FROST & SULLIVAN

INDEPENDENT EQUITY RESEARCH

# NRGENE TECHNOLOGIES LTD

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## INITIATION OF COVERAGE

Stock Exchange
**TASE**

Symbol
**NRGN**

Sector
**HI-TECH**

Sub-sector
**INTERNET AND SOFTWARE**

Stock price target
**NIS 30.9**

Closing price
**NIS 11.6**

Market cap
**NIS 142.9 Mn**

No. of shares
**12.3 Mn**

Average Daily Trading Volume
**207 stocks**

Stock Performance (since the IPO)
**-61.1%**

NRGene Technologies Ltd (TASE: NRGN) is a global genomics company that provides several innovative solutions for many agricultural applications. At its core, NRGene is a software company that uses AI to analyze big genomic data to optimize and accelerate the natural breeding of plants and animals used in agriculture. NRGene's mission is to provide an enabling platform for naturally strengthening the structure and performance of plant and animal genomes through cost-effective bioinformatics. The solutions provided by the company have been widely accepted by research organizations and key industrial players across ~300 projects. **On January 26, 2021, NRGene closed its TASE listing, raising ~$30M gross according to approx. $114.6M post-money valuation.**

**The bioinformatics technology market** for agricultural applications generated revenue of $3.3 billion in 2020 and is expected to generate $7.5 billion in 2026, representing a CAGR of 14.7%. **The seed market** generated revenue of $42.4 billion in 2020 and is expected to generate $54.9 billion in 2026, representing a CAGR of 4.4%. **The genotyping technology market** generated revenue of $1.8 billion in 2020 and is expected to generate $3.1 billion by 2026, representing a CAGR of 8.9%. NRGene's long-term go-to-market strategy is to become a one-stop shop for all plant and animal genomic requirements. We deem that NRGene is in strong position for growth due to its initially strong market penetration, scalability potential, know-how, and agile business model.

**Based on market benchmarking for Agtech firms we value NRGene's equity at NIS 381.4 million; price target range of NIS 29.4 to NIS 32.4 with a mean of NIS 30.9.**


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# Investment Thesis

Agriculture is one of the oldest areas of technology and innovation in existence. Its objectives have changed little throughout history: finding ways to increase yields and maximize key traits of crops or animals, such as size, flavor, color, and resistance to pests. Agtech startups provide farmers with a variety of strategies and technologies to help improve crop resiliency and output. These include agrifinance tools, biotech solutions that can improve yields and resiliency, farm management software, and an emerging focus on data-driven AI & ML that can help automate decision making.

Modern Agtech startups began attracting venture funding roughly a decade ago, with the industry raising $322.2 million in 2010. Since then, VC funding in agtech has grown to $6.1 billion in 2020, a 33.8% CAGR. This explosive growth is a direct result of two primary factors: population growth and climate change. The global population is expected to swell to 9.8 billion people by 2050, driving more demand for food.[i] At the same time, greenhouse gases and warming climates are creating increasingly frequent extreme weather events that threaten crop yields.

NRGene Technologies Ltd is a leading global genomics company that provides several innovative solutions for many agricultural applications. At its core, NRGene is a software company that uses AI to analyze big genomic data to optimize and accelerate the natural breeding of plants and animals used in agriculture. NRGene's mission is to provide an enabling platform for naturally strengthening the structure and performance of plant and animal genomes through cost-effective bioinformatics. Notable, NRGene has successfully demonstrated that its AI-enabled trait prediction tool is superior in the marketplace (e.g., the company successfully assembled the full genome of the hexaploidy wheat in just ten days).

NRGene's technology is widely used to create disease-resistant and climate-resilient varieties with healthier nutritional compositions and maximizes yield potential. In the field of plant genomics, the company offers a vast proprietary database and AI-based technologies. The solutions provided by the company have been widely accepted by several research organizations and big industrial players across ~300 projects. To name a few, Syngenta, Bayer Crop Science, Mondelez, Bridgestone and Nestle are using NRGene's AI tools to improve agriculture production in various industries, including food & beverage, rubber, and paper & pulp industries.

The core of NRGene's technology is its cloud-based AI tool coupled with its extensive database of genomic information, field performance data, and information on pests, diseases, and seed and irrigation considerations. This information is fed into NRGene's AI model and computationally predicts elite varieties that consider the mentioned variables. Once the predicted variety is identified, then the variety is produced either using an expedited breeding process, gene editing, or CRISPR. This process allows improved varieties to develop in **half of the time and at half the research and development costs.**

NRGene's solution can be applied and utilized early in the R&D cycle to identify interesting or problematic genes. NRGene intends to grow its seed and traits royalty business to solve specific challenges on the farm directly and to breeding organizations (seed, food & beverage, processor, retailer, etc.), including offering diseases resistance, drought-resistant, and pest-resistant varieties.

The company is also among the most trusted emerging cloud-based genomic data solution providers with applications in both animal and plant breeding. The company has an extensive R&D team that offers innovative solutions in the field of genomics. These capabilities have been combined and have allowed the company to easily identify several proprietary traits across a wide set of plant genomes that it can license in the future.

NRGene's long-term go-to-market strategy is to become a one-stop shop for all plant and animal genomic requirements. We deem that NRGene is in a strong position for growth due to its initially strong market penetration, scalability potential, know-how, and agile business model.

*Market*

The following three markets encompass significant portions of NRGene's addressable market: bioinformatics technologies, genotyping, and seeds (both genetically modified (GM and non-GM).

**The bioinformatics technology market** for agricultural applications generated revenue of $3,296 million in 2020 and is expected to generate $7,509 million in 2026, growing with a CAGR of 14.7% in 2021-2026.
Due to the rise of the need to use bioinformatics to identify and cultivate unique traits and the amount of unaddressed opportunities across the world, it is expected that the demand for bioinformatic technologies will be immense. In general, Frost & Sullivan expects that revenue growth will range from 13% to 25%, dependent on the target application.

A key growth opportunity in the bioinformatics sector is addressing the need for integrated solutions and systems. *NRGene's solution could help bioinformatics firms compensate for the lack of skilled personnel that hampers the market growth and facilitate their transition into integrated solutions and systems companies*.

**The seed market** generated revenue of $42,424 million in 2020 and is expected to generate $54,926 million in 2026, growing with a CAGR of 4.4% in 2021-2026. Non-GM Seeds will also grow during the forecast period as some farmers, consumers, governments, and other relevant stakeholders slowly move away from GM-produced varieties. Non-GM crop demand is rising in Asia and the EU, and consequently, these crops command premia over GM varieties despite possible lower yields.

*NRGene could help GM/non-GM companies boosting their R&D efforts and quickly achieve varieties with desirable traits such as increasing resistance to pests and tolerance to herbicides, and adverse weather (e.g.,* drought).

**The genotyping technology market** generated revenue of $1,855 million in 2020 and is expected to generate $3,087 million by 2026, growing with a CAGR of 8.9% in 2021-2026. With the rise in the adoption of technologies in the plant and animal genomics market post COVID-19 pandemic, the market size of support services is expected to grow simultaneously by 2026 to facilitate the adoption of services amongst the researchers and industrial giants.

## Valuation summary

NRGene is a growth firm. Thus, we based our valuation on current and future market trends and the company's assumption for future operations. Due to the high growth in the Ag Biotech market and the uniqueness of NRGene solution, we estimate the company is well-positioned to generate significant growth in the foreseeable future.

**We conducted NRGene's valuation using market benchmarks from recent deals and analysis of VC's activity; Given the assessments and findings mentioned above, we value the company's stock price target in the range of NIS 29.4 to NIS 32.4, and a mean of NIS 30.9.**

# 1. Company Overview

## 1. Company Description

NRGene Technologies Ltd is a leading global genomics company focused on innovative trait and variety development for a wide number of agricultural applications. At its core, NRGene is a software company that uses artificial intelligence to analyze big genomic data (e.g., bioinformatics) so as to optimize and accelerate the natural (e.g., non-GM) breeding of plants and animals used in agriculture. NRGene's technology is widely used to create disease resistant and climate resilient varieties with healthier nutritional compositions and maximizes yield potential throughout the value chain. In the field of plant genomics, the company offers a vast proprietary database and AI-based technologies to several largest seed and agriculture companies. The company's tools and services are already being deployed by several agribiotech companies and research institutes around the world for innovative trait and variety development. The company's solutions have been broadly implemented across ~300 projects and leading companies, including Syngenta, Bayer Crop Science, Bridgestone, Nestle, Suntory, and Mondelez are using NRGene's AI tools to improve agriculture produce in a variety of industries including food & beverage, rubber, and paper & pulp industries. Today, the company's annual turnover is $US 7 to 8 million but revenue growth is expected to cumulatively grow between 150%-250% over the next two years. Below is a selection of NRGene's key solutions:

- **DeNovoMAGIC**: A genome assembly tool which constructs and reveals the full genome content (usually in the order of hundreds of millions to billions of DNA letters) of any individual by assembling small DNA pieces (150-15,000 DNA letters long) in the right order. The DeNovoMAGIC assembly tool uniquely and accurately phase the two mixed genomes in every individual (one originated from each parent) to deliver a correct and accurate representation of the genome.
- **GenoMAGIC**: The company offers an advanced breeding analytic platform, to support key breeding decision making and to organize and efficiently store massive genomic data. GenoMAGIC is a cloud-based big data analytical technology which enable to reveal the full genomic makeup of any individual tested during the breeding program. The system can analyze millions of individuals simultaneously. The system helps to identify the individuals with superior genetic content to be used as parents for creating the next generation of progenies during the breeding process.

- **PanMAGIC**: This tool allows for the accelerated discovery of genomic and structural variations for a given species which provides a full genome-to-genome map of the trait for more effective exploration of genomic variation which enables comprehensive gene comparisons.
- **TraitMAGIC:** TraitMAGIC allows customers to discover the phenotype-genotype correlations in any organism with a complete trait-mapping package by generating a high-resolution recombination map which is used to reveal the complete segregation pattern in each progeny. This solution allows customers to discover the genetic markers of a desired trait. These markers can be later used to optimally integrate the discovered trait in a breeding program.
- **SNPer**: In September 2020, the company launched SNPer, which helped optimize genotyping processes and gather relatively more information and reduce the ordinary genotyping cost by up to 70%. SNPer is based of vast genomic data analysis on a broad breeding population and the discovery of the minimal DNA marker set best representing the natural genetic diversity exists in the breeding population. The company offers a fully customized genotyping solution that utilizes the company's experience and data in multiple species.
- **SNPro**: SNPro™, available for soybean varieties, is an optimized and predesigned solution for soybean genotyping that uses NRGene's unique sequence-based diversity analysis to design SNP sets which significantly reduces genotyping costs.
- **CannSCAN**: CannSCAN™ is a genotyping analysis solution that provides breeders with a unique dated, genetic ID for each plant, as well as an analysis of relatedness between samples. CannSCAN™ is based on NRGene's proprietary database of heterozygous genome assemblies, providing an affordable solution for genotyping large or medium volumes of samples
- **QuickGENETICS**: The company offers a service package under the QuickGENTICS trademark, which is aimed for introducing genomics into cannabis and hemp breeding programs for the first time. QuickGENETICS helps in analyzing the breeding population and generates unique genetic markers that enable the customer to stack the desired traits in elite varieties.
- **Comprehensive Genomic Databases for a given crop/animal:** The database is specially developed and curated for the organization with molecular breeding capabilities. The database helps in searching and discovering novel gene candidates and in designing DNA markers for the development of key traits. One such a database offered for customers is CannaGENE, which is a broad Cannabis and Hemp genomic database.

- **Full genomic solutions:** The Company also offers full tailor-made genomic solutions based on customer's specific needs. This solution package is made from a mix of its products and services operated by the company's R&D stuff in a collaboration with the customers R&D and breeding teams.

The list of NRGene's current and past clients is impressive. Below is a selection of top customers and partners by key target markets:

- Seeds and Agro-chemicals: BASF, Syngenta, Bayer Crop Science, Topseeds, Nuseed, Sakata Seed America
- Food & Beverage: Nestle, Mondelez, Suntory
- Natural Raw Materials: Bridgestone, FuturaGene, Cotton Incorporated
- Cannabis and Hemp: Scotts, Cronos Group, Aurora, Kayagene, PureGene

## 2. Vision & Mission

NRGene's mission is to provide an enabling platform for naturally strengthening the structure and performance of plant and animal genomes through cost-effective bioinformatics. NRGene intends to deliver on this vision by leveraging its core advantages including the improvement of variety development, enabling lower cost, more efficient, and shorter duration of R&D projects, broader data usage in decision making process, increased cost efficiency in genomics big data management that relies on cloud technologies (AWS), and a strong network of reliable and efficient genomic analytics partners.

## 3. Strategy

NRGene's long-term go-to-market strategy is to become a one-stop shop for all plant and animal genomic requirements independent of where their partners and customers are in the agriculture value chain, from data production (development) with laboratories and other R&D services to support variety identification to production of the variety to providing the seeds\varieties to various breeding entities that support farmers around the world. Since year 2020 the company is actively involved in partnering with its customers in several crops/animals and geographies. The company and the customer co-invest into breeding new crop/animal, and following commercialization, the company is entitled for royalty from

sales. The company currently has two main activities centers to realize its objective in becoming the preeminent plant and animal genomics company – (1) the GENOMICS Excellence Center and (2) IP co-development. The GENOMICS Excellence Center, located in Saskatchewan, Canada is a local cash crop-oriented center (e.g., wheat, canola) focused on solving local production challenges. The other center of NRGene's long-term go-to-market strategy is IP co-development with major agricultural companies and breeders. Through these collaborations, NRGene will license its proprietary traits to these major breeders with the footprint to address global demand.

NRGene is in this strong position for growth through the successful implementation of its strategies due to the following factors:

- Initially strong market penetration: NRGene has already successfully signed deals with worldwide market leaders which provides the companies the needed case studies it needs to continue to drive market penetration growth
- Scalability: The company is ready to scale up its AI systems after completing ~300 projects focused on product improvement
- Knowledge, experience and expertise: NRGene has curated a robust knowledge base, based on data accumulation including exclusive expertise in all key cash crops
- Agile Business Model: The company offers a unique range of services and products (e.g., seeds) with proven capabilities to deliver value in various industries

At the beginning, customers and partners engaging with NRGene were very much on a bespoke project basis. Through these projects not only did the company's internal database grow exponentially (in many projects the company received the approval to use the established data) and the AI tools were constantly improved, but also the natures of its relationships with market leaders change. NRGene then moved to provide a subscription- based model that provided customers and collaborators access to its database and software solution. Specifically, the customer engages in a multi-year agreement and receives a cloud-access to the company's software and analytics to support their breeding programs. This ensures that the revenue was coming into the company on more regular and predictable basis and provided the company a strong foundation to support continued growth. Today, the company is yet again evolving its business model aimed at deriving long-term returns on traits that would only be possible with the support and use

of NRGene's unique tools and bioinformatics technologies. The company joins forces with its clients to conduct co-development of new elite varieties (IP) (e.g., Mitsui & Co.). The revenue includes one-time down-payment plus royalties from sales of the co-developed products. Specifically, NRGene is licensing its novel IP (seed traits and or varieties) to seed companies/distributors in return for royalties from seed sales to farmers. For example, NRGene discovered a tomato trait in Ecuador for a known disease after its customer asked it to make a hybrid tomato using varieties from Ecuador and from Israel. NRGene and customer co-own the IP on disease resistance tomatoes, and it has already begun licensing this trait. To date, it has already signed five deals some are market leaders and NRGene will earn royalties from all tomato seed sales that harbor NRGene's trait for 10 years since first commercialization.

All of the aforementioned factors positions NRGene to being one of the most innovative companies in the plant and animal genomics market. The solutions offered by the company have been widely accepted by several research organizations and big industrial players and allows for the company to consider a wide range of go-to-market strategies to capture the value it's creating in the agriculture value chain. The company has an extensive research and development team, which mainly focuses on developing innovative products in the plant and animal genomics market with its large network of R&D facilities in the U.S. and Israel.

## 4. Business model

Until recently, NRGene provided AI-based software solutions through two complementary business models:

1. **Subscription to access a genomic data analysis software** - The customer engages in a multi-year agreement and receives access to the Company's software and services.
2. **Data analysis services** - The Company provides computational and bioinformatic services to support the R&D efforts of its customers, aiming to develop new elite varieties. The Company revenue is comprised of payments for those services.

As part of its strategy, the company decided to focus on long-term and recurring transactions. As estimated by the company, these types of engagements are preferable for its clients as it reduces the involved risk for them and expands NRGene's profit at the same time.

Therefore, in the past months, the company refined its focus of the business model to include the following segments:

1. **IP Development –** In this model, NRGene initiates and leads projects to develop IP with partners (such as the development of peas and hemp for the meat substitutes industry or the development of high-quality cherry tomatoes) and even develops IP independently of a partner (such as the development of canola resistant to fungal disease).

   In a mutual development project, the partner enjoys a final product (seeds or varieties) and pays the company royalties from its revenue. Therefore, the partners' financing and business risk decrease, as the payment to NRGene depend on achieving the development goals and the customer's future revenue. The royalty rates for developed traits can vary between 1%-15%, on certain traits and for new variaties between 35%-70% of partners income (minus production and S&M costs). In some cases, partners also pay a down payment for securing the right to integrate the developed trait or variety.
2. **Genetic testing** - In this model, the company provides its customers with a complete genetic testing solution including custom project design, data production, generic panels, and genetic test analyses. These tests efficiently identify the individuals within a broad breeding population with the most favorable genetic makeup. NRGene estimates that the costs of its solution are lower compared to existing solutions in the market. In addition, following results from the company's existing projects, its solution achieves even more accurate results than other solutions existing in the genetic testing market.

