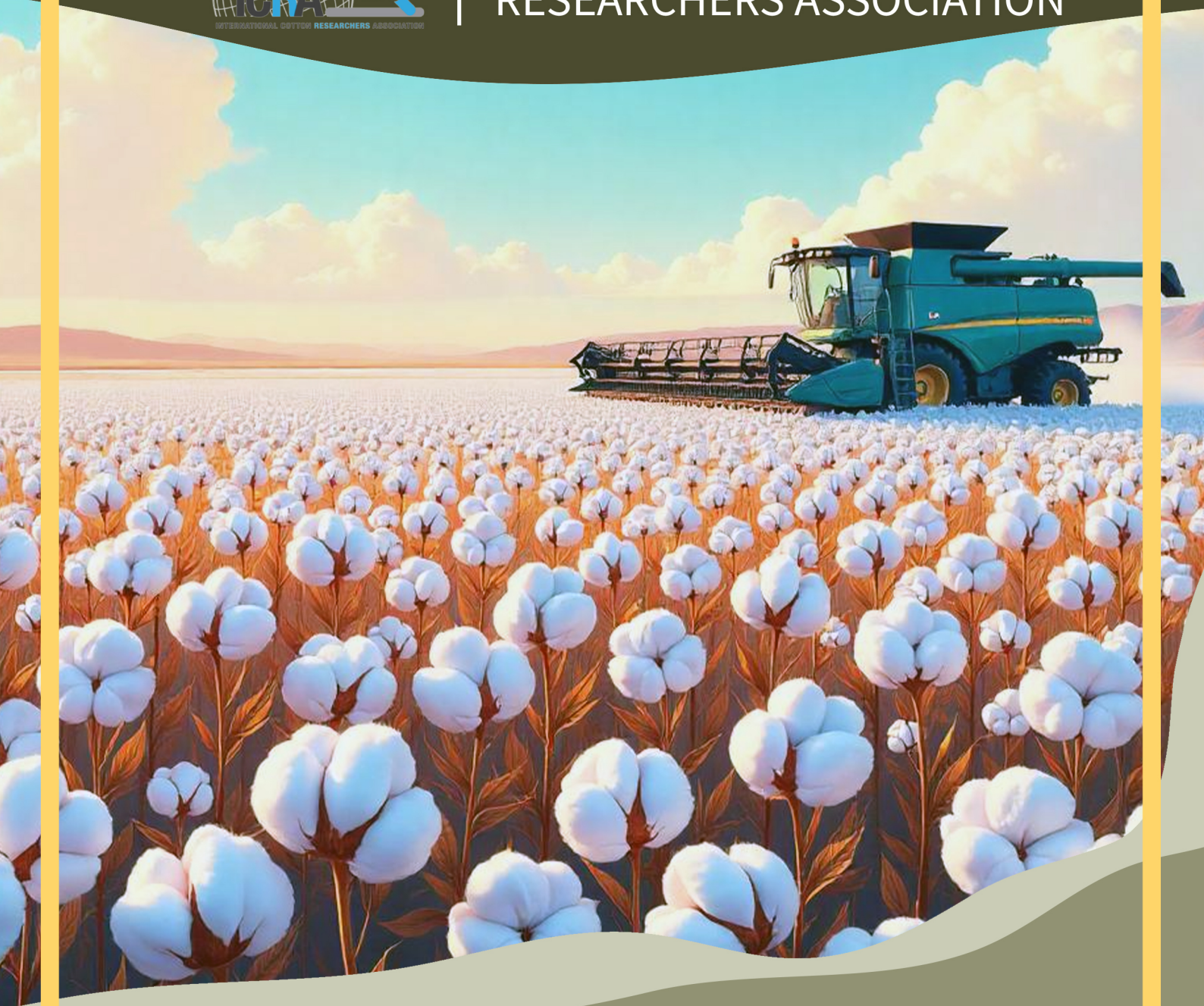




**INTERNATIONAL COTTON
RESEARCHERS ASSOCIATION**



COTTON

INNOVATIONS

**VOLUME 5
ISSUE 4**

www.icra-cotton.org

JUNE 2025

Content

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Cotton Innovations Journal

The Cotton Innovations Journal is published twelve times annually. Contributed articles, pictures, cartoons, and feedback are welcome at any time. Please send contributions to the General Editors (see below). The editors reserve the right to edit. The deadline for contributions is one month before the publication date.

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The newsletter is also available at URL:

<http://www.icra-cotton.org/page/cotton-innovations>

ISSN 6611-2788

COTTON SEED PRODUCTION, PROCESSING AND TECHNOLOGY IN IRAN, AN OVERVIEW

Mohammadreza Ramazani moghaddam^{1*}, Aidin Hamidi², Omran Alishah¹, Seyed Bagher Mahmoudi³, Gholamreza Golmohammadi⁴, Hassan Najjar¹, Ahmad Harati⁵, Somayeh Rezaei⁶, Masoud Hakimi⁷, Yaser Esmaeilian⁸, Ali Akbarzadeh⁹, Mahdi Khodaei¹⁰ and Mohsen Bakhshi¹¹

¹ Cotton Research Institute, AREEO, Gorgan, Iran.

² Seed and Plant Certification and Registration Institute, AREEO, Karaj, Iran.

