

Guar

—A golden crop for arid regions

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Parts of India and Pakistan have distinct climatic advantages favouring cultivation of the drought hardy legume, i.e. clusterbean occupying almost 90% global area. The crop has also been successfully cultivated to a limited extent in other parts of the world, particularly, USA, Australia, South Africa, Brazil, Zaire, Sudan and Zambia. Guar constitutes almost 0.27% share in India's agricultural GDP. Import and export items of guar gum contribute almost 0.23% of India's total export under agricultural products. The crop is known for low inputs requirements and restricted after cares. It is being largely preferred by the resource constraint farmers due to non-shattering pod's habit and restricted damage during storage mainly due to bruchid infestation. Guar may supplement major crops proving uneconomical like, groundnut in Rayalseema region, cotton in canal command area of Haryana and Punjab, and bajra in certain pockets.

Clusterbean [*Cyamopsis tetragonoloba* syn. *C psoraliodes*], commonly known as guar, is a drought hardy, deep rooted, summer annual legume of great significance. It is grown for grain, vegetable, green fodder, cattle feed, and for green manuring purposes mainly in arid habitats of Rajasthan, Haryana, Gujarat, Punjab. Guar has recently been introduced as rainfed low input crop in Rayalseema region of Andhra Pradesh, for grain purpose.

Guar is cultivated on marginal lands, with marginal inputs, for marginal, ends, has, however, occupied the status of international, cash crop with great export significance. The same has been due to presence of natural polysaccharide galactomannan gum content in seed endosperm. Guar gum is purely an export oriented commodity and 85-90% of guar gum produced in India is exported worth Rs. 1000-1200

crores annually for a number of industrial products.

Guar is exclusively cultivated as rainfed crop on light to medium textured soils with poor fertility. It requires almost 250-350 mm rainfall in 3-4 spells. It is basically *kharif* crop and requires 90-130 days for completing its life cycle. Pod formation stage particularly, 50-70 days of planting, is rated crucial for this crop in respect of soil moisture availability. The crop thrives well in temperature range of 25-30°C, RH 50-75, longer days with 8-9 hr sunshine towards maturity.

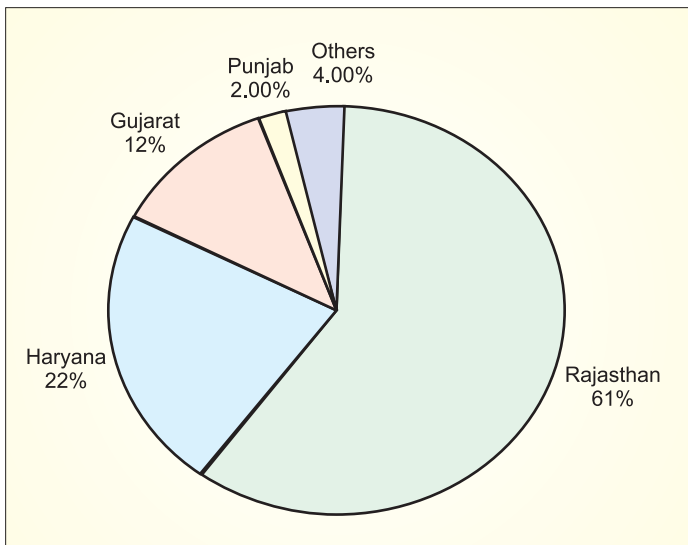
Guar production

Total global guar production is realized to the tune of 10-15 lakh tonnes annually. However, India is the most important guar producer at the world level and contributes almost 75-82% global guar grain production, followed by Pakistan (15%), USA, South Africa, Sudan and Australia. In Pakistan, guar is mainly grown in Punjab and Sindh