We believe that this model benefits NRGene for two main reasons:

A. The company could accumulate know-how with each project, which will support its future growth and will be a crucial differentiator.
B. The mentioned business model allows the company to unlock a portion of the potential value stored across the value chain that wasn’t accessible beforehand (through royalties received from its clients).

## 5. Intellectual Property

The company has successfully assembled over 500 genomes of several species of which some are housed in its internal database using its proprietary AI model. The database includes plants that are the most

commonly planted in the world (e.g., wheat, maize, rice and soybean), the most fecund (e.g., sugar cane, sugar beets and tomatoes), and plants that generate the most revenue for producers (e.g., cannabis). The company is also among one of most trusted emerging cloud-based genomic data solution providers with applications in both animal and plant breeding. The company has an extensive R&D team that offers innovative solutions in the field of genomics. These capabilities have been combined and has allowed the company to easily identify several proprietary traits across a wide set of plant genomes that it can license in the future.

## 6. Key Projects and Grants

Below is a summary of NRGene's key projects, partnerships and collaborations:

| Partner | Type | Description |
|---|---|---|
| **Protein Industries Canada, Farmer's Business Network Canada, Inc., Pulse Genetics and Manitoba Harvest** | Partnership and Collaboration | In July 2021, a new partnership with key companies in the Canadian protein market to develop pea and hemp varieties for alternative protein use in food processing |
| **Government of Saskatchewan** | Business Expansion | In May 2020, the company expanded its operations in Canada by opening an office in Saskatoon.<br><br>In October 2020, the company announced the opening of its genotyping lab. |
| **BGI** | Partnership and Collaboration | In June 2019, NRGene entered into a partnership with BGI for offering NRGene's technology as a part of a range of genomic analysis services in agriculture services. |
| **Macrogen Corp** | Partnership and Collaboration | In January 2019, NRGene Technologies Ltd. and Macrogen Crop entered into a partnership for the launch of ultra-high-density SNP genotyping service. |

| | | |
|---|---|---|
| **Bridgestone** | Partnership and Collaboration | In February of 2018, Bridgestone, The largest tire and rubber company, signed an agreement to enhance its U.S. alternative domestic natural rubber breeding program |
| **Bayer Crop Science** | Licensing Agreement | In In December 2016, Bayer selected GenoMAGIC™, a cloud-based big data analytics platform, to supports its molecular breeding program within its Crop Science Division |
| **Syngenta** | Licensing Agreement | In January 2018, Syngenta selected GenoMAGIC™, to supports its maize breeding program at the Research Triangle (North Carolina) |
| **Mitsui & Co. (TSI)** | Partnership and Collaboration | In October of 2021, it was announced that NRGene will partner with Topseeds international, a subsidiary or Mitsui & Co. in the research and development of improved cherry tomato varieties. |
| **Philoseed (TBRFV)** | Partnership and Collaboration | In 2020, NRGene and Philoseed began working together to create tomato varieties resistant to Tomato Brown Rugose Fruit Virus (TBRFV). NRGene's technology and Philoseed's breeding qualities, will speed up the development to commercial varieties which is expected in 2022. |
| **CRISPR-IL** | Partnership and Collaboration | CRISPR-IL is a consortium funded by the Israel Innovation Authority's (IIA) Technology Infrastructure Research Committee and made up of companies from a variety of related fields with the aim to integrate Israel's artificial intelligence (AI) and CRISPR technology capabilities to develop advanced tools for genome editing and thus making Israel a global center of the genome editing sector. |

| | | |
|---|---|---|
| **GAIN4CROPS consortium under Horizon 2020** | Partnership and Collaboration | GAIN4CROPS is a EC-funded project aimed at developing novel technologies to overcome photorespiration, a process that reduces CO2 assimilation efficiency, and thus biomass yield and agricultural productivity. Key partners include NRGene, Corteva Agriscience, University of Cambridge, CEA, and others. |

# 2. Technology overview

## 1. Main Applications

NRGene has completed comprehensive genomics projects for over >100 versetile species of plant and animals using its generic proprietary technology. This vast experience enables NRGene to address a wide range of markets that rely on agricultural crops and animals. However, four key end industries are targeted where the value of NRGene's technology has been demonstrated. These four segments include seed and agricultural chemical companies who are investing in R&D in order to discover new varieties, food & beverage companies who are seeking specific ingredients to improve their product's quality and reliability, natural raw material companies (e.g., paper & pulp, rubber, natural fiber) who are seeking the same thing, and cannabis & hemp companies who are always looking for high quality varieties to produce value-adding products in order to stay competitive. NRGene's solution can be applied and utilized early in the R&D cycle in order to identify interesting or problematic genes and NRGene also intends to grow its seed royalty business aimed at directly solving specific challenges on the farm including offering varieties that are disease resistance, drought tolerant, and pest resistant.

## 2. Summary of Technology

The core of NRGene's technology is its cloud-based AI tool coupled with its extensive database (e.g., Big Data) of genomic information coupled with information on pests, diseases, and seed and irrigation considerations. This information is fed into NRGene's AI model and computationally predicts the most favorable genetic makeup of elite varieties that include all the aforementioned considerations. This information is easily integrated into the development phase of their customers and generates insight ana a simple roadmap to advance their breeding programs. Once the predicted variety is identified, then the variety is produced either using an expedited breeding process, gene editing or CRISPR. This process allows for improved varieties to develop in half of the time and at half the research and development costs.

## 3. NRGene's Technology Compared to Other Technologies

While there are other companies that offer plant and animal genomic services including genotyping, sequencing, and gene editing, NRGene has successfully demonstrated that its AI-enabled technology is

superior in the marketplace. For example, NRGene easily solved one of the most challenging problems in plant genomics, sequencing the wheat genome, which if solved would prove to have a substantial impact on the entire global food and beverage value chain for years to come. Wheat is one of the oldest and most important sources of food for humans for multiple millenniums. Wheat provides of 20% of all the food calories consumed by humans in the world. However, the wheat genome is surprisingly very complex due to centuries of farmers growing and selecting varieties for a wide number of outcomes (e.g., taste, sugar content, protein content, etc.). Specifically, the 16 Gbp hexaploid wheat genome is five times larger than the human genome. A global consortium of 1,700 scientists challenged to solve this problem failed to complete even 5% of the full assembly after 12 years of hard work. NRGene stepped in using its AI technology and successfully assembled the full genome of the wheat in just 10 days. Now, NRGene is able to quickly identify useful or harmful wheat traits which in turn can be quickly applied on the farm and result in higher yield and lower cost wheat production.

# 3. Markets overview

## Total Market Overview, Scope, and Definitions

For the purposes of this assessment, three key markets are explored in detailed, which all encompass significant portions of NRGene's addressable market. These markets include **bioinformatics technologies**, **genotyping**, and **seeds**. **Bioinformatics technologies** are referred to as a combination of biology and information technology that integrate or tie the biological data with techniques for storage, collection, retrieval, and modeling of data for the analysis and prediction through several software and platforms. It combines different fields of studies, such as computer sciences, algorithm design, data science, AI, genetics molecular biology, statistics, biotechnology, and engineering. Bioinformatics utilizes information technologies to gather genome data and translate it into efficient information and various forms of knowledge. Development in plant and animal genomics is enabled by powerful bioinformatics tools allowing the integration of the build, design, and test stages of bioengineering cycles. Bioinformatics technology utilizes software systems that generate, process, and save a large amount of data and present them in an insightful way.

Furthermore, bioinformatics helps in the interpretation of the data generated through plant and animal genomics research. It offers a platform for researchers to use different tools and software to analyze the big-data generated and help in decision-making. Additionally, next-generation sequencing and conventional Sanger sequencing methods are of great importance to identify the genetic makeup of the complex plant genome. These different sequencing technologies constantly generate heaps of sequence data for analysis, annotation, and storage. This has created a progressive demand for bioinformatics tools and software to perform these specific functions. With the utilization of bioinformatics tools, the researchers can easily analyze and store the vast amount of data in a readable format.

**Genotyping** refers to the technology that helps in the detection of small genetic differences which can lead to major changes in the phenotype and thus field performance, including both phenotypic differences and pathological changes in the plant. Moreover, genotyping helps in identifying inherited alleles and differences in the genetic makeup and composition between the plants. Genotyping technology utilizes the extraction of DNA from plant and animal matter and amplifies them with the help of PCR. It helps the

researchers to identify the young plants with desirable genotype and phenotype for further molecular biology-based studies.

Genotyping is of great interest and broad day-to-day use to identify the variation at specific points in the DNA sequence of any plant species. The genotype occurs naturally and is considered as a source of the genetic fingerprint of an individual species. Additionally, it acts as distinct compared to the reference sequence derived from the defined group and can differ from the reference sequence in a numerous way. Genotyping, particularly in plant genomics, is utilized to streamline the single-nucleotide polymorphism (SNP) discovery and empower the researchers to achieve experimental goals in a much more effective way.

**All plants start as seeds** that must be planted to activate and grow the desired crop. Consequently, the seed market is big business. There are two main types of seed categories: genetically modified (GM) and non-genetically modified (non-GM). GM seeds are seeds developed by biotechnology companies that are genetically-modified to protect and/or enhance the yield of the crop grown in less than ideal growing conditions. Key traits include herbicide tolerance, insect resistance, virus resistance, and desired traits. With new genomics tools, including synthetic biology, genome editing and sequencing, the trend is moving towards more extensive changes to the plant genome, resulting in stacked traits. Non-GM, of course, has not been directly modified.

Rising pressure to increase crop production worldwide will support seed market growth. GM seed revenue is forecast to grow faster due to rising demand for seeds which are resistant to pests, herbicides and damaging weather e.g., drought. GM crops have helped farmers to achieve certain economic benefits (higher yields, pest / disease resistance, pesticide tolerance) in both emerging and developed countries. Row crops and legumes (detailed below) account for nearly 80% of the seed market and are expected to remain so in the forecast period. Most GM crops grown in North America, e.g., soybean, corn and rapeseed, have reached or are close to maximum levels and GM seed market growth is expected to achieve a mature rate of just over 3% a year. South America is likely to continue to see increasing GM seed use following crop production patterns, particularly in soybean and corn. In regions highly dependent on crop imports, government drive to become more self-sufficient may support GM crop adoption and trials

to boost production (e.g., GM banana, cowpea, sorghum in Africa). Also, increasing global trade flows encourage country specialization and adoption of GM crops to further their competitive advantages (e.g., Brazilian soy, US corn). Countries embracing GM crop cultivation have a politically encouraging environment for GM crops in general.

Regarding target applications, the end applications are segmented into two key categories; Crops and Animals. Crops are further segmented in the following crop types:

- Row crops (e.g., Maize, soybean, cotton, canola, wheat, rice, barley):
- Vegetable crops (e.g., tomato, pepper, melon, watermelon)
- Fruits and berries (e.g., apple, citrus, banana, strawberry, blueberries)
- Legumes (for Alternative meats)
- Cannabis
- All Other Crops/Plants (e.g., non-hemp fiber crops, tree nuts)
- Dairy (Milking) Cows
- All Other Animals (Poultry, Beef, Seafood, etc.)

**Row Crops**, or Cash Crops, are a collection of basic agricultural commodities that are grown and used throughout the world and include maize, soybean, cotton, canola, wheat, rice, barley, sorghum, rye, oats and more. Most are some type of cereal, also referred to as grains, which are any type of grass yielding seeds full of starch and suitable for food and feed. Most of the cereals have common dietary properties, such as carbohydrates richness. However, they are comparatively low in protein and are deficient in calcium and vitamin A. Cereals are the main staple food in most diets, and these types of crops are mainly grown in semi-arid and sub-humid areas. Furthermore, around 50% of the world's calories are provided by rice, maize, and wheat. However, in many parts of Africa and Asia, the population relies mainly on grains such as sorghum. Cereals crops consist of barley, buckwheat, canary seed, grain, maize, millet, oats, quinoa, rice, rye, sorghum, triticale, and wheat. Cereals are utilized in the industry to produce a wide range of substances, including glucose, oils, alcohols, and adhesives, among others.

To keep pace with the global food demand, cereal production would need to increase at the same rate as the population is increasing. For the cultivation of these types of crops, advancing plant genomics, such as DNA sequencing, genotyping, and marker-assisted selection, can be employed for sustainable production. The farming of cereals varies, as it depends on various factors such as soil characteristics, rainfall, and farm techniques applied to improve the growth. For the cultivation of higher crop yield for cereals, good soil management is necessary to ensure good soil fertility. Farmers across the globe especially in developed regions, such as North America and Europe, are rapidly adopting different advanced plant genomics to improve the yield and confer resistance from diseases and pathogens.

Furthermore, recent advancement in the plant genomics has made it possible to analyze the architecture of cereals genome and their expressed components, which lead the researchers and companies to know the specific gene linked to key agronomically important traits. Plant genomic technologies utilized the molecular genetic mapping of quantitative trait loci of several complex traits that are important for breeding. The alleles identified by functional genomics technologies can enrich the genetic basis of cultivated crops to enhance productivity. Moreover, the availability of mutants, introgression libraries, and advanced genome technologies make the functional genomics in cereals more manageable. A wide array of technologies and genetic markers, such as anchor markers for comparatively mapping, SSRs, and SNPs are widely used in genetic mapping and MAS. Additionally, the database of the rice, maize and wheat genomes and other cereals is key to the effective utilization of genome data to improve cereals crop productivity.

Also included among row crops are oil crops, most common being soybean and canola/rapeseed but also includes as castor oil seed, coconuts, cottonseed, groundnuts, hempseed, jojoba seed, karite nuts, linseed, melon seed, mustard seed, olives, palm kernels, poppy seed, safflower seed, sesame seed, sunflower seed, and tung nuts. These crops are generally cultivated for their oil content in their seeds but other nutrients like plant protein meal are used. Oils from these crops are used for vegetable oils, livestock feeds, and biofuels, among others. These crops are the category of food products that have high-calorie content. These crops play a major role in catering to the food demand majorly in developing countries and are also gaining attention due to their increasing demand in several industries, such as pharmaceuticals and other oleochemical industries. Advanced biotechnology-based technologies, such as plant genomics, help in

improving diverse traits, including herbicide tolerance and disease resistance that is sustainable for oil crop production, such as soybean, which is susceptible to pest attacks. With the aid of new advanced plant genomics such as genetic engineering, sequencing, and genotyping, the production of oil crops can be done with great precision. Recent advancements have been focused on new plant genomics such as marker-assisted selection, next-generation sequencing, genetic engineering, tilling, targeting local lesions in genomes, among others to improve the oil crops in terms of both yields, and nutritional quality of oils.

**Vegetables** are a rich source of vitamins, fiber, and minerals. The demand for the vegetable crop type is increasing as the world's population is increasing. According to the European Parliamentary Research Services, in 2013, fresh vegetables were cultivated on 1.6-million-hectare land in Europe. However, vegetables are a high-value crop and contribute to a greater proportion of value in agriculture production. The yield of vegetable crops shows great variation across the globe, and it is mostly affected by climate change and topography. To cater to the growing demand for vegetables, researchers, and agriculture industrial giants are rapidly utilizing advance biotechnology-based solutions such as plant genomics to enhance the crop yield.

Additionally, the rapid development in genomic technology and its tools leads to a drastic variation in vegetable crop research. With the advent of sequencing technology, the researchers and breeders can access and explore the enormous, sequenced data to get an understanding of genetic variation at the DNA level. Furthermore, the availability of DNA sequence data for vegetable crops in the public database has constantly increased, which offers the researchers to design and develop the genetic markers, SNP genotyping, and SSR markers, among others. The analytics tools such as bioinformatics technology are also being deployed in many aspects of vegetable genomic research particularly for functional and computation genomics analysis, and phylogenetic analysis, among others. These advanced plant genomics are being rapidly utilized across the world to producing improved vegetables with climate-smart traits.

Root and tubers, classified under vegetables for the purposes of this assessment, are considered important cultivated staple energy sources, majorly in tropical regions in the world. They are primarily used as human food and animal feed, as well as for the production of starch, alcohol, and fermented beverages. This category of farm produces consists of root crops, including beets, carrots, and tuber crops, including

potatoes and sweet potatoes. Many countries such as sub-Saharan Africa and some countries of the region Ghana have a high dependence on this farm produce and low food consumption levels across the population. Roots and tubers crops receive a little consideration, although the majority of the plant genomics are deployed for potato. Several plant genomics such as genotyping, sequencing, and MAS are being rapidly implemented to improve the crop yield of roots and tubers crops, as the production of these types of crops using conventional methods are more susceptible towards pathogen and diseases.

**Fruits** are a major source of nutrition and contain fiber and antioxidants. Fruits are recognized for the role in preventing the deficiency of vitamin C and vitamin A. With the increasing urban population across the globe and increasing consumer awareness regarding heath, the demand for the fruit type crop is also increasing. Fruit crop types include apple, citrus, banana, strawberry, blueberries, among others. Fruits required individualized attention and condition for growth and harvest. Moreover, with the shortage of labor across the world, the cost for the same is increasing. To overcome the aforementioned challenges, the utilization of plant genomics is increasing to improve the quality and stress tolerance ability of the crops. The newly advanced plant genomics have emerged as a powerful tool and have wide application coverage as compared to classic genetic engineering tools. The advent of next-generation sequencing tools and platforms offers researchers and food biologists with valuable data to develop new varieties of fruits more efficiently and easily with new traits.

