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Seed market outlook

Presentation at Seed Congress of the Americas

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Agribusiness | Crop Science

September 2024

Agenda

- Industry background
  - Global Seed Market Performance (GM and conventional)
  - Market drivers – area growth, new trait introduction
  - GM traits pipeline 2024 to 2034 – (Impact on NA and SA through seed prices)
  - New GM crop introduction and adoption in new region
    - HB4 wheat
    - Latest regulatory developments
  - GM in China
  - China market outlook for 2024-2034 with and without GM seeds commercialization
  - Impact of GM adoption in China on the global seed market
- Developments in NBTs (long term market driver)
  - Regulatory framework development and status country wise
  - Updates on product development
  - Product analysis by country
- Long term market outlook
  - Key market drivers
  - Comparison between key technological drivers and recent trends

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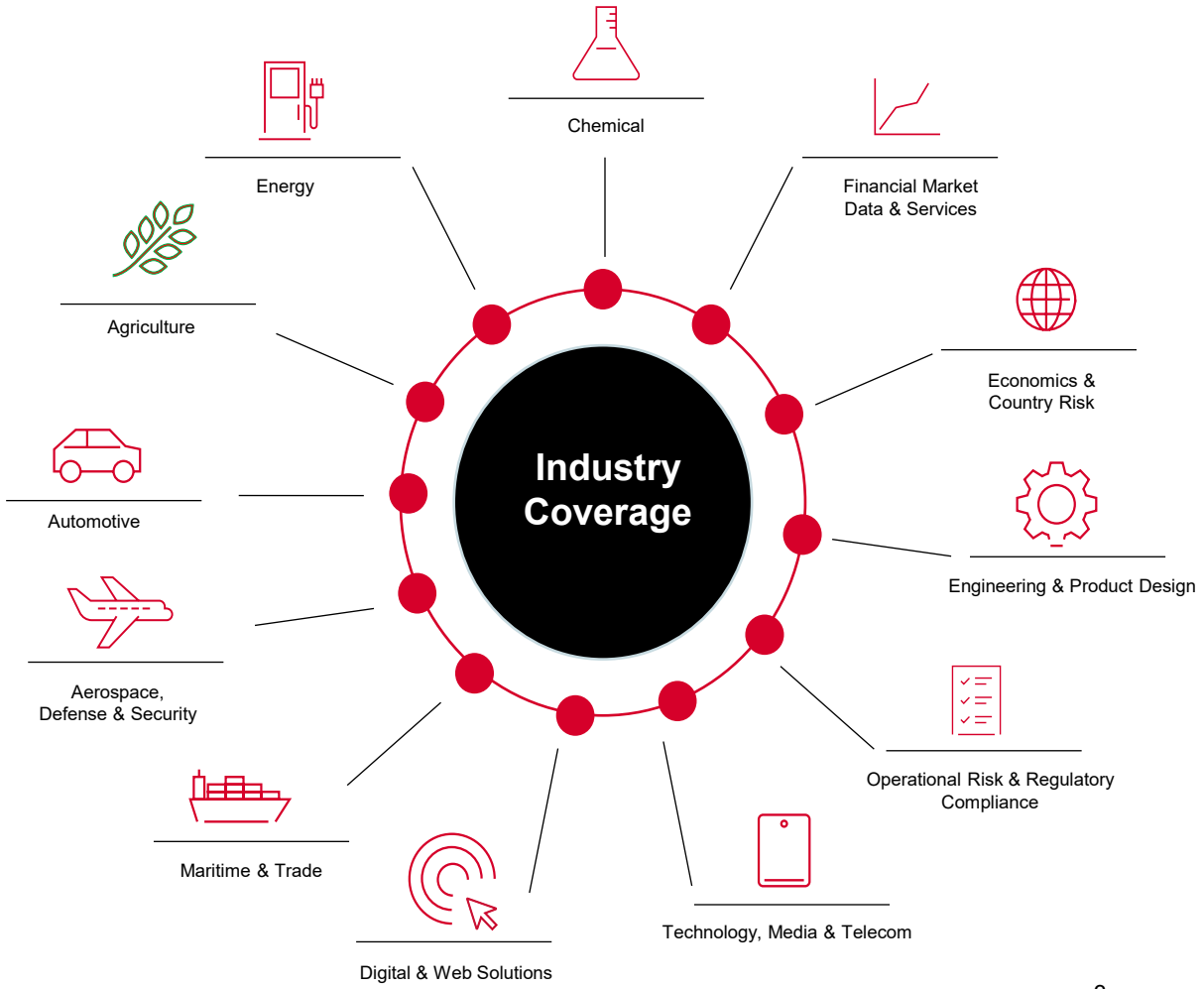

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- Sulphuric Acid

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- Seed / GM Crops: input & output traits, and seed treatments
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- Commercial deals and more

Food and Agricultural Commodities

- **Crops**: Soybean, corn and feed grains, wheat, rice, oilseeds and more
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- **Proteins**: livestock, beef, pork, poultry, eggs and dairy
- **Foods:** Fruit & vegetables, dried fruit & nuts, frozen foods, beverages and more

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- Nutrition, feed and additives
- Investment and M&A developments
- Policy and regulation
- Major disease outbreaks

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- **Procurement** - Help develop sourcing strategies and confidently negotiate cost-effective contracts
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- **Finance** - Help develop economic models, understand the industry landscape and evaluate investments
- **Business Management** - Help identify and implement growth opportunities to achieve revenue targets
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- **Regulation and Policy** - Help understand how changing regulation impacts an organization while mitigating risk

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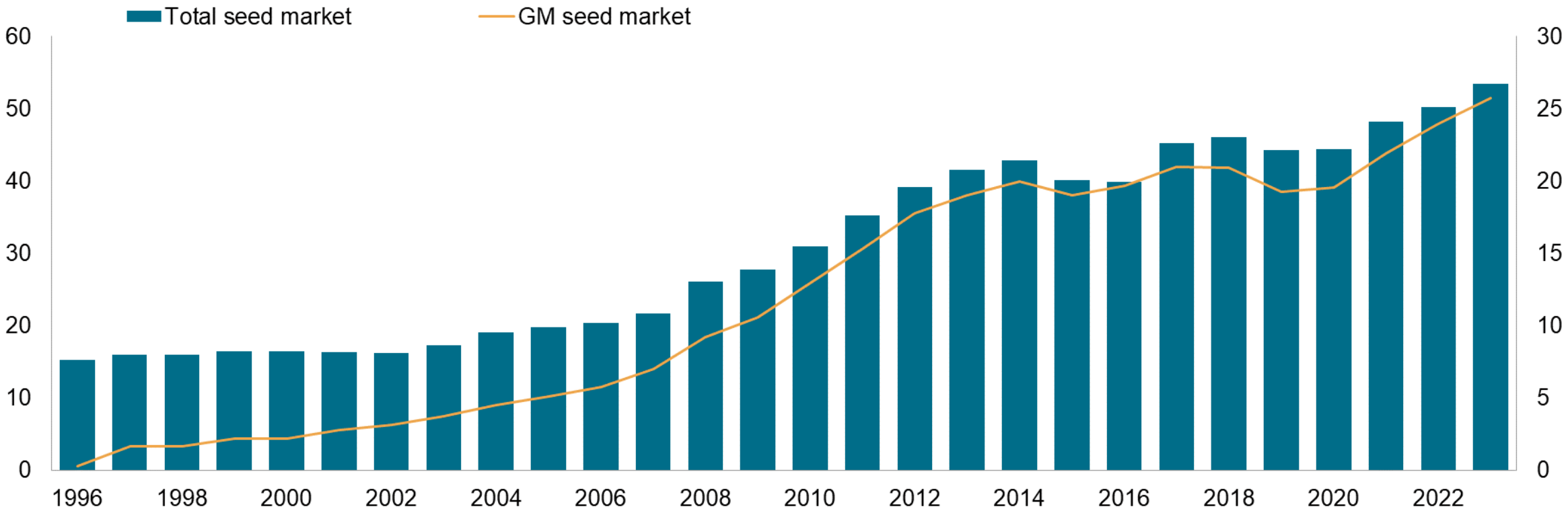
Historical market performance

