植物生物技術 101
解答您的疑問

生技基本原理

您對植物生物技術是否有所疑問？如果是，您並不孤單。許多人都覺得要到處尋找資源或是解讀難懂的科學用語，才能獲得完整正確的答案。

這本深入淺出的資訊圖表彙編手冊將一次解答您的疑問，其中包含有關植物生物技術的基礎知識，幫助您明白一些常聽人提起的深奧問題。

什麼是植物生物技術？

植物生物技術是一種精密複雜的育種技術，讓植物育種專家能精確的將有益特性加入植物中。目前獲得核准之基因改造作物係經改良，幫助農民更有效防除有害雜草，保護作物不受害蟲和疾病侵害，並改善作物的營養品質及儲存壽命。未來，這些作物將能提供具有更高維生素含量或更長保存時間的糧食，或更能適應氣候變遷條件。

植物生物技術也稱為基因改造 (GM)、基因工程 (GE) 或是基因改造生物 (GMO)。

植物生物技術將能

幫助農民

增加70% 糧食產量

以滿足隨著地球人口數量持續增加的糧食需求。

2012 年全球人口數為 **70 億人。**

2050 年全球人口將增加至 **90 億以上。**

目錄

仍有疑問？ 請至 CROPLIFE.ORG 瞭解詳情。

關於國際作物永續發展協會 CROPLIFE INTERNATIONAL

國際作物永續發展協會 CropLife International 積極推動全球植物科學產業，力求以農業創新推動作物保護及植物生物技術發展，進而支持並促進永續農業；幫助農民滿足隨人口而不斷增加的糧食需求，同時給予植物適當照顧，並提升農村發展。世界需要農民，而農民需要植物科學。扶植農民就是國際作物永續發展協會 CropLife International 引以為傲的使命。

為何農民需要防治雜草及害蟲？

大多數雜草和害蟲對農民的田地有害無益。

若不加以防治則雜草和害蟲可能損害植物健康，降低作物的產量和品質，間接影響農民收益；因此我們必須控制雜草和害蟲的增生，才能確保安全、價格合理且供應充足的糧食收成。

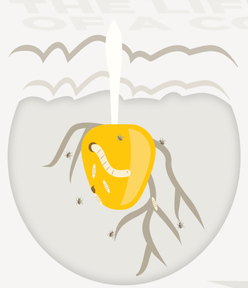
[1] James, C. 2003. Global Review of Commercialized Transgenic Crops: 2002 Feature: Bt Maize. ISAAA Briefs No. 29. ISAAA: Ithaca, NY
[2] Oerke, E.C., 2006, "Crop losses to pests," Journal of Agricultural Science, vol. 144, pp. 31-43
[3] Graham Brookes and Peter Barfoot. Economic impact of GM crops: The global income and production effects 1996-2012. www.landesbioscience.com/journals/gmcrops/article/28098/

玉米穗軸生命週期

種植

玉米在生長期的不同階段會歷經各種挑戰，首先是雜草、昆蟲和疾病，這些威脅甚至在作物發芽前就會造成損害。

生物技術能為玉米提供與生俱來的力量，抵禦昆蟲和雜草威脅，讓玉米能在強壯健康的情況下開始生長。



生長

雜草會劫奪玉米生長所需的養分、水分、陽光和空間，也會成為害蟲和疾病隱藏的溫床。

以玉米為食的昆蟲會造成損害，並傳播疾病。

耐除草劑和耐昆蟲生技特性能幫助玉米抵禦雜草和昆蟲威脅，讓植物充分發揮生長潛力。

收穫

蟲害會影響玉米作物的品質，導致產量降低，間接危及農民收入；蟲害也會產生黴菌毒素（菌類生成的毒性物質），影響糧食品質和安全性。[1]

雜草競爭會導致穗軸難以長大，而降低產量。

生技作物免除傳統作物所面臨的雜草競爭及蟲害問題，因此能完全發揮產量與品質潛力。

消耗

全球每年因為雜草、昆蟲和疾病損失的可能作物產量高達

40%[2]

生技作物幫助農民生產更多糧食

自1996年起
生技作物讓農民的

玉米產量增加2.31億噸。[3]