**Pulses**, also referred to as **grain legumes**, are a group of 12 major crops that includes dry beans, chickpeas, dry peas, among others. Pulses are mostly cultivated because of their valuable properties as they are high in protein, fiber, vitamins, and amino acids. Pulses are considered popular in developing countries but are increasingly becoming recognized as a part of a healthy diet throughout the world. These crops are the most sustainable crops, as they require minimal resources for their cultivation. For instance, it takes 43 gallons of water to produce one pound of pulses as compared with 368 gallons for peanuts and 216 gallons for soybeans.

Pulses are very commonly produced in developing regions, but there is a massive production gap of pulses crops inside and outside the developing region. Advanced biotechnology-based solutions, such as plant genomics are increasingly being employed, as they provide critical insights regarding the crop genome.

Pulses have been considered orphan crops but the recent advancements in the plant genomics such as the discovery of genome-wide genetic markers, sequencing platforms, QTL maps, and genotyping are being increasingly deployed in order to enhance the pulses crop yield. Moreover, with the availability of the genomic sequence, the application of genome-wide study with speed up the progress of genetic improvement in pulses, leading to the rapid development of cultivars with enhanced yield, stress tolerance, and broader adaptability.

**Cannabis** is a generic term that denotes several psychoactive preparations of the flowering plants named Cannabis sativa. There are several species existing within the genus "Cannabis"' and are recognized as Cannabis sativa, Cannabis indica, and Cannabis ruderalis. The genus is widely accepted to be originated either from Central Asia or upper South Asia. Cannabis is often classified as a cannabinoid or a psychoactive drug extracted from the cannabis plant and is used for medical or recreational purposes. The main psychoactive chemical in cannabis, responsible for most of the intoxicating effects that people seek, is delta-9-tetrahydrocannabinol (THC). THC is obtained from the resin produced by the leaves and buds primarily of the female cannabis plant.

Apart from THC, the plant also contains more than 100 compounds that are chemically related to THC in addition to 400 other chemical compounds. Intake of cannabis causes a general change in perception, heightened mood, and an increase in appetite. Onset of effect starts within minutes when smoked and about 30 to 60 minutes after, if it is cooked and eaten.

Cannabis plant cultivated for non-drug use is often referred to as hemp. The leaves of these hemp plants are used as vegetables and as juice, and also for different medicinal purposes as well as a recreational drug. Industrially, hemp plants have long been used to produce an abundance of fiber. Some cannabis strains are bred to produce minimal levels of THC, minimizing its psychoactive effect in order to comply with the UN Narcotics Convention. However, based on application some cannabis strains are also selectively bred to produce a maximum of THC, the strength of which is enhanced by curing the flowers.

In the cannabis market, the foremost step of the supply chain begins with the identification and segregation of genetics and seeds, followed by crop production of cannabis plant. The identification of

specific cannabis traits that modulates the amounts and distribution of certain cannabinoid compounds is critical for product differentiation within the marketplace. Growing the crop is then followed by harvesting, processing, and packaging. Once the product is packaged, it gets ready for distribution. The distributor finally sells the products to the consumer through retailer or via e-commerce.

**Other Crops** includes other (non-hemp) fibers like flax fiber and tow, hemp, jute, kapok fruit, manila fiber (abaca), ramie, and sisal. These types of crops present some important differences from other commodities. The cultivation of fiber crops has several production concerns, such as the concern related to quality, the formation of dust, physiological order, and post-harvest fiber extraction. Several plants that are a rich source of fiber produce seed fibers, bast fibers, and leaf fibers. The demand for these crops is growing rapidly in developing countries, and plant genomics are being increasingly used to cater to the need. Also included in other crop types are tree nuts which is a collective term used to describe the wide variety of nuts grown on trees. These are relatively high-value products and are used majorly for snack foods and ingredients. Tree nuts include almonds, Brazil nuts, cashew, chestnut, hazelnuts, pistachios, and walnuts. The cultivation of tree nuts is associated with different risks such as diseases, seasonal water damage, and extreme weather damage. Conventionally, farmers used old traditional equipment to cultivate, which increases the labor cost and decreases profitability. With the widespread adoption of advanced biotechnology-based technologies, researchers around the world are utilizing plant genomics to produce tree nuts. With the help of molecular and genetic engineering technologies, the yield and quality of tree nuts can be improved. Recent advancements in the plant genomics enable the production of tree nuts with improved yield and traits. The utilization of morphological markers and genome analysis helps in the examination, diversity, and phylogenetic analysis. The genetic improvement in the walnut crop has majorly undergone a great revolution and with the advent of next-generation sequencing, the availability of the genome data helps the researchers to know the genetic variation at the DNA level and thus enhance the tree nut crop yield.

**Dairy (milking) cow** production systems are solely dependent on the execution of strategies for maximizing production in order to match the increasing demand for food worldwide. The use of reproductive biotechnologies has begun from recent times to enhance productivity and attain higher economic returns. However, frequent innovations in the biotechnology sector and government initiatives

to support biotechnology research have improved the production output. Advances in reproductive biotechnologies have a huge impact on cattle genetics, since they have significantly increased the accuracy of assessments. Most of the companies breeding dairy cattle have implemented the latest genotyping solutions such as marker assisted/genomic selection, next-generation sequencing, and gene expression analysis, which have improved the quality of stock supplied across global trade channels. The bovine segment in general has huge impacts on global economy, since this industry faces shortage of enriched protein content in the animal product. In July 2019, Brazilian scientists at São Paulo State University (UNESP) collaborated with colleagues at the University of Maryland and the United States Department of Agriculture (USDA) and developed a dairy cattle breeding method, which takes into consideration genetic value associated with milk, fat, and protein yields, and variance in genetic diversity. Bovine genetic technologies and acceptance of resulting products by consumers are expected to push the industry sales during the forecast period.

For the purposes of this assessment, the **Other Animals segment** includes all other animals expect for dairy cows. Among this set of animals, poultry is the largest segment. In the poultry genetics industry, emphasis is given on rendering specific traits in male and female stocks. For example, traits emphasized in a male include meat yield, weight for age, days to market, feed efficiency, and fat content, while traits emphasized in female are fertility, hatchability, age at sexual onset, rate of egg production, and growth performance. The poultry genetics industry and other poultry products have penetrated most of the food sectors including food services and quick service restaurants in developed regions. However, developing regions still have a significance of breeding poultry for combined purposes. This has given a rise to the acceptance of foreign products due to their product specificity and sanitation standards, further leading to a rise in imports. Porcine, or swine, is also an important segment globally along with beef cattle.

Market size is calculated based on the total sales of each respective technology or the total unit shipment sales with respect to the seed market. All monetary values were captured and reported in US dollars and the base year of this assessment is the year 2020. The forecast period is five years (2021 to 2026). The regional scope of study is global, and the sub-regions include:

- United States
- Europe

- Asia-Pacific (APAC)
- Rest of the World (ROW)

## Global Bioinformatics Market for Agricultural Applications

The bioinformatics technology market for agricultural applications generated revenue of $3,296 million in 2020 and is expected to generate $7,509 million in 2026, growing with a CAGR of 14.7% during the period 2021-2026. The market growth drivers of bioinformatics technology are attributed to the increasing demand for nucleic acid sequencing of the plant due to the reduction in the sequencing cost. Moreover, utilization in analysis, annotation, and storage of data, and expanding initiatives from government and private organizations to cater to the increasing food demand is expected to boost the growth of the market in the coming years. In 2020, the bioinformatics technology segment experienced a significant increase in the plant genome market due to the COVID-19 pandemic as majority of the industries have limited their operation due to lockdown being imposed to contain the spread of the virus. Therefore, the adoption of bioinformatics technologies is expected to rise, owing to the application of bioinformatic technology such as storing, retrieving, and analyzing the relevant biological data.

### *Market Drivers and Restraints*

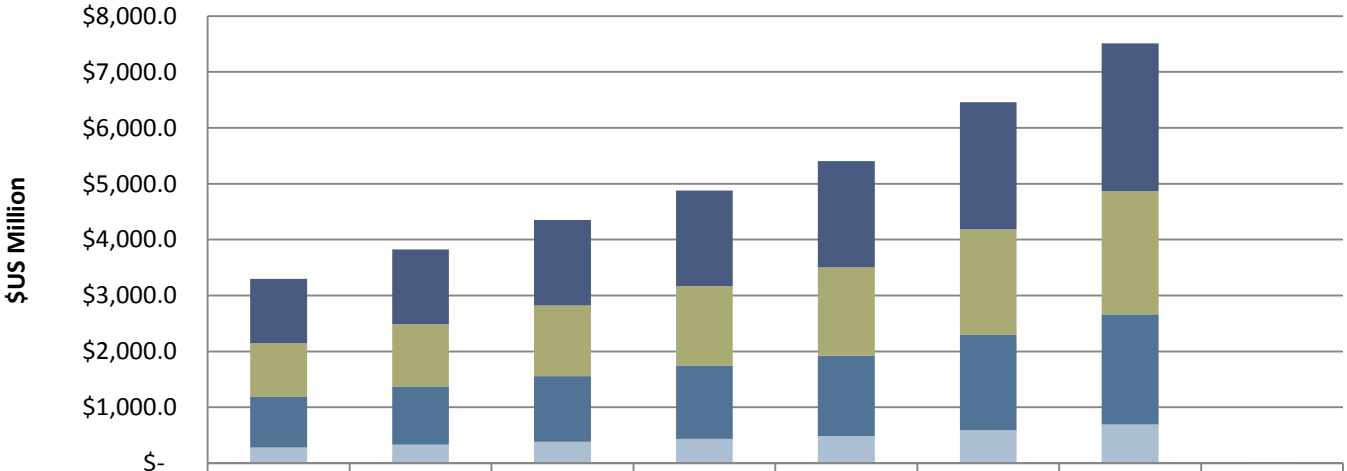
With respect to the key growth drivers and growth restraints, the rise in need for integrated data and increase in growth of proteomics & genomics are the factors that drive growth of the bioinformatics market. There is large amount of data that is generated during various tests and feed trial processes. Various other major applications where large number of data is generated are high throughput screening and target identification that requires effective analysis. The bioinformatics sector is developing various tools that are capable of handling large and complex data. These tools simplify and deliver required data to end users. Thus, these applications attract biotechnology firms to handle their data.

In addition, growth in genomics research & development is expected to boost the market growth during the forecast period. However, lack of skilled personnel hampers the market growth. Currently, tools used in bioinformatics are limited to specialized end users, as there are masses of data that needs to be

handled. These require skilled and professional staffs. In addition, bioinformatics software is complex in nature of work, which adds high operation costs of tools. Thus, training is required for individuals who do the work, which limits growth of the bioinformatics market. Thus, increase in need for integrated solutions & systems are expected to offer remunerative opportunities for market players.

## *Target Regions*

**Global Bioinformatics Market for Agricultural Applications: Revenue Forecast by Region, 2020-2026, $US Million**




| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | CAGR |
|---|---|---|---|---|---|---|---|---|
| North America | $1,150.9 | $1,337.2 | $1,523.5 | $1,709.8 | $1,896.2 | $2,268.8 | $2,641.4 | 14.8% |
| APAC | $957.5 | $1,113.2 | $1,268.9 | $1,424.6 | $1,580.3 | $1,891.7 | $2,203.1 | 14.9% |
| Europe | $905.8 | $1,038.7 | $1,171.6 | $1,304.5 | $1,437.5 | $1,703.3 | $1,969.1 | 13.8% |
| RoW | $281.4 | $333.2 | $385.0 | $436.8 | $488.6 | $592.2 | $695.8 | 16.3% |
| Global | $3,295.6 | $3,822.3 | $4,349.1 | $4,875.8 | $5,402.5 | $6,455.9 | $7,509.4 | 14.7% |

Note: All Figures rounded. Base year is 2020. Source: Frost & Sullivan analysis.

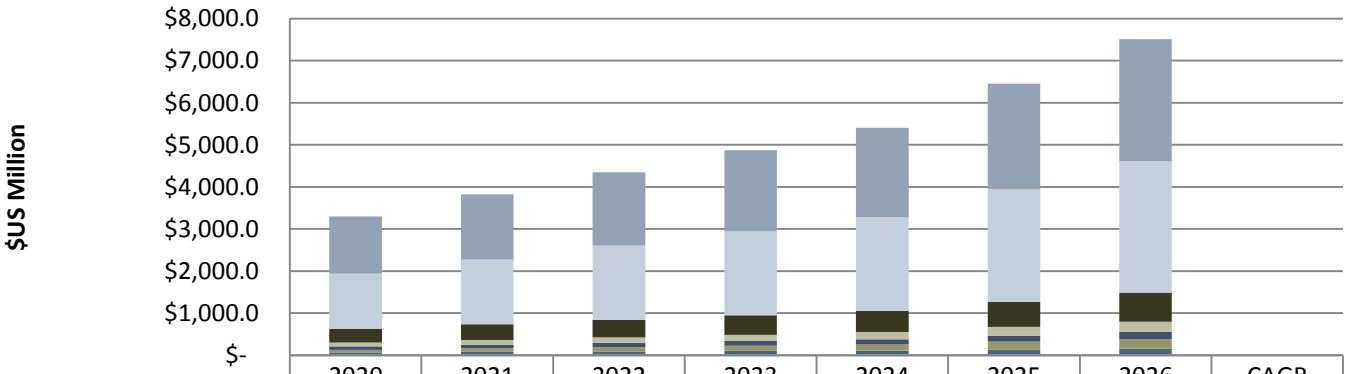
The governing trends of the bioinformatics market for agricultural applications market vary across different regions. The bioinformatics market holds a prominent share in various countries of North America, Europe, APAC, Middle East and Africa, U.K., China and South America. In 2020, North America is expected to be at the forefront of the market, with a large market concentration in the U.S. ($1,151 million in 2020). The large market share of the region has been attributed to the developing advanced technology-based infrastructure, growing government and academic support and initiatives to adopt innovative technologies in the agriculture industry, and an increasing number of companies, which offer

plant genomics services in the region. The U.S. market for bioinformatics market for agricultural applications is expected to witness a growth of 14.6% CAGR in the forecast period.

During the forecast period 2021-2026, the APAC region is expected to flourish as one of the most lucrative markets for plant genomics. APAC region is expected to exhibit significant growth opportunities for bioinformatics market for agricultural applications due to the increased optimism in the economic conditions of these countries. The countries in this region will witness rapid development of its bioinformatics technologies for agricultural applications due to increasing urban population size, growing market penetration of advanced technologies, and favourable government investments on the adaptation of innovative farming technologies.

## *Target Applications*

**Global Bioinformatics Market for Agricultural Applications: Revenue Forecast by Target Applications, 2020-2026, $US Million**




| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | CAGR |
|---|---|---|---|---|---|---|---|---|
| Row crops | $1,360.7 | $1,553.0 | $1,745.3 | $1,937.6 | $2,130.0 | $2,514.6 | $2,899.2 | 13.4% |
| All Other Animals | $1,306.2 | $1,533.4 | $1,760.5 | $1,987.7 | $2,214.9 | $2,669.3 | $3,123.6 | 15.6% |
| Dairy Cows | $326.5 | $371.4 | $416.3 | $461.2 | $506.1 | $595.9 | $685.7 | 13.2% |
| Legumes | $92.4 | $111.8 | $131.3 | $150.8 | $170.2 | $209.1 | $248.0 | 17.9% |
| Vegetable crops | $77.1 | $87.8 | $98.5 | $109.2 | $119.9 | $141.3 | $162.7 | 13.3% |
| Cannabis | $61.4 | $82.7 | $104.0 | $125.3 | $146.6 | $189.1 | $231.7 | 24.8% |
| Fruits and berries | $59.1 | $67.7 | $76.3 | $84.9 | $93.6 | $110.8 | $128.1 | 13.8% |
| All Other Crops/Plants | $12.3 | $14.5 | $16.8 | $19.0 | $21.3 | $25.8 | $30.3 | 16.2% |
| Total | $3,295.6 | $3,822.3 | $4,349.1 | $4,875.8 | $5,402.5 | $6,455.9 | $7,509.4 | 14.7% |

Note: All Figures rounded. Base year is 2020. Source: Frost & Sullivan analysis.

Due to the rise of the need to use bioinformatics across all categories to identify and cultivate unique traits and the amount of unaddressed opportunities across the world, it is expected that the demand for bioinformatic technologies will be immense. In general, Frost & Sullivan expects that revenue growth will range from 13 to 25%, dependent of target application. Even row crops, the largest segment at $1,361 million in 2020 will grow at an expected CAGR of 13.9% and approach $2,900 million by 2026. The bioinformatics market for cannabis applications is expected to witness the greatest growth. In 2020, the bioinformatics market for cannabis applications was $61 million and is on track to hit $232 million by 2026 given a CAGR of 24.8% during the forecast period. Legumes are another category that will become increasingly important for bioinformatics technologies due to the rising demand for alternative meats/proteins. In 2020, the bioinformatics market for legume applications was $92.4 million and is on track to hit $248 million by 2026 given a CAGR of 17.9% during the forecast period.

