Review
The Seed Quality Assurance Regulations and Certification System in Soybean Production—A Chinese and International Perspective
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Abstract: Soybean is an important and valuable crop for global food and feed supply, providing high-quality nutrition. Globally, five countries—namely Brazil, the USA, Argentina, China and India—have dominated soybean production for many years. The intention of this paper is to review the reasons for their dominance, starting with seeds. High-quality seeds enable stress-free, high-density and even planting of soybean in the field. Seed quality assurance is essential for the successful expansion of soybean cultivation. The aim of this review is to compare and contrast the factors impacting soybean seed production in these top five soybean-producing countries, including the situations at different stages of the supply chain; research and development on new soybean varieties; and regulations, rules and quality assurance systems (seed testing, certification and labeling). Since the soybean supply chain involves many different operating parties, principles and practices, efforts on different fronts need to be well coordinated by a central authority to ensure successful production. Recently, China has implemented a revised national “Seed Law”. The possible impacts of this new legal framework on soybean seed development and trading in China are also discussed. The strengthened China Seed law to protect resources and encourage variety innovation, as well as the clearer China GM soybean commercial release policy, implies future soybean cultivation expansion with elite varieties. A continuous global production increase will require every party’s compliance to the sustainability principles.

Keywords: soybean; seed standard; seed certification; seed law; cultivar registration

1. Introduction
Soybean is one of the most important cash crops in the world. It is among the few plant-based foods that provide high-quality proteins, with nine essential amino acids [1]. This unique quality makes it an ideal candidate as both a direct and indirect protein source for humans and farm animals. Today, more than 85% of soybean harvest is extracted for oil and crushed into meal to make animal feed, oil and biodiesel; the rest is used for human consumption and industrial ingredients [2-4]. The production and movement of this crop is closely associated with a country’s economy, food security and social equality.
Soybean is grown in many different parts of the world. Its production has expanded fast, with the USA leading the growth trend since the 1950s (Figure 1). Brazil first surpassed the USA in 2019, and grew steadily higher in the following two years. Global production quantity was estimated to be over 380 million metric tons in 2021/22 [3]. The top five producing countries (Brazil, the USA, Argentina, China and India) have accounted for over 80% of global production since 2012/13 and reached nearly 90% of the total output in 2020/21 (Figure 2) [12].

Figure 1. Soybean production in the five major soybean-producing countries from 1961 to 2021. Data from 1961–2019 were retrieved from FAOstat (https://www.fao.org/faostat/en/) on 1 February 2022. Data from 2020 were retrieved from USDA (https://ipad.fas.usda.gov/cropexplorer/Default.aspx) on 1 March 2022.

Figure 2. Production volumes of soybean in the top 10 producing countries/regions in 2021. Data were retrieved from USDA (https://ipad.fas.usda.gov/cropexplorer/Default.aspx) on 1 March 2022.

Out of the 366 million metric tons of soybean produced in 2020/2021, 165 million metric tons (45%) was exported. The major exporting countries are Brazil, the USA and Argentina. China was, by far, the leading importer of soybean (estimated to import 60% of the world’s total export), followed by the E.U. (12%) and Mexico (3.6%) [13].

Soybean is also gaining importance in sustainable agriculture due to its nitrogen fixation ability. Soybean has been demonstrated to be an effective nitrogen supplier in cropping systems that can significantly reduce demand on synthetic fertilizers, nitrogen leaching and air pollution [9,10]. Shifting to a soybean-oriented plant-based diet could also significantly reduce PM$_{2.5}$ and consequential premature death [11].

Apart from the traditional soybean-producing countries/regions in America and Asia, Africa is also predicted to be next major soybean-producing continent [8].
Soybean production originated in China in ancient times [14,15]. China used to top the world in soybean production and export before World War II. During and after World War II, soybean production and export in China were interrupted for various reasons [16]. The status of China as the world’s top producer has never resumed since, with only one exception in 1957. In recent years, due to economic improvements, lifestyle changes (an increase in meat consumption) and population growth, the demand for soybean in China has been steadily increasing. Insufficient domestic supply has resulted in large import quantities every year [17–19].

