Genetically modified (GM) sugarcane update

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South African Sugarcane Research Institute is a division of the South African Sugar Association

Food without conventional breeding

Crop Modification Techniques

Cross Breeding

Combining two sexually compatible species to create a variety with the desired traits of the parents

The Honeycrisp Apple gets its famous texture and flavor by blending the traits of its parents.

Mutagenesis

Use of mutagens such as radioactivity to induce random mutations, creating the desired trait

Radiation was used to produce a deeper color in [illegible]

Polyploidy

Multiplication of the number of chromosomes in a crop to impact its fertility

Seedless watermelons are created by crossing a plant with 2 sets of chromosomes with another that has 4 sets. The seedless fruit has 3 sets.

Protoplast Fusion

Fusion of cells or cell components to transfer traits between species

Male sterility is transferred from radishes to red cabbage by fusing their cells. Male sterility helps plant breeders make hybrid crops.

Transgenesis

Addition of genes from any species to create a new variety with desired traits

The Rainbow Papaya is modified with a gene that gives it resistance to the Papaya Ringspot Virus.

Genome Editing

Use of an enzyme system to modify DNA directly within the cell

Genome editing was used to develop herbicide resistant canola to help farmers control weeds.

www.biofortified.org

Follow [illegible] on Twitter (@franknfood[illegible]) or join our Facebook Page

By Layla Katiraee (@biochmlayla) in collaboration with Karl Haro von Mogel (@kjhvm)

BIOLOGY FORTIFIED

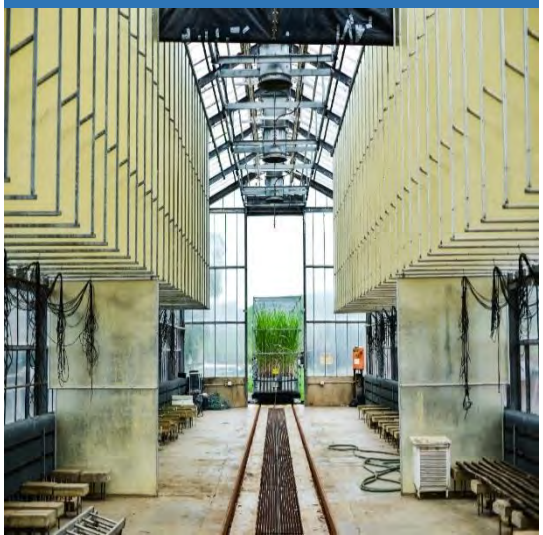
What is GM?

GM = Genetically modified

the **genes/genetic material which have been modified in a way that** does not occur naturally through mating or natural recombination or both

Rationale for GM crops

Conventional breeding constraints



Improve yield, reduce crop loss, solve a particular problem

Technology is working in the field

Do you know where biotech crops are grown?

More than 30 countries have planted biotech crops since 1996. See where they were grown in 2019.

17 MILLION
small, resource-poor farmers and their families totaling >65 million people benefited from biotech crops in 2019

USA
is the largest producer of biotech crops in the world, planting 37.6% of global biotech crop area

Biotech canola's adoption rate in Canada reached **95%**

SPAIN
is the leading country planting biotech maize in Europe

More than **6 MILLION**
farmers in India planted 11.9 million hectares of Bt cotton in 2019

Portugal
Spain
Canada
USA
Mexico
Honduras
Costa Rica
Colombia
Brazil
Bolivia
Paraguay
Chile
Uruguay
Argentina
Nigeria
Sudan
Pakistan
Ethiopia
India
Malawi
Myanmar
Bangladesh
China
Vietnam
Philippines
Indonesia
South Africa
Eswatini
Australia

10 countries
in Latin America planted biotech crops in 2019

BRAZIL
is the top developing country in the world planting biotech crops

MALAWI, ETHIOPIA, & NIGERIA
planted Bt cotton for the first time in 2019

2.7 Billion
hectares of biotech crops planted since 1996

Soybeans
Maize
Cotton
Canola
Sugar beets
Alfalfa
Papaya
Squash
Potato
Apples
Eggplant
Sugarcane
Pineapple
Safflower

For more information on biotech crops, visit
www.isaaa.org

ISAAA

Source: ISAAA. 2019. Global Status of Commercialized Biotech/GM Crops in 2019. *ISAAA Brief* No. 55. ISAAA: Ithaca, NY.