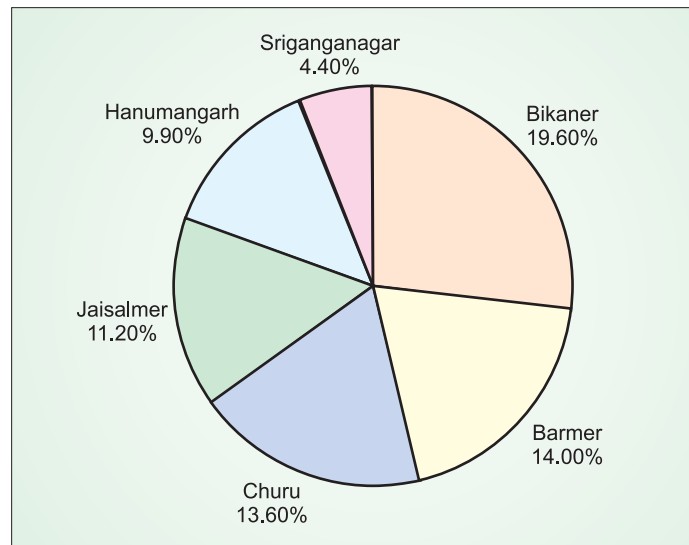
provinces, which contribute almost 80% of total guar production in Pakistan under irrigated condition.

Average productivity of guar in India greatly fluctuates due to rainfall pattern in Western districts of Rajasthan. For instance, during severe drought year of 2002-03, the production sharply dropped to 2.0, whereas the same dramatically climbed to 15.0 lakh tonnes during 2003-04 probably due to high price rise during previous year and increased area during 2003-04. Rajasthan alone grows country's 70-75% guar and produces country's 60-62% guar. In Rajasthan, districts (Bikaner, Churu, Barmer, Jaisalmer, Hanumangarh and Jodhpur) occupy 60% State's guar area. Haryana contributes 25-29%, Gujarat contributes 10-11% towards total guar production in India. Punjab and Uttar Pradesh contribute marginally. As per 2007-08 figures, there was mismatch between area and production of guar at the districts level in Rajasthan. For instance

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Share of Indian states in guar production (av. 2003-04 to 2006-07)



Contribution (%) of main districts of Rajasthan in respect of guar area in the state

maximum area was occupied by Bikaner (19.6%) but maximum production (20.0%) was realized from Hanumangarh district.

Critically reviewing the growth and instability in area, production and productivity of guar in India and Rajasthan, it becomes evident that cv. values for India were 26.61, 43.73, 32.62%, and for Rajasthan 29.18, 61.13, 51.13%, respectively, for the period of 1970-71 to 2007-2008, indicating somewhat stability in area. Thus, production could be increased by imparting stability in production via productivity.

Uses

Guar is a multi-purpose arid legume and is known for the following uses:

Guar gum: Guar gum hydrates fairly and rapidly in cold water to give highly viscous pseudo plastic solution of generally greater lower-shear viscosity when compared to other hydrocolloids and much greater than of locust bean. It is an economical thickener and stabilizer with good binding properties. Being non-ionic, it is not affected by ionic strength but will only degrade at 50°C and pH 3. Guar gum also retards ice crystal growth. Due to

aforesaid chemical properties, guar gum has diversified uses in textile, paper, petroleum, food, mining, oil drilling, cosmetic, explosive, purification of potash, photography, pharmaceuticals, and tobacco industries etc.

Guar meal: By product of guar gum industries consisting of seed-coat and germ material is called guar-meal. It contains almost 40-45% crude protein, being one-and-a-half time more than found in its seed. The quality protein of guar meal, is well comparable to oil cake and can completely replace groundnut cake as protein supplement in ruminants. It is also used as a feed for livestock including poultry. Two anti-nutritional factors (residual guar gum and Trypsin inhibitors) found in guar meal can be improved by toasting of guar meal for chickens. It could be used in limited quantities, i.e. up to 10% in poultry diets.