幫助農民提高收入並改善生活品質。

生技作物是如何誕生？

數千年來，農民和科學家運用傳統育種方法開發出我們現今看到的許多人工栽培作物。在過去 100 年間全球人口已增為三倍之多，因此植物育種專家必須以更快速且更有效的方法跟上世界持續成長的糧食需求。科學家運用生物技術，透過精準的方式將「特性」或「特徵」加入植物中；這些特性能讓作物越來越健康、增加維生素含量或是延長收成後的保存時間 – 蘊含無盡可能。

www.irs.gov/Businesses/Biotech-Industry-Overview---History-of-Industry
www.gmoanswers.com/explore
www.nature.com/scitable/knowledge/library/history-of-agricultural-biotechnology-how-crop-development-25885295
www.croplife.org/biotech-crop-development/

生技作物

讓農業得以跟上糧食需求快速增加腳步的重要里程碑。

為了培養出高產量作物和更具營養價值及風味的糧食，早在一萬年之前的農民和植物育種人就已經開始調整植物基因；植物育種技術發展的歷史至今也有數世紀之久，而生物技術正是同一脈絡的延伸。

西元前 8000 年
簡單篩選：農民挑選表現最佳的植物擷取種子。許多「現代」或大家熟悉的蔬果都是經由育種的過程逐漸歸化而成。

回溯至 1800 年代的科學發現，就已經啟發現代植物育種人運用分子生物學排除傳統育種方法的猜測與不精確之處。

1700 年代
交叉育種：農民和科學家將同類植物雜交（例如蕪菁甘藍就是經由蕪菁和甘藍雜交而來）。

1940 年代
種子培育：植物育種人利用輻射或化學物質來產生具有所需特性的種子，這些隨機突變創造出新的有益植物特徵包括大小、甜度或是顏色等等（例如紅色葡萄柚）。

1865 年
科學家 Gregor Mendel 的豌豆育種實驗證明，遺傳和遺傳學是「天生而來」。

1953 年
James Watson 和 Francis Crick 這兩位科學家發現 DNA 的雙螺旋結構。

1973 年
Stanley Cohen 和 Herbert Boyer 這兩位科學家找到基因重組 DNA 發展的最後一塊拼圖 – 透過這項技術能剪貼 DNA 並在細菌中複製新的 DNA；此一發展象徵了基因工程的誕生，開啟現代生物技術先河。

1980 年代
胰島素是首項獲得核准的現代生物技術產物。植物育種人將新的生物技術工藝運用於植物。

1996 年
首批生技大宗作物商品化且可供種植。

1996 年-2013年
科學家將生技玉米、大豆、棉花、芥花籽、木瓜等等作物介紹給世界各地農民。

2014 年以後
植物生物技術持續發展，以各種工藝幫助農民提高糧食產量並滿足消費者需求（例如基因組編輯、基因靜默、質體轉殖及可誘導基因）。

創造生技種子

植物生物技術是從一種植物或有機體上複製具有所需特性（例如昆蟲抗藥性）的基因，並將之用於另一種植物。實際做法雖然持續發展演進，但最常用的方法是：

1. 鑑別
找出能提升植物營養成分、健壯程度或抗病或抗蟲能力的基因或遺傳材料。

2. 移轉
遺傳科學家運用革命性技術，透過百年前為人所發現的天然有機物農桿菌，將基因傳遞到植物上。農桿菌就像一輛運輸車，將乘客（基因）載運到種子中，讓基因結合於植物遺傳材料的正確位置。

接著農桿菌就會離開種子，將新增的有益特性留在種子中。

3. 種植
新的種子繼而接受安全性、可靠性和有效性測試。只待獲得主管當局核准，農民就能種植並收穫此項新技術的益處。

生技作物是否安全？

是的。衛生主管當局、科學專家及各國政府全都認同生技作物是市面上通過最嚴格測試的產品，對糧食及人類健康的安全性均經證明。

[1] Critical Reviews in Biotechnology, March 2014, Vol. 34, No. 1
[2] ISAAA Brief 46-2013
[3] Agricultural Biotechnology Council

生技作物安全性獲得各方權威背書：

衛生主管當局

「在核准基改糧食的國家中，並未發現有一般人食用基改糧食而影響身體健康的情形。」
-世界衛生組織

世界衛生組織 (WHO)・美國醫學學會 (AMA)
皇家醫學會（英國）・英國醫學協會・加拿大衛生部

科學專家

「科學十分清楚：經由生物技術中現代分子工藝所改良的作物安全無虞。」
-美國科學促進會

美國科學促進會 (AAAS)・各國國立科學學會・非洲科學會網路 (NASAC)
歐洲學院科學諮詢委員會 (EASAC)・國際科學理事會・羅馬教皇科學院

政府組織

「GMO 運用精確技術且接受嚴格安全性規範，因此可能反而比傳統植物和糧食更為安全。」
-歐盟委員會

歐盟委員會・聯合國糧農組織 (FAO)・美國食品藥物管理局
紐澳食品標準局・菲律賓食品藥物管理局・法國食品安全署
加拿大食品檢驗局・美國國際發展署 (USAID)

