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CLUSTERBEANS *Cyamopsis tetragonoloba* (L.) Taub. — PROPERTIES, USE, PLANT GENETIC RESOURCES AND EXPECTED INTRODUCTION IN RUSSIA
(review)

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Abstract

Clusterbeans *Cyamopsis tetragonoloba* (L.) Taub. is annual leguminous plant of multipurpose use. In India it is known as a forage crop, green mass serves for animal feeding and as a green manure (K.V. Muradov, 1973). Young green pods are used as vegetable, and many vegetable guar varieties are cultivated (N.K. Dwivedi, 2009). Guar meal (husk and germ) is a high-protein ingredient for feeding cattle, broilers and fish, its antidigestive factors can be reduced by temperature treating and adding enzymes (M. Hussain et al., 2012). Guar powder Churi 40 contains about 40 % of protein, granular guar fodders Korma 50 and Korma 60 contain 50 and 60 % of protein. Guar gum extracted from endosperm of guar seeds is used widely in food, textile, paper, cosmetic and oil industries for its ability to emulsify and thicken liquids (D. Mugdil et al., 2014). The demand in guar gum is increasing in domestic and world markets. Plant genetic diversity of the crop is allocated mainly to India where guar had been growing from ancient times. In USA guar breeding has succeeded with improved varieties (W. Liu, 2003). Guar collection founded in the Institute of Plant Genetic Resources (VIR), Russia, by N.I. Vavilov lists more than 100 accessions. Germination of guar seeds from VIR collection after 40-year storage even at the room temperature remained high. The research data and the practice of guar growing in Russia testify that the crop could be successfully cultivated in the southern regions. Here, the main desired traits of the guar are short time for crop maturation and high gum viscosity.

Keywords: guar, guar meal, granular guar fodder, guar gum, galactomannans, genetic resources of clusterbeans, introduction

Guar *Cyamopsis tetragonoloba* (L.) Taub. is annual tropical legume. Like other beans, guar seeds contain a significant amount of protein, its green mass is used fresh and dry, the plants enrich soil with nitrogen. Guar gum [1], which is obtained from endosperm of seeds is of particular value and widely used in food, cosmetic, textile, paper, oil industry. In recent decades, from a little-spread tropical culture, guar is turning into one of the most popular in the world, which updates the task of its introduction in Russia.

The purpose of this review is to summarize information about the particular plant features and products, genetic resources preserved in world's collections and in Russia, and about the perspectives of cultivation of this crop non-traditional for Russia.

Botanical and ecogeographic description. Guar (cluster bean, Indian acacia) — hewar *Cyamopsis tetragonoloba* (L.) Taub. of *Fabaceae* L. family, tribe *Indigofereae*. Synonyms: *Cyamopsis psoraloides* (Lam.) DC, *Dolichos fabaeformis* L'Herit., *Dolichos psoraloides* Lam., *Lupinus trifoliatus* Cav., *Psoralea tetragonoloba* L., *Cordaea fabaeformis* Spr. (http://www.theplantlist.org). The genus Cyamopsis comprises four species: *C. tetragonoloba* (L.) Taub., *C. senegalensis* Guill. & Perr., C. *serrata* Schinz., *C. dentata* (N.E. Br.) Torre [2]. J.B. Gillett divided the genus into three species: *C. tetragonoloba* (L.) Taub., C. *senegalensis* Guill. & Perr., *C. serrata* Schinz., without identifying *C. dentata* (N.E. Br.) Torre as a species; in his opinion, the genus *Cyamopsis* is closest to the tropical genus of the *Indigoferae* family [3]. H.A. Senn expected that the genus *Cyamopsis* originated from the genus *Indigofera* due to aneuploidy [4]. *Cyamopsis senegalensis* is regarded as the ancestral form of cultural *Cyamopsis tetragonoloba* (L.) Taub. species [5]. An argument in favor of such origin is the presence of galactomannan in seeds of *C. senegalensis* which is similar in structure and content to the guar galactomannan. Potentially *C. senegalensis* can be considered as a source of gums [6].