Fodder: Guar provides nutritious fodder and concentrate to the livestock. It is a rich source of protein but low in TDN (Total Digestible Nutrients). The green forage contains (on dry matter basis) about 16% crude protein, 46% TDN, 11-12% DCP (Digestible Crude Proteins) and 60% matter

digestibility. However, nutritional value of fodder varies with the stage of maturity. It is advisable to feed guar at 50% flowering stage. The voluntary dry matter intake of guar fodder is quite high, i.e. 2.50 to 3.53 kg/100 kg body weight. Guar hay is quite nutritive, makes good silage specially when mixed with wheat straw.

Green manure: The crop meant for green manuring is sown early (April-May) and is ploughed down in blooming stage (50-60 days stage). It is largely used as green manuring crop in canal irrigated areas. Guar has tolerable moisture content (75-80%) and has ability to decay and integrate in the soil, in the presence of minimum soil moisture.

Medical purposes: Guar has medicinal values for curing various diseases. Leaves of guar are eaten to cure night blindness. Ashed plant is mixed with oil and is used as a poultice on cattle boils. Seeds are used as chemotherapeutic agent against small pox, and also used as laxative. Boiled guar seeds are used as poultices for the plague, enlarged livers, head swellings, and on swellings due to broken bones.

Human consumption: Guar pods are consumed as a delicious green

Table 1. Industrial uses of guar gum along with expected functions

Industry	Uses	Expected Functions
Textile printing	Cotton, rayon silk, wool sizing, carpet printing	Reduces wrap breakage Reduces dusting film Formating thickening for dye.
Paper	Wrapping paper, craft, photographic paper, filter	Replaces hemi-cellulose. Increases strength, fold, pick. Pulp hydration.
Oil well drilling	Drilling fluids hydraulic fracturing	Control of water loss, viscosity, suspension, turbulence, mobility, friction reduction.
Explosive	Stick explosive, blasting slurries.	Water proofing, gelling agent.
Mining	Concentration of ore, filtration.	Flocculating and settling agent.
Fire fighting	Water for fighting fires.	Friction reducing, dispersion and direction control.
Coal mining	Coal suspension, shock.	Friction reducing suspending agent.
Tobacco	Reconstitution of fragmental tobacco.	Binding agent, strengthening agent.
Water treatment	Industrial water, drinking water.	Coagulant aid (food approved).
Photography	Emulsions, gelatine solutions.	Gelling hardening agent.
Food uses		
Bakery	Bread, cakes, pastry, icing.	Dough improvement, greater moisture retention, prolonged self life.
Frozen foods	Ice-creams, soft serves, frozen cakes.	Water retention, ice crystal inhibitor, and stabilizer.
Dairy products	Yoghurts, desserts, molasses	Inhibits when separate, keeps texture after sterilization.
Processed cheese	Cottage cheese, cream, cheese	Increases the yield of curd solids, improves tenderness.
Instant mixes	Pudding sauses, desserts, beverages.	Fast, cold dispersible thickening and text rising agent.
Canned foods	Pet foods, corned meal baby foods	Acid resistant thickening and suspending agent.
Dressing and sauses	Salad, cream, pickles.	Fast, cold dispersible thickening and text rising agent.
Beverages	Cocoa drink, fruit nectar, sugarless beverages	Acid resistant thickening and suspending agent.
Pharmaceuticals uses		
Pharmaceuticals	Cholesterol Diabetic treatment Laxative slumming aids Gastric hyper acidity Vitamin formation preparation	Reduction of urinary glucose loss. Bulking agent, bulk forming appetite depressant. Reducing and stable water soluble suspension.
Cosmetics uses	Hair shampoos, Hair conditioners Lotions Ointment Tablets	Detergent, compatible thickener, Protective colloid film forming agent. Lubricating suspending agent. Thickening agent gives unctuousness. Disintegrating and granulating agent.

vegetable during summer season from March to September when good vegetables are not available. Green pods are found rich in minerals like iron, calcium, phosphorous and vitamin, A and D. Mature pods are dried and fried like potato chips and can be cooked like French bean. Green pods are dried, salted and

preserved for future use.