³ Sugar beet seed Institute, AREEO, Karaj, Iran.

⁴ Iranian Research Institute of Plant Protection, AREEO, Tehran, Iran.

⁵ Razavi Agriculture Company, Astan Qods Razavi, Mashhad, Iran.

⁶ Islamic Azad University, Neyshabour Branch, Neyshabour, Iran

⁷ Deputy of Agronomy, Ministry of Agriculture, Tehran, Iran.

⁸ Faculty of Agriculture, Gonabad University, Gonabad, Iran.

⁹ University of Science and Culture, Kashmar Branch, Kashmar, Iran.

¹⁰ Behdasht Cotton Seed Company, Boshrouyeh, Iran.

¹¹ Behfaravaran Knowledge Based Company for Cotton Seed and Fiber, Aria Behgozin Holding, Mashhad, Iran.

* Corresponding Author: m.ramezanomoghadam@areeo.ac.ir

Abstract

Cotton is one of the dicotyledonous plants with sexual reproduction and is propagated by seeds; Cotton seed is an oilseed with orthodox behavior. Cotton is an industrial crop that is cultivated primarily for fiber production and secondarily for grain production and food use. The product harvested from cotton fields, called seed cotton, consists of approximately 32 to 38 percent of its weight in fibers (lint) and 55 to 60 percent in seeds. In the world, 1 to 4 percent of the total cotton seed produced annually from the cotton ginning process is processed as seed and used in cotton cultivation. Cotton seed, which is obtained from the cotton ginning stage, consists of three parts: linter, seed coat, and kernel, and is used as the starting input for seed production in the next stage of processing (cotton seed delinting). Undoubtedly, the quality of the cottonseed produced is related to its production and processing stages on the farm and then in the two subsequent industrial processes mentioned above. Also, the impact of the maintenance and storage stages of this oilseed on the quality of the produced seed should not be overlooked. In addition to the genetics and inherent genetic vigor in the hereditary characteristics of a cotton cultivar for germination and seedling establishment in the field, environmental factors including temperature, existence and quality of available water (moisture), soil salinity, oxygen, as well as biological factors and biotic stresses such as soil-borne and seed-borne pathogens, and early season insect pests can affect the stages of seed

germination, seedling emergence and plant establishment in the field and the expression of the cultivar genetic potential and ultimately its yield. It should also not be forgotten that the germination of this dicotyledonous plant is epigeal and it encounters soil resistance when emerging from it and intensification of other biotic and abiotic stresses mentioned. Therefore, accurately identifying factors that reduce the quality and quantity of cotton seeds, applying new technologies for its processing stages, and arming seeds with materials and coatings to prevent or reduce damage from these stresses can greatly help improve the plant population density level of the field canopy, economical yield and increase production of this crop in a region or country. In this review article, we try by investigating and studying the current experiences and achievements regarding the above issues, we are trying to help develop it in Iran in addition to presenting successful experiences in this regard. Also, relying on these successful experiences and existing knowledge and research results, we introduce and remind in some cases the opportunities and challenges ahead in this field. We hope to help improve the quantity and quality of cotton seed production in Iran and other similar countries by providing operational and applied suggestions.

Keywords: cotton, seed, ginning, delinting, processing, technology, germination, coating.

Introduction

Cotton (*Gossypium* sp.) is a globally important fiber crop belonging to the genus *Gossypium* of the family *Malvaceae*. The plant species of this genus are perennial and tropical and they have a woody stem, but by breeding and improving that is therefore cultivated as an annual plant worldwide. In the world, about 34 million hectares of land are annually planted the cotton between 47 degrees north latitude and 32 degrees south latitude, and over 50% of the production comes from areas located above 30 degrees north latitude.

In the genus *Gossypium*, 51 wild and domesticated diploid and tetraploid species have been identified to date, but only two

diploid cultivated species *G. herbaceum* and *G. arboreum* ($2n = 2X = 26$) and two allotetraploid cultivated species *G. hirsutum* and *G. barbadense* ($2n = 4X = 52$) as the four domesticated species of this genus and to some extent the wild species *G. africanum* have spinnable fibers.

According to the reports of the International Cotton Advisory Committee (ICAC), during the last decade, about 93% of the cotton produced in the world has medium-length fiber or upland (*G. hirsutum*), 4% has long-length fiber or pima (*G. barbadense*), and the rest belongs to the two cultivated diploid cotton species *G. herbaceum* and *G. arboreum*. Therefore, it is important to note that in discussions and issues related to cotton, the tetraploid species *G. hirsutum* or

upland, or medium-length fiber cotton, is mainly intended and targeted.

In addition to cotton fiber, which is the main reason for its cultivation, its seed is also important. Cottonseed oil is an important source of vegetable oils. In cotton crop species, the oilseed amounts 14.6-25.6 percent of the dry weight of the seed, and the meal remaining from oil extraction is used for animal feed. Cotton seed contains a high percentage of protein and is an important source of essential amino acids. Also, the cotton plants residues after harvesting provide raw materials for the paper and chipboard industries. In total, products derived from the cotton plant directly and indirectly provide raw materials for about 70 large and small industries in the world.

