GLOBAL STATUS AND ECONOMIC BENEFITS OF BIOTECH MAIZE PRODUCTION BY 2017

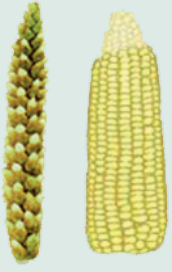
The Evolution of Maize (Corn)

The wild ancestor

Teosinte

America

Domestication

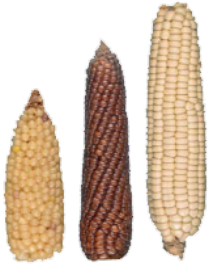


7000 years BC

First Maize

Mexico

The adaptation to Europe



1494

Populations

South of Europe introduction

Extension of maize crop areas

1930s-40s

Hybrids

First creation of hybrids in France

Introduction

Maize is at the center of global food security, as one of the most important cereal crops in human and animal diets worldwide. Together with rice and wheat, it provides at least 30% of the food calories to more than 4.5 billion people in 94 developing countries. This include 900 million consumers for whom maize is the preferred staple. Aside from providing nutrients for humans and animals, maize serves as a basic raw material for the production of starch, oil, alcoholic beverages and biofuels. In the past decade, increasing demand and production shortfalls in global maize supplies have seen a surge in global maize prices. This problem has further been aggravated by climate change and the consequent rise in both crop biotic and abiotic stresses. In the wake of these challenges, vigorous concerted efforts have been geared towards development of high-yielding, stress-tolerant maize varieties through conventional breeding and modern biotechnology.

Biotech or genetically modified maize has been engineered for protection against both biotic and abiotic stress including pests, herbicides and drought. Herbicide tolerant maize was first commercialized in 1996. To achieve this, a gene was incorporated in maize that confers tolerance to glyphosate herbicides such as Roundup® hence their name 'Roundup Ready' maize. Maize has also been engineered with ability to tolerate glufosinate herbicides.

To protect from key insect pests, a bacteria Bacillus thuringiensis (Bt) gene has been engineered in maize. The protein product of the Bt gene targets lepidopteran insects like the maize stalk borer and the fall armyworm, therefore conferring resistance to these destructive pests. The proteins are highly selective, binding only to receptors in the target insect gut.

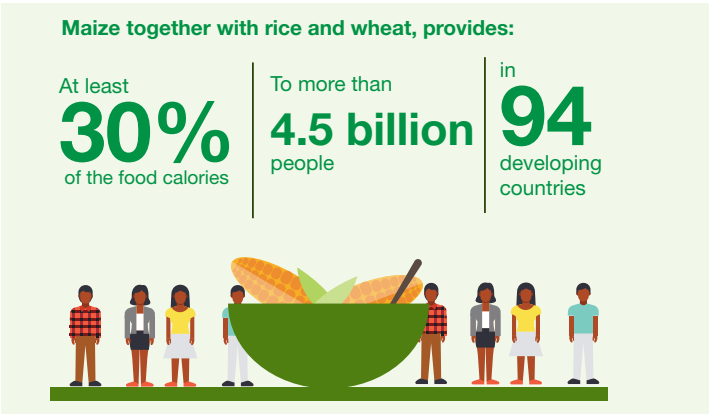
Recently, incorporation of more than one gene for crop improvement has led

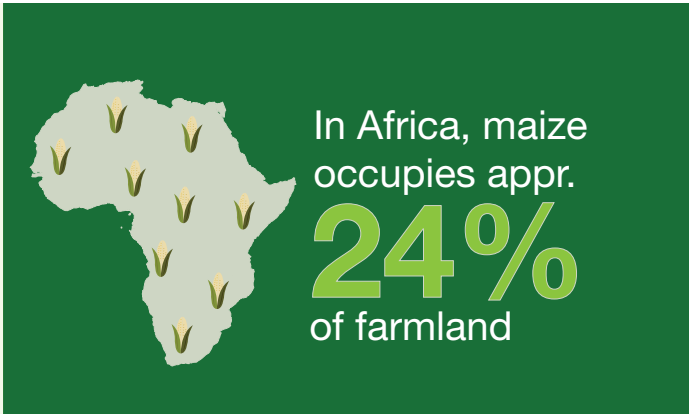
Maize is the preferred staple for approx. 900 million consumers