In this review, the factors impacting soybean production and the quality assurance legislations in these top producing countries will be reviewed. Soybean can be traded as seeds for sowing (planting), as food for direct human consumption, or as raw material for industrial processes (oil and meal). The testing criteria and standards are different based on final applications. For sowing, the seed variety, purity and germination quality are important. For food and industrial processing, bean grading and fat/protein content analyses are pertinent. This review will focus mainly on seeds for sowing (planting).

2. Factors Impacting Soybean Production and Supply Chain

Country-specific agriculture policies dictate crop production output [20]. The size of the arable land and freshwater resources allocated, the farming system, the choice of crop, and the decision of whether to plant genetically modified (GM) soybean are the important factors directly influencing crop yield, aside from the political and financial considerations and impacts of climate disasters. China hosts ~20% of the world’s population but only possesses 9% and 6% of the world’s arable land and freshwater resources, respectively [21]. In view of these limitations and the large population in China, staple cereal crops have a higher priority than soybeans. Moreover, the prospect and regulation of the application of GM technology to soybeans has been unclear until the implementation of the revised national “Seed Law” very recently in 2022 (see later sections).

The areas in the USA and in Latin American countries under soybean cultivation are 2–3 times larger than those in India and China [12]. Larger farm sizes, along with investment, facilitate farm mechanization, allowing farmers to grow more at lower costs. The economics of competing crops among rice, corn, wheat and soybean vary by country and year, causing soybean production to fluctuate annually [22,23].

The USA was first to adopt the cultivation of genetically modified (GM) soybeans. Growing GM soybeans can help generate higher yields and reduce herbicide and pesticide usage [24,25]. Easier cultivation with a lower cost attracts more producers. USA commercialized Roundup Ready® soybean in 1996. Brazil and Argentina have adopted a similar GM soybean growing model/system with further innovations over the years. More than 90% of the total output from these top three producing countries are GM soybeans. Innovations in genetic modification have driven the rapid growth of soybean production [4]. The large-scale production of GM soybeans over the years has also generated concerns about long-term environmental pollution and adverse biodiversity impacts, particularly in the South American Amazon region [26,27]. Until now, China and India have only grown non-GM soybeans for local food consumption (China), oil crushing (India) and minor exports at premium prices (both China and India). Soybean yield in the top three countries is consistently higher than in China. India trails far behind China in total soybean production and yield per unit area despite having a larger area for soybean cultivation [28–30]. Although both China and India import GM soybeans for oil crushing and feed meals, local acceptance of GM soybeans as food is still low [31–33]. Debate over GM soybean cultivation also continues in other areas, particularly in the EU [34].

Good-quality seeds are the basis for successful agricultural production. Assurance of the seed quality using trusted and certified testing methods is critical for planting success. Well-organized production management by providing a proper seed supply to farmers and to markets is even more crucial to realize a significant output. The soybean production
supply chain can be divided into three stages: seed breeding, farming, and harvesting and distribution (Figure 3) [3,29,35].

**Figure 3.** Soybean production supply chain.

At the breeding stage, factors impacting production include basic research and cultivar development by private and public sectors (an elite cultivar will give a good yield if planted properly), cultivar registration, testing and trials, cultivar approval and listing, intellectual property (IP) protection, and cultivar commercialization. Since many new varieties are developed each year, it is essential to have an up-to-date, easily accessible database to provide farmers/buyers with the requisite educational and training information associated with the new varieties.

At the farming stage, farmers need to select the right cultivar for maximum yield; optimal adaptation to local geography, climate and soil conditions; and cost considerations. Preparation for sowing needs to include acreage/location planning and cropping considerations (crop rotation or intercropping). Electronic systems/tools for monitoring/recording climate (temperature, rainfall, day length, etc.) and soil (pH and mineral nutrient contents) conditions need to be made available for farmers’ use. Other aspects of management, including the applications of fertilizers, inoculants, herbicides, insecticides...
and other disease-control measures, also require thorough planning, review and execution to ensure efficiency and maximize economic benefits.

At the harvesting and distribution stage, harvesting and processing by mechanical means to minimize loss and reduce cost is critical [36,37]. Harvested seeds are authenticated by various accredited technicians and labs, and they need to be certified/labeled based on their destination for the domestic/international markets. It is critical to ensure that farmers comprehend all the necessary processes and adhere to the established standards and systems. Providing support to farmers to connect them to reliable financial transaction networks will contribute to their success [25].