### *Key Competitors and End User Companies*

The global bioinformatics market is fragmented with presence of many large players and other local-, small-, and mid-sized manufacturers, which have started developing bioinformatics tools used to link biological data with techniques for information storage, distribution, and analysis to support multiple areas of scientific research, including biomedicine. Agilent Technologies, Inc., PerkinElmer Inc., QIAGEN N.V., Illumina, Inc., and Thermo Fisher Scientific, Inc. held a high market position in 2019, owing to sales and availability of their software products majorly across the Americas, Europe, and Asia-Pacific. Other players include Bruker Corporation, The Seven Bridges Genomics, DNAnexus, Inc., Biomax Informatics AG, Intrexon Bioinformatics Germany GmbH, The Dassault Systemes, Eurofins Scientific, Geneva Bioinformatics SA, and among others. Key players develop different strategies to improve their product portfolio and strengthen their market presence. For instance, in April 2018, Agilent Technologies released OpenLab CDS 2.3 with better functionality aimed at user experience and better supportability requirements for chromatography data systems in labs. This update includes enhancements focused on getting more key insights from LC and LC/MS systems (Liquid Chromatography/Mass Spectrometry) and data portability in and out of OpenLab CDS. Moreover, in October 2018, Sanofi Genzyme and PerkinElmer Genomics together launched a free genetic testing program, which aims to spot certain undiagnosed lysosomal storage disorders.

With respect to key end users, major seed and agricultural companies are the target end users of agricultural bioinformatics and include the likes of Corteva Agriscience, Syngenta, Tyson Foods/Cobb-Vantress, and Bayer Crop Science. More details on these players can be found in the global seed market section.

### *Growth Opportunities*

A key growth opportunity in the bioinformatics sectors is being able to address the need for integrated solutions and systems. Innovative product development and engineering is key to stay competitive in the agricultural sector. Bioinformatics field is utilized and seen as an IT tool, which deals in recording, annotation, storage, analysis, and retrieval of nucleic acid sequence, protein sequence, and structural information. However, bioinformatics firms are undergoing gradual transition and are now seen as an integrated tool. Software used in bioinformatics has the capability to integrate data analysis and management required for various applications such as genome sequencing. In addition, it has several applications in fields of biology including molecular medicines, preventive medicines, gene therapy, drug developments, biotechnology, and forensic analysis of microbes. Thus, there is an increase in demand for integrated solutions & systems in the agricultural sector.

## Global Seeds Market

The seed market generated revenue of $42,424 million in 2020 and is expected to generate $54,926 million in 2026, growing with a CAGR of 4.4% during the period 2021-2026. The market growth drivers of seeds are attributed to significant gains in GM corn cultivation in developing and growing countries, though discouraging political views might slow down this expected progress. Geographical expansion will support this growth, such as drought resistant corn in Africa, and specific crops in Asia. Newer GM crops in GM crop growing countries such as GM apple and potato, oilseeds with modified fat contents for healthier oil, and oilseeds with higher protein content are also expected to support market growth during the forecast period. Finally, engineering seeds to be compatible with certain pesticides will also support market growth, though this may create product dependence from farmers. Gene-editing techniques offer modified crop traits at much lower costs, making seeds more affordable and easier to increase market penetration.

## *Market Drivers and Restraints*

Non-GM Seeds will also grow during the forecast period as some farmers, consumers, governments, and other relevant stakeholders slowly move away from GM-produced varieties. For example, sizeable growth is expected in most regions except for North and South America where GM seeds dominate many industrial crops. Carbohydrate and oilseed crops will remain the most significant crops; sugar beet and vegetables seeds offer significant growth as consumers increase sugar and vegetable consumption. Opportunities in this segment include focusing on varieties with desirable traits such as increasing resistance to pests and tolerance to herbicides and damaging weather (e.g., drought), specific product traits (e.g., oilseeds with higher protein content), and vegetable seeds as consumers increase consumption.

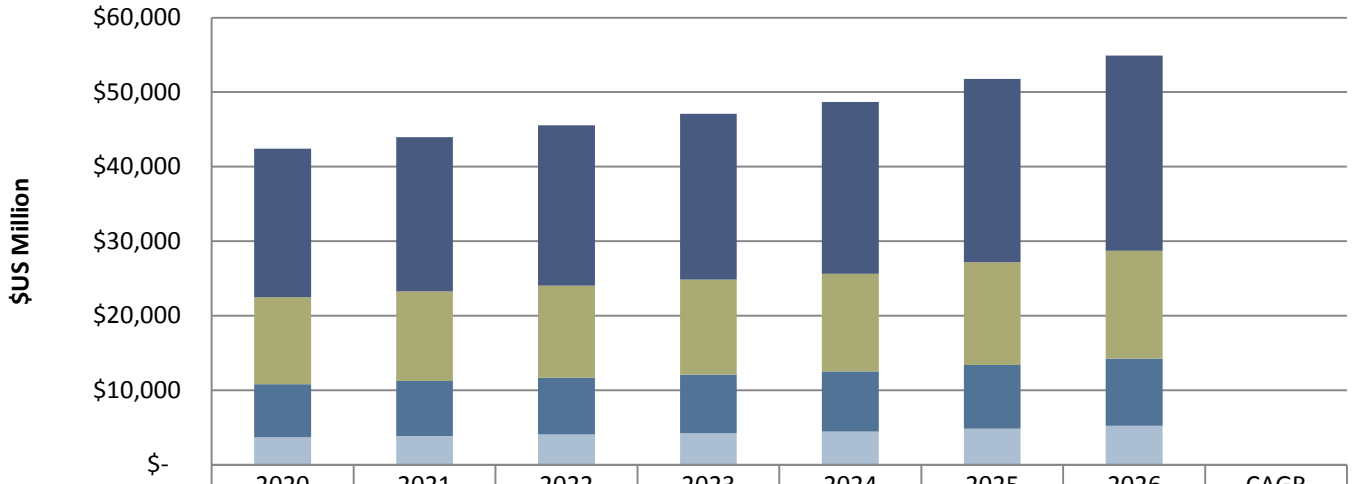
With respect to the key growth drivers and growth restraints, government encouragement to increase domestic crop production will increase demand and support seed prices (e.g., Blacksea grains, South America soybeans, China staple crops) though some reluctance to grow GM crops in certain regions/countries (EU, APAC) will limit growth during the forecast period. Rising demand for higher yielding seeds, which are more costly, is expected and thus for seed suppliers enjoy higher bargaining power to command higher prices due to the increasingly technical requirements of consumers and producers.

Non-GM crop demand is rising in Asia and EU, and consequently, these crops command premia over GM varieties despite possible lower yields. This will help support seed market revenue growth.

Key market growth restraints include the possibility of farmers quickly reverting back to non-GM seeds if it is economically beneficial, contamination from neighboring GM crop fields would force farmers to adopt GM seeds or impel them to sue in order to restrict their neighbor's ability to use certain GM seed. GM seeds may not be widely adopted due to debates and mistrust over GM crops' impact on the environment and human health (EU, Japan, China). However, the seed market is dominated by a relatively small number of players and competition is relatively limited, with restricted seed choices for farmers. This is likely to persist in the long term.

## *Target Regions*

**Global Seed Market: Revenue Forecast by Region, 2020-2026, $US Million**




| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | CAGR |
|---|---|---|---|---|---|---|---|---|
| APAC | $19,921 | $20,704 | $21,486 | $22,269 | $23,051 | $24,617 | $26,182 | 4.7% |
| Europe | $11,674 | $12,027 | $12,379 | $12,732 | $13,085 | $13,790 | $14,496 | 3.7% |
| RoW | $7,140 | $7,374 | $7,607 | $7,841 | $8,074 | $8,541 | $9,008 | 3.9% |
| North America | $3,689 | $3,883 | $4,077 | $4,271 | $4,465 | $4,852 | $5,240 | 6.0% |
| Global | $42,424 | $43,986 | $45,549 | $47,112 | $48,675 | $51,800 | $54,926 | 4.4% |

Note: All Figures rounded. Base year is 2020. Source: Frost & Sullivan analysis.

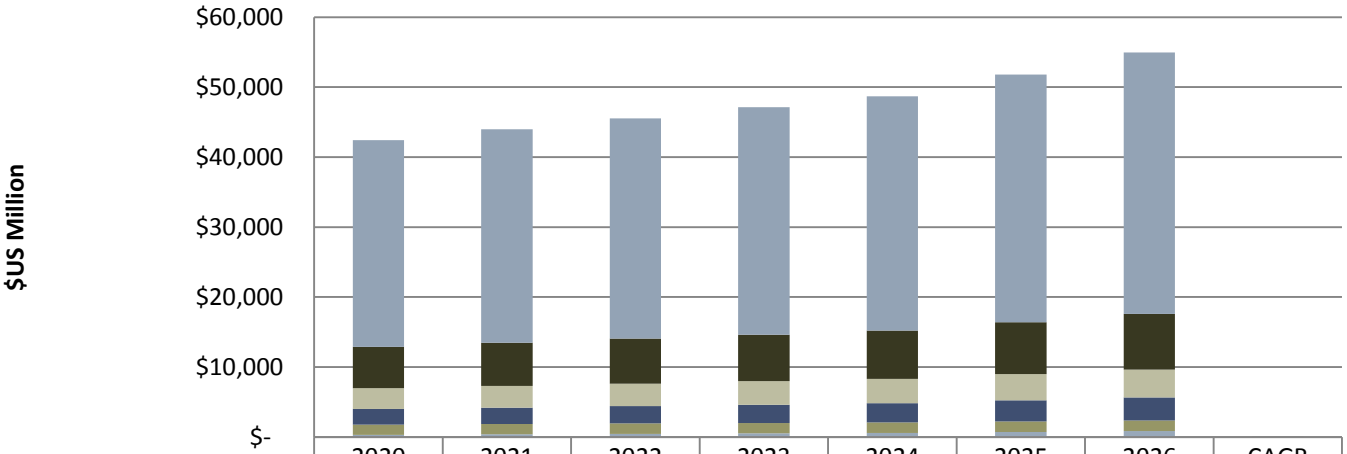
In 2020, APAC was the largest seed market in the world, reporting annual revenue of $19,920 million and is expected to grow at a compound annual growth rate of 4.7% during the forecast period. Europe is also a significant region of the seed market, recording $11,674 million in 2020, though growth is expected to be slightly slower than the global average at 3.7% during the forecast period. The North American recorded total seed market sales of $3,689 million in 2020 and is expected to grow at a CAGR of 6.0% during the forecast period. The higher than global average growth rate for the U.S. seeds is attributed to farmers seeking greater efficiencies in maize and oilseed production coupled with the string growing cannabis seeds market.

Most growth in the North America is likely to be seen in GM seeds and less growth is expected in non-GM seeds, with the latter demanded by consumers preferring non-GM products. South America is also expected to see little growth in non-GM seeds due to its widespread adoption of GM seeds. Due to the region's political views and consumer perception, Europe is expected to remain reliant on non-GM seeds.

Asia has a sizeable demand for non-GM seeds as GM crop cultivation is limited in this region. Asia has also shown a preference for non-GM over GM materials for food use and the Rest of the World is largely non-GM cultivating areas due to prohibition of GM crop cultivation, or a lack of policy to enable GM crop growing. Despite the lack of GM crop cultivation in regions other than North and South America, most regions import significant volumes of GM materials for various uses in food, feed and fuel applications.

## *Target Applications*

**Global Seed Market: Revenue Forecast by Target Applications, 2020-2026, $US Million**




| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | CAGR |
|---|---|---|---|---|---|---|---|---|
| Row crops | $29,552 | $30,526 | $31,501 | $32,476 | $33,451 | $35,400 | $37,350 | 3.98% |
| Vegetable crops | $5,910 | $6,162 | $6,413 | $6,664 | $6,915 | $7,418 | $7,920 | 5.00% |
| Fruits and berries | $2,955 | $3,086 | $3,216 | $3,346 | $3,477 | $3,737 | $3,998 | 5.17% |
| Legumes | $2,216 | $2,352 | $2,487 | $2,623 | $2,758 | $3,029 | $3,300 | 6.86% |
| y_All Other Crops/Plants | $1,478 | $1,478 | $1,479 | $1,480 | $1,480 | $1,481 | $1,483 | 0.06% |
| Cannabis | $312 | $383 | $453 | $524 | $594 | $735 | $875 | 18.73% |
| z_Total | $42,424 | $43,986 | $45,549 | $47,112 | $48,675 | $51,800 | $54,926 | 4.40% |

Note: All figures rounded. Base year is 2020. Source: Frost & Sullivan analysis.

In general, the seed market is a mature market, but with the advent of plant genetics, Frost & Sullivan expects that revenue growth will range from 3 to 6% for most crops, depending of target application. Row crops are the largest segment at $29,552 million in 2020 will grow at an expected CAGR of 4.0% during the forecast period and approach $37,350 million by 2026. Continued adoption of GM seeds for row crops in new regions will support market growth during the forecast period. The cannabis seeds market is expected to witness the greatest growth; in 2020, the seeds market for cannabis was $312 million and is on track to hit $875 million by 2026 given a CAGR of 18.7% during the forecast period. Growth in the use of cannabis

products in under-penetrated regions will support market growth during the forecast period. Legumes are another category that will become increasingly important for seed supply due to the rising demand for alternative meats/proteins. In 2020, the legume seeds market was $2,216 million and is on track to hit $3,300 million by 2026 given a CAGR of 6.9% during the forecast period. Vegetable seeds are also a part of a significant market space. Demand growth for vegetable seeds is expected to be 5.0%, compounded annually over the forecast period, and approach $7,920 million by 2026.

### *Key Competitors and End User Companies*

Leading companies in the global agricultural seed market include Bayer Crop Science, Conteva Agriscience, and Syngenta/ChemChina. These three industry participants control more than 80% of the global branded seeds and agtech market. The agricultural seed genomics industry uses the biotechnology tools to develop novel germplasm for seeds. Key traits include herbicide tolerance, insect resistance, virus resistance, and desired traits. With new genomics tools, including synthetic biology, genome editing and sequencing, the trend is moving towards more extensive changes to the plant genome, resulting in stacked traits. The creation of unique seed products with highly desirable traits is a goal of companies in this industry. Central to achieving this goal is ready access to high quality germplasm banks; breeding expertise to develop a seed with desirable traits; ability to develop unique GM traits; ability to multiply worldwide; and access to large numbers of contractual farmers and land to grow seeds.

The main structural feature of the seed industry is the creation of barriers to entry. Few companies can bring all of the expertise needed as described above to be successful in the seed business. As a result, the global industry has consolidated to a very small number of companies that control the majority of the seed market. These barriers include:

- Exclusive access to germplasm: Starting material for trait development
- Breeding know-how: Shortens the time to get a good trait
- GM traits: Introduces unique traits not possible with hybrid seeds
- Global capabilities: Multiplying worldwide introduces flexibility and saves development time.
- Access to contractual farmers and land: Provides the wherewithal to produce newly developed seeds

Because this industry is dominated by proprietary genomics technology, new product development is the main way companies can increase their market share. This places a strong demand on R&D, in which sequencing tools are very important. All the major competitors have invested in next generation sequencing technologies. The top companies compete mainly on the basis of product performance, safety and innovation. Research & development is important to developing new products, and each of the companies is active in corporate deal making to strengthen its biotech seed R&D pipeline.

## *Growth Opportunities*

*GM Seeds*

Most growth is expected to come from the pro-GM crop regions of North and South America. Significant gains are likely in GM corn as cultivation spreads to other corn growing countries, though discouraging political views might slow down progress. Opportunities lie in:

- Geographical expansion of areas cultivating industrial GM crops, such as drought resistant corn in Africa, and specific crops
- Newer GM crops in GM crop growing countries, e.g., GM apple and potato, oilseeds with modified fat contents for healthier oil, oilseeds with higher protein content
- Engineer seeds to be compatible with certain pesticides. This creates product dependence from farmers
- Gene-editing techniques offer modified crop traits at much lower costs, making seeds more affordable and easier to increase market penetration

*Non-GM Seeds*

Sizeable growth is expected in most regions except for North and South America where GM seeds dominate many industrial crops. Carbohydrate and oilseed crops will remain the most significant crops; sugar beet and vegetables seeds offer significant growth as consumers increase sugar and vegetable consumption. Opportunities lie in:

- Varieties with desirable traits such as increasing resistance to pests and tolerance to herbicides and damaging weather, e.g., drought, remain important
- Specific product traits e.g., oilseeds with higher protein content
- Vegetable seeds as consumers increase consumption

## Global Market for Genotyping Services (Total R&D Expenditure of Seed Manufacturers and Animal Breeders on Genotyping Services)

The genotyping technology segment generated revenue of $1,855 million in 2020 and is expected to generate $3,087 million by 2026, growing with a CAGR of 8.9% during the forecast period 2021-2026. The market growth of genotyping technology is attributed to facilitate the evaluation of genetic inconsistency in existing crops and livestock and to develop the crop/animal with high nutritional content. Moreover, the adoption and utilization of genotyping is rapidly increasing in several research centers and universities across the globe to produce novel products that are also fueling the growth of the market. With the ongoing pandemic, agriculture industries are operating with a limited workforce. Therefore, the research and development for plant and animal genomics will contract due to the ongoing COVID-19 conditions in many parts of the world, thereby impacting the genotyping market.

### *Market Drivers and Restraints*

The demand for genotyping services is driven by the core motivations of growers and breeders and includes the rising need for improved crop traits that maximizes yield, minimizes production costs, and ensures high and standardized final products that their downstream customers expect. The need for improving crop traits is a concern for many government and private organizations. Crop traits improvement is one of the major tasks in the current agriculture sector, as the demand for plant-derived products is rising exponentially, owing to the growing human population and the variable climate across the regions. Moreover, environmental and aerial pollution has a drastic impact on the soil, climate, and water, which creates increasing stress for growing crops. Furthermore, according to the projection made by the Food and Agriculture Organization (FAO) of the United Nations (UN), the global population is expected to increase to 9.1 billion by 2050, and with the drastic change in the population over the coming period of time, the global demand for food to double from 2005. The demand for plant-based food is growing exponentially, and the agriculture industry is facing constant pressure from society to keep up with the demand. With 90% of the growth in the global crop production being dependent on increased cropping intensity and developing improved crop traits, the role of genotyping has risen to become a necessity for the agriculture industry.