The place of guar origin is India, Pakistan, and probably Africa [2], but it has never been found in the wild. N.I. Vavilov considered that the center of guar origin and diversity was India [7]. Although, green guar beans are used in India as a vegetable, the Indian name of guar is "gau-aahaar" ("cow's food") [8], that is, traditionally the guar is primarily an ancient forage crop [9]. There is a belief that guar *Cyamopsis tetragonoloba* originated through trans-domestication from an African species which were imported to India as horse fodder by Arabian traders [5]. The guar is mainly cultivated in the arid regions of northwestern India, the Thar desert territory, which covers the Indian states of Rajasthan, the southern part of Haryana, Punjab and north Gujarat, also the southeast Pakistan. In this area with 90-200 mm of rainfall annually, most of precipitations fall during the summer monsoon (from July to September). Pasturing is dominated in the region, and perhaps, guar for centuries served as forage for cattle, camels, horses, and sheep. Not long ago, it was announced about the finding of missing link between wild species of the genus *Cyamopsis* and the cultigene. In the Northwest India, the wild-type forms have been found in the domesticated guar crops. To date, 66 samples of the so-called adak guar have been collected. These plants are prostrate, have small inedible dehiscent pod, its seeds are characterized by a rest period. Further study is necessary to clear up the role of native forms in the guar origin and possibility of using additional genetic variation which was lost during domestication [10].

Guar, like many annual legumes, is self-pollinating plant (percentage of natural crossing is incidental) [11, 12]. Plants vary significantly in height being 50 cm to 1.5 m tall. Stem is solid and lignified by the maturing time. Taproots can access moisture in low soil depths, so that the plant can tolerate short-term drought. As to morphology, guar plants have basal branching or fine branching along the stem may be single stemmed. Leaves are trifoliate, pubescent or smooth. Flowers almost peduncles, with corollas from white to bright pink in color, the inflorescence is axillary raceme and born in clusters. Pods settle tightly forming groups (clusters), due to which English name of cluster beans originated. Pods are straight, slightly curved, from 4 to 14 cm long, containing 5 to 12 seeds. Mature seeds vary greatly in color (dirty white, pinkish-gray, gray-beige, brown, black), seeds are rounded-quadrangular, flattened, have a large spherical endosperm which contains a spare galactomannan polysaccharide. Diploid chromosome number is 14*n* [13]. Guar is a thermophile plant, undemanding about soil (growing on sandy soils and well drained clay soils). Like other legumes, guar refers to soil-improving crops. It is used in crop rotation with cotton, sorghum, wheat [2]. Nowadays, guar is mainly grown for grain; its seed consists of embryo (40-45 %), seed coat (14-16 %) and a large endosperm accounting for 38-45 % of the total seed [14-16].

Application. In Indian breeding and genetics guide (1957), guar was listed as forage plant and vegetable crop "for poor people" [17]. Nowadays, in India guar is cultivated as livestock fodder, vegetable and technical plant and it is also used in Indian traditional and modern medicine [18, 19]. Young beans are eaten stewed and salted [20].

Guar green mass, which is used for cattle forage and as green manure, contains 15.56 % of crude protein and 15.74 % of crude fiber [21]. The best time to cut guar for green forage is the flowering phase and the milk ripeness of the beans. The attractivity of the guar green mass for cattle is increasing after grinding and pre-wilting. The recommended guar hay proportion in the diet of adult sheep may be up to 70 % [22]. In the arid regions of India, after harvesting beans, cattle and camels are grazing on the guar plant residues in the fields [23]. Guar is recommended as an alternative to water intensive crop alfalfa in a country with such arid conditions as the Arab Emirates [24].

The guar bean contains antinutritional substance, so when whole grain feeding, thermal treatment is required [25], and in poultry nutrition guar beans should not exceed 10 % [26]. The guar protein is well balanced in amino acid composition [27]. The protein amount in the embryos and spermoderm is 28.9-46.0 %, embryos and husks in the raw material for guar fodder account for about 25 and 75 %, respectively [28]. Guar meal Churi and granulated feed Korma (the exchange energy in the latter is 2022-2074 kcal/kg)are using in dairy cattle feeding. Guar meal Churi 40 % is obtained after splitting, refining, roasting, triturating and sterilizing. The feed contains 5-7 % fat, 5-10 % fiber (with humidity up to 10 %), the amount of raw protein (38-42 %) is higher than that in corn gluten fodder (http://guarprotein.com/). Guar meal digestibility is 76 % after heat treatment and 71 % without treatment. Thermally processed Churi food can replace soybean meal in the bovine ration. Korma 50 feed is obtained mainly from the embryos fraction (raw materials are purified without roasting). It contains 48-50 % protein and is used in cattle and poultry diet. Roasted Korma 60 contains up to 56 % protein with improved digestibility. Feed is recommended for animals and fish, replaces a more expensive soybean meal. Bio Guar Protein (Pro NX 60+ (Cyamopsis Biotech, India), the premium segment feed, is a roasted guar meal with a protein content of 60 % and higher, is destined for aquaculture, feeding salmon fish and shrimp (http://guarprotein.com). Producers of guar feed export it to many countries, including Russia. Guar seed feed is the cheapest source of vegetable protein for ruminants and poultry, its addition to diet reduces costs significantly. It is well eaten by cattle but can cause problems in monogastric animals [29]. Guar-based feeds increase fat content and milk yield in cows, positively affect diet digestibility, guar fodder may be used separately or as an ingredient of the compound feeds, but the transition to this feed must be gradual [30, 31]. The high amino acids content makes guar fodder a useful additive for broilers and laying hens, but the increase in its proportion in the poultry diet is limited by antinutrients such as trypsin inhibitors, gum residues and saponins. Roasting destroys trypsin inhibitors, resulting in their less amount in guar fodder compared to soybean meal [28]. Basically, the growth of broilers is slowed down by traces of gums, rather than seed antinutrients [26]. One of the methods to eliminate the negative consequences of eating guar fodder by the bird is the addition of the enzyme β-mannase directly to the compound feed, resulting in a decreased viscosity of the gum trace amounts [32, 33].