3. Rules and Regulations for Seed Quality Assurance

As shown in Figure 3, many parties, influencing factors, standard compliance and delivery steps are involved in the soybean supply chain. The whole supply chain can be complex and confusing. To strengthen the seed sector, it is crucial that seed producers and companies adhere to regulations, rules, policies and standards that have been consequentially established to guarantee quality. Subsequent management and enforcement of the rules and regulations by a centrally coordinated body is paramount for success.

An overview of the seed laws, rules, regulations and systems in the top five soybean-producing countries (the USA, China, Argentina, Brazil and India) is displayed in Table 1. Internationally, several organizations, conventions and treaties exist to deal with the regulation of seed trade. Together, they provide an international regulatory framework to oversee the interests of breeders, producers and buyers. The Organization for Economic Cooperation and Development (OECD, http://www.oecd.org, Seed Schemes, accessed on 14 October 2021) defines Seed Schemes that are globally recognized for the varietal identity and purity of agricultural seeds moving in international trade [38]. Soybean is under the varietal certification of the Grass and Legume Seed Scheme, Glycine max (L.), Fabaceae family. This scheme lays out the minimum requirements for the soybean seed production procedures, methods and standards, including field inspections and post-control tests [39]. Currently, over 62,000 varieties from 204 species are under the OECD seed schemes. Sixty countries participate in various schemes, with 54 (including the USA, Argentina, Brazil and India, but not China) in the soybean scheme. OECD appoints a National Designated Authority (NDA) from each participating country to collaborate with other member countries. The International Seed Testing Association (ISTA, http://www.seedtest.org, accessed on 13 October 2021) develops globally recognized standard procedures for seed sampling and testing. The International Union for the Protection of New Varieties of Plants (UPOV, http://www.upov.int, accessed on 1 November 2021) provides the breeders of new plant varieties with intellectual property protection. The International Seed Federation (ISF, http://www.worldseed.org, accessed on 1 November 2021) sets the trade and arbitration rules. The food and Agriculture Organization of the United Nations (FAO, http://www.fao.org, accessed on 14 October 2021) provides the international regulatory framework for related aspects of the seed trade, including plant health and phytosanitary measures, access, and benefit-sharing for plant germplasm and pesticide uses [38,39].

Nationally, each country promulgates its own national seed laws that govern domestic and international seed trades (Table 1). Domestically, each state/province/zone complies with the national principles and implements them with variations to suit local needs. The purpose of the seed laws, rules and regulations is to prevent misrepresentation of the seeds, to ensure good seed quality with agreed-upon testing standards and to check and prevent the spread of weeds/diseases/pests. Ultimately, it is to protect the right of the sellers (breeders, innovators and companies) and buyers (farmers and commercial entities). Hence, the laws include clauses for punishing false representation with penalties and seizure. The national rules and regulations align with international standards and requirements. Additional agreements can also be drawn up separately between individual
exporting and importing countries to align with the specific requirements defined by the importing country.