Crop losses are another important factor that threaten the productivity of agriculture and drives the demand for genotyping services in this sector. The interdependent relationship between the two becomes essential as the impact of crop loss due to pest attack, diseases, and herbicide, among others, reducing the productivity of the crops, therefore both the challenges need to be address simultaneously. Diseases, weeds, insects, and pests annually cause considerable losses in the crop yield and quality of fruits and vegetables produced across the globe. Moreover, with the extensive usage of pesticides, the estimated reduction in crops in the U.S. caused by the diseases ranges from 8% to 23%, by insect 4% to 21%, and by weeds 8% to 13%. The crop losses also vary amongst the crops. For instance, the global potential loss due to pests varies from 50% wheat to more than 80% in cotton production. Furthermore, the estimated losses for soybean varies from 26-29% and 37% for rice, 31% for maize, and 40% for potatoes. Also, drastic weather events such as droughts and heavy rainfall have increased in the past years.

The current traditional farming activities are a significant contributor to greenhouse gases and generate the highest amount of CO2. This happens because agriculture requires a huge amount of space along with a massive amount of chemical fertilizer to fulfill demand requirements. Moreover, the varied climate change also acts as a significant factor for crop loss. The impact of climate change is more severe in these developing countries due to their extensive dependence on the agricultural sector. The inter-linked relationship between climate change and agriculture is very important as the imbalance between the world food production and world population increases. Improving crop production to meet the rising demand for food, owing to the increasing population against the threat of climate change, is a very challenging task.

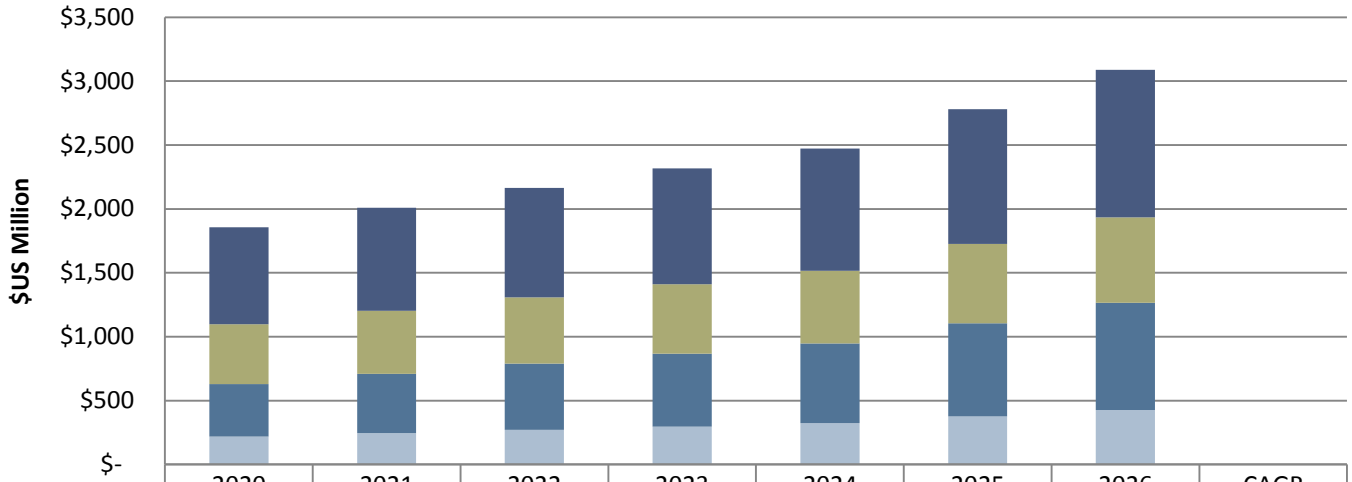
A key restraint to the adoption of genotyping services is the cost of adoption, though this challenge is expected to diminish over time. Advances in technology in the field of plant genomics have unlocked several new dimensions providing a unique solution to cater to the increased demand for food. Despite various benefits offered by plant genomics, the market growth of these products may experience restraints due to their high initial deployment cost. The requirement of high capital investment on a large scale is acting as a burden impeding the growth of the global plant and animal genomics market. In addition to this, the cost involved in establishing and maintaining different technology platforms

associated with plant genomics is exorbitantly high, which tends to limit its adoption in low-income countries.

The median capital cost of genotyping varies in the range of $400-$60,000. Small and medium scale companies in the emerging markets, such as Brazil, India, Mexico, and Indonesia, lack significant funding for the incorporation of these platforms, thereby affecting the adoption rate of genotyping services. The deployment of capital-intensive plant genomics has been found to be a difficult proposition for small businesses. Furthermore, the necessary capital that is required to establish the infrastructure for utilizing modern technologies in plant genomics and its consequent comprehensive interpretation is often not present in most academic medical centers (AMCs), particularly in the current funding scenario. Also, these technologies require regular maintenance in order to keep them running. This concern of financial barriers has restricted some sections of industries and countries from adopting plant genomic solutions, including genotyping services. This restraint is anticipated to be tackled in the longer run, due to an increase in health consciousness among consumers, the development of advanced sequencing technology that enables lower cost investment, and an increase in the investments and funding by governments and several private and public organizations should help in building economies of scale.

## *Target Regions*

**Global Genotyping Technology for Agricultural Applications Market: Revenue Forecast by Region, 2020-2026, $US Million**



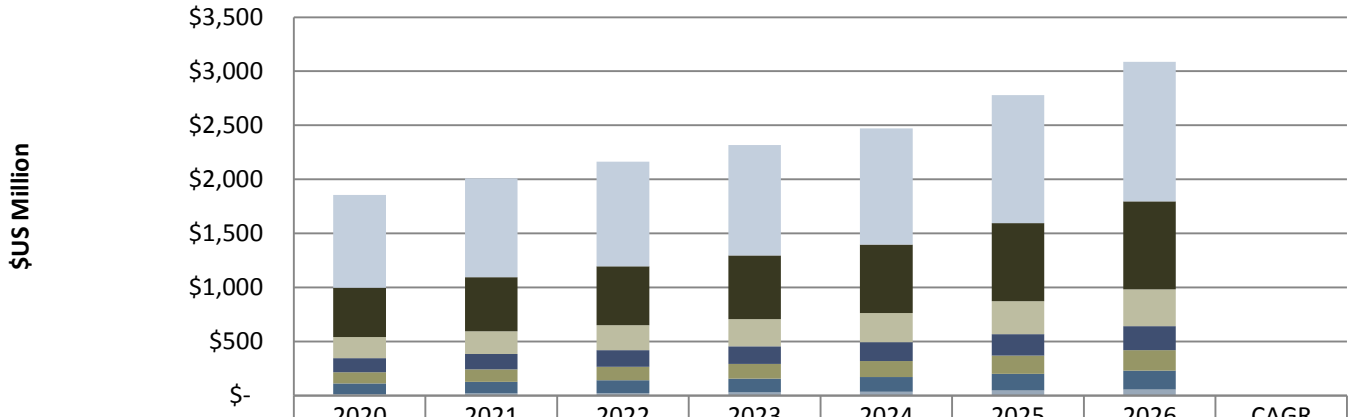

| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | CAGR |
|---|---|---|---|---|---|---|---|---|
| US | $758 | $807 | $856 | $906 | $955 | $1,054 | $1,153 | 7.3% |
| Europe | $468 | $493 | $519 | $544 | $569 | $619 | $669 | 6.1% |
| APAC | $410 | $463 | $517 | $570 | $624 | $731 | $837 | 12.6% |
| RoW | $219 | $245 | $271 | $297 | $323 | $375 | $427 | 11.8% |
| Global | $1,855 | $2,009 | $2,163 | $2,317 | $2,471 | $2,779 | $3,087 | 8.9% |

Note: All Figures rounded. Base year is 2020. Source: Frost & Sullivan analysis.

The US market for genotyping services for agricultural applications generated revenue of $758 million in 2020 and is expected to generate $1,153 million in 2026, given a CAGR of 7.3% during the 2021-2026 forecast period, thus making it the largest region in terms of current adoption. The large market share of the region has been attributed to the developing advanced technology-based infrastructure, growing government and academic support and initiatives to adopt innovative technologies in the agriculture industry, and an increasing number of companies, which offer genomics services in the region. Europe is also a significant market segment for genotyping services. The European market for genotyping services for agricultural applications generated revenue of $468 million in 2020 and is expected to generate $669 million in 2026, given a CAGR of 6.1% during the 2021-2026 forecast period. The fastest growing region is expected to be APAC. During the forecast period 2021-2026, the APAC region is expected to grow at a compound annual growth rate of 12.6% and reach $837 million in regional revenue by 2026.

## *Target Applications*

**Global Genotyping Technology for Agricultural Applications Market: Revenue Forecast by Target Applications, 2020-2026, $US Million**




| | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | CAGR |
|---|---|---|---|---|---|---|---|---|
| Row crops | $859 | $913 | $967 | $1,021 | $1,075 | $1,183 | $1,291 | 7.0% |
| Dairy Cows | $456 | $500 | $545 | $589 | $634 | $723 | $812 | 10.1% |
| Legumes | $194 | $213 | $231 | $250 | $269 | $306 | $343 | 9.9% |
| Vegetable crops | $130 | $141 | $153 | $164 | $176 | $199 | $221 | 9.3% |
| Cannabis | $103 | $114 | $125 | $135 | $146 | $168 | $189 | 10.6% |
| Fruits and berries | $99 | $109 | $118 | $127 | $137 | $155 | $174 | 9.7% |
| All Other Crops/Plants | $14 | $19 | $24 | $30 | $35 | $46 | $56 | 26.6% |
| Total | $1,855 | $2,009 | $2,163 | $2,317 | $2,471 | $2,779 | $3,087 | 8.9% |

Note: All Figures rounded. Base year is 2020. Source: Frost & Sullivan analysis.

The genotyping services market is in the growth stage of its market lifecycle, though the adoption and utilization of genotyping services varies target crop/animal. Frost & Sullivan expects that revenue growth will range from 7 to 10% for most crops, with some exceptions. Row crops are the largest addressable segment at $859 million in 2020 and this market segment is expected to grow at an expected CAGR of 7.0% during the forecast period and approach $1,291 million by 2026. Continued adoption of GM seeds for row crops in new regions will support market growth during the forecast period. Outside of niche crop types contained within the All Other Crops segment, the cannabis market is expected to witness the greatest growth. In 2020, the cannabis segment for genotyping services was $103 million and is on track to hit $189 million by 2026 given a CAGR of 10.6% during the forecast period. Growth in the use of cannabis products in under-penetrated regions will support market growth during the forecast period.

## *Key Competitors and End User Companies*

Overall, the genotyping services market is relatively fragmented with key industry participants located throughout the world. Key players (in alphabetical order) include Agilent Technologies (Agilent), BGI Genomics (BGI), Eurofins Scientific (Eurofins), Floragenex, Genewiz, Genotypic Technology Pvt. Ltd. (Genotypic), Global Plant Genetics (Global Plant), Hazera Genetics (Hazera), Hi Fidelity Genetics (Hi Fidelity), Illumina Inc (Floragenex) Inc. (Illumina), Keygene, LC Sciences LLC. (LC Sciences) Ltd. , (Novogene), Neogen Corporation (Neogen), Novogene Co., NRGene, Oxford Nanopore Technologies (Oxford), Plant Sciences Inc. (Plant Sciences), Qiagen RAPiD Genomics (RAPiD), Rev Genomics (Rev), Sequentia Biotech (Sequentia), and Traitgenetics GmbH (Traitgenetics). With respect to key end users, major seed and agricultural companies are the target end users of agricultural bioinformatics and include the likes of Corteva Agriscience, Syngenta, Tyson Foods/Cobb-Vantress, and Bayer Crop Science. More details on these players can be found in the global seed market section.

## *Growth Opportunities*

Genotyping services are one of the most important offerings in the entire plant and animal genomics market. Genotyping, particularly in plant genomics, is utilized to streamline the single-nucleotide polymorphism (SNP) discovery and empower the researchers to achieve experimental goals in a much more effective way. Genotyping services help in identifying inherited alleles and differences in the genetic makeup and composition between the plants and helps in the detection of small genetic differences which can lead to major changes in the phenotype and thus field performance. Genotyping is of great interest and broad day-to-dy use of genotyping to identify the variation at specific points in the DNA sequence of any plant species is growing.

Advances in technology in the field of plant genomics have unlocked several new dimensions providing a unique solution to cater to the increased demand for food. Despite various benefits offered by plant genomics, the market growth of these products may experience restraints due to their high initial deployment cost. The requirement of high capital investment on a large scale is acting as a burden impeding the growth of the global plant genomics market. In addition to this, the cost involved in establishing and maintaining different technology platforms associated with plant genomics is exorbitantly high, which tends to limit its adoption in low-income countries.

For example, the cost of NGS-based sequencing instruments ranges between $30,000 to $120,000. On the other hand, the median capital cost of genotyping varies in the range of $400-$60,000. Small and medium scale companies in the emerging markets, such as Brazil, India, Mexico, and Indonesia, lack significant funding for the incorporation of these platforms, thereby affecting the adoption rate of plant genomics in these countries. Furthermore, the necessary capital that is required to establish the infrastructure for utilizing modern technologies in plant genomics and its consequent comprehensive interpretation is often not present in most academic medical centers (AMCs), particularly in the current funding scenario. Also, these technologies require regular maintenance in order to keep them running. This concern of financial barriers has restricted some sections of industries and countries from adopting plant genomic solutions.

The development of several DNA sequencing strategies has been a high priority in plant genomics research. Moreover, the emergence of NGS technology has enabled high-throughput molecular analysis while playing an important role in exploring plant genomes in the construction of vast databases of the entire genomes. The field of genomics and proteomics research has undergone neoteric fluctuations because of next-generation sequencing (NGS). A paradigm-shifting technology, NGS provides higher accuracy, larger throughput, and more applications than the other platform. NGS technologies have well-founded applications in de novo assembly sequencing, whole-genome sequencing, transcriptome sequencing, and resequencing, at the DNA or RNA level.

Additionally, resequencing the plant genome with a known genome provides information about the relationship between genotype and phenotype and helps in identifying the differences in the reference sequences.

Next-generation sequencing offers enormous benefits in plant genomics as it determines the order of nucleotide basis in the DNA molecule. Additionally, DNA sequencing information is extremely useful for identifying the key genes to control the important plant genomic traits and identifying the genetic variation in the genome. Consequently, the number of sequenced crop genomes and associated genomic resources is growing rapidly with the advent and utilization of newly developed NGS methods. Next-generation sequencing is not only about increasing speed, but it also enables more cost-effective

sequencing in general. In September 2020, NRGene launched a SNPer that optimizes the genotyping processes and reduce genotyping costs by 70%. The sequenced data of the crops provide essential genomic resources for accelerating the knowledge of the biological properties of the plant. Thus, the growth in the utilization of next-generation sequencing technologies has opened new classes of opportunities for plant genome companies and researchers that allow them to invest in technologically advanced and unique technologies such as nanopore sequencing.

# 4. Competitive Landscape

The competitive landscape of the plant and animal genomics market consists of different strategies undertaken by major players across the industry to gain market presence. The competitive landscape for the plant and animal genomics market demonstrates an inclination toward companies adopting strategies, such as product launch and development and partnerships, collaborations, and joint ventures. The major established players in the market focus on partnerships, collaborations, and joint ventures to introduce new technologies or develop further on the existing product portfolio. KeyGene, N.V., Novogene, NRGene, Benson Hill, Oxford Nanopore Technologies, Genewiz, Eurofins Scientific, Computomics, LGC and Neogen are some of the prominent players in the plant and animal genomics market. The market is highly fragmented with the presence of a large number of small- to medium-sized companies that compete with each other and the large enterprises.

In order to generate public awareness about their existing and new products, technologies and compete with the competitors' product portfolio, key players operating in this market have ramped up their partnerships, collaborations, and joint venture activities over the recent years. This has been one of the most widely adopted strategies by the players in this market. For instance, In June 2019, NRGene entered into a partnership agreement with BGI for offering NRGene's technology as a part of its wide range of genomic analysis services in agriculture research. In October 2020, KeyGene and Tierra Seed Science entered into a research collaboration to identify the genes that are involved in the crop traits. Similarly, in January 2017, NRGene and Monsanto (now Bayer Crop Science) entered into a global licensing agreement for the utilization of big data genomics technology.

Moreover, extensive R&D activities and appropriate regulatory environments are also a prerequisite for the sustained growth of this market. Various government and private research institutes and favorable trade policies are putting in substantial efforts to identify the benefits of the plant and animal genomics market for augmenting global food production. The increase in the adoption of sophisticated biological-based technologies is necessary to bridge the demand and supply gap, along with attaining sustainability in production.

Overall, the market is highly fragmented and encompasses many private companies. However, there are basically three tiers of companies in the plant and animal genomics market which corresponds to their scale. Each tier is described below.