Herbicide tolerant maize was first commercialized in 1996

to development of highly adaptable maize. This combination of traits is commonly referred to as stacked traits. Various combinations of stack traits including herbicide tolerant/insect resistant (HT/Bt) and insect resistant/drought tolerant (Bt/DT) have been achieved in biotech maize. The recently released eight-gene maize stack known by its trade name SmartStax™ is the result of crossing four different biotech maize lines to combine two herbicide tolerance genes with six Bt genes. The resulting stack features dual modes of control for weeds, lepidopteran and coleopteran insect pests.

In Africa, maize occupies approximately 24% of farmland, which is more than any other staple crop. However, production is continuously and severely affected by a number of threats, such as weeds, insect pests, viruses, fungi, low quality seed, suboptimal post-harvest management, drought and climate change. Given that Africa grows 90% of its maize under rainfed conditions, drought has an enormous impact on yield. Erratic rain patterns, pests, inadequate farming methods and drought stress can lead to 70-100% crop loss, which is dramatic for both farmers and consumers, as the whole food chain is affected. To mitigate for the pest and drought challenge, stacked biotech insect resistant/drought tolerant (Bt/DT) maize hybrids have been developed by the Water Efficient Maize for Africa (WEMA) project. It is projected that these hybrids will increase maize production by up to 2 to 5 million tons under moderate drought.





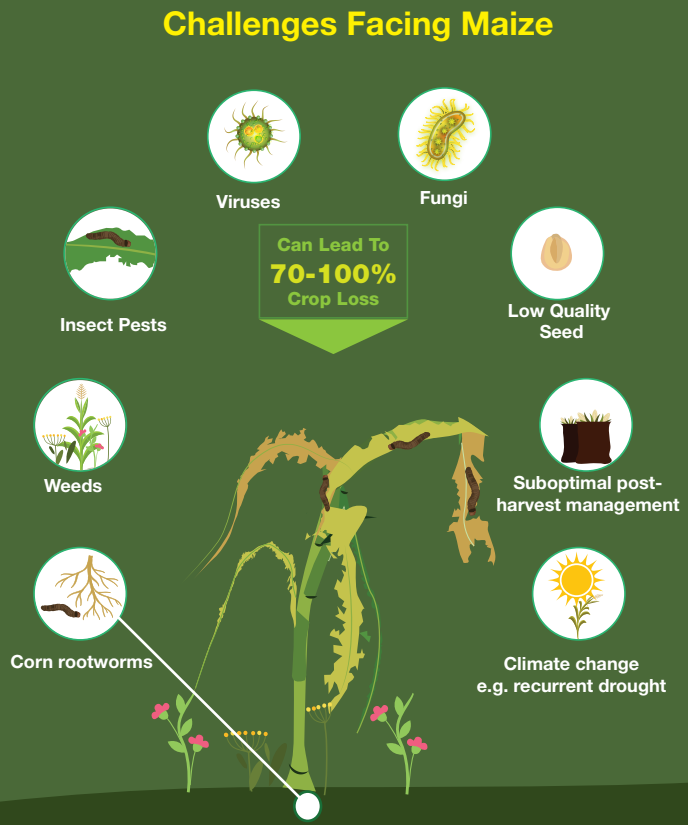
Biotech Maize Brief 2017

In Kenya, two seasons of Confined Field Trials (CFTs) have produced promising results with the Bt/DT maize recording considerable yield advantage over the conventional counterpart under mild drought and stem borer infestation. Interestingly, the Bt trait seems to be controlling the fall armyworm, a current maize production menace in the country.

The WEMA project coordinated by the African Agricultural Technology Foundation (AATF) started with five African countries including, South Africa, Kenya, Uganda, Mozambique, and Tanzania.