The difference in cotton yield in different countries is related to the type of cultivar cultivated, in addition to various factors such as weather and climate, water quantity and quality, soil type of the region and agronomical management factors such as the cropping system, cultivation method, nutritional management, pest and disease and weed control in the field. Regarding the type of cultivar and its genetic potential for the expression of desirable characteristics, the quality of its produced seed is very important in terms of the processing method and technologies used in seed production and can even provide many of the above-mentioned agricultural management measures from the beginning of cultivation. According to the definition of the International Seed Testing Association (ISTA), seed vigor is: ((The sum of all seed characteristics that determine the potential level of activity and efficiency of the seed or its mass at the

time of germination and emergence of the seedling)). Alishah (2012) reported that the use of high-quality seeds is an important first step in cotton growing and production as such seeds have greater vigor and germination speed and also produce higher yields.

The area under cotton cultivation in Iran has fluctuated greatly over the past three decades, and unfortunately, the overall trend has been declining, reaching about 85,000 hectares in 2024, which is cultivated in 17 provinces of the country. According to statistics the 3 Khorasan provinces (Razavi, South and North) account for about 45 percent of the country's total area under cotton cultivation and rank first in cotton production. After them, Fars, Golestan and Ardabil provinces are in the next ranks, respectively.

According to the assessment, in 33 percent of the cotton-growing lands in Iran, the seed consumption is 40 to 45 kg, in 37 percent, the seed consumption is 70 to 80 kg, and in 30 percent, the seed consumption is more than 100 kg. Considering this, the average weight of cotton seed consumption in Iran will be about 77 kg.

In previous years, when cotton cultivation was more prosperous in Iran, the domestic seed requirement was about 10,000 tons, but currently, the annual domestic cotton seed requirement is not less than 5,000 tons on average. On the other hand, considering the potential and advantages for seed production and the quality of seeds produced in dry regions, it is possible to increase seed production for exporting to other countries.

In this review article, an attempt has been made to study the results and research achievements, especially applied research, by its authors and other scientists, as well as to study the technical and scientific experiences available in Iran regarding the processing of cotton seeds as an industrial plant at different stages from the farm to the industry, to present recommendable results, successful experiences, and new technologies to those involved in the production and processing of its seeds, and also to introduce, with a critical look, the weaknesses and challenges in its production chain so that appropriate measures can be taken to address them. In addition to addressing the two issues or goals above, an attempt has been made to express the opportunities and potentials available in this country for the quantitative and qualitative production of cotton seeds to cover domestic needs, as well as with a view to exporting cotton seeds outside Iran.

Cotton cultivars in Iran and their seed production:

Today's cotton cultivars in the world have been improved by one of the methods of selection, hybridization, mutation breeding, and genetic engineering. Among the types of cotton cultivars used in the world, namely standard or open pollinated (OP) varieties, hybrid, transgenic, or transgenic hybrid, Iran uses only the seeds of standard (OP) varieties. However, in recent years, with the support of the Ministry of Agriculture, interspecific and intraspecific hybrid seeds have been produced and cultivated on a limited scale by hand.

In Iran, from 1968 to 2007, 9 cotton cultivars (on average, one cultivar every 4 years) were introduced with the names Deltapine-16, Hopi Cala, Varamin, Sahel, Doctor Omumi, Bakhtegan, Ultan, Pak, and Mehr. During the years 2007 to 2014, 9 new cotton cultivars with desirable agronomic characteristics (especially early maturity) and suitable with the country's needs were introduced with the names Khordad, Sepid, Golestan, Armaghan, Khorshid, Kashmar, Latif, Shayan, and Sajedi, thus the average time of production and introduction of cultivars during this period reached one cultivar per year. After that, the Hekmat variety was introduced in 2018 and four mutant varieties of Parto, Taban, Fakhre and Jahesh were introduced during the years 2019 to 2024. Currently, the country has introduced more commercial varieties of cotton than its area under cotton cultivation. In addition to the above standard cotton varieties, four hybrid varieties are in the process of being registered and commercialized, so the agricultural executive department can select the appropriate seeds according to the agricultural needs of each region and supply them to cotton farmers.

The average seed cotton yield in the cotton-growing area of Iran before the development of the cultivation of new improved varieties was reported to be about 2200 to 2500 Kg per hectare in different years (Iranian Textile Industry Statistical and Strategic Studies Office - 2009). The cultivation of new cotton varieties has resulted in an increase in seed cotton yield from 500 to 3000 kg per hectare, and in recent years the average yield of new improved varieties in different regions of the country has increased to more than 3300 kg per

hectare. The newly introduced varieties are earlier and has more uniformity in maturity compared to previous cultivars. By cultivating these new cultivars, the possibility of cotton cultivation as a second crop (after wheat, barley and rapeseed), intercropping cotton with other crops, and also machinery harvesting of cotton crops has been provided.

The breeding and development of new cotton cultivars and the preparation of their seed nucleuses, and also the maintenance of their hereditary characteristics in Iran are carried out by Cotton Research Institute (CRII), which is a government institution. The Seed and plant Certification and Registration Research Institute (SPCRI) is another

government institution in Iran that is responsible for overseeing the seed propagation stages of crops, including cotton, and grants the necessary approvals and final labels to the produced seeds after approval.