Tier One: These companies lead the market by the innovation of products, diversification of product portfolio, strong market share, and prominent clientele. They have made strong strategies in recent years to become market leaders in the plant genomics market. Wide market coverage based on large plant genomics market's shareholding and applications served along with the development of strong market leadership allows them to expand their potential to grow in the global plant and genomic genomics market in the next 5-10 years. This segment includes companies such as Eurofins Scientific, Agilent Technologies, BGI Genomics and Illumina, Inc.

Tier Two: These companies possess strength in the plant and animal genomics market due to their large market coverage. The large market coverage is majorly credited to the possession of the product portfolio that serves an agriculture application and holds a large market share. In recent years, these companies have made strong decisions to increase their capability and market coverage, which has successfully given them a competitive advantage in their domain. However, these market players have the scope to build upon their market leadership in different ways, such as increasing investment in R&D or growing brand popularity. This segment includes companies, such as Hazera Genetics, NRGene, Qiagen, RAPiD Genomics, Novogene Co., Ltd, Neogen Corporation, Floragenex, Inc. and Genewiz.

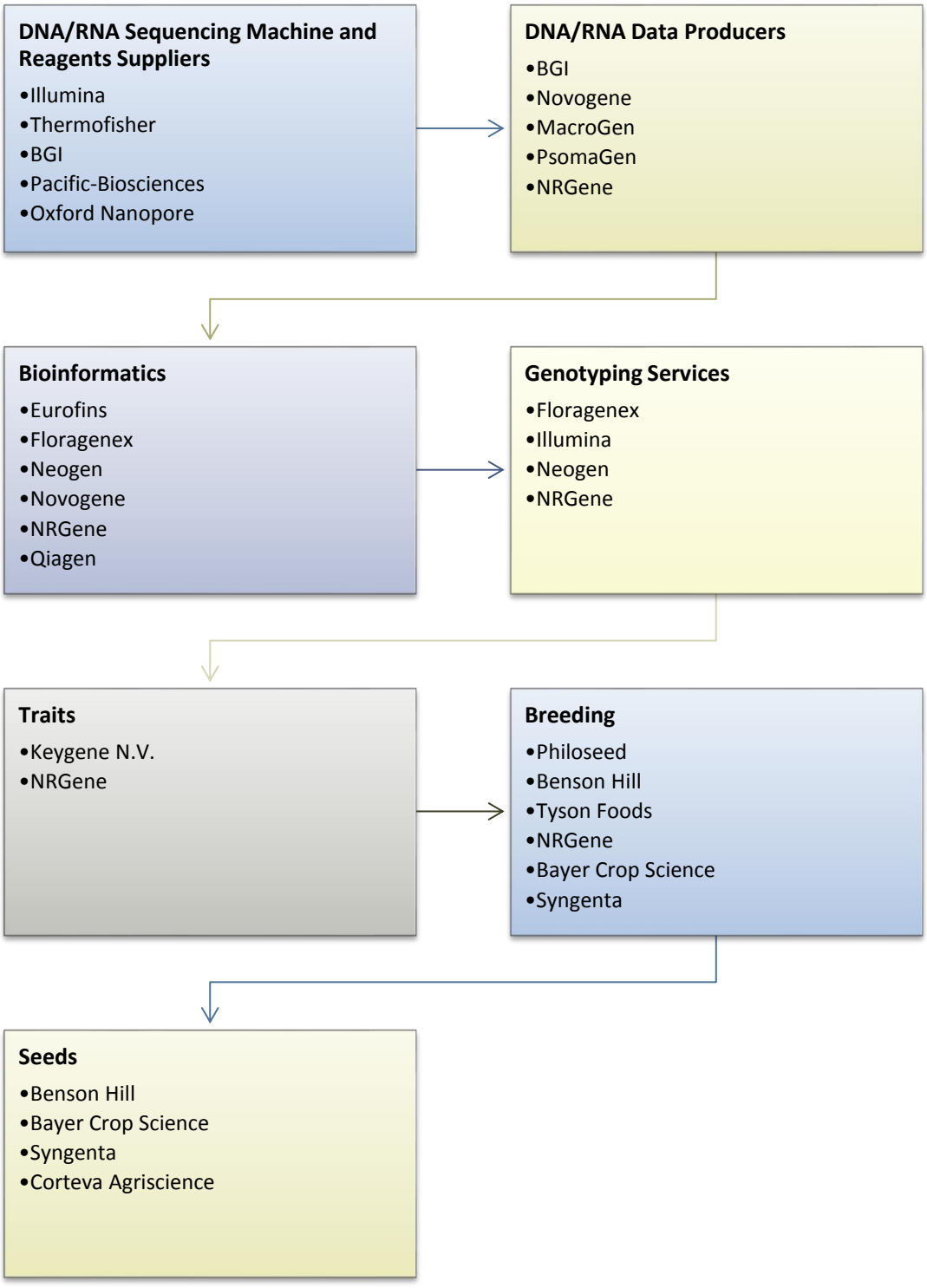
Tier Three: These companies are either new to the plant genomics market or concentrate on a niche area of the market. The product offerings by these companies do not necessarily cover a large market shareholding application, geography covered, or market strategies executed. These companies also possess an 'emerging' status in the market where they have scope to improve their leadership status in the market to invest further into the plant genomics market. This includes companies such as Rev Genomics, Computomics and Traitgenetics GmbH.

There are 7 levels of value chain in the plant and animal genomics market. DNA/RNA sequencing machine and reagents suppliers develop machines and reagents to downstream industry participants which turn

the DNA/RNA from a chemical compound to data (e.g long sequences of the four letters representing the four different basic building blocks of the DNA/RNA. This is a highly concentratd area where the 5 leading companies occupy more than 90% of global sequence data production market. DNA/RNA sequencing machine and reagents supplier companies include Illumina, Thermofisher, BGI, Pacific-Biosciences, and Oxford Nanopore. The next level of the value chain are the DNA/RNA data producers who operate thousands of labs globally which run the DNA/RNA sequencing machines and produce data for customers as a service. Most of the service labs are within academic/government institutes and hospitals. Over 100 companies perfom those services as their main business model. Some of the leading ones are BGI, Novogene, MacroGen, and PsomaGen.

Companies that collect and provide bioinformatics through DNA/RNA data analysis is the next level of the value chain. These companies provide the critical DNA/RNA data the rest of the value needs to identify genes that needs modification to change the final plant or animal product's quality and ability to successfully live and grow under certain unfavorable conditions (such as draught conditions). Bioinformatics is also used in genotyping services, the process of determining differences in the genetic make-up (genotype) of an individual by examining the individual's DNA sequence using biological assays and comparing it to another individual's sequence or a reference sequence. It reveals the alleles an individual has inherited from their parents. Traditionally genotyping is the use of DNA sequences to define biological populations by use of molecular tools. The output of genotyping service are traits, or an exact mapping of the genotype of the target plant and animal that will ultimately be cultivated and sold to downstream industry participants. Often times these traits are highly proprietary and only offered to downstream companies through licensing agreements. The IP for these traits are held by the company doing the genotyping service or is owned by the company who paid for the genotyping service from a third party. Most trait IP is help by the large agricultural companies who also sell proprietary seeds and other agricultural inputs. Key seed, trait and agricultural input companies in the value chain include Bayer Crop Science, Syngenta, and Corteva Agriscience.

## Global Plant and Animal Genomics Market Generalized Value Chain and Key Companies, 2021



## *Company Profiles of Key Industry Participants*

### BGI Genomics Co Ltd.

**Role of BGI Genomics Co Ltd. in Global Plant Genomics Market:** BGI Genomics Co Ltd., headquartered in China, is one of the leading companies in genomic sequencing services and and bioinformatic services. The company has a global footprint across all major regions and has customers in more than 60 countries. The company provides services to several research organizations, healthcare providers, pharmaceuticals, and other organizations. In the field of plant genomics market, the company offers sequencing services through the Illumina sequencing system or with the DNBSEQ sequencing system. Sequencing services are offered by identifying the genetic variation and discovering genetic changes of the sequenced species. The leading competitors of the company contributing significantly to the plant genomics market include Novogene Corporation, Illumina, Eurofins Scientific, and Genentech, among others.

**Product Portfolio**

| Solution | Description |
|---|---|
| **BGISEQ Sequencing Technology Service** | The company offers high-throughput sequencing solution which is especially developed BGI's Complete Genomics subsidiary in Silicon Valley. |
| **Whole Genome Resequencing** | The company also offers whole-genome resequencing services that are executed with DNBseq sequencing system or with the Illumina sequencing system. |

**Production Sites and R&D Analysis**

The company has operations in more than 60 countries and has research and development centers in all regions, including North America, Europe, Asia-Pacific and Japan, and China.

**Corporate Strategies**

| Company A | Company B | Type | Description |
|---|---|---|---|

| | | | |
|---|---|---|---|
| **BGI Genomics Co Ltd.** | genomiQa | Partnership and Collaboration | In March 2019, BGI Genomics and genomiQa entered into a partnership through a service agreement for whole-genome sequencing on BGI's DNBseq sequencing platform. |

**Strengths and Weaknesses of BGI Genomics Co Ltd.**

*Strengths*

- With good brand recognition and customers in more than 60 countries, the company has been able to offer sequencing services by partnering with the big industrial player.
- The company caters to a wide variety of sequencing services such as next-generation sequencing services, whole-genome resequencing services for the plant genome and basic bioinformatic analysis.

*Weakness*

- The company lacks presence in the U.K and the Middle East and Africa region with no research centers. This gives it limited access to Europe and the Middle East and Africa region, which is the emerging market for plant genomics technology.
- With political stress between the US and China, western companies might avoid using BGI services for high value or national sensitive projects.

## Eurofins Scientific

**Role of Eurofins Scientific in Global Plant Genomics Market:** Eurofins Scientific is one of the largest European companies that provides testing and support services to different industries, including pharmaceutical, food, environmental, and agriculture industries, among others. The company was founded in 1987 and is headquartered in Luxembourg. Eurofins Scientific is among the key players in the plant genomics market, having more than 30 years of experience. The company is globally known for its technologies and have established an outstanding team of more than 300 genomics experts. The established research and development team offers best practices and flexibility to their clients, which includes established large industry players to academic institutes. In the plant genomics sector, the company offers Agri genomics service support, which includes plant breeding. The company offers several latest technologies, such as sequencing and genotyping, in the plant genomics market. The leading competitors of the company contributing significantly to the plant genomics market include LGC, SGS, NRGene, Qiagen, Agilent Technologies, Neogen Corporation, KeyGene, and Illumina, Inc., among others.

**Product Portfolio**

| Solution | Description |
|---|---|
| **DNA/RNA Sequencing Technology** | The company offers advanced DNA and RNA sequencing services to decode the biological function of plants. The sequencing technology helps in knowing the genetic makeup of the plant, which helps build |

**Production Sites and R&D Analysis**

The company has more than 800 laboratories across 50 countries, including Argentina, Australia, Austria, Brazil, Germany, Chile, China, and India, among others. Eurofins Genomics, a subsidiary of Eurofins Scientific Group, has over 25,000 workforces in over 250 laboratories across 39 countries. Moreover, the Eurofins Genomics India corporate office is located in Bangalore with a 14000 sq. ft. facility and has more than 50 highly qualified and trained workforce.

**Corporate Strategies and Activities**

| Company A | Company B | Type | Description |
|---|---|---|---|
| **Eurofins Scientific** | na | Business Expansion | In March 2019, Eurofins Scientific expanded its business of AgroSciences services in the Mediterranean basin. |
| **Eurofins Scientific** | na | Business Expansion | In November 2018, Eurofins Scientific opened its first European field facility, which is majorly dedicated to variety testing in South-West France. |
| **Eurofins Scientific** | na | Business Expansion | In August 2017, Eurofins Scientific expanded its business operation in Chile and further expanded its capabilities in South America. |
| **Eurofins Scientific** | Agrowing | Partnership and Collaboration | In June 2017, the companies signed a collaboration agreement to develop the concept of automatic pests and disease detection. |
| **Eurofins Scientific** | Japan Analytical Chemistry Consultants Co. Ltd, Ecopro Research K.K. | Merger & Acquisition | In August 2017, the company acquired Japan Analytical Chemistry ConsultantsCo. Ltd. and Ecopro Research K.K. to provide agroscience services in Japan. |

**Strengths and Weaknesses of Eurofins Scientific.**

*Strengths*

- The company has strong recognition and brand value in several countries across the globe. Also, the company has an extensive R&D facility along with a number of talented employees to make them a leader in genomics technology.
- The company also formed various initiatives promoting the use of genome technologies for agricultural use.

*Weaknesses*

- The company's unstandardized usage of technology is subject to some restrictions, majorly due to regulations by government bodies.
- The company needs to modify its business model and infrastructure to accommodate the use of advanced genome technologies, which requires a lot of time and investment.
- The company needs to improve its internal bioinformatic services to significantly increase value for customers.

## Illumina, Inc.

**Role of Illumina, Inc. in Global Plant Genomics Market:** Illumina, Inc., headquartered in the U.S., is the global leadier which develops, manufactures, and markets several integrated systems for the DNA/RNA data production and analysis of genetic variations. The company has an extensive research and development team, which mainly focuses on several genome-related technologies. The company offers genomic sequencing and array-based solutions for genetic analysis in the area of consumer genomics and cancer, among others. The company has distributors in several locations across the globe such as the Americas, Asia-Pacific, Europe, and the Middle East and Africa. In the field of plant genomics market, the company offers several sequencing services, training, and consultations. The company offers its services to several industries, including agriculture, pharmaceuticals, genomic research centers, academic institute, and clinical research organizations, among others. The leading competitors of the company contributing significantly to the plant genomics market include NRGene, BGI, Thermofisher, Pacific-Biosciences, Oxford-Nanopore, Qiagen, Agilent Technologies, Neogen Corporation, KeyGene, and Eurofins Scientific, among others.

**Product Portfolio**

| Solution | Description |
|---|---|
| **Genotyping Solution** | The company offers genotyping services to their customers. The company's microarrays solution enables high-throughput screening of genomic markers for breeding decisions and informed selections. |
| **Sequencing Solution** | The company offers several tools for sequencing the plant genome of diverse species that helps in improving the productivity of crops. |

**Production Sites and R&D Analysis**

The company has rich employee strength across the globe, with about 65% of its global workforce located in San Diego and the Bay Area. The company has R&D and manufacturing centers in the U.S. and Singapore.

**Corporate Strategies and Activities**

| Company A | Company B | Type | Description |
|---|---|---|---|
| **Illumina, Inc** | na | Business Expansion | In August 2017, the company expanded its operations in the U.S. by opening a new 7-acre, 316,000 sq. ft. campus. |

**Strengths and Weaknesses of Illumina, Inc.**

*Strengths*

- The company has a strong global presence, brand-value in the market, and a great business strategy. This allows it to cater to a wider customer base across the globe.
- The company has an extensive research and development facility in the U.S. and Singapore, which focuses immensely on providing differentiated technologies and products across the globe.

*Weaknesses*

- The company has not been able to manage the challenges present by the new entrants in the plant genomics segment and has lost a small market share in niche categories.
- The investment in research and development is less compared to other companies in the industry. The company has not been able to compete with other players in terms of innovation.

## Neogen Corporation

**Role of Neogen Corporation in Global Plant Genomics Market:** Neogen Corporation is a U.S.-based company that develops and markets its products related to plant, food, and animal safety. The company has extensive research and development teams, focusing on expanding its services in genotyping for plants, animals, and microbes. The company's major products include diagnostic test kits, spoilage organisms, pesticide residue, and disinfectant. In the field of plant genomics, the company offers extensive options for plant genotyping. The company utilizes fixed arrays, SNP discovery, and genotyping by sequencing all sizes and species of plants. With the precise genotyping and sequencing information, the company aids in developing customized genotyping tools tailored to customer needs. Some of the services offered by the company include sequencing for SNP discovery, utilization of diagnostic tools to identify resistance of susceptible lines, and usage of bioinformatics to select the best SNPs for genome- wide association studies. The leading competitors of the company contributing significantly to the plant genomics market include key gene, LGC, Eurofins NRGene and Qiagen, among others.

**Product Portfolio**

| Solution | Description |
|---|---|
| **Plant Genotyping Service** | The company offers broad options for plant genotyping services, including sequencing for SNP discovery, building high and medium density SNP arrays to create genomic-based models, utilizing bioinformatics to select the best SNPs for genome studies, and utilizing diagnostic tools to identify resistant of susceptible lines. |
| **Fixes Array Testing** | The company offers fixed array testing services for different plant species such as apple, brassica, cherry, cotton, cowpea, grape, maize, peach, potato, rice, soy, tomato, and wheat. |

**Production Sites and R&D Analysis**

The company has research and development centers in the U.S., the U.K., Brazil, and Australia. In 2019, the company spent $12.8 million in research and development, which was 18% more compared to 2018.

**Strengths and Weaknesses of Neogen Corporation.**

*Strengths*

- The company has a strong research and development team placed in several locations across the globe. Moreover, the company spent $12.8 million in 2019, giving the company an edge over its competitors.
- The company has a stronghold in providing several services related to plant genomics due to its high research and development capabilities.

*Weaknesses*

- The company is highly prevalent and dependent on North America. High dependence for revenue generation on one or two regions can be a risk factor for the company.
- The company undertakes very limited strategic developments to increase its global footprints.

## QIAGEN

**Role of Qiagen in Global Plant Genomics Market:** Qiagen, headquartered in Germany, is one of the leading providers of samples to insight solutions to transform biological materials into valuable insights. The company has a strong research and development team, which majorly focuses on providing genomics services to the customers. In the field of plant genomics, the company offers genomic services, which include gene expression analysis, GMO DNA detection, and DNA methylation analysis. Moreover, the company also offers DNA extraction kits for the efficient isolation of high-quality DBA from different plant species. The leading competitors of the company contributing significantly to the plant genomics market include Keygene, NRGene, and Novogene Corporation, among others.

