SEED TREATMENT INDUSTRY-
HISTORICAL PERSPECTIVES

Presented By
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<tr>
<th><strong>AGENDA</strong></th>
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STRUCTURAL SHIFT IN SEED TREATMENT TECHNOLOGY

**Till 1990**
- Old chemistry
- Imprecise application methods
- High loading rates
- Exposure concerns
- Poor handling formulations

**Till 2010**
- Highly active and low-rate chemistry
- Better seed treatment formulations & consistent performance
- More precise application equipment
- Introduction of seed coating

**Current & Forward**
- Evolution of agricultural biologicals use in seed treatment
- Combination of chemistry & biologicals
- Commercialization of seed products as yield enhancement products
- Evolution of precision farming concept
- Seed treatment products for abiotic stress tolerance
SEED TREATMENT TECHNOLOGY – HISTORICAL PERSPECTIVE - 1800’S

First soaking technique, use of sap of wine, onion & cypress leaves extracts
APPROX. 2000 B.C. TO 100 A.C.

MIDDLE AGES
Soaking in Chlorine salt and manure

1600’s MID
Soaking in salt water

1700’s
Beginning of fungicide seed treatment - introduction of copper salt

1740’s
Introduction of arsenic chemicals

1760’s
Soaking in hot water (Germany)

1770’s
Widespread of seed treatments with the identification/discovery of seed-borne fungus (bunt)

1807
Discovery of the black smut dust
Copper sulfate was discovered

1808
Ban on arsenic chemicals in Germany

1897
Formaldehyde was introduced as a replacement for copper sulfate

EVOLUTION, IMPORTANCE, UNDERSTANDING, & BEGINNING OF ADOPTION OF SEED TREATMENT TECHNOLOGY
SEED TREATMENT TECHNOLOGY – HISTORICAL PERSPECTIVE - 1900’S

- **1900’s**: Era of introduction of new modern fungicides and insecticides.

**1928**
- The first international rules for testing seed increased attention to seed-borne pathogens and insects.

**1948**
- Discovery & use of Captan fungicide.

**1950's**
- First use of seed treatment insecticides.

**1960's**
- Introduction of first systemic fungicide.

**1970's**
- First systemic fungicide against airborne pathogens.

**1982**
- Ban of organo-mercurial compounds.

**1984**
- Water based seed treatment formulations developed.

**1985**
- Discovery of Imidacloprid & concept of film coatings.

INNOVATIONS & DEVELOPMENTS IN SEED TREATMENT TECHNOLOGY (EQUIPMENT)

INNOVATIONS ON CHEMISTRY & COMMERCIALIZATION OF NEW SEED TREATMENT FUNGICIDE PRODUCTS

1900’S IS THE ERA OF INTRODUCTION OF NEW MODERN FUNGICIDES AND INSECTICIDES
An active substance was launched as a liquid seed treatment under the brand name Uspulun in Germany.

Authorities in the Grand Duchy of Baden order farmers to treat cereal seed with Uspulun to recover from the mass starvation from 1916-1918.

Uspulun first exported to Mexico.

Bayer Biological Institute setup in Leverkusen.

Mechanical seed treater invented in the U.S.

Bayer launches Caresan, a dry seed treatment.

- First commercial seed treater developed in the U.S
- Contract seed treatment concept emerged

Ben Gustafson develops first cottonseed treater in North Dakota (U.S.).

Seed Testing stations opened in Japan.
### SEED TREATMENT TECHNOLOGY (EQUIPMENT) INNOVATIONS & DEVELOPMENTS