The global seed market value has grown 3.5 times between 1996 and 2023

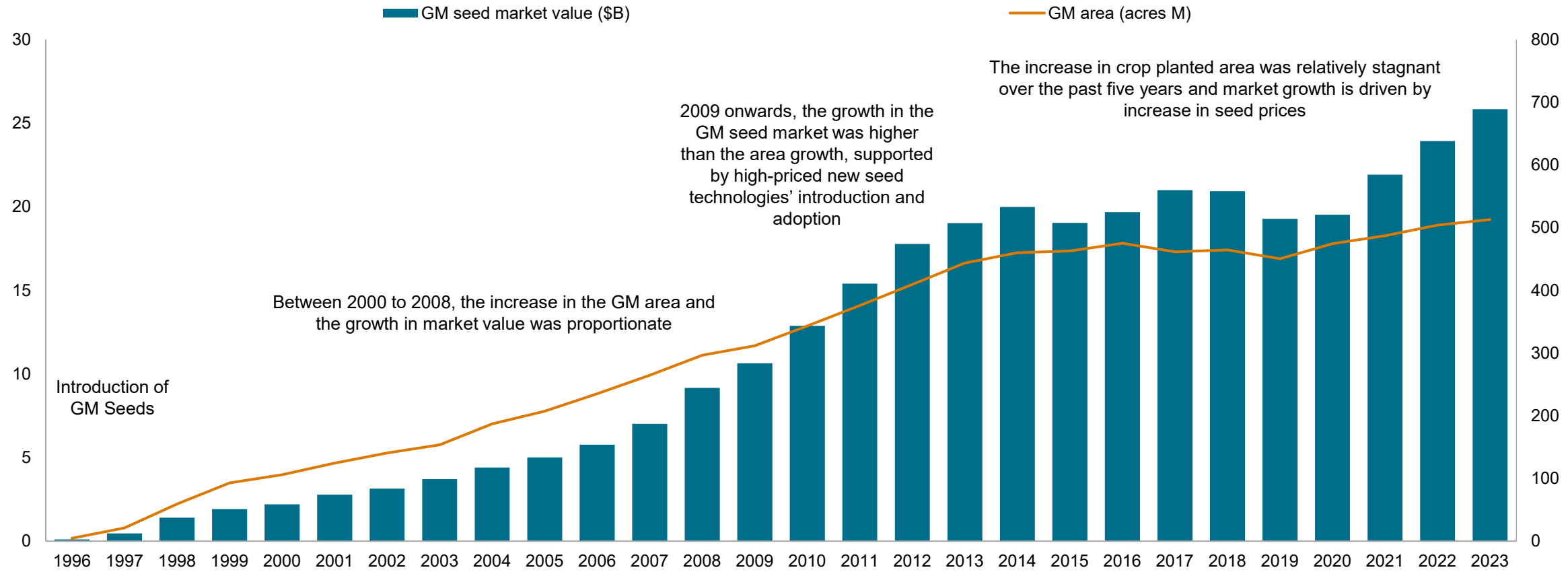
Global seed market value between 1996 and 2023 in $ billion



Historical GM seed market performance

The global GM seed market value is estimated to be $25.8 billion in 2023

Global GM seed market value and area 1996-2023



Data compiled May 1, 2024.
Source: S&P Global Commodity Insights.

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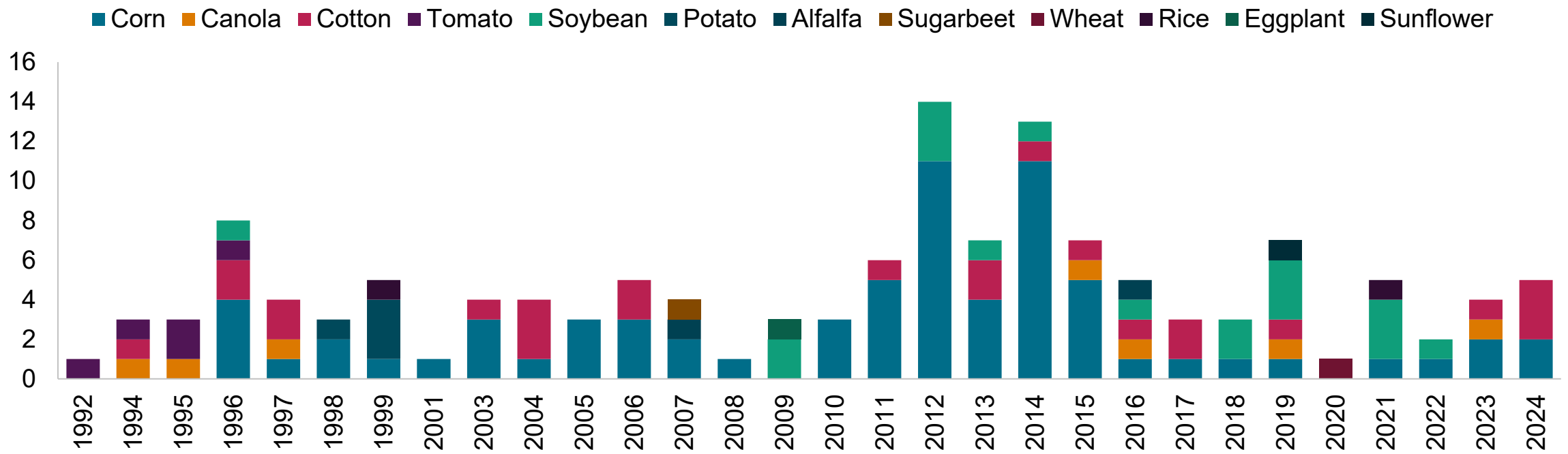
Time series analysis of GM trait introductions

A total of 137 GM traits were introduced in 12 crops between 1992 and 2024



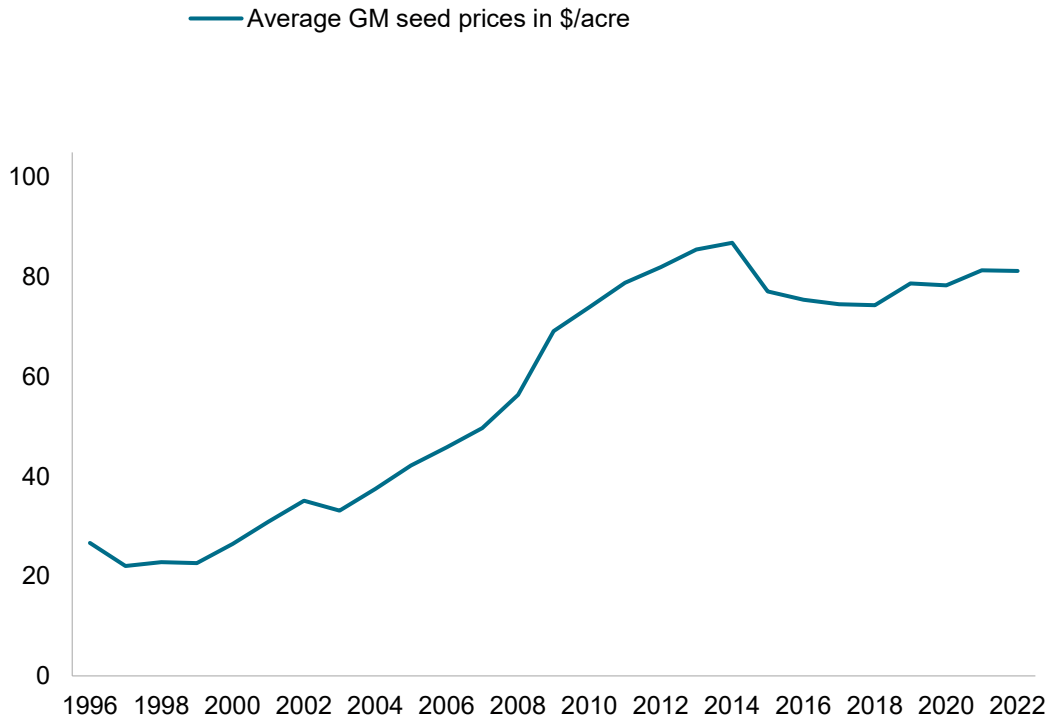
Corn leads the board with the largest number of traits, accounting for 52% of the traits developed between 1992 and 2024. It is followed by cotton, soybean, canola, tomato and potato. Notably, 88% of the total traits developed over the past 32 years were from corn, cotton, soybean and canola alone. Looking at the trait pipeline for this decade, corn will continue to dominate trait development. However, soybean is set to surpass cotton as the second most targeted crop for new traits.