**Product Portfolio**

| Solution | Description |
|---|---|
| **Genomic Services** | The company offers genomic services for several plant species, including genotyping, gene expression analysis, GMO DNA detection, and DNA methylation analysis. |
| **DNA Isolation Kit** | The company also offers the DNA isolation kit for efficient isolation of high-quality DNA from a wide variety of plant species. |

**Production Sites and R&D Analysis**

The company has more than 35 subsidiaries in over 25 countries and has distributors in more than 60 countries. The company has research and development centers across the globe, which include countries such as Germany, the U.K., the U.S., and India.

**Corporate Strategies and Activities**

| Company A | Company B | Type | Description |
|---|---|---|---|
| **Qiagen** | na | Product Launch | In May 2018, the company launched the DNeasy PowerSoil pro kit to enhance the microbiome characterization in soils. |

| | | | |
|---|---|---|---|
| **Qiagen** | na | Product Launch | In November 2018, the company launched the DNeasy Plant Pro kit for efficient isolation of DNA from a wide variety of plant species. |
| **Qiagen** | OmicSoft Corporation | Mergers and Acquisitions | In January 2017, the company acquired the OmicSoft Corporation to enhance its bioinformatics portfolio. |

**Strengths and Weaknesses of Qiagen.**

*Strengths*

- The company has established research centers and distributors in most of the regions across the globe, which strengthen its brand value.
- The company has advanced in providing genomics services along with kits to isolate DNA of different plant species, which gives a competitive edge to the company.

*Weaknesses*

- The company is less active in collaborating with key players in the plant genomics market, affecting its distribution channel.
- The company is less active in the premium sequencing machines and reagent market.

## Benson Hill

**Role of Benson Hill in Global Plant Genomics Market:** Benson Hill, founded in 2012 and headquartered in the USA is focused on plant biology, agricultural gene-editing services and plant breeding. Leveraging its CropOS platform, the company combines plant science, data science, and predictive analytics to accelerate the development of new plant varieties. The company is moving toward becoming a more vertically-integrated food company focused on developing solutions for sustainable trends in the industry. Specifically, the company has formed two business segments and a new research facility to support the business expansion. One of the new business segments is its Ingredients business which is focused on enhancing plant-based protein attributes (e.g., soybean and pea) for use in the development of alternative meat products. Its other business unit, Fresh, is geared toward producing innovative functional foods with pharmaceutical benefits. The leading competitors of Benson Hill include Inari, Pairwise and VoloAgri, among others.

**Corporate Strategies and Activities**

| Company A | Company B | Type | Description |
|---|---|---|---|
| Benson Hill | Lagomaj Capital | Partnership and Collaboration | In February 2021, the two organizations set up a "Crop Accelerator" research facility in St. Louis |
| Benson Hill | CropTrak | Partnership and Collaboration | Benson Hill farmers are using CropTrak's cloud technology solution to track agronomic information, improve farmer profitability and deliver ESG metrics |
| Benson Hill | GV Wheatsheaf Group | Last Completed Financing | $159.1M of Series D venture funding deal |

**Strengths and Weaknesses of Benson Hill.**

*Strengths*

- The company has evolved into a vertically integrated food company with business lines directly aligned with two Mega Trends in the F&B industry – Alternative Meats and Functional Foods

*Weaknesses*

- Directly competing instead of collaborating with large Ag companies like Bayer, BASF, and Corteva Agriscience's biotech business lines may constrain the company's ultimate scale.

# 5. Financial Analysis & Valuation

## Valuation Method & Approach

In its early stages, a startup company's valuation can be challenging due to limited cash flow (if any) and uncertainty regarding the future. As part of a Discounted Cash Flow (DCF), the accepted method used in financial valuations, there are several modifications to a startup company's valuation. In general, there are four primary methods within the DCF method:

1. Real options – this valuation method is designated for pre-clinical and early-stage clinical programs/companies. The assessment is binary during the initial phases and based upon scientific-regulatory assessment only (binomial model with certain adjustments).
2. Pipeline assessment – a valuation method used for early-stage companies before the market stage where time-to-market may be a few years for full operations. The company's value is the total discounted cash flow for its products/signed agreements plus unallocated costs and its technology platform assessment.
3. DCF valuation - this method applies to companies with products that have a positive cash flow from operations.
4. Market benchmark – this method is based on recent deals (M&A and/or fundraising) within the company's domain and market multiples.

To evaluate NRGene's equity value, we based our valuation on the market benchmark approach.

## Company Financial Overview

NRGene's total revenue for H1 2021 amounted to $2.1M ($1.5M from Subscription, and the rest from Data analysis services), compared with $2.8M in H1 2020. The Company's backlog as of June 31, 2020, was approx. $6.6M. As of June 30, 2021, the company's backlog was estimated at approx. $6.1M.

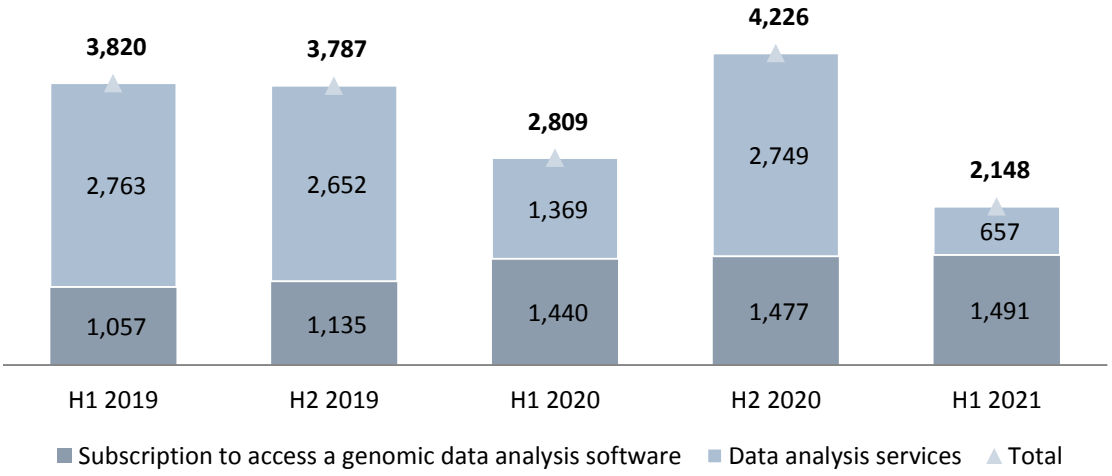
As of June 30, 2021, the company had $21.9M in cash, $5.0M in short term bank deposits and an insignificant amount of loans; the company equity was NIS 20.5M; net loss in H1 2021 was $4.7m, compared to a loss of $1.9M in H1 2020.

In 2021 H1, NRGene closed its TASE listing, raising ~$30M gross according to approx. $114.6M post-money valuation.

Until recently, NRGene provided AI-based software solutions through two complementary business models:

1. **Subscription to access a genomic data analysis software** - The customer engages in a multi-year agreement and receives access to the Company's software and services.
2. **Data analysis services** - The Company provides computational and bioinformatic services to support the R&D efforts of its customers, aiming to develop new elite varieties. The Company revenue is comprised of payments for those services.

**Revenue By Product (in thousand USD), 2019-2021**




As part of its strategy, the company decided to focus on long-term and recurring transactions. As estimated by the company, these types of engagements are preferable for its clients as it reduces the involved risk for them and expands NRGene's profit at the same time. Therefore, in the past months, the company refined its business model to include the following segments:

1. **IP Development –** In this model, NRGene initiates and leads projects to develop IP with partners (such as the development of peas and hemp for the meat substitutes industry or the development of high quality cherry tomatoes) and even develops IP independently of a partner (such as the development of canola resistant to fungal disease). In a mutual development project, the partner enjoys a final product (seeds or varieties) and pays the company royalties from its revenue. Therefore, the partners' financing and business risk decrease, as the payment to NRGene depend on achieving the development goals and the customer's future revenue. The royalty rates for developed traits can vary between 1%-15%, on certain traits and for new variaties between 35%-70% of partners income (minus production and S&M costs). In some cases, partners also pay a down payment for securing the right to integrate the developed trait or variety.
2. **Genetic testing** - In this model, the company provides its customers with a complete genetic testing solution including custom project design, data production, generic panels, and genetic test analyses. These tests efficiently identifies the individuals within a broad breeding population with the most favorable genetic makeup. NRGene estimates that the costs of its solution are lower compared to existing solutions in the market. In addition, following results from the company's existing projects, its solution achieves even more accurate results than other solutions existing in the genetic testing market.

Since its IPO, the company has invested heavily in building a medium- and long-term growth infrastructure that focuses on **developing IP against royalties** and developing the company's activities in the field of **genetic testing** (e.g., the establishment a genotyping lab to enable greater scale of operation). To achieve these goals, there was an increase in the Company's operating expenses. At the same time, the Company's revenues were affected by a decrease in the resources allocated to the field of genetic information analysis services. The company estimates that the development process of a new IP development project is 2-5 years until commercialization begins.

In light of the shift to recurring and royalties-based revenue, we expect the company revenues in 2021 to decrease compared with 2020. Yet, we believe that the Company's potential will be seized in the next few years, as projects currently under development will reach commercialization and generate significant revenues.

## Financial AgTech Market Overview

Agriculture is one of the oldest areas of technology and innovation in existence, and its objectives have changed little throughout history: finding ways to increase yields and maximize key traits of crops or animals being raised, such as size, flavor, color, and resistance to pests. Modern Agtech startups began attracting venture funding roughly a decade ago, with the industry raising $322.2 million in 2010. **Since then, the agriculture industry has consistently gained VC interest over the past decade, attracting $6.4 billion in funding in 2020. This explosive growth is a direct result of two primary factors: population growth and climate change.** The global population is expected to swell to 9.8 billion people by 2050, driving more demand for food.[ii] At the same time, greenhouse gases are warming climates and creating increasingly frequent extreme weather events that threaten crop yields. We estimate the AgTech market opportunity generated roughly $280 billion in revenue in 2020, growing in the low single digits annually to reach $345 billion by 2025.

**Pandemic Reveals Vulnerabilities in the Agriculture Ecosystem**

COVID-19 exposed vulnerabilities in the agriculture system, such as suppliers' inability to pivot packaging and supply chain capabilities, leading to significant food waste. We believe the pandemic will accelerate trends such as the adoption of automation and robotics technologies. We expect new opportunities to arise as growers seek solutions in this new environment.

### Ag Biotech Market Overview

Ag biotech includes agricultural inputs and services that improve crop or animal production yields using biological or chemical processes. Technologies in this segment are expansive, including everything from genetics and microbiomics to fertilizers and genetically modified organisms (GMOs), from breeding technologies to animal health feed additives.

For decades, the industry has been dominated by the "big six" agribusinesses: Dow (NYSE: DOW), DuPont (NYSE: DD), Monsanto, Bayer (ETR: BAYN), Syngenta, and BASF (ETR: BAS). However, recent consolidation and the emergence of innovative VC-backed startups have allowed the industry to evolve. Despite several new names, the new "big five"—ChemChina, Bayer (ETR: BAYN), BASF (ETR: BAS), DuPont (NYSE: DD), and Dow (NYSE: DOW)—continue to overshadow the industry. However, ag-biotech startups are finding a niche by addressing emerging trends and evolving consumer preferences, such as developing inputs that support sustainable, organic, and GMO-free agriculture. Current sub-segments of ag-biotech include:

**Plant biotech:** Companies developing GMOs, microorganisms, fertilizers, and other treatments to maintain and improve crop yields.

**Animal biotech:** Companies developing biotech solutions to optimize animal health and production including genetics, breeding, feed, and animal health.

### Market size

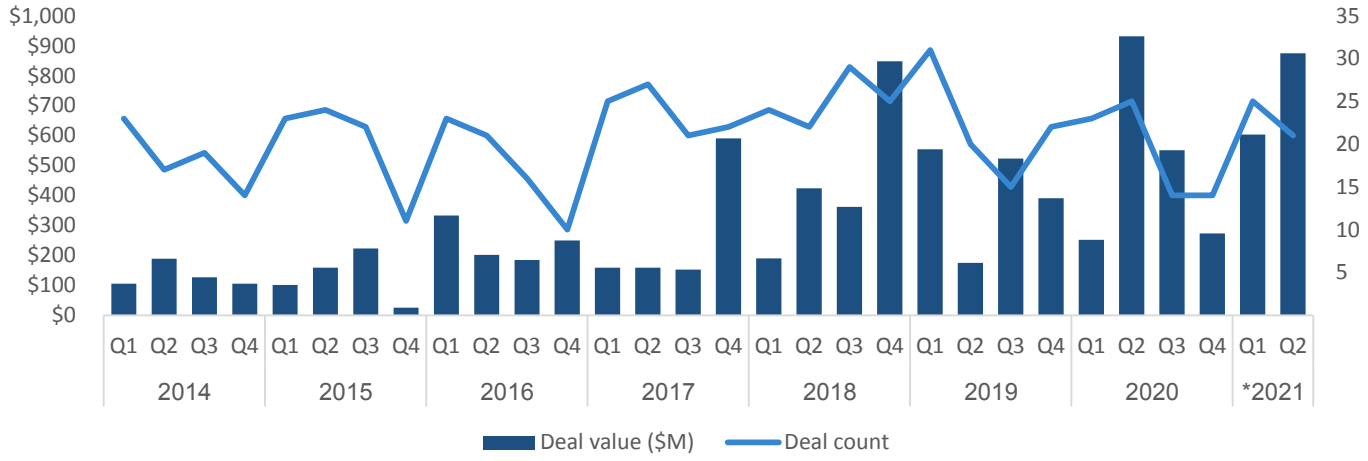
We estimate the global Ag biotech market to be $34.7 billion in 2021, growing at 10.1% CAGR to reach $56.2 billion by 2026, excluding any structural market disruptions due to COVID-19[1].

### VC activity

Ag biotech continues to be a magnet for venture activity, attracting $874.2 million across 21 deals in 2021 Q2, a 45% increase over Q1 deal values. In 2020, VC deal activity reached $2.0 billion across 76 deals, up 21.8% YoY.

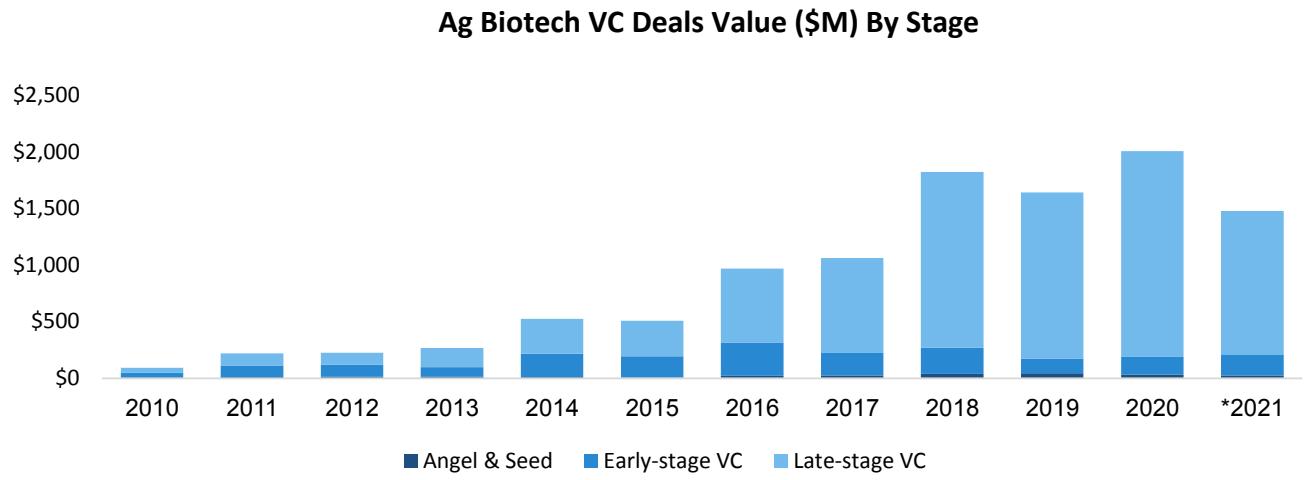
We anticipate continued substantial investment in ag-biotech companies given the price premiums retailers are willing to pay for organic products, growing demand for resilient and environmentally friendly agricultural practices, and increasing awareness of climate change and food security issues.

**Ag Biotech Quarterly VC Deal Activity**




Source: PitchBook | Geography: Global | *As of June 30, 2021

[1] Source: Reportlinker, Research & Markets, and PitchBook.




Source: PitchBook | Geography: Global | *As of June 30, 2021

## Recent deals as a valuation benchmark

### Last Known Pre-Money Valuation

We analyzed a database of approx. 630 deals of Ag Biotech companies, using data from Pitchbook, a financial database. To form a representative sample, we cleaned the data by removing deals made before 2019, angel/seed deals, or observations that had partial data. Based on the mentioned sample, we calculated the Ag Biotech VC's average last known pre-money valuation size to be $146.0M (n=22, appendix 2). **This benchmark stands in line with NRGene valuation at its IPO of approx $114M.**

## Valuation by EV/Revenue multiple

A revenue multiple measures the value of the equity of a business relative to its revenue. As with other multiples, other things remaining equal, firms that trade at low multiples of revenues are viewed as cheap compared to firms that trade at high multiples of revenues. Companies that are evaluated based on future growth are expected to sustain high growth rates over a longer period, have a significant TAM with insignificant penetration, and have a significant competitive advantage over their competitors. The multiple used is often a function of the sustained growth rates. However, we see the downside of focusing on revenues, which can lead to high values for firms generating high revenue growth while losing significant amounts of money, ending in raising more funds and diluting existing shareholders. As long as the valuation

increase is based on high growth rates rather than the dilutive factor – shareholder value is sustained. As a general note, ultimately, a firm has to generate earnings and cash flows to have value.