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1945</td>
<td>Gustafson develops first slurry treater to treat hybrid corn seeds</td>
</tr>
<tr>
<td>1946</td>
<td>First patent for seed pelleting technology</td>
</tr>
<tr>
<td>1955</td>
<td>Launch of Mist-O-Matic seed treaters</td>
</tr>
<tr>
<td>1958</td>
<td>Triple Treat seed treater introduced</td>
</tr>
<tr>
<td>1961</td>
<td>Introduction of Mesurol seed treatment</td>
</tr>
<tr>
<td>1966</td>
<td>Variable speed seed treaters introduced</td>
</tr>
<tr>
<td>1978</td>
<td>Incotec started seed coating activities in U.S.</td>
</tr>
<tr>
<td>1979</td>
<td>Concep, the first sorghum seed safener, is introduced</td>
</tr>
<tr>
<td>1980</td>
<td>A broadly based communication campaign introduced the new era in seed treatment as Baytan replaced banned mercury based products</td>
</tr>
<tr>
<td>1881</td>
<td>Model 200 Rotary Seed Cleaner introduced</td>
</tr>
</tbody>
</table>
| 1982 | • Apron, the first seed treatment fungicide to offer protection from downy mildew, enters market  
• Launch of on-farm seed treater |
INDUSTRY STRUCTURAL CHANGES OVER THE YEARS – TECHNOLOGY & COMPANY DEVELOPMENTS (3/6)

1984
Water based seed treatment formulations developed
• Discovery of Imidacloprid.
• Patented metering system in the U.K. for liquid based formulations
• Launch of Certop film coatings

Bayer opens first Seed Growth center in Monheim (Germany).

1985
• Discovery of Imidacloprid.
• Patented metering system in the U.K. for liquid based formulations
• Launch of Certop film coatings

1986
Bayer opens first Seed Growth center in Monheim (Germany).

1987
Bayer launches film coating brand Peridiam

Introduction of computerized seed treaters

1988
Launch of on-seed fungicide Raxil

1989
Launch of on-seed insecticide Gaucho

1991
Maxim seed treatment fungicide, the first seed treatment to be registered under the EPA's “Reduced Risk” classification, is launched

1993
Dividend, the first broadspectrum systemic fungicide for cereals, receives registration

1994
Cruiser, the first seed treatment insecticide launched globally

1997
Launch of Bayer Quantum 30 TPH batch treater in the UK.

2000
INNOVATIONS ON CHEMISTRY & COMMERCIALIZATION OF NEW SEED TREATMENT FUNGICIDE PRODUCTS
### INDUSTRY STRUCTURAL CHANGES OVER THE YEARS – TECHNOLOGY & COMPANY DEVELOPMENTS (4/6)

<table>
<thead>
<tr>
<th>Year</th>
<th>Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Cruiser insecticide is introduced in the U.S.</td>
</tr>
</tbody>
</table>
| 2003 | • Cruiser Extreme 250, the first insecticide/ fungicide combination of separately registered products for corn, enters market.  
• Launch on on-seed insecticide Poncho  
• Launch of root protector Galmano  
• CruiserMaxx Beans, the first insecticide/fungicide seed treatment combination of separately registered products for soybeans, is introduced.  
• Bayer acquires Gustafson. |
| 2004 | On-seed fungicide Lamardor introduced |
| 2006 | Avicta, the first seed treatment nematicide, receives registration for use on cotton |
| 2007 | • 2007 - Syngenta opens Seedcare Institute in Stein, Switzerland.  
• Launch of Aeris, a nematicidal seed treatment in cotton |
| 2008 | • BASF & Monsanto entered into agreement for new fungicide seed treatment in soybean  
• Germains Seed Technology was the first to introduce T-22 (organic biological ) seed treatment to North America and Mexico  
• Avicta Complete Corn, the first nematicide/insecticide/ fungicide seed treatment combination of separately registered products, is launched |
| 2009 | Launch of Poncho/VOTIVO in the U.S |

“~2.8 TIMES GROWTH IN GM CROP AREA”
### Industry Structural Changes Over the Years – Technology & Company Developments (5/6)