In recent ten years, the exclusively on the production of cotton seed cultivars has been delegated from the Cotton Research Institute to the private sectors. The cotton seed production and propagation system in Iran is based on a four categories system and conducted by the private sectors. Table 1 lists of companies active in the production of cotton seeds that have been exclusively responsible for propagating CRII cultivars cotton seed in recent years.

Table 1- Active private companies responsible for the propagation and production of seeds of Iranian cotton cultivars.

no	Company's name	Location	Exclusive cotton cultivars
1	Razavi Agricultural Company	Mashhad	Varamin and Khorshid
2	Mazraeh Nemooneh Company	Agh Ghala	Golestan, Hekmat and Taban
3	Fajr Sabz Khavarmianeh International Company	Tehran	Armaghan and Sajedi
4	Behdasht Corporation Company	Boshrouyeh	Khordad
5	Zarindasht Corporation Company	Zarindasht	Parto
6	Tehran Ginning Company	Gonbad	Latif
7	Jamil Corporation Company	Neyshabour	Shayan
8	Behfaravaran Knowledge Based Company	Mashhad and Gorgan	Kashmar and Sepid

Also, for more than a decade, foreign cotton seed companies, mainly from Turkey (May, Agrobrest, Livagro, etc.) and Greece (American Genetics, Golden West, etc.) have started selling their certified seeds to Iranian cotton farmers. Some of these companies have simultaneously registered their cotton varieties in the national list of varieties in Iran and are carrying out seed production and propagation programs for their varieties in

Iran, possibly with the aim of exporting to other countries.

Seed processing operations in the stages after seed cotton harvesting from the field:

Cotton seed processing operations include seed cotton drying (in humid climates), ginning, seed delinting, seed separation, seed gravity, seed treatment, seed coating, and seed packaging. The

main purpose of the ginning process is to separate the fibers from the seed. This process is carried out by a machine called a gin, which comes in two basic types: the saw gin, which is mainly used for medium-staple cottons, and the roller gin, which is used for long-staple and extra-long-staple cottons.

After the ginning process, the short fibers or so-called linter that remain on the cotton seed constitute about 10-11% of the cotton seed weight. Therefore, most of the surface of the seeds of a cotton seed mass is covered with the linter. These linters interfere with the mechanized planting of cotton seeds and also these linters on the surface of cotton seeds provide a suitable environment for the growth of plant pathogens, therefore, these linters must be removed before planting.

The process of removing the linters on the surface of cotton seeds is called delinting, and its advantages include: making them separable by their gravity and volume, and consequently improving the vigor of the seed mass by removing small, broken, and light and Hollow seeds, preventing disruption in mechanized planting, and thus reducing the amount of seed used, facilitating seed packaging, storage, and transportation steps. Delinting process reduces the volume of seeds, making them prepared for seed treatment and coating, and also improves seed health by removing the linters on the seeds, which are a good place for pests and diseases, and accelerating the germination of cotton seeds due to the ease of water absorption, reducing damage from pests and diseases during germination stage, and resulting in uniform emergence of seedlings in the field (Hamidi et al., 2012). Iranian researcher also could to improve the physical purity and germination percentage of cotton seeds from 65.2 and

74 percent to 98 and 100 percent, respectively, through gravity operation.

The quality of cotton seed after harvest may also be affected by post-harvest conditions and ginning and other processing steps, cotton seed is also sensitive to mechanical damages to seed has both direct and indirect effects. Severe damages to sensitive areas such as the radicle can cause rapid losses in germination capacity. Less severe damages increase the number of abnormal seeds, reduces storability, vigor, seedling emergence and establishment, so the indirect effects of seed damage are also important. In the soil bed, damaged seeds are susceptible to rot caused by microorganisms, as they will easily enter the seed through wounds on the shell. Such seeds are also more sensitive to processing operations and the compounds used for treatment and coating. In acid delinting, cracks in the seed coat allow the acid to reach the embryo, resulting in damage and burning of the embryo. Broken seeds are often damaged by chemical treatments such as systemic pesticides and mercury compounds. In these seeds, damage to embryonic tissues begins through cuts and wounds on seed coat, germination and storage capacity decrease with increasing mechanical damage, and the increasing effects of acid immersions.

Available technologies for cotton seed delinting process in Iran:

In Iran, in the 1990s, in order to improve the processing of cotton seeds and enjoy the benefits of delinted seeds, four delinting factories were located, assembled, and set up in four provinces of the country.

- 1- Gorgan factory in Golestan province, established in 1993, with a nominal

- capacity of 4 tons per hour, manufactured by the Greec Gin Supply Company.
- 2- Parsabad Moghan factory in Ardabil province, established in 1994, with a nominal capacity of 700 kilograms per hour, manufactured by the French CFDT company.
 - 3- Kashmar factory in Khorasan Razavi province, established in 1997, with a nominal capacity of 4 tons per hour, which was modeled by the Iranian Machine Daru Company on the Gorgan factory.
 - 4- Darab factory in Fars province, established in 1999, with a nominal capacity of 700 kilograms per hour, which was modeled by the Iranian Machine Daru Company on the Parsabad Moghan factory.