International GM sugarcane landscape

USA

- GM sugarcane field trials and regulatory dossier (mosaic virus and herbicide tolerance)
- GM sugarbeet deregulated
- Cane sugar and ethanol from GM plants on world market

Brazil*

- CTC – insect resistance – Bt cane – commercial release June 2017
- CTC - field trials – 2nd generation ethanol, weed control

Argentina Colombia

- research

South Africa

- SASRI – Bt cane, GM field trials 2025
- Other traits: herbicide tolerance

India

- research

China, Japan

- research

Indonesia*

- Drought tolerant sugarcane passed through biosafety committee (sugar - local market)
- Research

Australia

- Not active currently, but SRA - GM field trials
- UQ – research on sucrose enhancement and biofuels

GM crops in SA

- Maize, soybean and cotton – insect resistance and herbicide tolerance and ‘stacked’ traits
- Legislation (a) GMO Act no. 15 of 1997; (b) signatory to Cartegena Protocol for Biosafety
- DALRRD Registrar GMO Act issues permits issues for:

Facilities registration

Contained field trial

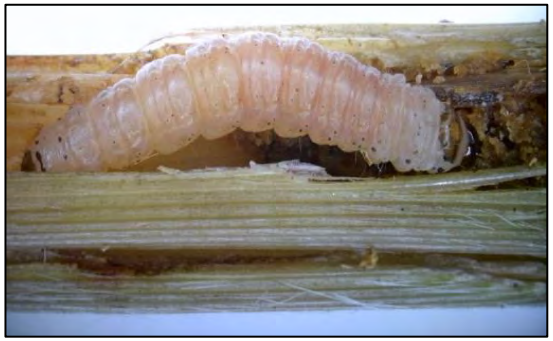
General release (commercial cultivation)

Commodity Clearance (import for food and feed)

Main problem: sugarcane

- Lepidopteran borers ~ R1 billion loss in revenue.
- SA biosecurity risk = *Chilo sacchariphagus* in Mozambique.

Eldana saccharina



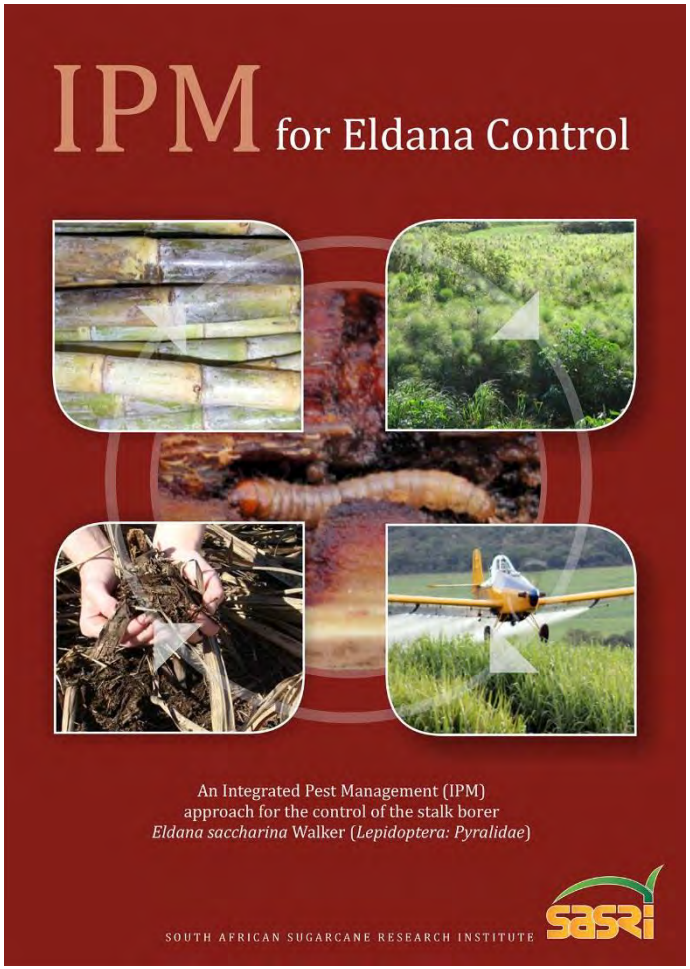
Sesamia calamistis

Chilo sacchariphagus

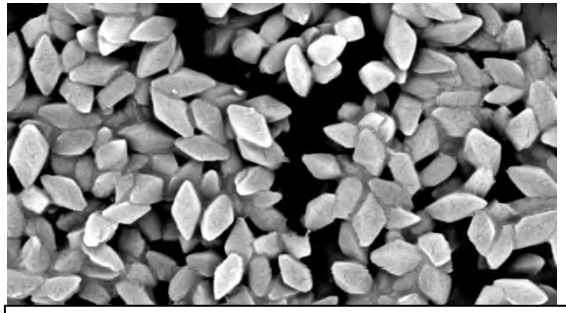
The approach

Integrated Pest Management:

- breeding
- insecticides
- soil health
- agro-ecosystem
- sugarcane genetically modified to produce lepidopteran-specific toxin from bacterium *Bacillus thuringiensis* (Bt).