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
</table>
| 2011 | • New Bayer SeedGrowth centers opened in Argentina, China, Brazil & Mexico.  
      • Bayer acquires biological companies AgraQuest & Prophylta. |
| 2012 | • EverGol registered in North America                                   
      • Vibrance, the first fungicide developed specifically as a seed treatment from Syngenta, is introduced.  
      • Bayer introduced On-Demand automated seed application system        
      • Launch of SeedGrowth competence brand                                
      • Clariva first biological seed treatment nematicide introduced         
      • Restriction and ban on the use of three neonicotinoids in EU countries |
| 2013 | • Syngenta AG registered and launched FORTENZA                          
      • Nufarm established a new manufacturing facility in Chicago to support growth in the fungicides, insecticides, and seed treatment segments. |
| 2014 | • Launched Clariva Complete Beans, nematicide/insecticide/ fungicide seed treatment combination of separately registered products Bion 500FS, a fungicide seed treatment for sunflower and sorghum, introduced  
      • Valent Canada Inc. signed an agreement to provide exclusive rights to Nufarm Agriculture Inc. (Canada) to distribute NipsIt seed treatments (NipsIt Inside and NipsIt Suite) for on-farm use in Canadian markets.  
      • Valent U.S.A Corporation launched INTEGO SUITE (fungicide) System for protection of soybean seeds and seedling |
### INDUSTRY STRUCTURAL CHANGES OVER THE YEARS – TECHNOLOGY & COMPANY DEVELOPMENTS (6/6)

#### 2015
- BASF SE received the approval for their seed treatment Systiva in Australia
- Koppert launched new biostimulant seed treatment product
- Syngenta AG introduced Mertect 340-F fungicide to its portfolio of seed treatments
- Bayer CropScience introduced Redigo Pro and Deter seed treatments in the U.K.
- Valent U.S.A Corporation, a subsidiary of Sumitomo Chemical, acquired Mycorrhizal Applications, Inc. (U.S.), the world's largest producer of mycorrhizal fungal inoculum

#### 2016
- Syngenta launched EPIVO, a range of new biostimulants to address abiotic stresses through seed treatment
- Koppert and Lantmännen BioAgri partner to further develop biological seed treatment
- The BioAg Alliance Launches new yield-boosting microbial seed coating
- BASF launched a new seed treatment facility in Argentina.
- BASF's fungicidal seed treatment Systiva XS was approved for use on the sugar beet crop in the U.S.
- Syngenta and Oscar Pemán Semillas (Argentina) co-launched a seed treatment product, namely Plenus technology for use on pastures.
- Syngenta launched a seed treatment, Visivio in Canada
PLAYERS IN THE SEED TREATMENT INDUSTRY

Many more.....
SEED TREATMENT MARKET GROWTH TREND

GLOBAL SEED TREATMENT MARKET TREND

Tremendous growth witnessed during the period from 2011 to 2016

Note: E- estimated, P - projected

SEED TREATMENT SALES EXPECTED TO GROW FROM USD 5.88 BILLION IN 2016 TO 10.91 BILLION BY 2022
SEED TREATMENT TECHNOLOGY – HISTORICAL PERSPECTIVE - 2000’S

SEED TREATMENT MARKET GROWTH FACTORS

- Innovations & adoption of seed technologies
- Increased awareness & adoption of crop protection chemicals

12.9% CAGR

FOCUS ON CROP-WISE & PEST SPECIFIC SEED TREATMENT PRODUCTS

ATTRACTIONNESS OF SEED TREATMENT SEGMENT & LAUNCH OF INNOVATIVE PRODUCTS

PATENT REGISTRATIONS FOR COMPOSITION OF PRODUCTS AND TREATMENT METHOD

NEWER OPPORTUNITIES WITH AGRICULTURAL BIOLOGICALS & BIOSTIMULANTS

COMBINATION OF CHEMISTRY & BIOLOGICALS TO LEAD THE SEED TREATMENT INDUSTRY IN FUTURE

0.95 1.36 2.43 5.88 10.91


10.9% CAGR
CHANGING FOCUS ON PRODUCT CATEGORIES

GROWTH STAGES OF PRODUCT INNOVATIONS

- New Active Ingredients
- Specific Traits
- Multiple Benefits & Process Improvement
- Application Innovations

PRODUCT CATEGORY

- FUNGICIDES
- SYSTEMIC INSECTICIDES
- NEMATICIDES

SCOPE FOR INNOVATIONS

- Additional chemistries with different mode of action

BIODIVERSITY

- BIOLOGICALS
- STARTER NUTRIENTS & STRESS TOLERANCE

Companies investments in R&D for seed treatment product combinations (chemistry & biologicals) to meet growers need along with seed treatment services
Rapid Growth in Seed Treatment

Opportunities in Seed Treatment Equipment & Services Industry

- Launches of advanced technologies such as On Demand seeks to bring the accuracy, efficiency and reporting available at commercial plants downstream to the seed retailer or dealer.
- Seed treatment equipment industry players venturing to provide seed treatment services to farmers on demand.