Succession of WEMA by TELA project in 2018 has seen Ethiopia added to this list. TELA project is aimed at providing farmers with climate smart technologies that would enable them to mitigate the impacts of climate change.

In 2017, Mozambique planted the first field trial of biotech maize (insect-resistant and drought tolerant) as part of the WEMA program. Tanzania also approved the same stacked trait, demonstrating a growing interest in the continent to incorporate more traits in various crops. South Africa, Kenya and Uganda continued to conduct multi-location trials on biotech maize for insect resistance and drought tolerance. Nigerian and Swaziland governments issued import permits for biotech maize to meet food and feed deficits. Approval of nine biotech maize lines was granted to WACOT Nigeria Limited for feed processing.



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In Kenya, discussions are still on-going to initiate insect-resistant maize National Performance Trials (NPTs) following the conditional approval for general release granted for WEMA maize in 2016. This is particularly urgent for the country and the continent given significant levels of control of the devastating fall armyworm (FAW) have been observed in the insect-resistant maize experimental trials even though this particular trait is not for FAW control. Promising results with specific FAW control are already at advanced stages of research in South Africa.

The increase in income benefits for farmers growing biotech maize during the 21 years (1996 to 2016) stood at US$63.7 billion. Only one African country (South Africa) benefitted from these revenues at the time when over 300 million Africans who depend on maize as a staple were denied the choice to adopt biotech crops, suffering a huge opportunity cost.

BIOTECH MAIZE HAS LARGEST NUMBER OF APPROVED LINES

232 APPROVED LINES IN 30 COUNTRIES

Biotech Maize Brief 2017

Stacked biotech maize hybrids projected to increase maize production by up to

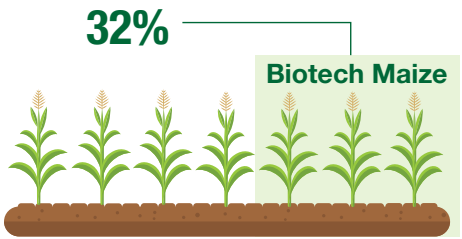
2-5 million tons

Under moderate drought

US $ 63.7 billion

The increase in income for farmers growing **biotech maize (1996 to 2016)**

In 2017.....



Of the **188 million hectares (ha)** maize area of global maize planted, **32% or 59.7 million hectares** were biotech maize

14 countries globally grew **biotech maize** in the year.

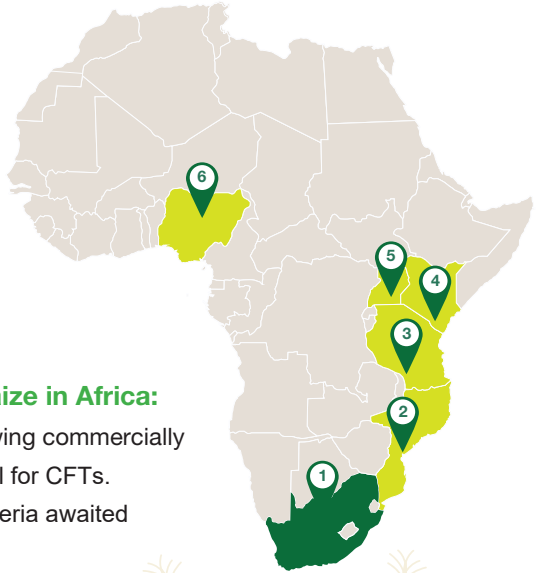
The income benefit for farmers growing biotech maize during the 21 years**(1996 to 2016)** was **US$63.7 billion** and **US$6.9 billion** for **2016** alone.

Commercialized Biotech Maize Traits

- Herbicide Tolerant (HT) maize varieties: These have been modified to tolerate a number of broad based, non-selective herbicides
- Insect Resistant (IR) maize varieties: Commonly referred to as Bt maize. These have been modified with the Bacillus thuringiensis (Bt) bacterium gene to protect against lepidopteran and coleopteran insect pests.
- Stacked traits (Bt/HT; Bt/DT) maize varieties that incorporate herbicide and drought tolerance traits in addition to insect resistance in one plant.