**Table 1. Overview of soybean seed laws, rules, regulations and systems by country.**

<table>
<thead>
<tr>
<th></th>
<th>The USA</th>
<th>China</th>
<th>Argentina</th>
<th>Brazil</th>
<th>India</th>
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<tbody>
<tr>
<td><strong>Seed Law</strong></td>
<td>Federal Seed Act [40]</td>
<td>PRC Seed Law [41]</td>
<td>Law No. 20247/73 on Seed and Phytogenetic Creations [42]</td>
<td>LAW No. 10.711 [43]</td>
<td>Seed Bill [44]</td>
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<td><strong>Central Governing</strong></td>
<td>USDA AMS</td>
<td>MARA NATESC</td>
<td>MAGyP, INASE, CONASE</td>
<td>MAPA, Consultative Seeds and Seedlings Commissions</td>
<td>Ministry of Agriculture and Farmers Welfare, Central Seed Committee</td>
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<tr>
<td><strong>New variety R&amp;D Public Sector</strong></td>
<td>USDA, State Agricultural Experiment Stations</td>
<td>Nanjing Agricultural University, CAAS, HAAS, etc.</td>
<td>CONICET, INTA, Universities</td>
<td>Embrapa</td>
<td>ICAR, IISR</td>
</tr>
<tr>
<td><strong>New Variety R&amp;D Private Sector</strong></td>
<td>Corteva Agrisciences</td>
<td>Shandong Shofine Seeds Technology Co., Beidahuang Kenfeng Seed Co., Syngenta</td>
<td>ADM, Criadero Santa Rosa, others</td>
<td>SLC Agricola, AMAGGI, BOM FUTURO, Terra Santa, others</td>
<td>Krishidhan Seeds Pvt. Ltd., Eagle Seeds, Bombay Super Hybrid Seeds Limited</td>
</tr>
<tr>
<td><strong>National Variety Registration and List (IP Protection)</strong></td>
<td>National list based on Plant Variety Protection certification database, plant patents, utility patents</td>
<td>National list based on Regulation of Protection of New Varieties of Plants and Measures</td>
<td>National Catalog of Cultivars based on National Register of Cultivars on Article 9 of seed law, National Register of Cultivar Ownership</td>
<td>National registration of Seeds and Seedlings (RENASEM), National Registration of Cultivars (RNC), National Registry of Registered Cultivars (CNCR), Plant Variety Protection Law No. 9.456</td>
<td>National Register of Seeds, The Protection of Plant Varieties and Farmer’s Rights Act</td>
</tr>
<tr>
<td><strong>Rewards for New Variety Developed</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Seed Classification</strong></td>
<td>Breeder, Foundation, Registered, Certified</td>
<td>Breeder’s original seeds, Breeder’s seeds, Pure-breed seeds, Certified seeds,</td>
<td>Original (basic or initial), Certified (Registered) 1st propagation, Certified subsequent propagation 2 and 3, Identified certified</td>
<td>Basic, 1st generation certified C1, 2nd generation certified C2, Supervised S1 and S2</td>
<td>Breeder, Foundation Stage I, Foundation Stage II, Certified</td>
</tr>
</tbody>
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Table 1. Cont.

<table>
<thead>
<tr>
<th>Seed Testing Methods</th>
<th>The USA</th>
<th>China</th>
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<th>Brazil</th>
<th>India</th>
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<tr>
<td>AOSCA, ISTA</td>
<td>GB 3543 Rules for agricultural seed testing (based on ISTA rule 1993)</td>
<td>OECD, ISTA, AOSCA, National Inspection for Exclusive Export Destination</td>
<td>OECD, AOSCA, ISTA</td>
<td>OECD, ISTA</td>
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| Seed Certification Standards | GB 4404.2 Seed of food crops—part 2: Legume | The Resolutions of the Secretary of Agriculture, Livestock and Fish of Argentina N° 2270-93 Tolerances for soybean seed and other species. | MAPA in Normative Instruction No. 45, 17 December 2013 ANNEX XXIII Standards for the production and marketing of soybean seeds (Glycine Max L.), general and specifics. | INDIAN min seed certification standards (general and specific) |