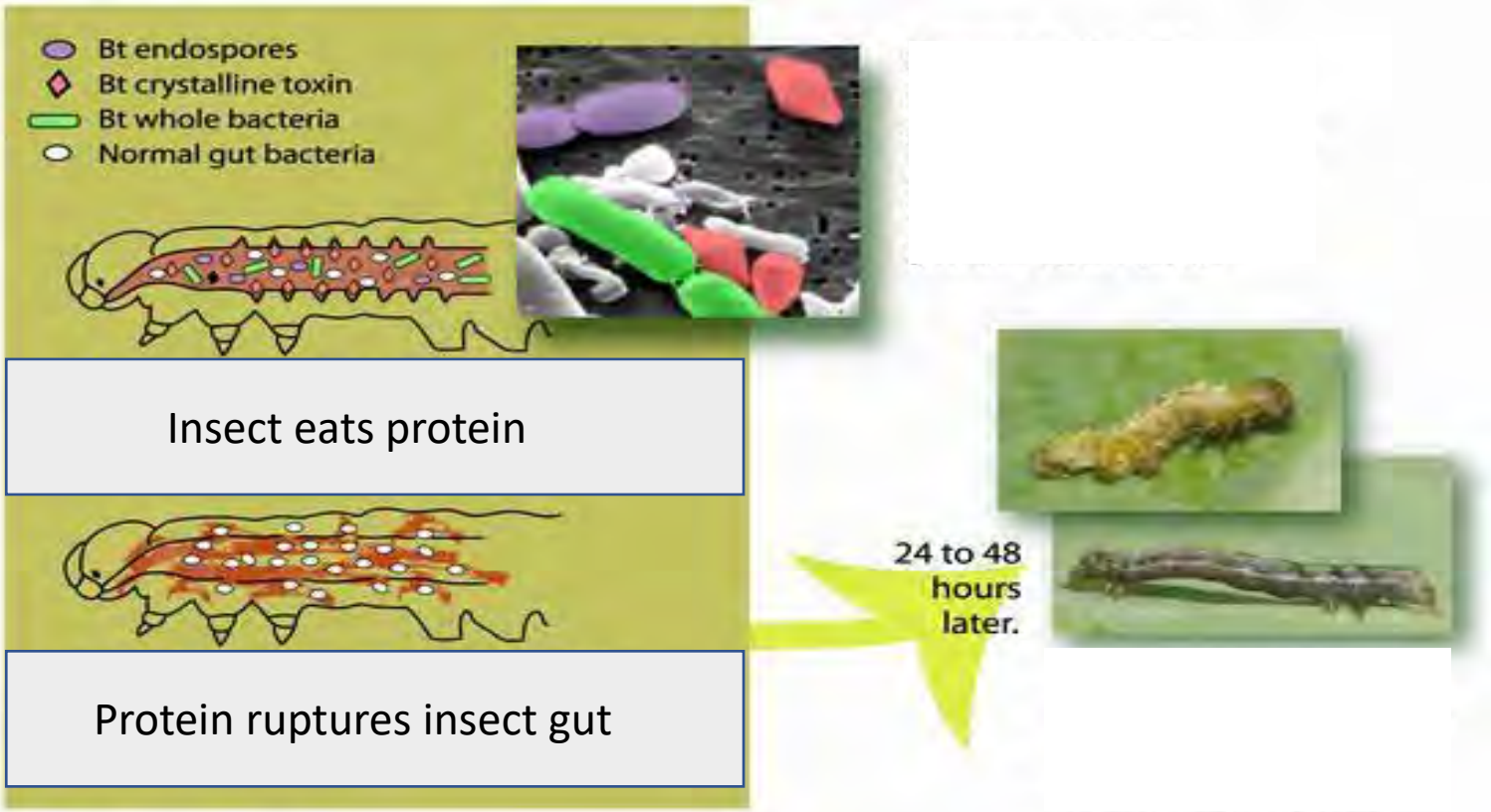


The insect resistance trait



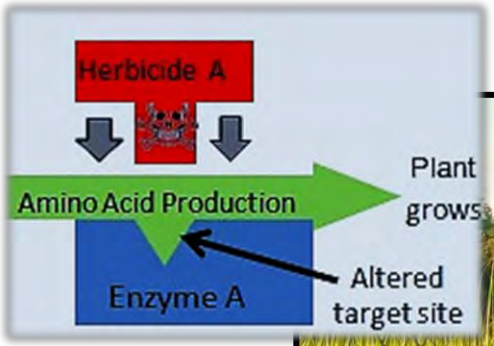
- specific mode of action
- Not toxic to non-target insects