Progress in New and Emerging Markets

- Adoption of biological seed treatment in emerging markets
- Demand for seed treatment technologies expected to grow continually in early adopting countries such as Brazil and exponentially in the new and emerging markets such as India and China.

Growing Environmental Considerations Driving Demand for Bio-pesticides

- Combination of Chemistry & Biologicals
- Crop & Pest/Disease Specific Products

• Combination of Chemistry & Biologicals
• Crop & Pest/Disease Specific Products

Growing Environmental Considerations Driving Demand

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Adoption of biological seed treatment in emerging markets

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IMPACT OF MERGERS & ACQUISITIONS ON SEED TREATMENT INDUSTRY

- R&D SYNERGIES FOR INNOVATIONS
- MUTUAL ACCESS TO EXPERTISE SEGMENTS (SEED, TRAITS, CROP PROTECTION CHEMICALS, & BIOLOGICALS)
- INCREASED MARKET CONCENTRATION & ACCESS TO BROADER CUSTOMER BASE
- OPPORTUNITY TO RESHAPE THE ACTIVITY PORTFOLIO
FUTURE OUTLOOK

NEEDS

• Refinement of carriers and polymers
• Diversify insecticide options
• Alternatives for restricted active ingredients

OPPORTUNITIES

• Increasing number of market players, mergers, acquisitions, collaborations and partnerships
• Establishment of supportive schemes such as European Seed Treatment Assurance Scheme

RISKS

• Reliance on few modes of action in broad portfolio of products
• Emerging insect resistance
• Regulatory limitations such as restrictions on use of neonicotinoids
APPENDIX
OVERVIEW ON PARENT MARKETS

Factors that contribute to the growth of seed & agrochemicals market

- GM crops in developed and developing markets
- Seed replacement (from farm saved to commercial seeds) in developing markets
SEED TREATMENT TECHNOLOGY - OVERVIEW

DEFINITION: Seed treatments refers to the application of biological, physical, and chemical agents and techniques to the seeds prior to sowing in order to provide protection from pests and to improve the establishment of healthy crops. (International Seed Federation)

ADVANTAGES
- Precise mode of applying products in the field
- High level of protection against insects and diseases
- Reduced exposure of crop protection products to human and environment

BENEFITS TO GROWERS
- Protection to high value seeds
- Allows for early season planting
- Uniform seedling emergence and crop stand establishment
- Higher plant population
- Reduces the need for additional rescue treatment or replanting of crop

HUMAN & ENVIRONMENT
- Precise application of crop protection products
- Reduces the need for application of crop protection products over the entire field and reduces soil surface exposure
- Reduces potential off-target exposure to plants & animals
# KEY PATENTS REGISTERED FOR SEED TREATMENT