According to data 2014, 79 large industry non-integrated works operate in India, where the guar seeds are divided into a shell and an embryo [34] as sources of the protein fraction and the endosperm (split) containing galactomannan, the base of guar gum which is considered the most valuable processed product of guar seeds.

Guar gum. Locust bean (*Ceratonia silique* L.), guar (*Cyamopsis tetragonoloba*), tara (*Caesalpinia spinosea Kuntze*) and fenugreek (*Trigonella foenum-graecum* L.) are commercial gum sources of plant origin [35]. Polysaccharides in seeds of *Fabaceae* family species, with different types of endosperm development, are mainly galactomannans which consist of D-mannose and D-galactose and are localized in the endosperm cell walls. Theoretical interest arouse from polyfunctionality characteristic of such phyto-polysaccharides [36, 37]. They show a protective function, as well as serve as the energy reserve and are involved in regulation of the water balance during seed germination [38]. Due to the hydrocolloid properties, the galactomannans which contained in endosperm provides moisture retention, necessary for seed germination in drought conditions. Galactomannans of legume seeds differ in the ratio of mannose and galactose (M:G), in molecular weight and galactose group location on the mannose skeleton. In galactomannans, the mannose units form a chain consists of hundreds (1→4)-β-D-mannopyranose units with α-D-galactopyranose units, which are joined by 1→6 bonds and in different ways (depending on the plant species) are distributed along the main mannose chain.

Chemically, guar gum is a non-ionic polysaccharide the molecule of which is formed by a mannose skeleton with attached side galactose residues. The empirical formula of guar galactomannan is $(C_6H_{10}O_5)n$ [39]. The D-galactosyls are arranged in small groups of mostly two to four units, attached to contiguous D-mannosyl chains and separated mostly by two, or occasionally three, D-mannosyl residues [40]. The galactomannan molecule of guar gum has the largest molecular weight among water soluble natural hydrocolloids. Galactomannan content of guar seeds is up to 35 % of the seed dry weight [41].

Galactomannan is readily soluble in cold water with the formation of viscous colloidal solution, even in low concentrations, so guar gum is used as a natural thickener, sealant and stabilizer in many industries [8, 9]. Most people in developed countries consume guar gum daily in the form of food additive E-412 in dairy, meat, bakery products, ice cream, yogurt, sauces, etc. [41]. Guar gum as a product reached out to the international market in 1957. The main production of guar is concentrated in India. This country is the largest producer and exporter of guar gum in the world market. According to 2012 data, the market size of this product annually comprised from 1,000,000 to 1,600,000 tons [42].

India accounts for approximately 80 % of the world's guar gum production per year, followed by Pakistan (15 %), where the guar is grown on irrigated land, and the remaining 5 % is produced in the USA, Australia and South Africa [42)] Approximately 90 % of guar gum produced in India is exported, mainly to the US, China, Germany, Russia, Canada and Italy. The USA is the largest importer of this product (about a quarter of the world's consumed guar gum), and the main sphere of its use in the USA is the extraction of shale gas and oil. It is expected that in the coming years the demand for guar gum will grow by about 4 % annually due to the shale's boom in the USA and the popularity of natural thickeners in the food, cosmetics and other industries (https://marketpublishers.com/r/G6AA788F0A6EN.html).