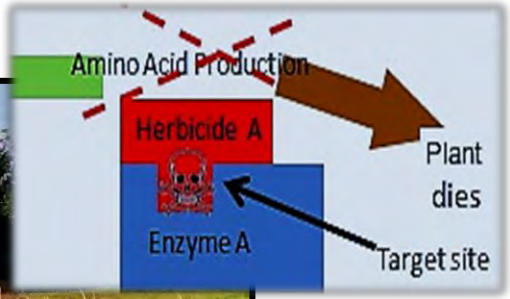
Crystal protein that is toxic to lepidopteran insect pests



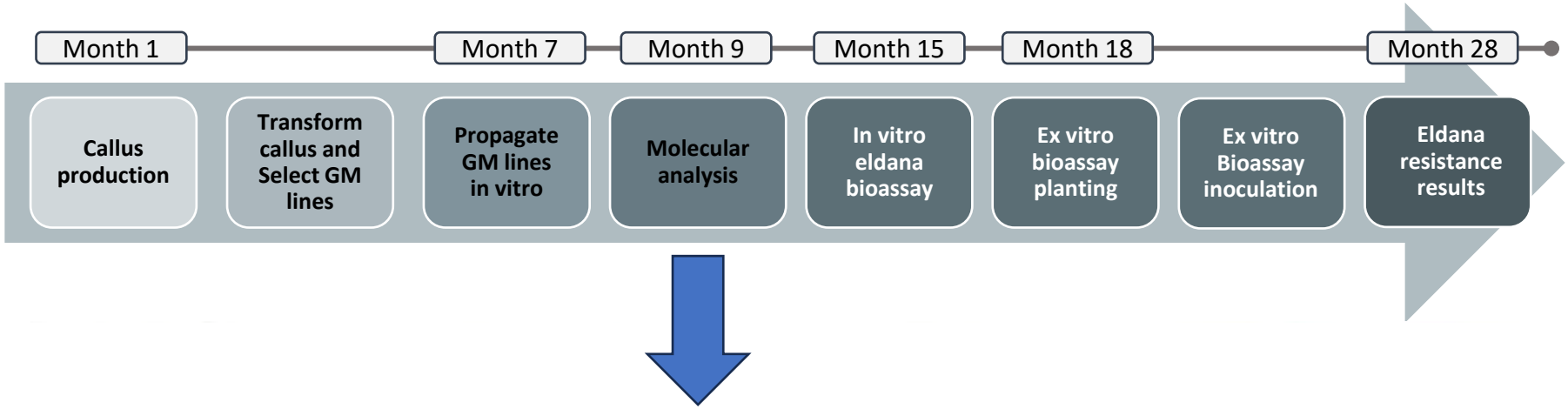
Herbicide tolerance

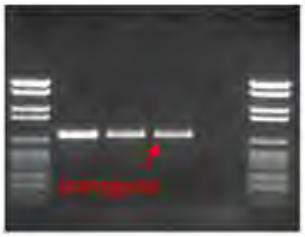
- Improved control of creeping grasses
- Tolerance to imazapyr (Arsenal)
- Conferred by single point mutation in enzyme acetolactate synthase (ALS)



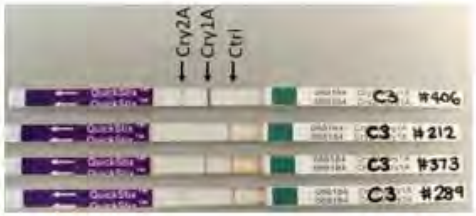


Timelines for GM plant production





i) PCR to determine lines containing the mALS transgene
Requires: 2mm x 10mm leaf tissue/line