Data compiled July 1, 2024.
GM = genetically modified.
Source: S&P Global Commodity Insights.

The growth in the seed prices has remained as the major GM seed market driver

US GM seed price analysis between 1996 to 2022

Average GM seed price ($/acre) analysis between 1996 to 2022 in US



- In US, the average GM seed prices have increased since the introduction of GM crops in 1996
- However, a slump in GM seed prices could be seen after 2014
- The average GM seed prices between 2005 to 2014 has grown at a CAGR of 7%; however, between 2014 to 2018, the prices have declined by 4%
- The GM seed prices recovered after 2018. A 2% increase in average GM seed prices have been observed between 2018 to 2022
- A decline in GM seed prices between 2014 to 2018 was mainly contributed from decline in GM cotton seed prices and partly due to decline in GM corn seed prices in the US

Data compiled Aug.29,2023
Source: S&P Global Commodity Insights and USDA

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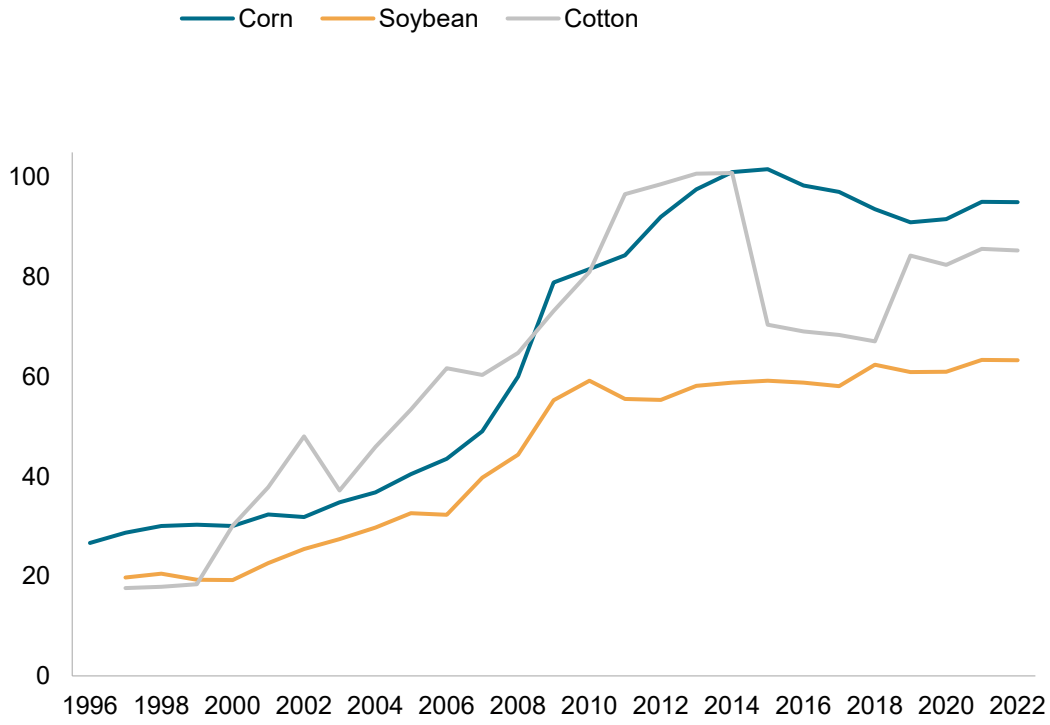
US GM seed price analysis by crop

US GM seed price ($/acre) analysis between 1996 to 2022 by crop

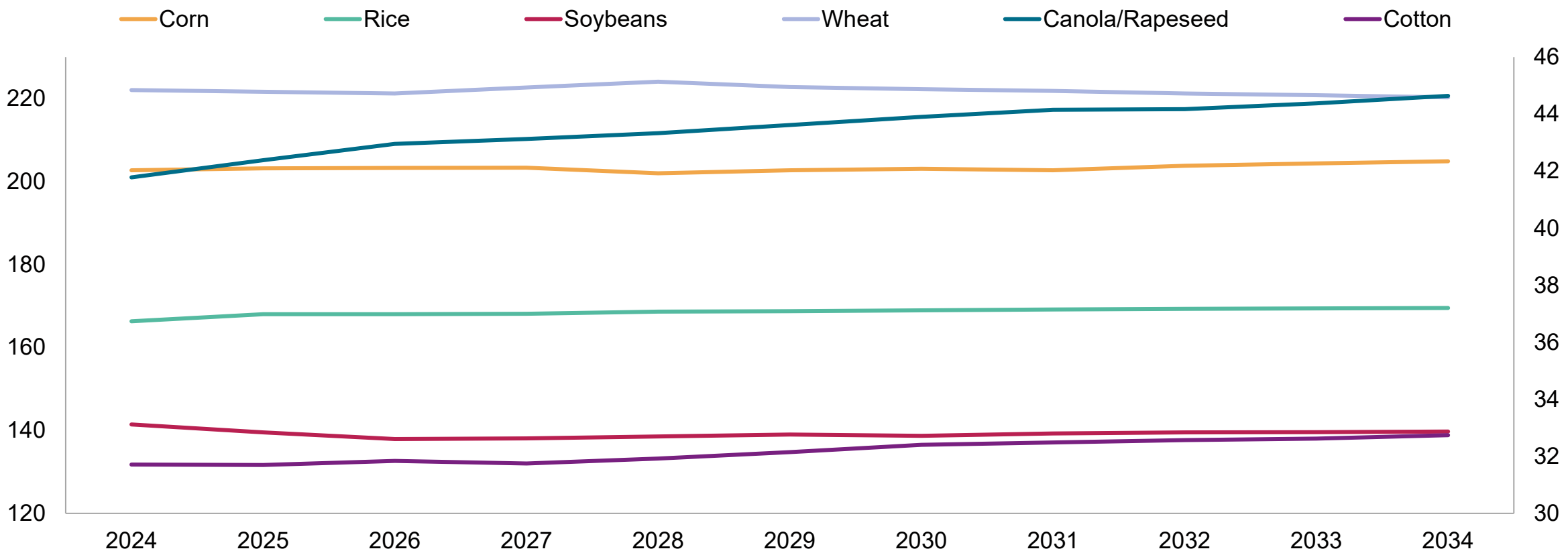


- In US, the GM cotton seed prices declined at a CAGR of 10% between 2014 to 2018
- Following factors that impacted the decline in GM cotton seed prices in the US
  - After the introduction of the Bollgard III trait in US cotton market in 2011, no new trait was introduced till the XtendFlex trait introduction in 2020
  - Starting from around 2015 onwards, US cotton farmers began to face significant challenges related to herbicide resistance in their fields. Glyphosate-resistant weeds, particularly Palmer amaranth became a major issue during this period
  - The US cotton planted area declined to 8.9 million acres of cotton in 2015, the lowest total since 1983
- 2021 onwards, seed prices have started to increase due to the high cost of seed multiplication, high commodity prices and increased farmer's income. Especially in the case of cotton, the seed prices were positively impacted from the introduction of new traits
- In case of corn, due to cash crunch from low commodity prices, farmers avoided multi-stacked traits for a couple of years and moved to low priced single or double stack trait seeds, leading to a slight declined of 2% in seed prices between 2014 to 2018

Data compiled Aug.29,2023
Source: S&P Global Commodity Insights and USDA

Global area growth by crop

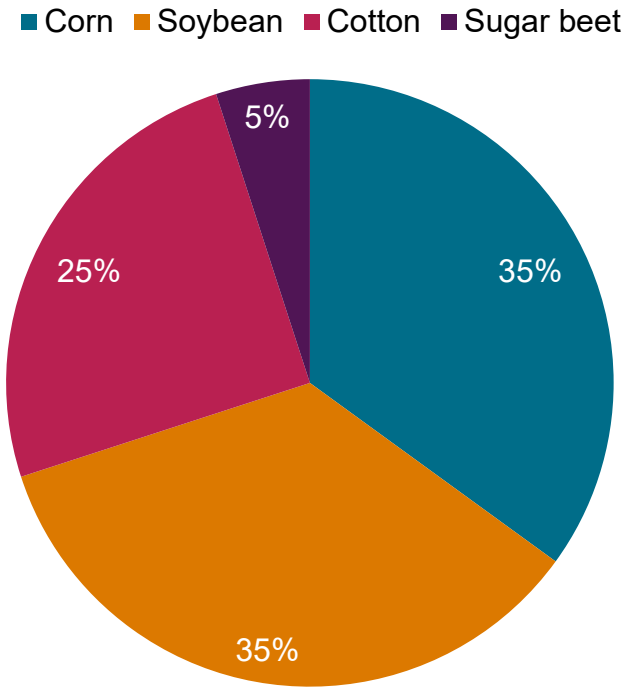
Global area forecast by crop from 2024 to 2034 (million hectares)



Data compiled August 23, 2024.
Corn, Rice, Soybeans and Wheat are represented on primary axis; Canola/Rapeseed & Cotton are represented on secondary axis
Source: S&P Global Commodity Insights.