Source of resistant starch (RS):

The RS are the total amount of starch that are not digested in small intestine and passed into the large intestine, hence, these starches are considered component of dietary fibres. Guar contains high level of resistant starch than cereals and grain

based foods products. These are RS 1, RS 2, RS 3 and RS 4 Resistant Starches based on their indigestibility. Guar contains RS 1 starch, which resists digestion because it is protected from digestive enzymes. RS provides many health benefits such as improving bowl health, blood lipid profile, increasing feeding of satiety and micro-nutrient absorption (Mg and Ca) in the colon. These factors may affect the risk of developing diseases (colorectal cancer, cardiovascular disease, osteoporosis and inflammatory bowel diseases). RS may be of benefit to healthy individuals who are trying to achieve and maintain healthy body weight. RS containing foods have low glycogenic index thus, release of glucose is slow resulting in lowered insulin response and greater access to and use of stored fat, ultimately used in the treatment of obesity and weight management.

Export of guar gum

In India, approximately 90% of guar seed is used for production of guar gum and rest is used for culinary purposes and cattle feed. India exports almost 75-80% of its guar gum including other derivatives annually. The export patterns of guar gum and its derivatives are largely influenced by the increasing demands from petroleum industries in USA and the oil fields in the Middle East. USA alone consumes almost 60-70 thousand tonnes of guar gum and its derivatives. The major derivatives of guar seed (refined splits, gum powder, and guar meal) are exported from India. It is appreciable that export of refined guar split has been increasing with 5.3% compound annual growth rate (CAGR) and 14% CAGR in respect of value; and the same values for treated and pulverized guar gum have been 8.3 and 18.0% CAGR, respectively, showing better growth for the latter. Further export composition of guar derivatives shows that export of

treated pulverized gum was more (53%) than refined guar split (47%) during 1990-91. India exported 2.58 lakh ton of guar gum worth Rs.13.8 crores during 2008-09. During later years export is likely to increase to more than 2.70 lakh tonnes due to lower guar production and high prices in Pakistan.

During 2006-07, top importing countries of guar products were; USA (75 thousand tonnes), followed by China (27 thousand tonnes), Germany (17.7 thousand tonnes), Italy and Netherlands (4.5 thousand tonnes, each). Global consumption of guar derivatives has in general been in food grade (50-55%), industrial grades (25-30%), textile, paper, tobacco, photography (10-15%) and pharmacy grades (5-10%).

Export of guar meal

Animal feed manufacturers and dairy owners are the large buyers of guar meal. The major importer of Indian guar meal presently is Malaysia, followed by Vietnam, Germany, China, Korea, Netherlands, Russia, Thailand and USA. Till 2006-07, USA was the largest importer of guar meal with about 40% share of total India's guar meal export. During 2007-08 Malaysia accounted for largest import of guar meal (57%). There is increasing demand of guar meal due to limited availability from conventional sources such as oilseed. Strong demand for "Churi" and "Korma" in both domestic and export markets, can stimulate further demands.

The issues related to gaps in research, growth, development, value addition, export and marketing of guar are many and if addressed accordingly, could help in horizontal and vertical expansion across the sectors. Some of the main gaps are briefed below.

Technological issues

More instability in guar productivity: Calibration of % cv

values (1970-71 to 2007-08) revealed that the same for area, production and productivity of guar at the country level were 26.6, 43.73, 32.62% and for mega state of Rajasthan were 29.18, 80.13 and 51.15%, respectively, revealing, therefore, stability in area but more fluctuations in production probably due to high instability in productivity.

Poor productivity in Rajasthan: Long range average productivity (past 15 years), reveals that guar productivity in Rajasthan, Haryana, Gujarat and Punjab have been 380.0, 850, 670 and 800 kg/ha, respectively. Poor productivity in Rajasthan is a matter of concern.

Strict adaptation: Guar is strictly adapted to dry habitat of arid regions, not permitting its extension towards less harsh environment of semi-arid regions with desired productivity potential.

Longer maturity: Still breeders are at large of any improved variety maturing in less than 85 days; leading to terminal water stress.