By launching and developing these 4 delinting factories in Iran, the country's need for the seeds of the country needed to be fully expected, but the deficiencies and limitations after the launch, especially the less attention to the educational programs and the skilled manpower, prevented the completion of the forecasts. So much so that in the 1380s and the first half of 1390s, mainly 25 to 40 percent of the domestic consumed seeds were supplied from the Delinted type. During this period, while partnership and replacement of the private sector instead of the government in the Cotton Seed Production Program in the country, the executive management of these seed production factories to that sector was also operational with the aim of promoting the quantitative and qualitative improvement of the Delinted seed in the country. As a result of these transfers, in the last few years, updating of the processing operations and technology of the two factories in Kashmar and Gorgan, whose executive management has been transferred to the two Razavi Agricultural

Companies and the Fajr Sabz Khavarmianeh International Company, respectively, have been carried out in a satisfactory manner, and now these two active cotton seed factories in Iran are equipped with a seed gravity system as well as a seed coating line.

Factors affecting seed quantity and quality during propagation stages:

In order to maintain and inherit the genetic characteristics of the seed from one generation to the next, maintaining its physical characteristics and purity (including size, physical purity, and germination abilities, etc.) during the propagation stages is very important. Certainly, without maintaining the physical characteristics of the seed, the genetic characteristics of the seed will not be manifested in the field. Seeds that are propagated and produced under inappropriate conditions are not of the desired quality and do not meet expectations in terms of germination and plant development, and ultimately have an adverse effect on crop yield in terms of quantity and quality. During the propagation stages, the physical properties of seeds can be affected by several factors. These factors can be classified into two periods in terms of time: from planting to harvest and after harvest, and into three types in terms of the nature of the damage caused: mechanical, chemical, and physiological. In this review article, our emphasis is on post-harvest stages and factors affecting seed quality during its processing stages in relevant industries (ginning, delinting and ...).

Ginning step:

In the ginning process, we have a mechanical operation and can be considered an important factor in seed

damage. These damages at this stage are mainly observed in the form of fractures and wounds in the seed coat. This is especially evident in saw gines than rolling gines. In general, physical damage reduces seed viability and germination. Different methods are used in different sections of cotton ginning factory to transport the seed

cotton and cotton seeds. A conveyor belt is usually used to transfer the seed cotton and deliver it to the pneumatic system and feeding line. While a screw is used to transport cotton seed and other residues. The pneumatic method and conveyor belt are more suitable for transporting seeds than the screw (figure 1).

Physical damages



Physical damages

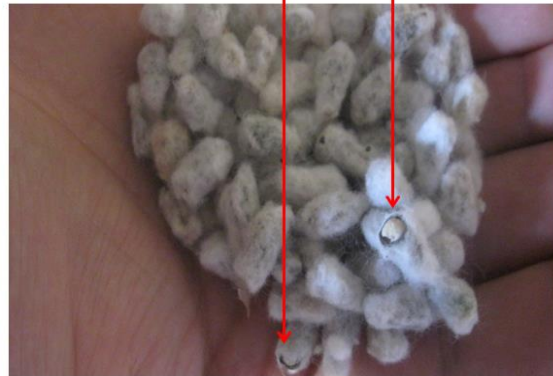


Figure 1 - Mechanical or physical damages (wounds, Scratches and fractures of the seed coat) caused during ginning process at the ginning factory.

Delinting and its subsequent processing steps in cotton seed production:

Today, seed processing is one of the essential steps in the seed industry. In general, cotton seed processing includes 3 stages: pre-separating and pre-processing,

delinting, final separating, and seed coating. Final processing also includes neutralization of chemicals remaining from acid delinting, additional separating to separate broken, hollow, and small seeds, and finally, packaging.



Figure 2 - fuzzy cotton seed (a), delinted cotton seed (b)

On the other hand, during acid delinting, cracks are created on the seed surface, which although these cracks can lead to better moisture absorption and faster seed germination, can be considered serious

damage to the seed if they are large. The higher acid concentration and the longer of acid treatment will be the more cracks. (Figure 3).



Figure 3 - Cracks formed on the seed coat after the acid delinting process in the Kashmar delinting factory.

Delinting using dilute acid is one of the acid-delinting methods that the concentration of sulfuric acid used in this method is about 10-14%. After mixing the fuzzy seeds with dilute sulfuric acid, some of the seed moisture is separated in a centrifuge and added about 10% to acid concentration. Then, in the next step, another amount of seed moisture is evaporated by hot air and the acid

concentration increases again. In the next step, the seeds are passed through a rotating cylinder with shield-like projections inside, which causes the linters to separate from the seeds over a certain period of time (Figure 6). Currently, it is the most common method for cotton seed delinting, and the four aforementioned delinting factories established in Iran use this method.