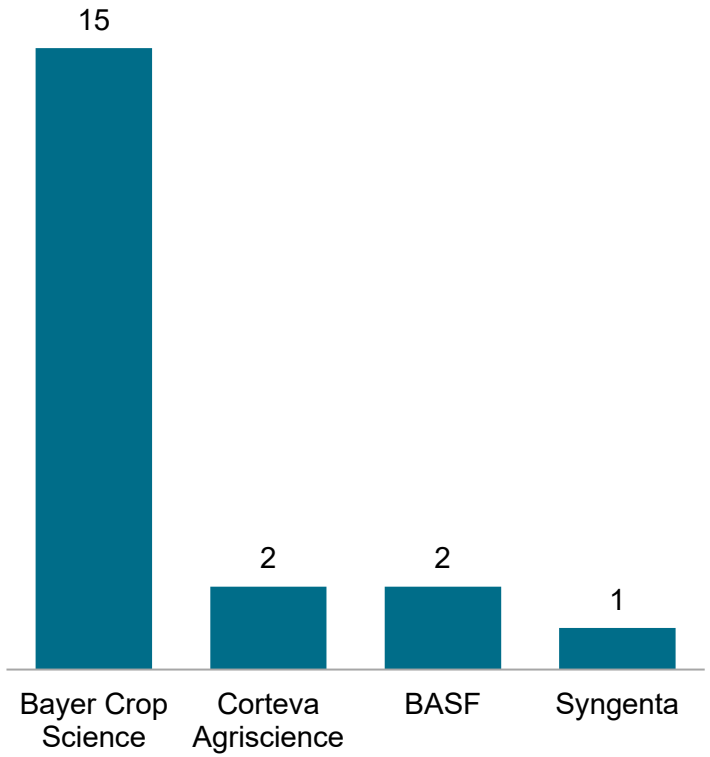
Analysis of GM traits in the pipeline from 2024 to 2030

Upcoming GM traits by crop

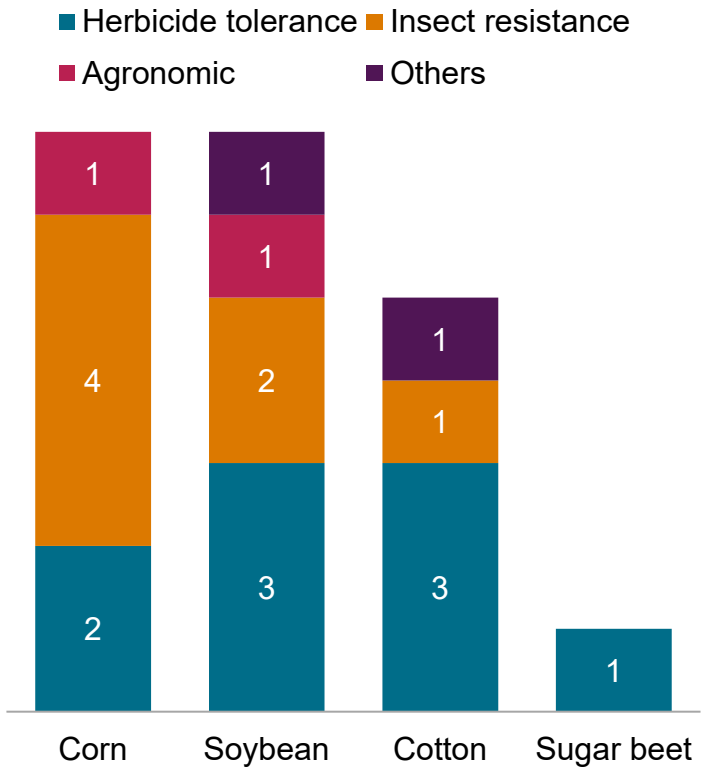


Analysis of 20 traits in pipeline, between 2024 and 2030. Launch year is missing for three traits out of 20 analyzed.

Upcoming number of GM traits by company



Upcoming GM traits by type



Others in soybean include stacked trait for Z series soybeans and Nemasphere. In cotton, it includes Bollgard3XtendFlex.

Data compiled July 1,2024
GM = genetically modified.
Source: S&P Global Commodity Insights.

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New GM crops and cultivation approvals (1/3)

HB4 wheat

- HB4 wheat, a drought-tolerant wheat variety developed by Trigall Genetics, a joint venture of Bioceres Crop Solutions and Florimond Desprez, received its initial approval for cultivation and consumption in Argentina in 2020.
- In 2022, Argentina cultivated HB4 wheat through identity-preserved channels over 50,000 hectares (ha) of area.
- In 2022–23, the company introduced nine wheat varieties with HB4 gene in Argentina.
- After receiving HB4 wheat cultivation approval in Brazil in 2023, the company is aiming to get cultivation approvals in Bolivia, Uruguay, Australia and United States.
- Bioceres' wheat breeding program is operated through its joint venture, Trigall Genetics, through which the company co-develops conventional and HB4 varieties with Florimond Desprez. They are expanding their target markets, such as developing germplasm adapted to important regions, like the United States, Australia and Brazil.
- HB4 wheat seeds are being sold through identity-preserved channels. The system requires having contracts with growers. The company contributes HB4 integrated seeds and other goods to growers for a pre-agreed price (based on prevailing market prices), which are later deducted from the service fees paid to growers at the time of harvest for the seed multiplication services they have provided to the company.

Country	Approval for food	Approval for feed	Approval for cultivation
Argentina	X	X	X
Brazil	X	X	X
Australia	X	X	
Colombia	X	X	
New Zealand	X	X	
Nigeria	X	X	
United States	X	X	X
South Africa	X	X	
Indonesia	X	X	
Paraguay	X	X	X
Thailand	X	X	
Chile		X	

- In Sep 2024- HB4 wheat approved for cultivation in US; 4th largest wheat producer globally
- Doesn't mean cultivation started but agency has allowed non-regulated field activities for production, development and commercialization
- It still might take 3-5 years of time for the trait to enter the market

Data compiled July.1, 2024.
Source: S&P Global Commodity Insights.

New GM crops and cultivation approvals (2/3)

Asia-Pacific region dominates new developments

Mainland China

- Mainland China has made considerable strides in the production of genetically modified organisms (GMOs), and several GM varieties with independent intellectual property rights and potential applications have been created.
- In a strategic shift toward self-reliance, food security and reduction in dependency on imports, the country has expanded the cultivation of GMOs by approving new soybean and corn varieties and expanding the planting areas for some varieties to nationwide.
- A detailed section on mainland China's GM market is covered in following slides.

India and Pakistan

- In India, an attempt to introduce Bt eggplant faced intense public scrutiny, although the country approved the cultivation of Bt cotton in 2005. The commercial release of Bt eggplant was halted in 2010 as it received concerns from environmental activists, nongovernmental organizations (NGOs) and state governments. However, later, several reports surfaced alleging illegal sowing of the crop in the state of Maharashtra in India.
- In October 2022, the environmental release of genetically modified (GM) mustard (Dhara Mustard Hybrid/DMH-11) was approved; however, the Supreme Court of India suspended the decision on Nov. 3, 2022.
- Pakistan has granted cultivation approvals of two GM sugarcane varieties, one with insect resistance trait (CABB-IRS) and another with herbicide tolerance (CABB-HTS), marking the first GM food crop adoption in the country. However, objections are being raised to reject their commercialization.