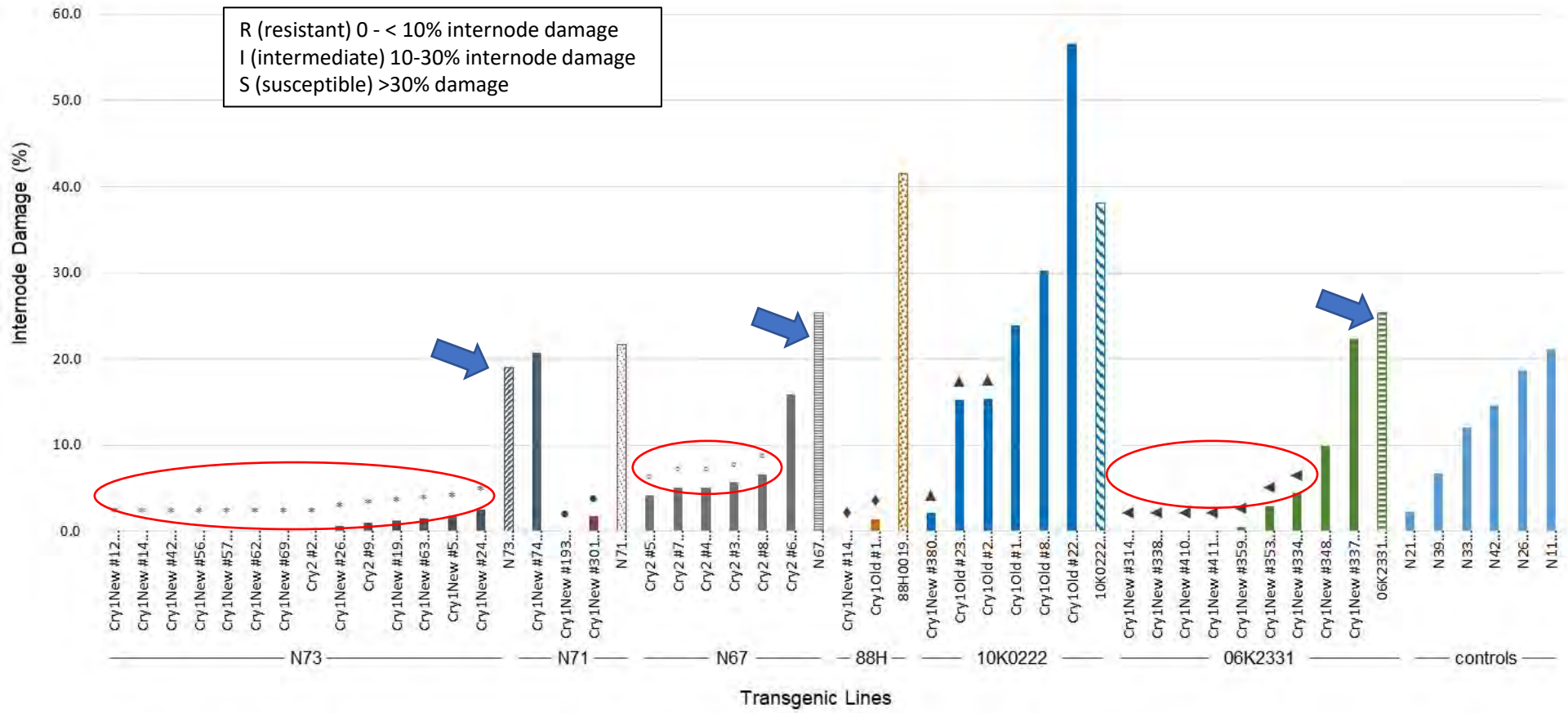


ii) Lateral Flow Strips to detect Cry protein expression
Requires: 50mg tissue/line

iii) In vitro re-rooting imazapyr screen for mALS91 functionality
Requires: five well rooted plants/line

iv) In vitro whole plantlet bioassay for the efficacy of the Cry proteins against eldana
Requires: 18 plants/line

Eldana bioassays



Damage to sugarcane internodes (%) by stalk borer *Eldana saccharina* 600-day-degrees after egg inoculation.

The timeframe

Year 1

- Intellectual Property audit
- Vector construction and genetic transformations
- Molecular and glasshouse assessment of lines
- Conduct field trials to check agronomic and yield characteristics
- Submit regulatory dossier to GM Registrar (DAFF)
- Obtain permit for commercial cultivation
- Bulk up the GM plant via NovaCane® and large-scale nurseries
- Deploy to the industry
- Use GM line as a parent in new crosses

Year 16








Global stewardship programme

excellence through STEWARDSHIP

www.excellencethroughstewardship.org/

Excellence Through Stewardship - ETS

- external audit 2022 and every 3 years

- Quality Management System
- Internal audit - annual

SASRI

Regulatory biosafety prep

- Gene flow between sugarcane and wild relatives (Miscanthidium spp)
- Refugia planting (mathematical modeling)
- Monitoring in the field (eldana traps and IRAC-approved lab assay)
- Effect on non-target arthropods
- Compositional analysis – substantive equivalence (OECD) for food and feed safety

technology innovation AGENCY

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Thank you

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