<table>
<thead>
<tr>
<th>PUBLICATION NUMBER</th>
<th>PATENT TITLE</th>
<th>PUBLICATION DATE</th>
<th>COMPANY</th>
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<tbody>
<tr>
<td>US9538751 B2</td>
<td>Canola seed treatment composition and method</td>
<td>10-Jan-17</td>
<td>Dow Agrosciences Llc</td>
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<tr>
<td>EP2524596 A1</td>
<td>Seed treatment uses</td>
<td>21-Nov-12</td>
<td>BASF SE</td>
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<tr>
<td>WO2012152737 A1</td>
<td>Seed treatment method and composition</td>
<td>15-Nov-12</td>
<td>Syngenta Participations Ag</td>
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<tr>
<td>WO2010100638 A2</td>
<td>Seed treatment and pesticidal composition</td>
<td>10-Sep-10</td>
<td>Celsius Property B.V. Amsterdam (NL)</td>
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<tr>
<td>EP1863350 A2</td>
<td>2-cyanobenzenesulfonamide compounds for seed treatment</td>
<td>12-Dec-07</td>
<td>Basf Aktiengesellschaft</td>
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<tr>
<td>WO2007003319 A2</td>
<td>Seed treatment method and pesticidal composition</td>
<td>11-Jan-07</td>
<td>Syngenta Participations Ag</td>
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<tr>
<td>WO2006024333 A2</td>
<td>Aqueous neonicotinoid compositions for seed treatment</td>
<td>9-Mar-06</td>
<td>Syngenta Participations Ag</td>
</tr>
<tr>
<td>US20030224936 A1</td>
<td>Seed treatment composition</td>
<td>4-Dec-03</td>
<td>Gerhard Kretzschmar</td>
</tr>
<tr>
<td>CA2485172 A1</td>
<td>Fungicidal seed treatment agent for oilseed rape</td>
<td>4-Dec-03</td>
<td>Basf Agro B.V., Arnhem (NL) Wadenswil-Branch</td>
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<td>WO2000063356 A2</td>
<td>Herbicidal seed treatment</td>
<td>26-Oct-00</td>
<td>Syngenta Participations Ag</td>
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<td>WO2000054568 A1</td>
<td>Seed treatment composition</td>
<td>21-Sep-00</td>
<td>Aventis Cropscience Gmbh</td>
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<td>WO2000028825 A1</td>
<td>Pesticidal composition for seed treatment</td>
<td>25-May-00</td>
<td>Syngenta Participations Ag</td>
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<tr>
<td>US5661103 A</td>
<td>Seed treatment composition and method</td>
<td>26-Aug-97</td>
<td>Donlar Corporation</td>
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<tr>
<td>US5586411 A</td>
<td>Method of preparing a seed treatment composition</td>
<td>24-Dec-96</td>
<td>Her Majesty The Queen In Right Of Canada, Philom Bios Inc.</td>
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<tr>
<td>EP 0150766 A2</td>
<td>Device for wet pickling of seeds</td>
<td>7-Aug-85</td>
<td>Mantis ULV-Sprühgeräte GmbH</td>
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<tr>
<td>CA976134 A</td>
<td>Methods of seed treatment and apparatus therefor</td>
<td>14-Oct-75</td>
<td>James, Michael Trading As Design Link,</td>
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<tr>
<td>US3155542 A</td>
<td>Cottonseed-treating maching</td>
<td>3-Nov-64</td>
<td>Ben Gustafson &amp; Son Mfg. Company</td>
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</table>

**SEED TREATMENT TECHNOLOGY PATENTS REGISTERED ARE MAINLY FOR COMPOSITION OF PRODUCTS AND TREATMENT METHOD**
GLOBAL SEED TREATMENT MARKET – MARKET SIZE ESTIMATION & FORECASTS

BY REGION

GLOBAL SEED TREATMENT MARKET, BY REGION (VALUES IN USD BILLION)

<table>
<thead>
<tr>
<th>Year</th>
<th>North America</th>
<th>Latin America</th>
<th>Europe</th>
<th>Asia-Pacific</th>
<th>RoW</th>
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<tbody>
<tr>
<td>2014</td>
<td>0.3</td>
<td>0.4</td>
<td>0.4</td>
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<tr>
<td>2015</td>
<td>0.4</td>
<td>0.5</td>
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<td>0.5</td>
<td>0.9</td>
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<tr>
<td>2016-e</td>
<td>0.4</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>2.1</td>
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<tr>
<td>2022-p</td>
<td>1.2</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
<td>4.5</td>
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North America will continue to dominate the market and more opportunities in other regions.

BY FUNCTION

GLOBAL SEED TREATMENT BIOLOGICALS MARKET, BY FUNCTION (VALUES IN USD BILLION)

<table>
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<tr>
<th>Year</th>
<th>Crop Protection</th>
<th>Seed Enhancement</th>
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</thead>
<tbody>
<tr>
<td>2014</td>
<td>4.24</td>
<td>0.59</td>
</tr>
<tr>
<td>2015</td>
<td>4.67</td>
<td>0.62</td>
</tr>
<tr>
<td>2016-e</td>
<td>5.21</td>
<td>0.67</td>
</tr>
<tr>
<td>2022-p</td>
<td>9.79</td>
<td>1.12</td>
</tr>
</tbody>
</table>
Corn, wheat, and rice crops are to lead the market for seed treatment.
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