Global Status of Biotech Maize Commercialization by 2017

AFRICA



Biotech Maize in Africa:

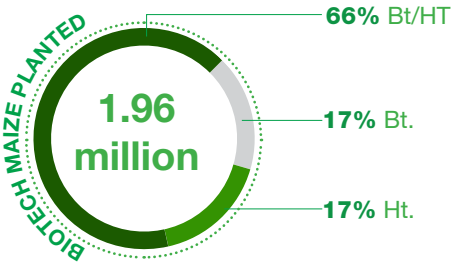
- Country growing commercially
- With approcal for CFTs.
  Plating in Nigeria awaited

1	5	3
Country growing commercially	countries conducting research	Trait Categories

1 South Africa

Has grown biotech maize for **20 years** since **1998**

Farm income gain from biotech maize was:
$17.4 million in 2016 alone



2 Mozambique
3 Tanzania
4 Kenya
5 Uganda
6 Nigeria

Opportunity Cost:

Over 300 million Africans who depend on maize as a staple were denied the choice to adopt biotech crops

EUROPE

1 Spain

The leading biotech country in Europe and has been planting biotech maize for **19 years** since **1998.**

BIOTECH MAIZE PLANTED

124,227 ha

Farm income gain from biotech maize was

US$23 million

in 2016 alone

2 Portugal

Has grown biotech maize for **10 years** since **2008**

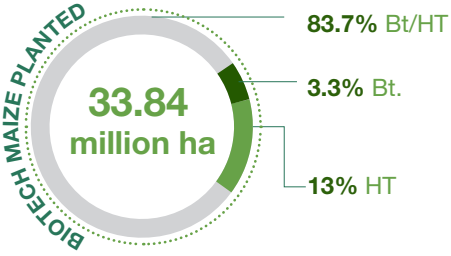
BIOTECH MAIZE PLANTED

7,308 ha

100% Bt.

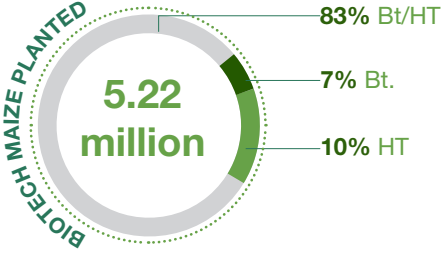
1 USA

Has grown biotech maize for **22 years** since **1996**



2 Argentina

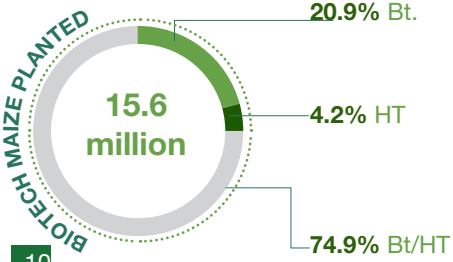
Has grown biotech maize for **20 years** since **1998**



