with nutrient uptake and content (Kumawat and Khangarot, 2002). Multi-location studies indicated a beneficial effect of application of both *Rhizobium* and phosphorus solubilizing bacteria [PSB] on cluster bean yield by about 22.35% (Kumar and Rodge, 2012).

Production systems: In the rainfed conditions of Rajasthan, cluster bean is traditionally grown as a mixed crop with pearl millet, mung bean, moth bean and sesame. But with the increase of its demand now it is grown as sole crop. Under rainfed conditions it is grown in 2:1 row ratio in of cluster bean and pearl millet intercropping system. This system is quite profitable as compared to sole cropping of pearl millet. Cluster bean is mostly used as a rotational crop with pearl millet under rainfed conditions to improve the soil health and nutrient status of the soil which is useful for the next growing cereal crop. Following crop rotations are recommended: (i) cluster bean - pearl millet [two year crop rotation in rainfed condition] (ii) cluster bean-wheat [one year rotation] (iii) cluster bean - cumin [one year rotation] (iv) cluster bean –wheat - cluster bean - cumin [2 year rotation] (v) cluster bean – wheat - mung bean - mustard [2 year crop rotation] (vi) cluster bean – cumin - pearl millet - mustard [2 year crop rotation] (vii) cluster bean – wheat - pearl millet - cumin [2 year crop rotation].

Properties of gum: Cluster bean gum consists of long, straight chains of α-D-mannopyranosyl units linked together by β-D ($1\rightarrow4$) glycosidic linkage. α-D-galactopyranose, is an hexose that forms the side groups (Stephen, 1983). The ratio of mannose to galactose in galactomannan of cluster bean gum is approximately 2:1 (Robinson *et al.,* 1982; Englyst and Cummings, 1988). Owing to the difficulty in determination of the single/exact molecular weight, its range is estimated to be 200,000 to 300,000 daltons (Glicksman, 1969). Galactomannan acts as a good water binder due to the binding of water molecules in the active sites of D-galactopyranose and D-mannopyranose. Ability to form viscous dispersions or solutions in water is the most important characteristic of cluster bean gum powder. Viscosity of the guar gum powder varies with the particle size, and moisture.

Nutritive composition of cluster bean seeds: Variations in chemical composition of cluster bean seed has been reported by different researchers. The content of different traits varied in seed: (i) crude protein - 28.3 to 35.0%, (ii) ash content - 3.5 to 6.0%, (iii) fat – 1.8 to 5.2%, (iv) carbohydrate - 38.8 to 59.1%, (v) crude fiber - 4.1 to 8.0 and (vi) gum content – -23.9 to 34.2% (Pathak *et al.*, 2011) . But, Ahmed *et al.*, (2006) observed lower values for carbohydrate [23.7%] and higher values for crude fiber [9.3%]. Further oil and moisture content in seed was reported to be 2.3% and 7.3% respectively. Ahmed *et al.*, (2006) also estimated certain anti-nutrient factors including polyphenols [25mg/100g], tannins [1750mg/100g] and phytic acid [540mg/100g] content in cluster bean seed. Kaushal and Bhatia (1982) reported the presence of several toxic compounds in cluster bean seeds including gallotannins, gallic acid/its derivatives, myricetin-7-glucoside-3, kaempferol-7-glucoside-3-glycoside, kaempferol-3-rutinoside, kaempferol-3-glucoside, chlorogenic acid, caffeic acid and ellagic acid. Variability in oil content [3.06 to 7.5%] was reported by Joshi *et al.*, (1990). Linoleic acid [38.85%], palmitic acid [24.97%] and oleic acid [23.59%] were the major fatty acids reported in guar seed (Arora *et al.*, 1985). Joshi *et al.*, (1981) observed higher linoleic acid content [55.1%] in cluster bean seed oil. The percentage of unsaturated and saturated fatty acids was 69.38% and 30.52% respectively (Arora *et al.*, 1985).