As an additive for drilling fluids, guar gum possesses unsurpassed properties. During oil drilling wells, guar gum prevents loss of water from the viscous mud and well suspends bentonite clay. Guar gum of rapid hydration with a viscosity of 6500 to 9000 units is in use in mining for hydrofracturing formation [43]. To obtain the quick hydration gum, the extrusion step [44] is introduced into the gum production process. A quick hydration gum forms a viscous gel in a few minutes (normal guar gum needs 2 hours).

In the guar gum manufacturing process, the seeds after husking are split into endosperm parts, between which the embryo is enclosed. After separation of the embryo and the hull, the so-called split is obtained during sorting. Guar split is a polished endosperm halves, in the water-insoluble cell walls of which galactomannan is deposited. To break down the cell walls and extract the gums, a fine grinding of the split is necessary. The water soluble fraction is 85 % of the split [43]. After processing, guar gum looks like a powder of cream color. The gum quality for food (additive E-412), cosmetic industry and other purposes depends on the production technology [41, 45].

Genetic resources of guar. Indian guar varieties and local guar plant populations have different morphological and agrobiological features depending on their use. Information about Indian guar varieties is given in an official publications [34, 46] and available online (http://agropedia.iitk.ac.in/content/guar-cluster-bean-varieties-india, http://www.seednet.gov.in). Forage species are tall, with good foliage, vegetable species are shorter; there are also universal varieties. The main center for guar breeding in India is the Rajasthan Agricultural Research Institute (RARI, Jaipur, Rajasthan). There, guar verities RGC-936, RGC-1002, PGC-1003, RGC-1017, RGC-1033, RGC-1038, RGC-1055, RGC-1066 etc. were developed for cultivation in this subarid state (http://raridurgapura.org/varieties-developed.htm). In the CCS of Haryana Agricultural University (http://hau.ernet.in, Hisar), guar selection is conducted for the increasing gum content in seeds (varieties HG75, HG182, HG258, HG365, HG563, HG870, HG20, HG884 are characterized by gum content from 29 to 32 %). In Haryana Agricultural University forage varieties HFG119 (with broad dark-green leaves) and HFG156 (tall, branched, disease-resistant) have been derived. Forage varieties Bungel, Agaita Guara, and RGC-936 are known. Some forage varieties (Durgapura Safed, Durgajay, Mara Guar, Uday, Lathi, Kranti-1031, RGC-1033, RGC-1038) are also grown for gums, so, they serve as dual-purpose varieties [47, 48]. In India, the guar is covering area over 2200 ha.

If in the states of Northern India (Rajasthan, Haryana, Gudirat and Punjab) guar is cultivated for gum and forage production, in the South India it is cultivated mainly for vegetable purposes. Young pods contain protein (3.2 g), carbohydrates (10.8 g), humidity (81 g), calcium (57 mg), fat (5 g), iron (4.5 mg), vitamin C (49 mg) for every 100 g of edible portion. In the state of Karnataka, in order to obtain young pods, guar is cultivated throughout the year. At the University of Agricultural Sciences (Dharwad), selection of vegetable guar to enhance bean yields and quality is ongoing. The aim is to distribute the vegetable guar cultivation in the north of the state to more arid regions [50, 51]. In vegetable guar selection, genetic diversity on qualitative and quantitative traits is preliminary estimated to select genotypes for hybridization [52-54]. One of the breeding programs included study of genetic diversity of 30 guar genotypes. The genotypes were clustered based on the feature similarity, and the hybridization programe for creation of varieties with improved qualitative and quantitative characteristics of beans was developed using inter-cluster distances and the percentage of trait contributions [55]. The most popular vegetable varieties are Pusa Navbahar, Pusa Sadabahar, Durgabahar, Kachan Bahar, Pusa Mausami. The most popular and widespread variety is Pusa Navbahar obtained in 1984 (its disadvantage is disease susceptibility).

The main purposes of guar breeding in India are early maturity, gum yield, and diseases resistance. Despite the fact that guar plants are widely cultivated in India, the average crop yields here is not high because of monsoon fluctuations in the main cultivation zone and insufficient amount of certified seeds. Growth of guar demand necessitates task of expanding guar area on irrigated lands [46]. Most researches confirmed low genetic diversity of the crop in India. Thus, SSR analysis of 31 genotypes on 17 traits and cluster analyses showed low genetic variability among plants. Within the guar breeding program for the southern states of India, 42 genotypes were evaluated on 12 traits; cluster analysis gave visual picture of four groups separated irrespectively of their geographic origin [57]. Other researches also failed to identify correlations between genetic diversity and geographical location of samples [58, 59].