The farm income gain from biotech maize was **US$ 5,510.50** million in **2016**

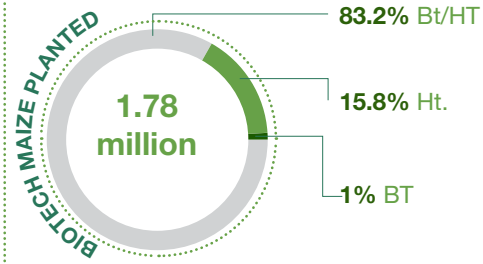
3 Brazil

Has grown biotech maize for **10 years** since **2008**



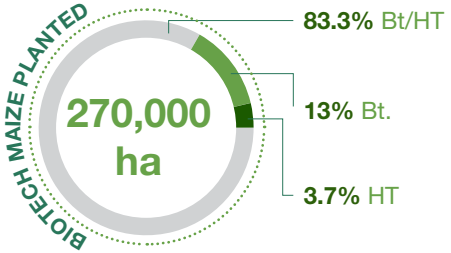
4 Canada

Has grown biotech maize for **22** years since **1996**



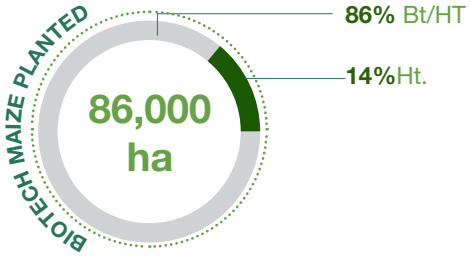
5 Paraguay

Has grown biotech maize for **5** years since **2013**



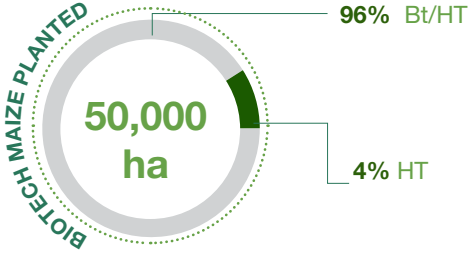
6 Colombia

Has grown biotech maize for **9 years** since **2009**



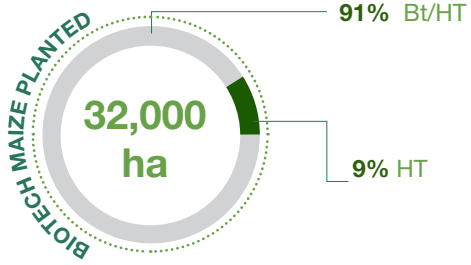
7 Uruguay

Has grown biotech maize for **15 years** since **2003**



8 Honduras

Has grown biotech maize for **16 years** since **2002**



9 Chile

Has grown biotech maize for **21 years** since **1996**

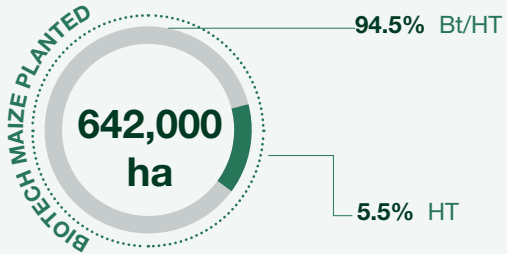
In 2016, the country grew **7,634 hectares** of stacked **Bt/HT maize** exclusively for seed export

Chile maintains its **fifth position** as the largest global producer/exporter of **biotech and non-biotech seeds.**

ASIA AND THE PACIFIC

1 Philippines

Has grown biotech maize for 15 years since 2003



The farm level economic benefit of planting biotech maize in 2016 alone was **US$82 million**