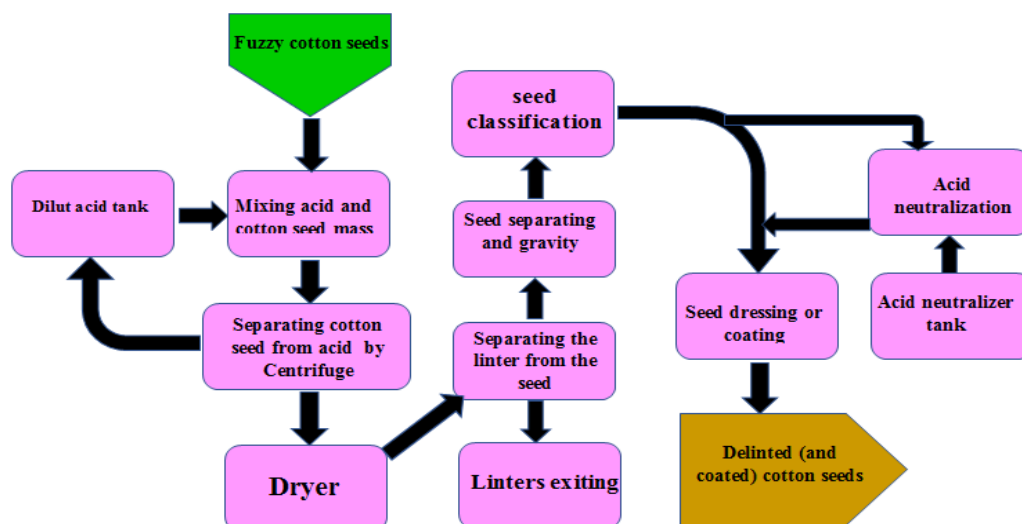


Figure 6 - Schematic steps of dilute acid delinting in 4 cotton seed delinting factories in Iran.

In this system, after mixing the acid, the seeds are collected around the centrifuge tank and the excess solution (acid and water) is separated from them and returned to the acid tank for reuse. To maintain the required acid concentration, it is necessary to add acid to the solution and adjust it. In

this method, almost no excess acid remains as waste, but the price of the centrifuge device is expensive and the cost of setting up the system is relatively high. In this method, the possibility of damage to seed quality is more related to the drying stage.



Figure 7 - View of the interior of the Kashmar cotton seed delinting factory, one of four factories located in Iran that works with the dilute sulfuric acid and heat method.

In recent years, a knowledge based company at the Iranian Cotton Research Institute, in collaboration with a chemical supplier, has studied and investigated organic acids similar to those used in cosmetics for delinting cotton seeds and reported that it has achieved favorable results in its preliminary work.

The cotton growing areas of Iran and consequently the areas of cotton seed propagation are located in two humid and dry climates. In a large project, the response of seeds of *Gossypium* species with different ploidy levels to the acid delinting process was investigated in the germination and establishment stages. Also, in this study, to investigate the effect of the variety and its propagation area on the de-linting process of seeds, in 2011, in the laboratory of delinted and hairy seeds from four varieties of Khordad, Golestan, Sahel and Sepid, all from the allotetraploid

species *G. hirsutum*, and two regions of Golestan and Razavi Khorasan, the traits of 100-grain weight, germination percentage, germination rate, root length, stem length, fresh and dry weight of stem and root were measured in this experiment. The results of this study indicated the superiority of seeds produced with the origin of Razavi Khorasan as a dry region compared to the humid region of Golestan province. Also, among the delinted seed varieties, Khordad and Golestan varieties were superior to the other varieties tested for all traits.

Processing steps after cotton seed delinting:

With a separating machine equipped with aeration and a screener, all large and small pieces, weeds, broken seeds and dust are separated. The gravity separator, which is of great importance, separates hallow,

immature or non-viable seeds along with light solid particles from the seed mass. Thus, if the machine is regulated correctly, not only is there no damage to the seeds,

but the germination and emergence rate of the seeds and the vigor of the cotton seedling are increased at this stage (Figure 8).



Figure 8- Gravity separator machine in Kashmar delinting factory.

Seed treatment and coating devices are usually used after or in conjunction with acid neutralization devices and coat delinted seeds with systemic fungicide and insecticide seed dressing compounds or other materials (Figure 9). In this regard, there are very valuable experiences in our country in the use of various insecticides

suitable for controlling cotton thrips, various fungicides suitable for controlling early season damping off pathogens, and in addition, in the treatment of seeds with enhancers, growth stimulants, seed priming, and also water super absorbing nanopolymers, which we will introduce later in this article.



Figure 9- Delinted cotton seed in the Kashmar factory - without any treatment (a), dressing with Cruiser (b), coating with Gaucho (c), and coating with gaucho, Super-absorbent nanopolymers and Carboxin Thiram(d).

Most of the current cotton growing areas in Iran are affected by salinity and alkalinity of water, soil, or both.

Therefore, using priming could also be a solution. In a laboratory and greenhouse study by several researchers of the author

of this article, the effect of potassium nitrate osmopriming was reported to be effective for salt stress conditions in cotton. According to the results obtained from the study by Rezaei et al., it was found that priming had a greater effect on delinted seeds than on fuzzy seeds. In general, seed priming increased the initial growth potential (seed vigor) in cotton seedlings under salinity stress, and hydropriming and potassium nitrate (KNO₃) treatments were suitable and acceptable materials for seed pretreatment in Varamin cotton cultivar, while the control treatment (no priming) was at a lower level in terms of all traits.

In a study in Iran by a group of authors of this article, the results of which have been presented in several other articles, seed samples of tetraploid cotton cultivars of two species *G. hirsutum* and

G. barbadense were collected from seed production areas throughout the country. In order to molecular detection of *Fusarium* species, different parts of the seed including whole seed, seed coat, and kernel (endosperm + embryo) were cultured and isolates belonging to the genus *Fusarium* were purified by single spore method and DNA extraction of pure isolates of the desired fungus was performed (Figure 10). Due to the highest percentage of *Fusarium* infection in cotton seed of Varamin, Khordad, and Bakhtegan cultivars, whole seeds and kernels of these cotton cultivars were used for DNA extraction. Three pairs of species-specific primers were used to isolate the two dominant species, *Fusarium equiseti* and *F. proliferatum*.