Bangladesh

- Bangladesh was the first country to commercialize Bt eggplant in 2013.
- It participated in an Asian project to develop an insect-resistant Bt eggplant based on Indian agriculture company Mahyco's (Dawalwadi) GM line, and initiated field trials from 2007. The GM event was developed by Monsanto using the Cry1Ac toxin and was subsequently licensed by Mahyco.
- Bangladesh has begun the commercial planting of GM insect-resistant Bt cotton in the country since August 2023, making it the second GM crop to be cultivated.
- The two varieties of GM cotton released are from India-based company JK Agri-Genetics and are resistant to cotton bollworms (*Helicoverpa armigera*) as well as caterpillars.

Note: Bt refers to *Bacillus thuringiensis*.

New GM crops and cultivation approvals (3/3)

Asia-Pacific region dominates new developments (continued)

Philippines

- In 2022, the government of the Philippines **marked Bt eggplant** as its third genetically engineered crop approved for commercial propagation, followed by **Bt corn and golden rice**. However, in April 2022, the **Philippine Court of Appeals ordered the suspension** of the commercial release of GM rice and eggplant products.
- The outcome of this suspension has halted the review/approval of the pending applications for GM crops.

Indonesia

- In August 2023, Bayer's Crop Science division launched the genetically modified **herbicide-tolerant Dekalb DK95R corn (maize)** in the Indonesian province of West Nusa Tenggara. The Indonesian government is encouraging the development of new seed varieties through biotechnology.
- Although no GM soybean events have cultivation approvals in Indonesia, the government has **plans to allow GM soybean cultivation in the country**. Based on a press release in September 2022 by Indonesia's Ministry of Economic Affairs, the government has plans to encourage farmers to use GM soybean varieties to maintain national food security. The country is preparing a budget of 400 billion Indonesian rupiah ($26.9 million) to expand the planting of soybeans to 1 million ha in the next few years.
- The Indonesian government **approved Bioceres' drought-tolerant HB4 wheat for human consumption in March 2023.**

Australia

- February 2024 marked the Australian government's approval of the commercial release of **GM** QCAV-4 **Cavendish bananas** developed by the Queensland University of Technology (Brisbane). These are the "first Australian GM fruit" approved for cultivation.
- The Australian regulatory body OGTR (The Australian Office of the Gene Technology Regulator) has approved GM wheat and barley field trials in the country and the Australian University of Adelaide has been granted the license (DIR 201) to assess the performance of GM crops under field conditions in the country. The project will run from May 2024 to January 2029. However, the GM wheat and barley grown during the period will not be allowed in food or feed.
- In May 2022, Food Standards Australia New Zealand (FSANZ) **approved the sale and use of food made from GM HB4 wheat** (drought-tolerant) developed by Bioceres.

GM market developments — Mainland China

- Recent timeline of key actions
- GM pilot areas
- Licenses
- GM events for corn and soybean
- Market forecasts

Image: Getty Images.

Summary of key GM regulations related developments in mainland China

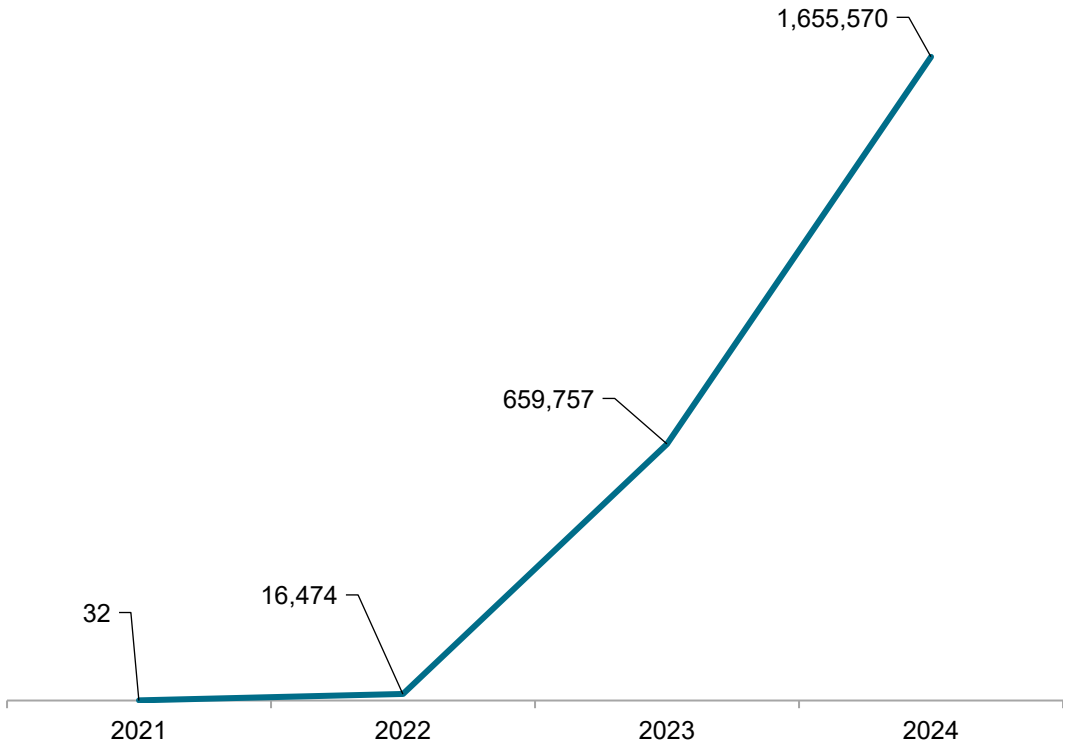
- Mainland China, the second-largest seed market in the world, has experienced rapid growth over the past 10 years, mainly due to increased utilization of certified and hybrid seeds, increased seed prices and positive government reforms, which eased the market for foreign-invested seed companies.
- In July 2020, the Ministry of Agriculture and Rural Affairs (MARA) issued biosafety certificates for some GM corn and soybean varieties. However, the variety registration path for all crops other than cotton and papaya was not established in mainland China and was the major reason for the delay in the commercialization of GM crops.
- In 2022, mainland China took meaningful steps regarding biosafety certification, field trials and established the process for GM variety registration for corn and soybeans.
- In 2023 and 2024, mainland China published two variety registration lists for GM corn and soybean and issued new and renewed biosafety certificates for domestic cultivation and processing of GM crops.
- The first finalized variety registration list, published in December 2023, included 37 GM corn and 14 GM soybean varieties. Of these 51 varieties, seed production and operational licenses were given to 24 GM corn and 3 GM soybean varieties, and the licenses were provided to Beijing Dabeinong Technology, Denghai Seed, Yuan Longping High-Tech Agriculture and Syngenta-owned business China National Seed, among others.
- A more recent second variety registration list for GM corn and soybean was published in March 2024. The list included 27 GM corn varieties developed by Beijing Dabeinong Technology Group, Beijing Liangyuan Biotechnology Co., Ltd., Hangzhou Ruifeng Biosciences Co., Ltd. and Zhejiang University, among others. In addition, it included three GM soybean varieties: two varieties developed by the Institute of Crop Sciences at the Chinese Academy of Agricultural Sciences and one variety developed by Beijing Dabeinong Technology. To access the event-level information for the registered varieties, please refer to Seed Innovation service.
- The country amended its "China seed law" in March 2022, focusing on protection of intellectual property (IP) rights in new plant varieties. Mainland China implemented stricter penalties for violators of intellectual property rights involving seeds and updated labeling for conventional, GM and imported seeds.
- Although there have been significant developments within the sector over the last year, we still see some regulatory hurdles on the path to full commercial cultivation. It also remains unclear how foreign investment in this area will proceed, as the less-clear path for outside players may support the domestic developers and limit access to varieties outside the country.