Cluster bean seed consists of hull [14-17%], endosperm [25-42%] and germ [43-47%]. Its seed is rich in lipids, protein and minerals (Das and Arora, 1978). Germ portion of cluster bean seed is highly proteinaceous in nature [55.3%] along with good fiber content [18%], and D-glucose which is the major carbohydrate in the germ (Das and Arora, 1978). Crude fiber content is highest [35%] in hull. A considerable percent of carbohydrates [78-82%] is present in the endosperm in the form of galactomannan (Das and Arora, 1978). D-galactose anhydride [36.6%] and mannose anhydride [63.1%] make up a unit of galactomannan (Daas *et al.*, 2000). But, Sabahelkheir *et al.*, (2012) have reported higher mannose content [67-73%] and lower galactose content [28-33%] with a total carbohydrate content of 83.3-87.5%. The gum possesses considerable fractions of Zn [5.6 ppm] and Cu [2.5 ppm] along with protein [5.0%] (Joshi and Arora, 1993). The cluster bean gum lacks uronic acid that is usually present in gums of other plant species, differentiating itself from other crops (Tripathy and Das, 2013).

Commercial applications: Cluster bean uses can be classified into two broad categories: (i) traditional uses and (ii) industrial uses (USDA, 2014). The traditional uses include: (i) dried immature pods are salted and preserved for future use (ii) immature green pods are used as vegetable (iii) plants are used as cattle feed and the beans are used as high protein feed (iv) boiled seeds are used in traditional medicine (v) cluster bean crop is used a shade crop for ginger and also as a cover and green manure crop in general. Industrial uses - because of development of new processing methods and better technology, cluster bean has diversified usages including food applications, pharmaceuticals, cosmetics, textiles, paper industry, drilling, exploration, mining, petroleum industry and beverages.

International markets : India is a major producer of cluster bean in the world. In 2012-13 its exports were ~4.1 lakh tons compared to ~2.19 lakh tons in 2009-10. Similarly foreign exchange earnings increased approximately from Rs.11.3 billion in 2009-10 to Rs. 212.9 billion in 2012-13 (Fig. 1). Guar now accounts for around 18 percent of India's total agricultural exports. USA is the major importing country followed by Germany. Both of these countries account for more than 50% of India's exports of guar products. The other important importing countries from India are Netherlands, U.K., Japan and Italy. The gum is mainly exported as: (i) gum treated and pulverized – constitutes ~83% of cluster bean gum trade (ii) gum refined split – share percentage is ~16% (iii) cluster bean meal [guar meal] – accounts for a ~1% (USDA, 2014). The export value of treated/pulverized gum, refined split and meal during 2012-13 was INR 177.6, 33.9 and 1.4 billion respectively. The quantity of these cluster bean derivatives exported during 2012-13 was ~263.2 thousand metric tons (MT), ~70.5 thousand metric tons and ~74.8 thousand metric tons respectively (USDA, 2014). India is the major exporter of refined split and India has recorded an increase of ~76%, 23% and 20% growth in 2012-13 [compared to 2011-12] in the export value of refined split, treated gum and meal respectively. Overall, India exported 409.0 thousand metric tons of cluster bean derivatives valued at INR 212.9 billion during 2012-13. In 2012-13, India

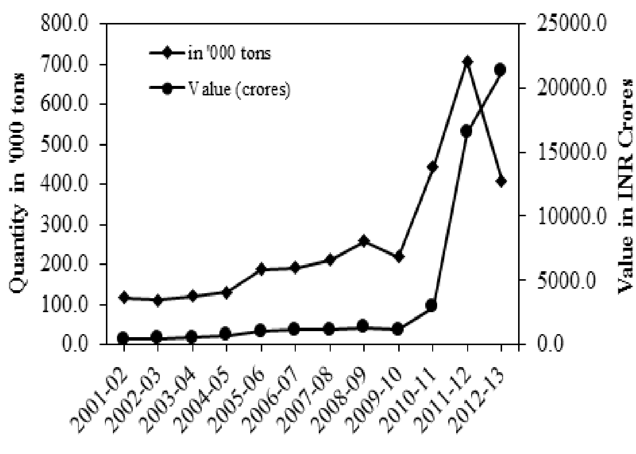

Fig 1: Export of cluster bean gum from India and its value in international market

Source: DGCIS Annual Export, APEDA Agrixchange exported about 245.0 thousand metric tons of cluster bean derivatives to USA alone, amounting to ~60% of India's total cluster bean exports.

CONCLUSION

Cluster bean cultivation has expanded to non-traditional areas including Andhra Pradesh, Karnataka, Madhya Pradesh and Tamil Nadu. Additionally, it is increasingly being grown under irrigated conditions in several parts of India. Overall, this review presents cluster bean as an important alternative for the farmers of arid and semi-arid regions of India and the world.

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