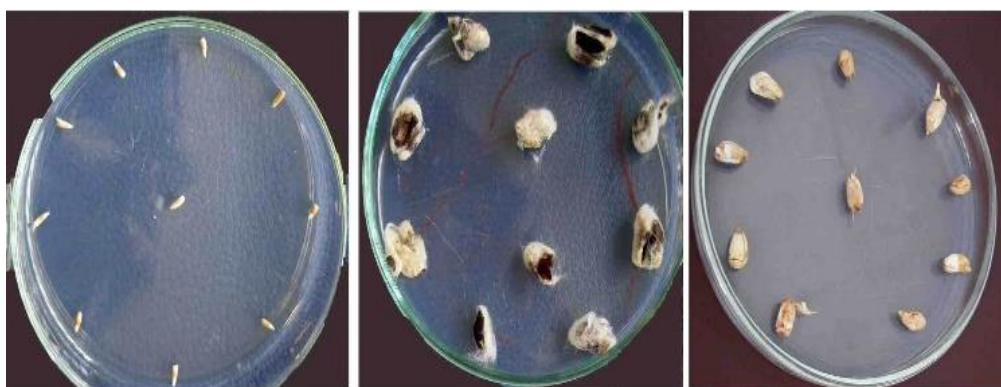


Figure 10- Embryo culture in WA medium a), Seed coat culture in WA medium b), Kernel culture in WA medium c) after 2 days.

In this study, which was conducted in 2014 and 2015, a total of 17 samples of fuzzy seed and six samples of delinted seed were collected from all over Iran. From a total of 23 cotton seed samples, 76 isolates of *Fusarium* fungus were obtained. The identified *Fusarium* species were: *F. equiseti*, *F. proliferatum*, *F.*

semitectum, *F. compactum*, *F. nygamai* and *F. solani*. The frequency of these species was 39, 23, 10, 2, 1 and 1 isolate, respectively. The percentage of infection of fuzzy seeds with *Fusarium* fungus was 98.7 and delinted seeds were 1.3. The Varamin cultivar had a high percentage of infection compared to other cultivars, so

that 34 isolates were obtained from this cultivar out of the total isolates (Table 2). In this study, *Fusarium* fungus was not isolated from the embryos of commercial cotton cultivars (Figure 11). These

Achievements explained that the acid delinting process removes almost all *Fusarium* fungus inoculum on the seed coat and its linters.



Figure 11 - Absence of *Fusarium* fungus infection in the embryo culture after 8 days..

Table 2- Number of *Fusarium* species isolated from different parts of the fuzzy cotton seed.

<i>Fusarium</i> species Cultured part	<i>Fusarium equiseti</i>	<i>Fusarium proliferatum</i>	<i>Fusarium semitectum</i>	<i>Fusarium compactum</i>	<i>Fusarium nygamai</i>	<i>Fusarium solani</i>	Total number of isolates
Seed coat	2	0	4	0	0	0	6
Complete seed	4	1	2	1	0	0	8
Kernel(Endosperm+ Embryo)	31	17	2	1	1	0	52
Endosperm	2	5	2	0	0	1	10
Embryo	0	0	0	0	0	0	0
Total number of isolates	39	23	10	2	1	1	76

Suitable pesticides for seed dressing or coating on cotton seeds according to the 2019 executive protocols for disinfecting cotton seeds against cotton thrips and seedling death diseases were compiled by a group of plant health researchers at the request of the Iranian Plant Protection Organization, some of whom are also involved in the team of authors of this article. The recommended fungicides in that protocol are Carboxin Thiram (Vitavax WP 75%) at a rate of 4-6 per thousand and Carboxin WP 75% at a rate of 4-6 per thousand for fungal disease control. The restarted insecticides in that

protocol are Imidacloprid (Gaucho) WS 70% at a rate of 5 per thousand for thrips control. Thiodiocarb (Larivin DF 80%) at a rate of 5-7 per thousand for thrips control . They also recommended generally Sulfur wettable powder at a rate of 4-6 per thousand for disease and pest control as an economical method.

In preparing a disinfection solution with thiodiocarb, it is better to use a surfactant or mouyan at a rate of 2.5 kg per 100 kg of seed, so that after the insecticide is dissolved, mouyan is added and the volume of the solution is brought to the

indicated amount with water. In the 1970s, the insecticide Larvin was used in Iran at a rate of 7 grams per kilogram of cotton fuzzy seeds and had good results for the desired control of thrips, but this insecticide did not have a desirable effect on the control of this pest in delinted seeds. Therefore, at the same time as the establishment of cotton seed delinting factories in Iran and the development of delinted seeds and its use in the cotton growing areas of the country, the insecticide Gaucho was replaced and was used as a seed dressing to some extent in delinting factories. Then the pesticide Cruiser was added to this list and was very effective in controlling this pest at the beginning of the season in the cotton fields. Cruiser insecticide is a neonicotinoid insecticide with the trade name Cruiser and the generic name thiamethoxam. It has contact, digestive and systemic activity that is rapidly absorbed by the plant and transported through the xylem. This compound is used for the seed treatment of corn, grain and cotton seeds.