2 Vietnam

Grew its first biotech maize in 2015

Grew its first biotech maize in **2015**

Benefits from biotech Maize in 2016 alone was **US$5 million.**

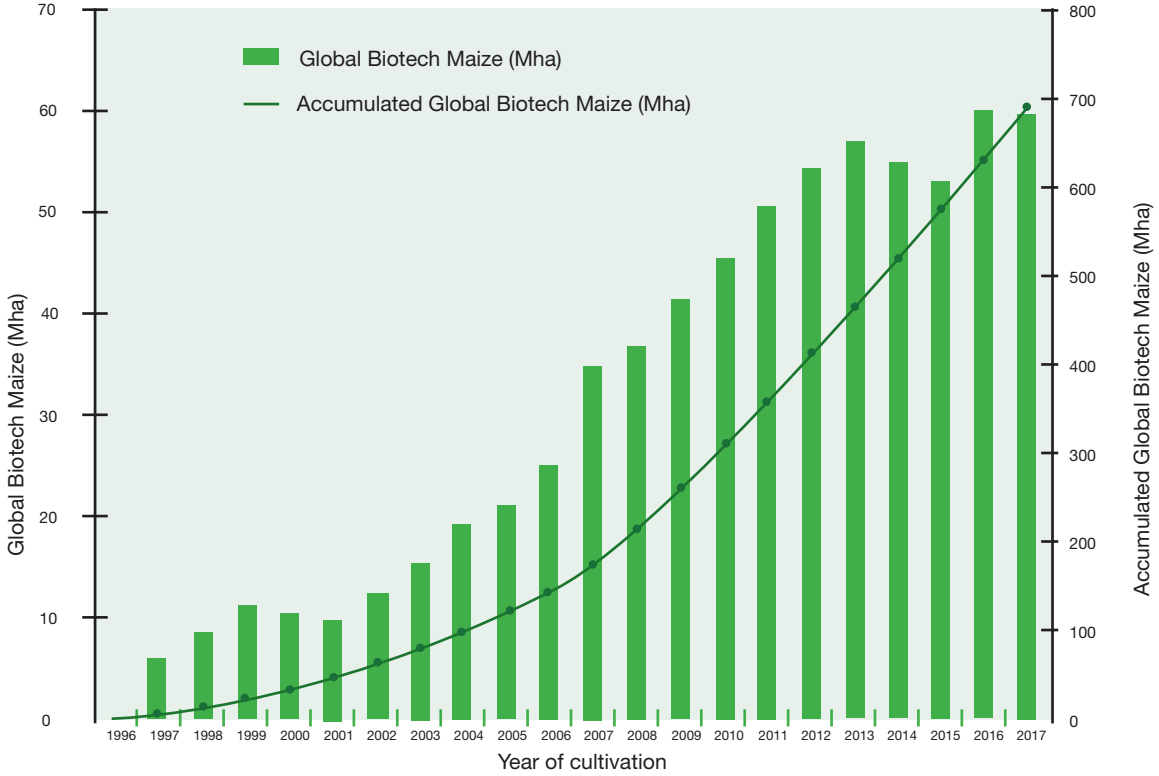
Ranking Global Biotech Maize Growers in 2017

	Country	Area (Ha) of Biotech Maize Planted in 2017
1.	USA	33840000
2.	Brazil	15600000
3.	Argentina	5220000
4.	South Africa	1960000
5.	Canada	1780000
6.	Philippines	642000
7.	Paraguay	270000
8.	Spain	124227
9.	Colombia	86000
10.	Uruguay	50000
11.	Vietnam	45000
12.	Honduras	32000
13.	Chile	7634
14.	Portugal	7308

Mr. Christopher Mwasia, a maize farmer from Kenya, displays the damage done to his maize by the fall armyworm (FAW) and the stem borer. Maize, the main staple in the diet of over 85 per cent of the population in the country, and grown in all the farming communities, is currently under heavy infestation by the pest. Detected in late 2016 and early 2017, the pest has so far affected over 250,000 hectares of maize farms in over 25 out of 47 counties. In 2016, maize farmers in Kenya reported up to 50 per cent losses on their crops due to the pest infestation. Interestingly, significant levels of the fall armyworm control have been observed in the insect-resistant WEMA-maize experimental trials even though this particular trait is not for FAW control

14

Global Adoption of Biotech Maize and Accumulated Hectares, 1996 - 2017



ISAAA
INTERNATIONAL SERVICE FOR THE ACQUISITION OF AGRI-BIOTECH APPLICATIONS

ISAAA AfriCenter
ILRI Campus, Old Naivasha Road,
P.O.Box 70-00605,
Uthiru, Nairobi, Kenya.
Tel: +254 20 4223618,
Fax: +254 20 4223634
Email: africenter@isaaa.org
Website: www.africenter.isaaa.org

OFAB Kenya
OPEN FORUM ON AGRICULTURAL BIOTECHNOLOGY IN AFRICA

AATF
ILRI Campus, Old Naivasha Road,
P.O.Box 30709-00100,
Nairobi, Kenya.
Tel: +254 20 422 3700,
Fax: + 254 20 422 3701
Email: ofab@aatf-africa.org
Website: www.aatf-africa.org

Karembu M. Global Status and Economic Benefits of Biotech Maize Production by 2017.
International Service for the Acquisition of Agri-biotech Applications (ISAAA AfriCenter), Nairobi Kenya.