<table>
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<tr>
<th>Seed Testing Technician Certification</th>
<th>Certified Seed Analyst (AOS) Certified Seed Technologist (SCST)</th>
<th>List of qualified Agricultural Seed Inspectors</th>
<th>List of Accredited Inspectors</th>
<th>Accredited Technicians</th>
<th>Accredited Seed Analysts</th>
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<tr>
<td>OECD Accreditation Program 46 AOSCA seed certifying agency USDA ASL 7 ISTA-accredited labs</td>
<td>2 ISTA-accredited labs Seed quality testing agency approved by MARA</td>
<td>1 ISTA-accredited lab (The Central Laboratory for Seed Analysis)</td>
<td>2 ISTA-accredited labs List of seed and seed analysis labs accredited in RENASEM</td>
<td>6 ISTA-accredited labs Central and state seed testing laboratory</td>
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<tr>
<th>Seed Certification Body</th>
<th>AOSCA, ISTA, OECD</th>
<th>MARA-approved Crop Seed Quality Testing Institutions</th>
<th>INASE</th>
<th>MAPA and its accredited legal entities</th>
<th>State Seed Certification Agencies appointed by Central Seed Committee</th>
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<tbody>
<tr>
<td>OECD Seed Schemes (Soybean)</td>
<td>State standard (GB) enforced by competent agriculture and forestry departments</td>
<td>OECD Seed Scheme (Soybean) AOSCA system National Inspection system with Exclusive Export Destination</td>
<td>OECD Seed Scheme (Soybean) AOSCA system</td>
<td>OECD Seed Schemes (Soybean) ISTA Certification</td>
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<tr>
<th>Certification System</th>
<th>Varieties and kinds, Net weight, % Germination, % Purity, % Dormant or hard seeds, % Inert matter, % Other crop seed, % Weed seed, Name of noxious weeds, Lot number, Origin, Test date, Name/ Address, Tag color for quality</th>
<th>Cultivar Name and category, Net weight, % Germination, % Purity, Seed classification, Information required by specific standards Batch number, Name/address and registration number of the seed producer, Validity month/year of the germination test</th>
<th>Name and variety, Net contents, % Germination, % Purity, % Inert matter, Seed classification, Lot number, Name/Address of producing institution, Date of test, Tag color for quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Label Contents</td>
<td>Variety and kind, Net weight, % Germination, % Purity, % Dormant or hard seeds, % Inert matter, % Other crop seed, % Weed seed, Name of noxious weeds, Lot number, Origin, Test date, Name/ Address, Tag color for quality</td>
<td>Cultivar Name (common and botanical name), Net contents, % Germination, % Purity, % Weeds Seed classification, Name/Address, Registration number of the certifier and seller, Harvest year</td>
<td>Name and variety, Net contents, % Germination, % Purity, % Inert matter, Seed classification, Lot number, Name/Address of producing institution, Date of test, Tag color for quality</td>
</tr>
</tbody>
</table>
USA, as the longest-leading producer of soybean in the past 70 years, instituted a complete set of rules, regulations and systems before 1940. The national seed law is publicized in the U.S. Code of Federal Regulations (CFR), Title 7, Part 201: Federal Seed Act Requirements [45] with periodic updates. It defines the roles and responsibilities of the regulatory and governing bodies and sets the regulatory framework for seed-production recording, testing, certifying and labeling. Soybean-producing states within the USA comply with the federal laws and could also develop their own detailed practices and standards. The seed laws and regulations in Brazil, Argentina and India follow a similar road map. The regulations in these four countries emphasize seed certification and label information accuracy (USA mandates label accuracy but leaves certification voluntary). China is the only major soybean-producing country that uses an administrative approval/confirmation/permit system with quality data on the label. Verification is performed by spot-check sampling. However, a seed certification system has recently been designed following the OECD seed scheme. Ten selected Chinese provinces tested the draft system with a good outcome. The system is anticipated to be formally implemented in the near future [46–48]. Some new developments in seed regulations in China will be discussed below.

4. Research and Development on New Seed Varieties

Research and development are critical for generating new varieties to improve growth and production results in specific areas/environments. The variety research and development in a country typically start in the public sector and then move into the private sector, due to the capacity and resources available there (Table 1). Private companies, in general, possess advanced technologies and hold IP patents that can assist farmers, particularly of small-to-medium-sized farms, at different stages of production. India implemented a project in Maharashtra (one of the key soybean-producing states) under the Public–Private Partnership Program for Integrated Agriculture Development (PPPIAD) Scheme and had good outcome [49]. Soybean breeding in China is still largely dependent on the public sector because of insufficient capacity in the local private sectors [50]. The USA is a good example of success in the private sectors in developing new varieties using biotechnology, resulting in major global success (e.g., Roundup-Ready® soybean and other crops devel-
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oped and marketed by Monsanto). Because objectives are different between the public sectors (open information sources for the public good) and the private sectors (patented IP for profit), complementary collaboration between them is suggested to have the potential to achieve maximum benefits [51].

Brazil has had a rapid growth in soybean production in recent decades. A key reason is the research success in developing “tropical soybeans”; these are varieties with long juvenility or late flowering, which have enabled soybean to be grown under short-day environments from subtropical regions in the south to the tropical region in the middle and north parts of the country [52,53]. New varieties were also developed to tackle soil fertility challenges. The improvements included various biotechnological inventions. The GM crops were developed with increasing numbers of beneficial traits. The first-generation GM soybean varieties contain a single herbicide tolerance trait [54,55]. The second and third generations contain stacked traits with a combination of insect, disease and multiple-herbicide tolerance, as well as other traits, e.g., drought/salt/cold tolerance and biofortification [4]. All these soybeans contribute to a very positive economic impact on Brazil and other South American countries. Due to the importance of innovations in new varieties, the seed laws and regulations of all five top producing countries include IP protection clauses with respect to breeders and inventors. A national list of new varieties is available on each country’s designated publication site (Table 1).