Slow initial growth: Initial growth is very slow posing serious exposure of weeds, if proper care is not taken within 20 days of its planting.

Disease susceptibility: There is no improved variety with inbuilt resistance potential towards major diseases like, bacterial leaf blight, *Alternaria* leaf spot and root/stem rot.

Effective and cheap planting devise to complete sowing of large area (20-25 lakh ha) in 2-3 days of rainfalls and providing uniform optimum plant stand is desired for Rajasthan at least.

Social

- Cultivation of this crop in poor textured and infertile lands.
- Cultivation of this crop with marginal inputs and providing restricted after care.
- Attaching second priority for cultivation of guar in respect of inputs, lands etc.
- Big seed companies are not

coming forward and showing interest in large scale seed production programme.

Marketing

- There is a wide fluctuation in availability of guar and its derivatives.
- Limited market intelligence available for guar grain, guar gum and its derivatives.

Taxation

- There is wide variation in tax structure for its entry in states. For instance, State tax on entry of guar in Rajasthan is 2% but there is no tax in states of Haryana, Gujarat, Punjab hence, imposing loads on guar industries, leading to their migration in other less important states.
- Market fee for sailing guar seed is maximum in Rajasthan (1.60%), followed by Haryana (1.0%), 0.50% in Gujarat but no fee in Punjab.

Value addition

USA, China and Germany are importer of guar gum powder/splits from India. However, these countries import 40% of their demand through guar splits only. We do not have product specific value addition. Considerable quantities of value added derivatives are re-exported back to India.

China's custom tariff on grain split is 5% but on guar powder is 15%, thus, encouraging export of raw guar products from India. On the contrary, import-tariff on guar products from Pakistan is nil, thus, showing discrimination between two neighbours.

Technology

During past 15 years more than 16 promising varieties have been developed having dent on grain yield, plant type, maturity period and quality values. Production and protection technologies have also

been developed and new varieties are leading to diversification in agriculture, supplementing major crop sequences.

Promising cultivars

Maturity Period

Early maturity (85-90 days):
RGM-112, RGC-936, HG-365, HG-563

Medium maturity (91-100days):
RGC-1017, RGC-1038, HG-884,
RGC-1002, RGC-1003

Medium late maturity (101-110 days) : RGC-197, RGC-1066,

Late maturity (111-120 days):
RGC-986, RGC-1031, HG-2-20

Single stem (unbranched): RGC-197, RGC-1066, (suited to intercropping).

High gum content (31-32%): HG-365, HG-563, HG-2-20, RGC-1002, RGC-986

Determinant type: IC-299971

High grain yield potential (1200-1600 kg/ha): HG-365, HG-884, RGC-1038, RGC-1002

Disease resistance: BLB(8-19% infection) and ALS (7-12% infection): HG-365, HG-563, HG-2-20, HG-75, HG-884.

Suitable for irrigated and better input situation: RGC-986, HG-2-20

Suited for red soils of Rayalseema region: RGM-112, HG-365, RGC-1017

Mechanical harvesting: RGC- 1066

Diseases

Guar suffers from following main diseases.

BLB: [*Xanthomonas axonopodis pv. (Cyamopsidis)*]. It may cause yield losses from 32 to 68%.

The congenial situations causing spread of this disease are : scattered rains, high temperature (20-30°C) and humidity. High nitrogen doses (20-40 kg/ha) may also result in higher disease index. Plants at early growth (20-30 days) may be more susceptible, leading to their drying due to stem rotting. Presence of high specific activities of oxidative

enzymes, viz polyphenol oxidase and per-oxidase enzyme have their possible role in disease resistance mechanism.

ALS (*Alternaria cucumerna var. cyamopsidis*): It may cause more than 55 grain yield losses in epiphytotic and favorable conditions. Temperature range of 25-30°C along with high humidity and scattered rains may prove congenial for spread of this disease. Infection increases with increasing plant growth period, may reach from 80 to 85% by November. Biochemical studies indicated that polyphenol oxidase and peroxidase activities increased intensity of this disease, while catalase activities reduced it.