On the contrary, in Pakistans local lines and varieties, the clustering of the tested samples corresponded to their geographic origin [60]. Chemical and physical mutagenes were used to extend range of genetic diversity of guar plants [61, but economically important traits were not found in the mutants.

Plant genetic resources in India are preserved in the National Bureau of Plant Genetic Resources (NBPGR, New Delhi). Annually more than 600 samples are sown for maintaining and studying to identify donors of valuable traits [62]. In Pakistan, guar is explored in the National Agricultural Research Center (NARC, Islamabad).

The USA is the third major guar producer in the world, after India and Pakistan. The first sample was registered in the USA in 1910, cultivation began in the 1940s. Guar was tested in the Arizona state as forage crop (haymaking and even pasture), also agricultural technology, the character of growth and susceptability to diseases were studied [63, 64]. Since 1950, after the guar gum discovery, researches continued at an experimental station in Oklahoma [65] in order to increase the seed yield and resistance to the major guar diseases. Brooks (1964) was the first variety improved in the USA. It replaced initial varieties such as Texsel and Groehler, then Hall and Mills verities were derived. In 1971-1979, Kinman variety in tests produced 17 % more seed than Brooks, and became the most popular [66]. Esser variety, released simultaneously with Kinman, has high resistance to diseases and later ripening. Lewis variety had more beans on the main stem than Kinman in yield tests during 1980-1983, and produced seed yield higher than that of Kinman and Esser [67, 68]. Santa Cruz variety (1982) was distinguished by drought tolerance [69].

Varieties of American breeding have a range of morphological features that distinguish them from Indian varieties, and are based on samples which has passed a long period of adaptation and breeding in the United States. From 1998 to 2007, in the researches which were supported by Halliburton PC (USA), 50 lines and guar species showed variation of the M:G ratio in seeds from 1.6:1 to 2:1 [43]. Selection for the maximum proportion of galactose to mannose resulted in Matador and Monument varieties. Matador (2005) is characterized by a numerous side shoots and maximum seeds. Monument (2010) is early maturing, nonbranching, having high position of the first fertile node and fits for mechanized harvest. The rights to use these commercial varieties are owned by Texas Tech University (Lubbock) and Halliburton [70]).

One thousand and fifty guar samples obtained through the introduction station and 33 breeding lines were deposited in the National Center for Genetic Resources Preservation (Fort Collins, Colorado) [71]. To date, there are about thousand accessions of guar collection in the United States, 500 samples have been deposited in Fort Collins, and an active collection of 410 samples is conserved in the Plant Genetic Resources Conservation Unit (Griffin, Georgia). In total, there are 355 samples from India, 32 samples from Pakistan, two from

Iran, by ones from South Africa, Senegal, Sudan, 10 species and breeding lines from the USA, as well as the African wild guar species *Cyamopsis senegalensis* Guill. Perr. and C. *serrata Schinz.* [72]. Guar can be successfully grown in Georgia state [72]. Alternative guar distribution to Wisconsin and Minnesota (more northern and wet states) were considered in addition to Arizona, Oklahoma and Texas. Dwarfish varieties of American breeding meet the early maturing requirements which are necessary for these areas [73].

In Australia, the guar varieties, which were periodically introduced from India and the USA, are studied on various traits (yield, gum production, etc.) [74-76]. There is the government program to support guar growing and processing gums [77]. In Italy feasibility and economic reasonability of guar farming is concerning [78, 79]. In Argentina, an agroclimatic zoning methodology was developed to determine the potential areas for guar growing [80]. In Egypt, the guar is suggested as a green fertilizer for the sandy soils remediation [81].