Recent timeline of key actions regarding GM in mainland China

June 8, 2022	Publication of the National Registration Standards for GM soybean and corn varieties (Trial).
Jan. 21, 2022	Amended “Administrative Measures for the Safety Assessment of Agricultural GMOs” to modify the biosafety evaluation process so that it is only based on "events" rather than "crop variety and event," which makes it easier to register GM crop varieties for domestic cultivation and allows for the biosafety evaluation of GM crops with "stacked traits."
Jan. 13, 2023	MARA published, revised and finalized “Guidelines for safety assessment of GM plants.” Applies to biosafety certificate application for both domestic cultivation and importation of processing materials.
April 28, 2023	MARA issued the “Rules for review of gene-edited plants for agricultural use (Trial).” The rules provide operational guidance in the areas of molecular function, environmental safety and food safety.
Oct. 17, 2023	The National Crop Variety Registration Committee (CNCVRC) published a variety registration list for GM corn and soybeans. This inaugural list includes 37 GM corn varieties and 14 GM soybean varieties.
Oct. 17, 2023	MARA published a draft revision of "Administrative Measures on Labeling Agricultural Genetically Modified Organisms (GMOs).” The same draft revision was notified to the World Trade Organization.
Dec. 7, 2023	MARA announced final registration approvals of 51 GM corn (37) and soybean (14) varieties.
Dec. 26, 2023	MARA announced the issuance of approvals to 85 enterprises. This included 26 GM seed production and operation licenses for corn and soybean varieties.
March 19, 2024	CNCVRC published the second variety list of GM corn and soybeans, which included 27 GM corn and 3 GM soybean varieties. The list was open for public comments until April 17, 2024.
April 3, 2024	MARA released a second list announcing the issuance of approvals to 35 enterprises for crop seed production and operation licenses

Mainland China’s GM pilot areas

Mainland China’s estimated GM plot areas in acres



Data compiled March 2024.
*Data for GM corn was the only data available when making this projection.
GE = genetically engineered; GM = genetically modified.
Source: S&P Global Commodity Insights.

2021

- Launched a pilot project for the commercialization of GM corn and soybeans.
- Carried out in scientific research and experimental fields.

2022

- Expanded the pilot project to farmer fields in Inner Mongolia and Yunnan.

2023

- Expanded the pilot project to 20 counties in 5 provinces including Hebei, Inner Mongolia, Jilin, Sichuan and Yunnan.
- Arranged GE seed production in Gansu.

2024

- GM areas expected to further expand with addition of new provinces. 1,655,570 acres of GM area is projected on the basis of data available for GM corn*.

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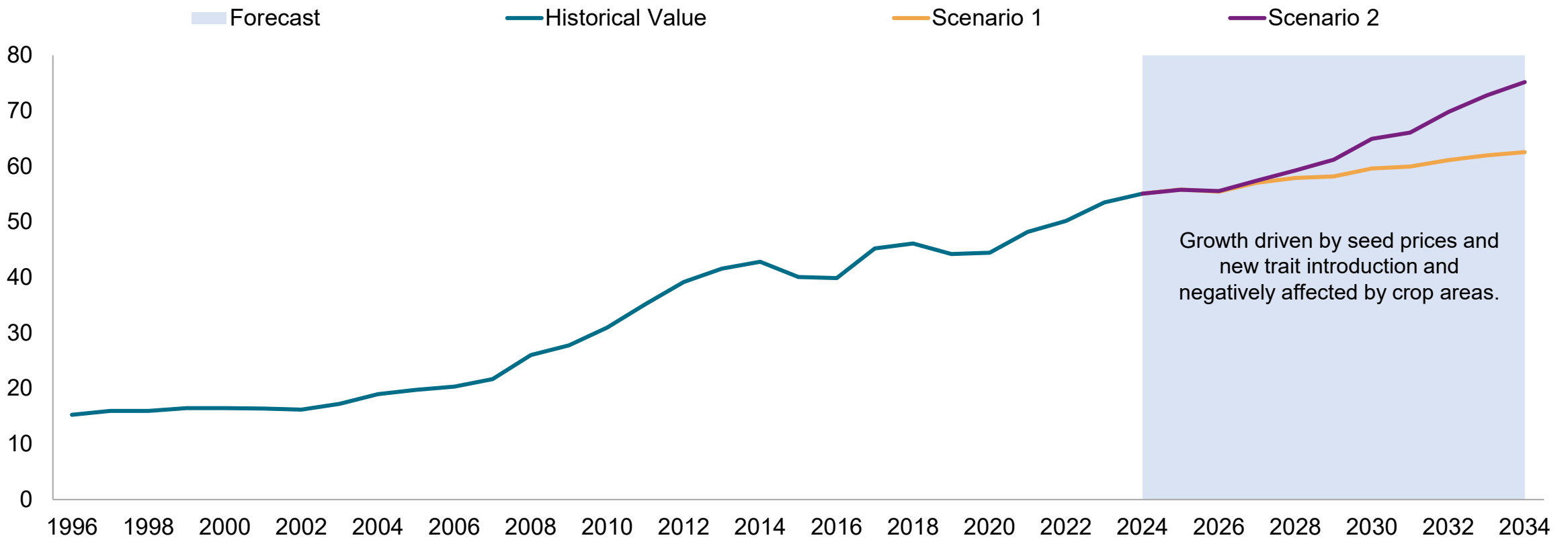
Global seed market outlook from 2024 to 2034

Seed Market Performance in $ billion



Without GM commercialization in China, we expect the global market to grow at +1.3% per annum. GM adoption in China and hybrid wheat might change the scenario. With GM commercialization in China, we expect the global market to grow at +3.2% per annum

As of July 19, 2024
Scenario 1 – No GM commercialization in China; Scenario 2 – GM commercialization in China
Source: S&P Global Commodity Insights

Developments in NBTs

Regulatory framework development and status country wise

Updates on product development

Product analysis by country

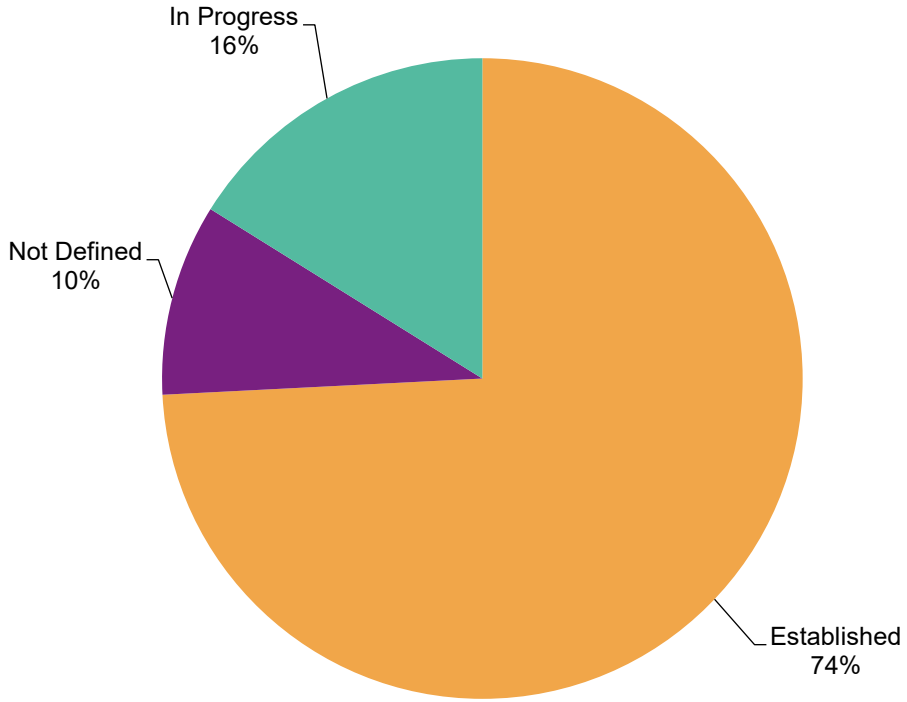
NBTs in China

Summary- discussing technological market driver

New breeding techniques (NBT) regulatory framework

Trend analysis

NBT regulatory framework development by country*



Established

US	Philippines	Malawi	Brazil	Honduras
Canada	India	Israel	Colombia	Guatemala
Norway	Kenya	Australia	Chile	El Salvador
England	Nigeria	New Zealand	Paraguay	Costa Rica
Japan	Ghana	Argentina	**Thailand**	