The results of several recent research megaprojects show that although Cruiser was superior to Gaucho for controlling cotton thrips and reducing its population and damage at the seedling stage and plant establishment in both fuzzy and delinted seeds for several different Iranian cotton cultivars, but Gaucho insecticide was better in terms of quantitative and qualitative indices of germination and seed vigor in most of the traits studied. Gaucho insecticide also has better ability to be combined and used together with fungicides such as Carboxin Thiram.

In addition to the above fungicides, preliminary tests have shown that the use of Insure Perform fungicide (as a fungicide suitable for controlling both seed-borne and soil-borne diseases) is suitable for coating delinted cotton seeds.

Polymer super-absorbents are materials that are capable of absorbing water but are insoluble in water. Superabsorbent polymers are 100% organic materials that are capable of physically and chemically absorbing water or aqueous solutions tens to thousands of times their own weight. Due to climate change and the occurrence of successive droughts, especially in the spring when cotton fields are emerging, in the last two years, a knowledge based company at the Iranian Polymer Research Institute has been using nanotechnology to produce super-absorbent nanopolymers, and with an innovative and intelligent technology for water absorption, it ensures complete germination and emerging in cotton fields even at low moisture. These nanopolymers are used with other seed coating materials and are now widely used.

Recently, specific research projects are underway on coating seeds of Iranian cotton varieties with biocontrol compounds (both fungicides and insecticides), and their preliminary favorable results will indicate a remarkable development in cotton seed technology and industry.

Cotton seed storage:

In general, seeds are divided into three groups in terms of shelf life and storage behavior: orthodox, intermediate, and recalcitrant. Seeds of most plants, including cotton, have orthodox storage behavior. One of the characteristics of seeds in the orthodox group is the possibility of long-term storage, because they have the ability to tolerate drought and low temperatures. By reducing the moisture content (to 5 to 6 percent), these seeds can be stored at temperatures below zero degrees Celsius for several years without causing damage (Nasiri, 2014).

Very good cotton seed usually has a germination rate of 90-95%, and the minimum acceptable germination rate for cotton seed in Iran like many countries is 80%. Another requirement for seed is that it be free from pathogens. Seed disinfection with recommended chemicals can greatly preserve seed in storage.

Humidity above 12% is not suitable for storing cotton seeds in the store. During the storage period, in addition to the moisture in the seed shipment, it is also important to control the ambient temperature and relative humidity of the store air; therefore, a ventilation system in the store is essential and its air should always be kept cool and dry. The best temperature for storing cotton seeds is stated to be below 15.5 °C. If the seed moisture is low, cotton seeds can be stored

well at a higher temperature (maximum 25 °C).

In the cotton seed store, each part contains a maximum of 250 packets (20kg) of delinted seeds of the same class and variety (Figure 15). The seed specifications for each part, including the date of ginning and processing, name of the ginning and processing factory, place of production, percentage of germination, date and location of the seed analysis laboratory, number of packets, and part number, are recorded. The method of stacking seed packets on wooden pallets should be such that the seed parts are separate from each other so that each can be easily accessed while allowing air to pass through.



Figure 12 – Storage of twenty-kilogram packets of delinted cotton seeds in the Kashmar delinting factory store.

Conclusion:

Results of these field surveys and a review of existing documentation is that there are potentials, facilities, very successful experiences, and desirable technical knowledge in Iran, which began with the establishment of cotton breeding, new research and propagation of cotton seeds in the 1950s with the cooperation of

France, and then simultaneously with the development of breeding activities and the introduction of new varieties with different growth types, including early mature cotton cultivars. However, it seems that in the development of seed processing issues and its new technologies, in sync with breeding and genetic activities and the release of cotton varieties, technological infrastructure for development and general

use of processing cotton seeds, especially in the post-delinting stages in the fields of seed coating and similar matters, significant measures have not been taken and require faster updating. This issue will be very important in the country in recent years, as the cultivation of this crop has shifted to saline and alkaline soil and water, and on the other hand, the type of cotton germination, which is epigeal.

Another notable issue is the existence and perhaps accumulation of up-to-date technical information as well as valuable experiences that should be delivered and extended to the country's cotton seed companies immediately so that the quantitative and qualitative level of seed production of this industrial product can be further improved. Also, considering the suitable climatic conditions of most cotton growing and cotton seed production areas in Iran, which can be said to have the best conditions in this regard, it is hoped that by planning and increasing the penetration rate of these technologies in seed companies and paying more attention to training human resources in this field, we will witness the export of seeds of superior Iranian cotton varieties abroad. Developing cotton seed technology infrastructure and emphasizing seed weaponization to control most biotic and abiotic environmental stresses, especially in climate change conditions, can be considered as smart innovations to reduce the adverse effects of these conditions in the programs of the country's government and non-government sectors. Another issue that should be emphasized is the use of biological materials and biocontrol compounds in seed coating and seed plating (in advanced level) to control pests and diseases in early season cotton,

especially fungicide and insecticide compounds that can be mixed together without negative effects on each other or on the quality characteristics of the seed.

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