PM [*Odiopsis Taurica, Erysiphe taurica*]. Late planting high humidity and warm temperature favour spread of this disease, while dusty patches can be seen on the leaves. Infected plants are defoliated, show premature dying and look weak. However, general high humidity and high temperature are not frequent in guar growing areas particularly in arid Rajasthan.

Root rot complex: [*Macrophomina phaseolina R. solani, Fusarium caeruleum, Sclerotium rolfsii, Neocosmospora vasinfecta*] . More than 90% seedlings mortality may be caused due to these pathogens. Root rot and wilts are major problems causing root disease. *R. solani* has been observed highly pathogenic, may kill 90% seedlings within 3 weeks. These fungi are more severe throughout soil moisture range of 15-16% and atmospheric temperature 28-30°C. Dry root rot and wilts are simultaneously caused by these pathogens.

Integrated disease management approaches: (i) Avoiding use of FYM and over irrigation in irrigated crop; (ii) Growing short duration varieties viz; HG-365, HG-563, RGC-936 to escape the diseases incidence; (iii) Using hot water treatment of the seed (56°C) for 10 min. before

sowing; (iv) Soil solarization in the month of May is understood most effective in checking soil borne pathogens; (v) Spraying Streptocycline @ 150 ppm twice at 15 days interval at the appearance of BLB. (vi) Spraying Di. M-45 @ 0.2% thrice at an interval of 15 days at the appearance of AB, also spray imidacloprid once to check insect pests; (vii) Use kitazin @ 2 ml/kg seed along with Chloropyriphos @ 4 ml/kg and streptocycline @ 1 g/kg seed to check the presence of insect pests, fungi and bacteria during storage; (viii) Using mustard residue (2.5 t/ha) + *Bacillus thuringiensis* (ST, 4 g/kg) + One summer irrigation to check pre and post-emergence seedlings mortality; (ix) Using Bavistin (ST, 2 g/kg) followed by one foliar application of Bavistin (0.1%) during 2nd fortnight of August to have maximum seed germination, minimum seedlings mortality and maximum grain yield; (x) Spraying the crop with wettable cresan and cupravid @ 1 kg/ha at an interval of 15 days at the appearance of PM disease.

Convenient production technologies

Guar farmers are not interested in more investment and feel hesitant in adopting full package of practices, particularly fertility and plant protection measures, hence technological options are limited. Thus, affordable and convenient technological back-up could be as follows:

- Early planting by first week of July is justifiable to overcome terminal stress and powdery mildew disease.
- Applying 20 kg N + 30 kg P₂O₅ + 25 kg ZnSO₄/ha before planting only; or spraying of urea (1-1.5%) at 45-50 days of planting.
- Keeping crop weed free up to 20-30 days of planting by hand practices.
- Keeping 40-50 cm inter-row

spacing for branched type, and 25-30 cm inter-row spacing for unbranched types.

- Using RGC-1066 var. at 20-25 cm inter row spacing for use of combine harvester in canal command areas of Ganganagar, Hanumangarh (Rajasthan) and Sirsa (Haryana) districts.