Not defined

Mexico
S. Africa
Ukraine

In progress

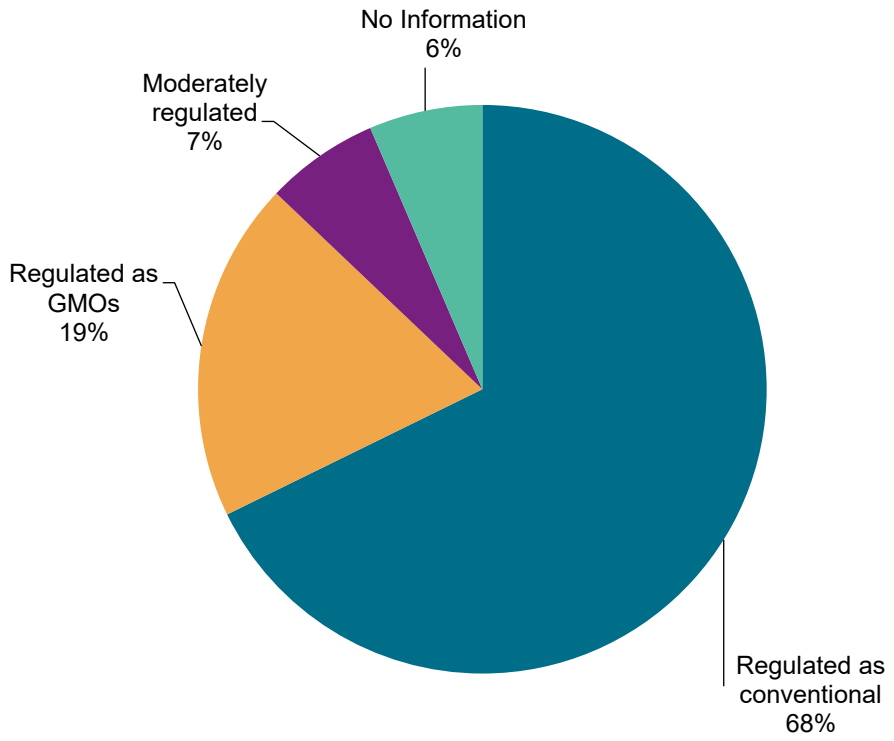
EU (region)
China (mainland)
Singapore
Russia
Uruguay

Data compiled May. 15, 2024.
*Analyzed for 31 countries.
Source: S&P Global Commodity Insights.

NBT regulatory status by country

Trend analysis

NBT regulatory status by country*



Data compiled May. 15, 2024.
*Analyzed for 31 countries.
NBT = new breeding technique; GMOs = genetically modified organisms.
Source: S&P Global Commodity Insights.

Regulated as conventional/ Minimal regulations

US	Philippines	Ghana	Brazil	Honduras
Canada	India	Malawi	Colombia	Guatemala
England	Kenya	Australia	Chile	El Salvador
Japan	Nigeria	Israel	Paraguay	Costa Rica
Argentina				

Moderately regulated

Singapore	Uruguay	Thailand

Regulated as GMOs

Mexico	EU	China (mainland)
Africa	Norway	New Zealand

No information

Russia	Ukraine

21 countries — NBTs are regulated as conventional, and all countries align on the definition for not having any transgene. However, there is still some nonharmonization in terminology used such as cisgenesis, SDN1, SDNII, etc.

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NBT product updates for leading countries/regions

Products are either commercialized or approved for near commercialization

Country	Commercialized products	Products in pipeline
US	Calyno™ (2019, Cibus) soybean producing oleic acid rich oil (Now out of market since 2021); Conscious™ greens (2023, Pairwise plants); Non-browning lettuce (2023, GreenVenus)	1. Three NBT soybean (two high proteins and one HT) from Benson Hills expected between 2024 and 2025 2. Nonbrowning banana (2024, Tropic Biosciences) 3. Glufosinate-tolerant camelina (2025, Yield10) 4. Non-browning Avocado (2023, GreenVenus)
Canada	Conscious™ greens with reduced bitterness (2023, Pairwise plants)	CLB-1 canola-ODM (2020, BASF) — Approved; Waxy corn (2020, Corteva Agriscience) — Approved; commercialization awaited
Japan	Sicilian Rouge high GABA tomato sold since 2021	Amylopectin rich waxy corn (2023, Corteva Agriscience) — Approved; Improved food quality of potatoes with reduction in steroidal glycoalkaloids; Rice with increased tolerance to stress and improved food quality
Philippines	None	Reduced-browning banana (2024, Tropic Biosciences); Sicilian Rouge high GABA tomato (2024, Sanatech Seed) — Approved; commercialization awaited
China (mainland)	None	Five biosafety approvals have been given in the years 2023 and 2024: one corn variety for increased yield trait, one wheat variety resistance to powdery mildew and three soybean varieties for improved traits of yield, quality and physiology
Argentina	None	Nonbrowning potatoes (2018) — Approved

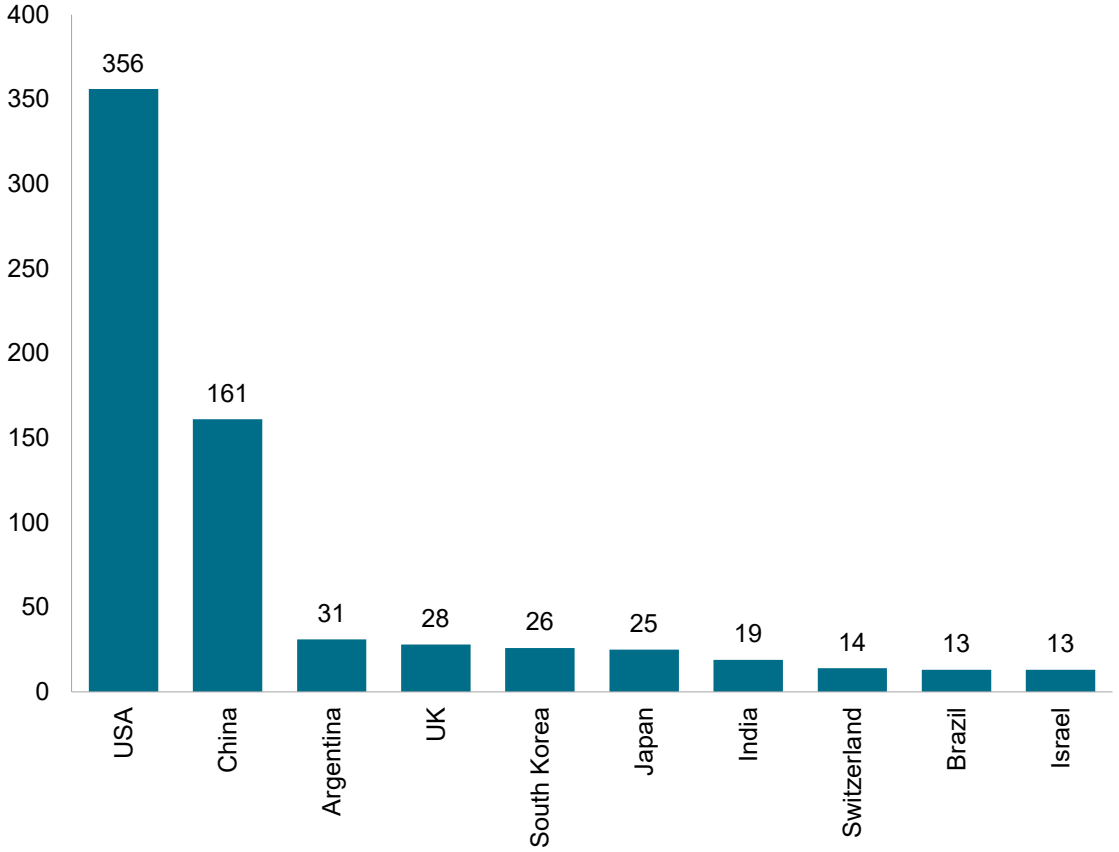
Countries where research is ongoing at an accelerated pace include India, Australia and within the EU. These countries do not have any commercialized/approved products yet.

Data compiled Jul. 15, 2024.
Source: S&P Global Commodity Insights.