Guar seeds were first imported by the All-Union Research Institute of Plant Industry (VIR) to the Soviet Union from India, including 8 samples collected in Punjab state during expeditions of V.V. Markovich in 1927-1929 and 6 samples from Pune, Maharashtra state, introduced in 1931). Experiments on guar cultivation were carried out at the southern experimental stations of the VIR. At the Sukhum Experimental Station in 1928 (humid subtropics), in the sowing, seeds were feeble. At the Maikop experimental station (the Republic of Adygea), in the years with low rainfall, the filled seeds were matured. At the Kharkov experimental station, the plants grew poorly, and the seeds could not be obtained [82]. In 1956-1966, after collection replenishment, mainly with Indian accessions from different areas, as well as accessions from the USA and Australia, the total number of guar samples in VIR collection had exceeded 100 accessions. While studying VIR Central Asian branch collection (Tashkent), the samples were differed in early maturity characteristics, in some areas they developed well, but in others the guar plants were damaged by *Fusarium* fungi and viruses. VIR scientists recommended guar cultivation in Uzbekistan for gum manufacturing [82]. In the USSR, guar was also studied in Turkmenistan. There, 59 samples of different geographical origin, including 50 samples from India, 2 samples from Pakistan, 2 samples from the USA, and 5 samples from Australia, were studied in the arid zone (1963-1970, The Central Botanical Garden) and in the sowing (1971-1980, Institute of Botany of the Academy of Sciences of the TSSR) [21, 83]. The aim was to assess the prospects of guar using as an annual forage crop. High seeds yield had breeding varieties from India and the USA (18.6-24.3 c/ha). Raw protein in seeds ranged from 25.8 up to 26.6 %, and galactomannan ranged from 29.6 up to 33.5 %. Growing period from seed germination to the end of fruiting season in the south of Turkmenistan under spring sowing was 85-111 days with a maximum green biomass yield of 589 c/ha. In Turkmenistan, because of the lack of annual legume capable to produce a significant green mass, guar was recommended as a protein-rich forage crop for the arid zone. However, it was unclaimed and not widely spread because of wrongly established sowing time as it was studied in 1966 in Sukhumi and the Leningrad region [84].

Guar seeds that were stored for 40 years at +4.5 °C (Kuban gene bank) had high sowing qualities with laboratory germination of 92 to 94 % [85]. Field germination of seeds stored at room temperature was high too, i.e. 48 of 50 samples dated 1977-1980 produced seedlings in the Krasnodar Territory in 2017.

Perspectives of guar cultivation in Russia. Based on comparative climatic characteristics of India and the USA with the Southern Russia conditions, the opportunities of growing early maturing guar varieties in some regions have been established. The suitability for cultivation of this crop determines the sum of effective temperatures > 10 °C which should be about 3400-3500 °C. According to summer temperatures and other climatic parameters, the agrarian regions of the North Caucasus and Crimea are less productive than India, but similar to the USA, where the guar is successfully grown in the Southern states. The vegetative growth guar cycle needs 350-500 mm of rainfall. Consequently, the flat part of the Stavropol and Krasnodar Krai is well provided with natural moisture to cultivate the guar. In the Crimea and the Rostov region, the additional irrigation is advisable. The optimal sowing dates are when the temperature of the arable soil layer passes through 20 °C [86].

In the Ust-Labinsk region of the Krasnodar Krai, guar growing was optimized and breeding was carried out. As a result, breeding material with valuable characteristics (seed productivity, lower bean attachment height, etc.) was obtained. The seed yield of the best samples in the variety tests has exceeded 24 c/ha. Experiments revealed factors limited crop yields (soil temperature and humidity at sowing, alternaria fungi and bacterial rot damage) [87].

In 2014-2015, under introduction of four Indian guar samples from the VIR collection, the seeds yield in the Rostov region was 16.4-19.5 c/ha, while the plants were infected with bean yellow mosaic virus and pea enation mosaic virus [88]. Further testing of the best samples was carried out in different ecogeographic conditions at the southern VIR stations. The optimal sowing dates in Krasnodar Krai are form the end of the first decade to the beginning of the second decade of May at a soil temperature of 20-24 °C. The early maturing guar lines have been identified which ripen steadily in the Kuban and the Volgograd region with a grain yield of more than 18 c/ha and green mass of 600 c/ha. Crude protein per absolutely dry matter was 33.59 % [85, 89]. Under southern Russia conditions, physiological maturity of guar seeds is reached within 100-130 days after sowing. The quality of the gum obtained from such seeds satisfies the requirements.

Thus, guar, which has been known for a long time as fodder, green manure and a source of food protein, now become one of the most important technical crops because of the growing need for guar gum in the food, cosmetic, and petroleum industries. India, Pakistan and the USA are the main producers of guar and its products. Conditions in some south areas of Russia are also suitable for industrial cultivation of this crop, which actualize its introducing and breeding. The experience in studying and cultivation of this crop in the USSR and Russia has been accumulated, and VIR collection maintained genetic resources of guar plants from the main areas of its origin and cultivation which can be used for introduction and as donors of valuable traits. The priority in breeding varieties for Russia is improved productivity, early maturity and disease resistance.

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