Awards are granted in some countries for new cultivar inventions (Table 1). The awards given in China, coupled with a breeder evaluation system, have promoted competition among breeders to release super varieties; however, sometimes, this may cause continuing segregation of a released cultivar [56]. This undesirable situation has been addressed in the revised national “Seed Law” of China (see below). Despite award granting, the government subsidy/funding/levies, fees and taxes in some countries—such as India [57] and Argentina [58]—have been shown to have detrimental impacts on soybean farming. These policies and practices require careful review for enhancing productivity.

5. International Seed Certification and Labeling

A third-party seed certification and labeling system for the verification of the quality of every lot of seeds before trading is adopted by the USA, Brazil, Argentina and India (Table 1). On the other hand, regulations in China are mainly performed by government agencies. An administrative approval system is used in China for the release of new varieties of five major crops (rice, wheat, maize, cotton and soybean) for the commercial production of seeds for sowing. China has also issued various seed standards with which the producers will need to comply. Those in violation of these standards will be prosecuted by the regulatory bodies.

The internationally adopted seed laws and regulations define which seed tests are to be conducted, the minimum standards the seeds are required to meet, and the certified analysts and labs that can carry out the tests. The standards to be met include those that are common to all seed varieties plus those that apply to the specific soybean cultivar. The established testing methods include those by OECD, ISTA and AOSA (the Association of Official Seed Analysts, www.aosaseed.com, accessed on 8 March 2021). The AOSA methods are in line with those by ISTA and are also adopted by OECD. In China, although seed certification is not mandatory by law, seed certification standards do exist. The China GB 3543 rules are based on the ISTA 1993 methods. In terms of testing methods, all five countries follow a standardized system in general. The certification agents can be ISTA, AOSCA (U.S. Association of Official Seed Certifying Agencies, www.aosca.org, accessed on 8 March 2021) or OECD (by collaborating with the individual national designated authority [NDA]), depending on needs.

The USA mandates label accuracy. Below is an example of a typical label used by the two-leading soybean-producing states, Illinois and Iowa, in the USA [59,60]:

1. Soybean variety (name, species, common name); 2. Lot#; 3. Origin; 4. Net weight; 5. % Purity including % pure seed, % inert matter, % other crop seed, % weed seed (these
The quantity standards vary among states and countries to suit local needs. They normally meet the minimum requirements defined by each designated certifying body. Seeds are classified into different classes and the use for each seed class is defined. All five countries apply a four-tier system (Table 1). The applicable standard for each seed class can vary.


In China, governmental regulation plays a central role in safeguarding seed production and utilization. China covers many landforms and climatic regions, and there is still a large portion of small-holder farmers [62]. It is important to choose the right types of varieties to grow in particular regions. Therefore, China has a stringent requirement for releasing new varieties of major crops to farmers for production, involving provincial and national approval procedures. For instance, there are several related national standards to define the evolution protocol (NY/T1299-2014), scope (DB32/T2077-2012) and seed description (DB51/T1929-2014) for soybeans. The key evaluation criteria for the approval of new soybean varieties (national level) include disease resistance, maturity group and quality (protein and oil contents). The soybeans will be further categorized into high- and stable-yield varieties, high-oil varieties, high-protein varieties and special-type varieties.

To produce seeds for sowing, China also has a series of national standards: GB4404.2-2020 involves seed quality, evaluation methods and criteria, to control seed purity (>99% for pure-breed seeds), germination rate (>85%), water content (<12%, except in high-latitude cold regions) and other seed properties; GB/T17318-2011 and DB64T1478-2017 provide operation guidelines for soybean seed production; and DB41/T997.7-2014 and DB41/T293.7-2014 define the quality standards and production procedures for four grades of soybean seeds (breeder’s original seeds, breeder’s seeds, pure-breed seeds and certified seeds). There are also additional standards for hybrid soybean seeds, for example, DB22/T2209-2014, DB14/T1423-2017, DB22/T2387-2015, DB14/T1342-2017, DB22/T2620-2017, etc.

China has highlighted “seeds” in its 14th 5-Year National Plan. Accordingly, the national “Seed Law” was revised [41] and implemented on 1 March 2022. The revised “Seed Law” aims to upgrade the utilization and protection of seed resources. There are several new developments that may bring profound impacts to seed industries, including soybean production in China.