We used the following multiples for our valuation:

1. We examined NRGene's agriculture/farming industry, using data from 32 firms (as of 2020[iii]). We found that the average EV/Revenue was 1.35.
2. We also calculated an AgTech industry revenue multiple based on a similar companies sample using Pitchbook's data set. The average revenue multiple for the mentioned sample is 12.5, and the median revenue multiple is 7.1 (for more details, see appendix 2).

Above all mentioned multiples, we determine that our median AgTech revenue multiple (=7.1) is the most suitable for evaluating NRGene activity.

We believe that NRGene is still in the early stages of penetrating the market with its products and anticipate high growth in revenues in the next 5-7 years. As mentioned above, we deem that the company revenues at 2021 aren't representing its potential.

We applied the First Chicago Method to use valuation multiples, which VCs use to evaluate growth firms like NRGene[iv]. NRGene's current revenue doesn’t reflect its potential, so we used similar companies' revenues as a benchmark. Based on our sample, the average revenue for a company in the same specific market was US$39.9M (see appendix 2).

Therefore, assuming it would take NRGene approx. 5 years to reach US$40M revenues, alternatively, US$13.1M at present (using our CAPM rate and additional risk we added to reflect future risk). Thus, following the first Chicago method, NRGene's current EV will be US$13.1M multiplied by 7.1, which equals US$93.0M. Lastly, we added the cash as a non-operational asset of US$26.9M. **Thus, according to our revenue multiple, we value NRGene activity at $119.9M.**

### Recent deals as a valuation benchmark

We present another benchmark to NRGene's equity value by pointing to specific deals we identified as highly relevant to NRGene:

- Benson Hill (NYSE: BHIL) focuses on plant biology, agriculture gene-editing, and plant breeding. The company's CropOS breeding platform allows plant breeders to combine plant science, data science, and predictive analytics tools to accelerate the development of new plant species. The company completed a $159.1M of Series D venture funding in a deal led by GV and Wheatsheaf Group. After the D-round financing, it was valued at US$2 billion at its IPO (May 10, 2021).
- 10X Genomics (NASDAQ: TXG) is a solutions and security systems company that provides an innovative genomics platform. 10X Genomics has raised a total of $242.6M in funding over 6 rounds. Their latest funding was raised on Jan 7, 2019 from a Series D round. After the D-round financing, it was valued at US$3.7 billion at its IPO (September 11, 2019). As of 28/10/2021, the company was traded at an EV/ TTM Revenue multiple of 43.7.
- Pacific Biosciences (NASDAQ: PACB) designs, develops and manufactures sequencing systems to resolve genetically complex problems. Pacific Biosciences has raised a total of $1.3B in funding over 8 rounds. Their latest funding was raised on Feb 10, 2021, from a Post-IPO Debt round. As of 28/10/2021, the company was traded at an EV/ TTM Revenue multiple of 53.6.
- Twist Bioscience (NASDAQ: TWST) is a synthetic DNA production for specialty chemical compounds and drug development. Twist Bioscience has raised a total of $253.1M in funding over 8 rounds. Their latest funding was raised on Apr 2, 2018, from a Venture - Series (Unknown round). The company was valued at US$372.4 million at its IPO (October 30, 2018) and is traded today for approx. $5.9 billion. As of 28/10/2021, the company was traded at an EV/ TTM Revenue multiple of 46.3.
- Illumina (NASDAQ: ILMN) is an innovative technology company that develops, manufactures, and markets integrated systems for the analysis of genetic variation and biological function. Illumina has raised a total of $28M in funding over 1 round. This was a Venture - Series (Unknown round) raised on Jan 10, 2000. As of 28/10/2021, the company was traded at an EV/ TTM Revenue multiple of 16.4.
- Invitae (NYSE: NVTA) is a medical genetics company that brings comprehensive genetic information into mainstream medicine to improve healthcare. Invitae has raised a total of $2B in funding over 8 rounds. Their latest funding was raised on Apr 5, 2021, from a Post-IPO Debt round. As of 28/10/2021, the company was traded at an EV/ TTM Revenue multiple of 15.4.
- Personalis (NASDAQ: PSNL) is a contract research organization and genome-scale diagnostics services company specializing in genome-guided medicine. Personalis has raised a total of $225.1M in funding over

4 rounds. Their latest funding was raised on Jan 27, 2021, from a Post-IPO Equity round. As of 28/10/2021, the company was traded at an EV/ TTM Revenue multiple of 10.3.

## Valuation summary

NRGene is a growth firm. Thus, we based our valuation on current and future market trends and the company's assumption for future operations. Due to the high growth in the Ag Biotech market and the uniqueness of NRGene solution, we estimate the company is well-positioned to generate significant growth in the foreseeable future.

**We conducted NRGene's valuation using market benchmarks from recent deals and analysis of VC's activity; Given the assessments and findings mentioned above, we value the company's stock price target in the range of NIS 29.4 to NIS 32.4, and a mean of NIS 30.9.**

## Appendix #.1: Capitalization Rate (CAPM)

The cost of equity capital (Ke) represents the return required by investors. The capitalization rate is calculated using the CAPM (Capital Asset Pricing Model). It is based on an Israeli long-term 10-year governmental bond with a market risk premium and based on Professor Aswath Damodaran's (NY University) commonly used sample (www.damodaran.com ). As of January 2021, the equity risk premium for Israel was estimated at 5.4%.

A three-year market regression averaged Beta is 0.66, according to a sample of 32 companies representing global Farming/Agriculture companies. We used an unleveraged beta of this sample, which is higher than a leveraged beta due to the high cash versus debt rate.

NRGene is a small-cap company in which marketability and size premiums need to be considered. Duff and Phelps' data research in 1963-2020 indicates that a 10.24% premium needs to be added to the CAPM for small-cap companies. Due to the company early growth stage, additional risk premium of 4% should be considered.

CAPM model (ke) is estimated as follows*:* ***ke = rf + β(rm-rf) + P***

| CAPM Model | Parameter | Data | Source |
|---|---|---|---|
| Long-term (10 years) T-bond | R(f) | 1.21% | Rf - Israeli treasury bonds - 10 years, as of 10/10/2021 |
| Market risk premium | R(m)- R(f) | 5.4% | Based on Damodaran (08/01/2021) - Israel |
| Beta | βe | 0.66 | Beta sample - Farming/Agriculture (Demodaran, 2021), 32 firms |
| Size Premium - micro cap | Sp | 10.24% | 10z decimal - Duff & Phelps, 2020 |
| Additional risk | Ar | 10.0% | |
| **CAPM** | | **25.0%** | |

We, therefore, estimate the company's CAPM to be 25.0%.

# Appendix #.2: AgTech Industry Revenue Multiple Calculation Dataset

| Company Name | Description | Revenue | Last Known Pre-Money Valuation | Revenue Multiple | Last Known Valuation Date | HQ Country |
|---|---|---|---|---|---|---|
| Agrivida | Developer of grainzyme technology designed to produce enzymes and other proteins inside a kernel of corn. The company's platform offers a natural, convenient, and profitable way to introduce beneficial enzymes such as phytase, glucanase, and other enzymes into animal diets, enabling poultry and swine market clients to reduce negative environmental impact and produce more healthy food. | 1.4 | 68.7 | 48.4 | 24-Jul-2019 | United States |
| Biome Makers | Developer of a microbiome technology designed to provide a functional understanding of soil to improve agricultural production and quality. The company's technology uses DNA sequencing and intelligent computing to provide detailed crop-specific insights and recommendations in a simplified manner, enabling growers and manufacturers to analyze the soil ecosystem and access data-driven insights. | 1.2 | 40.0 | 33.3 | 16-Aug-2021 | United States |
| Arcadia Biosciences (NAS: RKDA) | Arcadia Biosciences Inc is engaged in science-based approaches to developing high-value crop improvements primarily in wheat, soy, and hemp, designed to enhance farm economics by improving the performance of crops in the field, as well as their value as food ingredients, health, and wellness products, and their viability for industrial applications. It has used advanced breeding techniques to develop these proprietary innovations which it is now commercializing through the sales of seed and grain food ingredients and products, hemp extracts, trait licensing, and royalty agreements. | 9.7 | 320.3 | 33.1 | 15-May-2015 | United States |
| Pipe Ag | Developer of agriculture technology designed for farmers to improve in-field logistics and efficiencies with the existing equipment. The company's technology offers real-time harvest information, compaction mapping, farmland navigation, fleet or equipment management, tracking and reporting, and other related tools or features, enabling harvesters or growers to enhance their farm operations and save time and costs. | 0.3 | 8.0 | 32.0 | 31-Dec-2021 | United States |
| GroGuru | Developer of precision soil and irrigation monitoring systems designed to remotely monitor and analyze soil data. The company's systems offer an IoT sensor network for agriculture that gives farmers precise measurements of soil moisture, salinity, and temperature and also translates those into recommendations for timing, amount of water and fertilizer application, enabling farmers and agriculture industry players to decrease input costs such as water, energy and fertilizer expenditure. | 0.6 | 14.7 | 23.8 | 24-Aug-2021 | United States |
| Doselva | Provider of a platform intended to grow, process and market spices organically in agro-forests with smallholder farmers. The company serves as an anchor business for the provision of plant material, agriculture technical advisory and financial services, and market access, enabling farmers to specialize in vanilla, turmeric, | 0.2 | 3.9 | 17.0 | 01-May-2021 | Nicaragua |

| | | | | | | |
|---|---|---|---|---|---|---|
| | ginger, and cardamom cultivation and to successfully grow new crops. | | | | | |
| Persistence Data Mining | Developer of a non-intrusive remote survey platform designed to improve soil management and promote proactive and efficient fertilizer use. The company's platform provides real-time soil nutrient information mapped over very large stretches of farmland, enabling farmers to increase crop yields, optimize input costs and improve environmental protection. | 0.1 | 1.9 | 14.9 | 01-May-2016 | United States |
| Farmers Edge (TSE: FDGE) | Farmers Edge Inc leads the agricultural revolution with the industry's broadest portfolio of proprietary technological innovations, spanning hardware, software, and services. Powered by a unique combination of connected field sensors, artificial intelligence, big data analytics, and agronomic expertise, the company's digital platform turns data into actions and intelligent insights, delivering value to all stakeholders of the agricultural ecosystem. Farmers Edge disruptive technologies accelerate digital transformation on the farm and beyond, protecting its global resources and ensuring sustainable food production for a rapidly growing population. | 35.4 | 446.3 | 12.6 | 03-Mar-2021 | Canada |
| Verge (Business/Productivity Software) | Developer of farming operation management software intended to optimize and automate agricultural operations. The company's software offers path planning, growing season analysis, bulk operations, multi-field optimization, processing notifications, layering path plans, visualize optimized path plans, and other related services, helping clients to optimize field operations, visualize path plans and maximize productivity. The company's software empowers a farmer to execute their field operations with their existing equipment at a level of productivity and efficiency previously out of reach. | 0.5 | 6.0 | 12.0 | 17-Dec-2019 | Canada |
| Mesur.io | Developer of an earth stream platform designed to provide growers and enterprises with real-time environmental analytics. The company's platform calibrates and transmits relevant agricultural data while analyzing and combining it with other sources of information to make concise recommendations, thereby enabling agricultural enterprises to leverage their existing data to automate processes and save money on labor, water, and raw materials. | 0.6 | 5.0 | 7.9 | 23-Aug-2021 | United States |
| Precision BioSciences (NAS: DTIL) | Precision BioSciences Inc is a genome editing company dedicated to improving life through its genome editing platform, ARCUS. It leverages ARCUS in the development of its product candidates, which are designed to treat human diseases and provide food and agricultural solutions. The company's segments include Therapeutics and Food. | 101.4 | 768.5 | 7.6 | 28-Mar-2019 | United States |
| Bushel | Developer of an agricultural platform designed to connect and enhance the grain trading business through digital infrastructure. The company's platform provides growers with instant access to scale tickets, contracts, prepaid, commodity balances, cash bids, and market information through grain facility-branded applications, enabling farmers grain buyers, protein producers and food companies to share information, complete transactions | 18.0 | 120.0 | 6.7 | 20-Apr-2021 | United States |

| | | | | | | |
|---|---|---|---|---|---|---|
| | efficiently, and gain insights into commodity management. | | | | | |
| Croptimistic Technology | Developer of mapping software designed to develop resourceful Agtech solutions to increase productivity for users. The company's software integrates layers of field data into a single soil foundation map for variable-rate fertilizer and seed applications, collects soil electrical conductivity data and manages soil moisture and informs in-season decision-making for applications such as variable-rate topdressing, fungicide, or irrigations optimize inputs and manage field variability. | 2.0 | 12.3 | 6.2 | 04-Jun-2021 | Canada |
| Anupam Rasayan India (BOM: 543275) | Anupam Rasayan India Ltd is engaged in the custom synthesis and manufacturing of specialty chemicals in India. The company's business verticals are life science related specialty chemicals comprising products related to agrochemicals, personal care and pharmaceuticals, and other specialty chemicals, comprising specialty pigment and dyes, and polymer additives. | 123.4 | 657.3 | 5.3 | 24-Mar-2021 | India |
| AgEagle Aerial Systems (ASE: UAVS) | AgEagle Aerial Systems Inc is a provider of drone imagery data analytics for the precision and sustainable agriculture markets. It designs, produces, distributes, and supports technologically-advanced small unmanned aerial systems (UAVs) that it offers for sale commercially to the precision agriculture industry. The company derives revenue from product sales and subscription sales, of which most of the revenue is derived from product sales. | 4.5 | 23.1 | 5.1 | 15-Feb-2017 | United States |
| Zhejiang Benli Technology (SHE: 301065) | Zhejiang Benli Technology Co Ltd is engaged in the research and development, production and sales of pharmaceutical intermediates, pesticide intermediates, and new material intermediates. | 98.4 | 347.8 | 3.5 | 14-Sep-2021 | China |
| The Dream Farm | Developer of smart farm technology designed to help farmers in cultivation of crops without pesticides. The company's technology aims to maintain and manage farms in optimal conditions, plan production and mass production in a short period of time also the technology can be easily operated from mobile phone, enabling farmers to avail advance methods of farming. | 18.5 | 44.6 | 2.4 | 22-Jun-2021 | South Korea |
| Agrify (NAS: AGFY) | Agrify Corp provides hardware and software to grow solutions for the indoor agriculture marketplace. The products offered by the company include Integrated Grow Racks, LED Grow Lights, Hydroponics, and Vertical Farming Units. | 26.0 | 51.8 | 2.0 | 28-Jan-2021 | United States |
| Belchim Crop Protection | Manufacturer and seller of crop protection products based in Londerzeel, Belgium. The company's crop protection products offers specialized chemicals for sustainable crop management for agriculture industry. | 213.3 | 166.5 | 0.8 | 17-Jun-2021 | Belgium |
| Growgenics | Manufacturer of advanced LED horticultural lighting technology intended to optimize plant growth. The company's technology aims to address plant growth related problems via advanced variable color spectrum and LED shape lighting, enabling farmers to maximize the delivery of photonic energy. | 4.3 | 2.3 | 0.5 | 19-Oct-2018 | United States |
| Village Farms International (TSE: | Village Farms International Inc, along with its subsidiaries, owns and operates agricultural greenhouse facilities. It produces, markets, and sells tomatoes, bell peppers, and cucumbers. It also produces power. The company operates its business through | 213.2 | 101.9 | 0.5 | 11-Jan-2018 | Canada |

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|---|---|---|---|---|---|---|
| VFF) | segments that are Cannabis, Produce and Energy. The Produce Business segment generates maximum revenue for the company. The Cannabis segment produces and supplies cannabis products to be sold to other licensed providers and provincial governments across Canada and internationally. | | | | | |
| CubicFarm Systems (TSE: CUB) | CubicFarm Systems Corp is an ag-tech company providing automated growing systems for fresh produce and animal feed. It offers turnkey, commercial scale, hydroponic, automated controlled-environment growing systems that can grow predictably and sustainably for 12 months of the year virtually anywhere on earth. The company enables its customers to grow locally and to provide their markets with safe, sustainable, secure and fresh ingredients that are consistent in colour, size, taste, nutrition and allows for a longer shelf life. Further support is provided to customers through the Company's patent-pending germination technology and proprietary auto harvesting and processing methods. | 3.8 | 1.5 | 0.4 | 24-Oct-2017 | Canada |

## Appendix #.3: About Frost & Sullivan

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# Endnotes

[i] "World Population Projected to Reach 9.8 Billion in 2050, and 11.2 Billion in 2100," United Nations, June 21, 2017.

[ii] "World Population Projected to Reach 9.8 Billion in 2050, and 11.2 Billion in 2100," United Nations, June 21, 2017.

[iii] http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datacurrent.html#multiples

[iv] Rothman, T. "Valuations of Early-Stage Companies and Disruptive Technologies: How to Value Life Science, Cybersecurity and ICT Start-ups, and their Technologies'', Springer Nature, 2020.