Technology transfer

Suitable varieties, packages and the contribution of important factors have been identified for different regions and districts. For instance, for guar growing belts of S.K. Nagar, (Gujarat) variety GG-2; for Rewari and Hisar (Haryana) variety HG-563; for Agra (UP) var. HG-563; Bathinda (Punjab) var. HG-365; and for Chittoor, Koddappa and Anantpur (AP) HG-365 and RGC-1003, HG-563 for RGM-112, variety have been identified. Similarly promising varieties for different districts of Rajasthan have been tapped. For instance, RGC-1066 (1,800), RGC-217(1,848), RGC-936 (1,565) and RGC-1003 (1,462 kg/ha) for Jaipur district; RGC-1055 (1,412) and RGC-1002 (1,243 kg/ha) for Vanasthali; RGC-1033 (1,048 kg/ha) for Ajmer district and RGC-1077 (1,127 kg/ha) for Alwar district have shown worth under strictly rainfed conditions. Conclusive results have been generated following different inputs, cultivar and sowing methods. For instance, line sowing at 40 cm; 20 kg N + P₂O₅, and 25 kg ZnSO₄/ha were found effective in increasing grain yield by about 37, 26 and 18%, respectively. Maximum yield potential of guar following individual or integrated components were also determined and the results were quite convincing. For instance, the cv. RGC-1002 yielded maximum (1,870 kg/ha) at Durgapura during 2006; cv GG-2 with 20 kg N + 40 kg P₂O₅/ha yielded 2,300 kg/ha during 2006 at S.K. Nagar, perfect weed management at Bathinda during 2003 using cv. HG-365, yielded to the

extent of 1,680 kg/ha.

In view of rainfall pattern, soil types, social factors, availability of irrigation water, potential of guar in reference to area and production a road map was developed to provide guar technologies up to district level.

Future strategies

- Rajasthan occupies almost 65-70% guar area of the country but its productivity is 370 kg/ha, on the contrary productivity of Haryana, Gujarat and Punjab are much higher (800, 670, 820 kg/ha), respectively. Thus, for over all growth of guar in India, there is need for vertical expansion in Rajasthan and in other states horizontal expansion is desired.
- There is need to develop guar varieties maturing in less than 85 days (preferably 75-80 days) so as to avoid crop from terminal water stress.
- Farmers are not interested in plant protection measures as they see this crop from marginal angles, hence, inbuilt multi disease resistance (BLB, PM AL, Root rot) is extremely desired.
- Package of practices for subsistence and corporate farmings are required to be developed separately for marginal farmers and guar gum industrialists.
- Guar varieties with higher gum content (>32.0%) and viscosity profile (>5000cP) are desired from quality export angle.
- Instead of exporting guar gum powder or guar splits, value based guar gum derivatives may be developed and exported.
- In view to help marginal farmers, *Mandi* tax on guar may be scrapped.
- Private seed companies may be encouraged to help produce certified seeds in required quantities.
- Plant protection measures must be economic, feasible and related to pre-seed treatment stage only.

- Mind set of the farmers may be changed to attach status of the cultivation of guar crop from secondary to primary priority in respect of land, inputs and after care.
- More focus is required on introduction of mechanical operations by developing need based varieties and crop husbandry technologies to ensure large scale planting in stipulated timings, optimum plant geometry and reducing labour requirement and ultimately economizing cultivation of this drought hardy legumes.
- Technologies for summer cultivation with limited irrigation may be developed for expansion in area and diversification of agriculture.
- For meeting the requirement of fodder scarcity in arid regions, stress may be given on breeding dual-purpose varieties.
- There is ample opportunity to supplement the cultivation of crops like bajra, cotton and groundnut (uneconomic, high inputs required crops) in canal command, Rayalseema regions and other arid regions, hence need based dedicated efforts are required to be undertaken.

SUMMARY

Guar is drought hardy summer annual legume of great significance. Low productivity is a cause of great concern. To address related problems efforts have been undertaken to develop need based technologies. Guar varieties maturing in 85-90, 91-100, 101-110 and 111-120 days with high production potential (1,200-1,600 kg/ha), high gum content (31-32%), suited to mechanical harvesting have been developed. Integrated management strategies addressing the infestation by BLB, ALS, PM and RR diseases have been developed. Convenient and economic production technologies have also been

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developed. Large scale technologies through FLDs have been transferred. Results reveal that grain yield could be harvested up to 2,000-2,200 kg/ha on farmers' fields. By proper sowing

method having desired plant geometry grain yield could be increased by about 37.0%. Weeding is very crucial for the crop up to 25-30 days. In view of rainfall pattern

soil types, productivity level and social factors, technologies have been suggested up to the district level with setting production priorities for each district. ■