Seed germplasms will become national properties and the government will step up in seed conservation, including through the building of seed banks for collections of important and unique seeds. The new building of the National Crop Genebank of China was completed at CAAS at the end of 2021. Its capacity is as great as 1.5 million accessions, ranking first in the world.

The approval procedure for new varieties will be strengthened. The concept of substantially derived varieties will be implemented so that new varieties cannot be simple variants of original varieties, or replication of the same concepts. In conjunction, the rights of the seed inventors will be respected so that commercial production is not allowed without the consent or licensing of the seed inventors.

Due to the urge to develop new varieties, the application of GM technology in plant breeding will be enhanced, for reasons including the establishment of more thorough safety guidelines for breeding, testing, evaluation and propagation. Since clearer guidelines will
be implemented, it is expected that China will approve the commercial release of new varieties generated with GM technology, such as soybeans, in the near future.

The licensing of seed-producing companies will be tightened. New rules will be set up so that seed-trading companies will need to fulfil a set of criteria (e.g., space, manpower, seed licensing, etc.) to obtain permits for operation. Seed production should observe standards of seed quality and phytosanitary requirements. The related documentations will be monitored by regulatory bodies. This will upgrade the quality of seeds by asking the producers to bear the responsibility of following the standards.

7. Execution and Governance of Rules, Regulations and Production Systems

Seed certification and labeling involve an ample amount of information and can be complex at different stages. For the most suitable quality of seed variety to reach farmers requires well-coordinated efforts in marketing and education. Farmers need to fully understand and trust the certification process and label information to make the right choice for their successful production. A clearly designated organization with adequate central authority to oversee the whole process is critical for success. In the USA, the central authority is the USDA Agricultural Marketing Service; in Brazil, the Ministry of Agriculture, Livestock and Supply; and in Argentina, the National Seed Institute. The roles and responsibilities of these organizations are well defined in the seed law.

In China, the central governing body is the Ministry of Agriculture and Rural Affairs (MARA). Regulations related to soybean are defined in detail in different mandatory and voluntary national standards (examples are given above). Under MARA, the National Agriculture Technology Extension and Service Center (NATESC) is designated to oversee the connection and coordination of the whole regulatory process. However, because many departments and organizations in different provinces are involved, a clearly defined role and responsibility with granted authority for execution for each party is critical. In particular, good coordination among various agencies/organizations is often cited as a key issue in productivity enhancement in China and India [63,64].

8. Conclusions

Soybean is an important and valuable crop for global food and feed supply with high quality nutrition. Efforts on different fronts need to be well coordinated to ensure continuously successful production. The models presented by the top five producing countries provide clues for future success considerations. The farming policy in individual countries is critical. The associated legal framework needs to have clearly defined and encompassing rules, regulations and systems. Clauses for new cultivar registration, with IP protection for developers, will encourage more innovation towards scaling up production and adapting to changing environmental conditions. Collaborations between reputable private and public sectors is favorable for leveraging strength on both sides, particularly in terms of the offerings in modern technology. A transparent seed certification and labeling system managed by a trusted authority will boost farmers’ confidence in using the seeds.

Since the soybean supply chain is detailed and complex, the execution of the rules, regulations and systems requires excellent central coordination with easy and comprehensible information access. A national designated body with a clear role and responsibility to coordinate the different stages in the supply chain is a must for success. Since farmers need to be well informed of these rules, regulations and systems in order to make wise decisions, education programs and training materials must be offered and widely publicized to them. Only farmers who have profited from their crops have the interest and will to grow more.

China’s newly revised “Seed Law” provides more protection to national seed resources and rights for new plant variety owners. The stricter new variety registration rule pledges efforts for technological breakthroughs. Clearer guidelines on GM technology application, particularly on allowing GM soybean commercial release, implies future production increases with elite varieties.
Finally, due to the significant growth in soybean production in recent years, a larger landmass is continuously required. This can lead to deforestation, particularly in the South American Amazon region. Large-scale GM soybean cultivation over the years has also generated concerns about the long-term environmental pollution and adverse impacts on biodiversity. How to balance food security concerns with sustainable future production is a problem that demands as much effort as possible, from all parties involved, to find a solution.


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