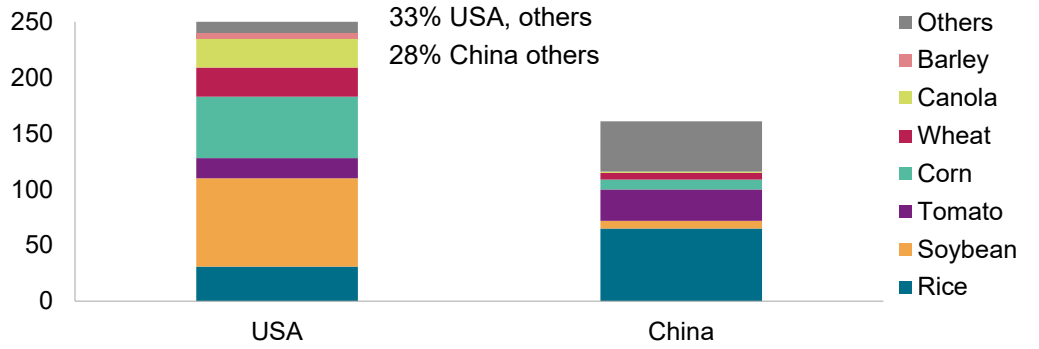
NBT product analysis by country

Trend analysis

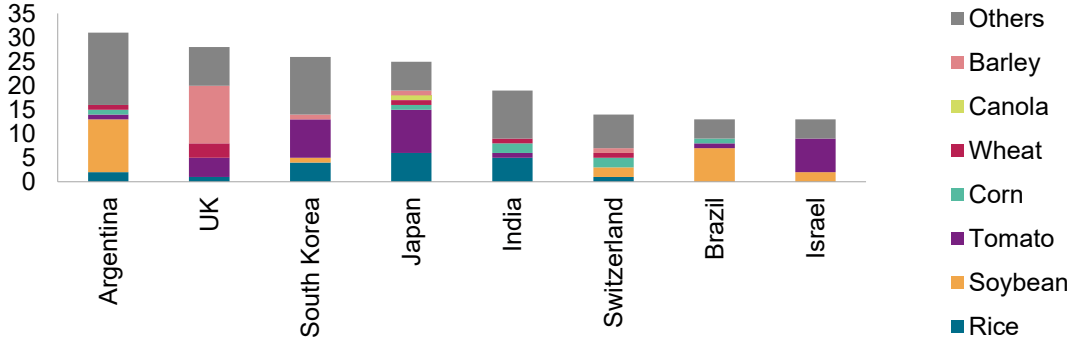
Analysis of NBTs in leading countries



Country specific analysis of NBTs in leading crops



Country specific analysis of NBTs in leading crops



Data compiled May. 15, 2024.
NBT = new breeding technique.
Source: S&P Global Commodity Insights.

Gene-edited events approved for cultivation/processing in China

Crop type	Variety	Trait	Developer	Issue date	Expiry date
Corn	179AC19-13-13	Improved yield traits	Shandong Shunfeng Biotechnology Ltd.	May 7, 2024	May 6, 2029
Wheat	MLO-KNRNP	Resistance to powdery mildew fungal infection	Suzhou Qihe Biotechnology Co Ltd., Chinese Academy of Sciences	May 7, 2024	May 6, 2029
Soybean	AE15-18-1	Increased oleic acid content and quality traits	Shangdong Shunfeng Biotechnology Co., Ltd.	April 21, 2023	April 20, 2028
Soybean	25T93-1	Improved physiological traits	Shandong BellaGen Biotechnology Co., Ltd.	January 2, 2024	January 1, 2029
Soybean	P16	Improved quality trait	Suzhou Qi Biodesign Co., Ltd.	January 2, 2024	January 1, 2029

Data compiled May 2024.
Source: S&P Global Commodity Insights.

Long term market outlook

Key market drivers

Comparison between key technological drivers and recent trends

Long-term seed market drivers

New GM trait introduction and GM crop adoption in China, S. Africa, and Kenya

China clearing the path for GM crop approval and commercialization, including GM corn and soybean. In 2024, China has also provided biosafety approval to powdery mildew resistance wheat, showing food safety as key driver for GM crop cultivation in China.

Advancements in vegetable breeding and introduction of hybrid wheat

Decarbonization policies influencing demand for high-yield, climate-resilient seeds with low resource requirements

Increased demand for advanced biofuels (sustainable aviation fuels, biodiesel)

Harmonization of NBT regulations to enhance market adoption (For NBT development and regulation details, refer to S&P Global's Seed Innovation platform)

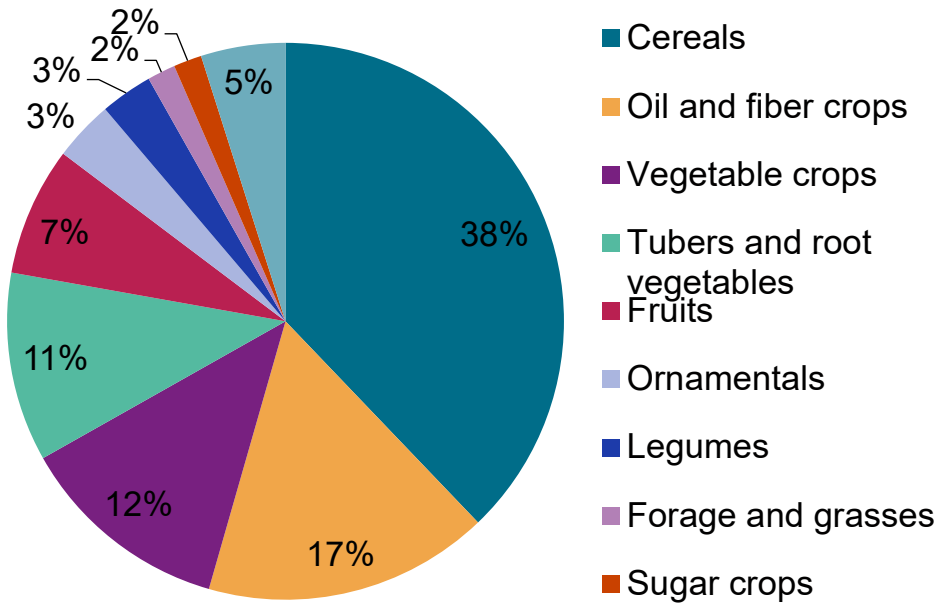
Growing demand for organic seeds in Europe

Summary

GM vs NBT product development by crop

Global NBT product development status by crop in 2024

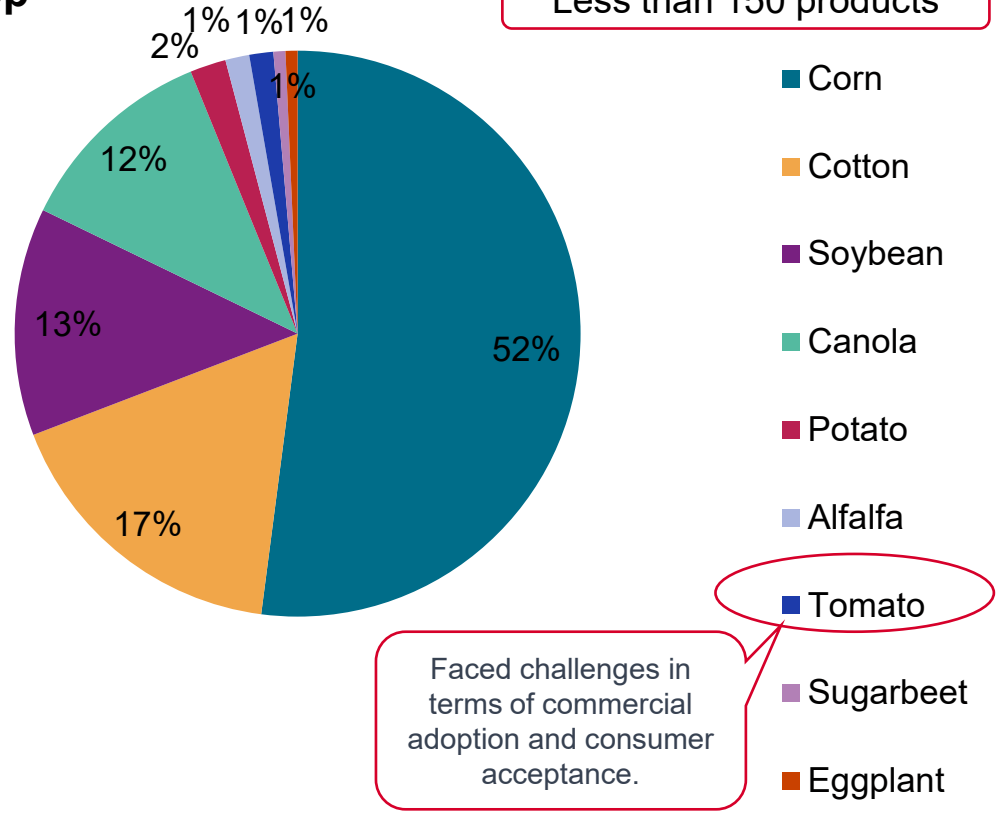
~800 products in pipeline



Cereals, oilseed and fiber together account for 55% of the research by crop

GM trait development between 1996 and 2024 by crop

Less than 150 products



Faced challenges in terms of commercial adoption and consumer acceptance.