過去 30 年超過 1,000 份科學研究[1]

生技作物納入糧食供應已將近 20 年[2]

已有 3 兆份內含生技原料的餐食點心為人所食用[3]

糧食安全性或健康問題[3]

哪些地方種植生技作物？

生技作物的種植遍及世界各地，並已然成為農業領域中採用率增加最快的作物技術。2013 年全球共有 27 國 1800 萬農民種植玉米和木瓜等各種生技作物，每年都有更多種植者開始採用這項技術。事實上，相較於 1996 年商業化種子首度播種之時，現今種植生技作物的農地面積已經增加百倍。美國、巴西及阿根廷是世界最大玉米及黃豆出口國，幾乎完全種植生技作物。在此方興未艾的趨勢帶領下，將有越來越多國家加入採用生物技術的行列。

[1] James, Clive. 2013. Global Status of Commercialized Biotech/GM Crops: 2013. ISAAA Brief No. 46. ISAAA: Ithaca, NY.

生技採用逐年增加

農民為快速採用者

1800 萬農民種植生技作物

90% 種植者為開發中國家人民，生技作物為他們帶來許多益處，包括收種量增加和收入提升，進而促進農村轉型。

將近 100% 農民每年持續選種生技作物。

總計 15 億公頃種植面積

自 1996 年起

50 億人居住於種植、食用或日常使用生技作物的國家。

各國紛紛採用生物技術

27 國種植生技作物*

開發中國家　工業國家

63 國
進口生技作物**

7 個非洲
國家實施生技現地實驗***

9 個亞洲
國家實施生技現地實驗****

生技採用率高

大豆
全球耕地的 **79%**
美國採用率 **95%**
巴西採用率 **92%**

芥花籽
全球耕地的 **24%**
澳大利亞採用率 **99%**
加拿大採用率 **96%**

棉花
全球耕地的 **70%**
種植第二年蘇丹採用率 **89%**
印度採用率 **93%**

玉米
美國、巴西和阿根廷的生技玉米種植面積比例，使其成為全球前三大玉米出口國 **90%+**

木瓜
夏威夷採用率 **75%**

糖用甜菜
美國採用率 **95%**

*阿根廷、澳大利亞、玻利維亞、巴西、布吉納法索、加拿大、智利、中國、哥倫比亞、哥斯大黎加、古巴、捷克、宏都拉斯、印度、墨西哥、緬甸、巴拉圭、巴基斯坦、菲律賓、葡萄牙、羅馬尼亞、斯洛伐克、南非、西班牙、蘇丹、美國、烏拉圭

**阿根廷、澳大利亞、奧地利、孟加拉、比利時、玻利維亞、巴西、保加利亞、布吉納法索、加拿大、智利、中國、哥倫比亞、哥斯大黎加、克羅埃西亞、賽普勒斯、捷克、丹麥、埃及、愛沙尼亞、芬蘭、法國、德國、希臘、宏都拉斯、匈牙利、印尼、印度、伊朗、愛爾蘭、義大利、日本、拉脫維亞、立陶宛、盧森堡、馬來西亞、馬爾他、荷蘭、墨西哥、緬甸、紐西蘭、挪威、巴基斯坦、巴拿馬、巴拉圭、菲律賓、波蘭、葡萄牙、羅馬尼亞、俄羅斯、斯洛伐克、斯洛維尼亞、南非、南韓、西班牙、瑞典、臺灣、泰國、土耳其、英國、美國、烏拉圭

***喀麥隆、迦納、肯亞、馬拉威、奈及利亞、烏干達　****孟加拉、中國、印度、印尼、日本、馬來西亞、巴基斯坦、菲律賓、越南

生技作物有何效益？

植物生物技術幫助全球農民提升獲利性、產能及農田永續性，並進而藉由改善地方經濟、為消費者提供優質營養作物及保護地球自然環境，為農民帶來更好的生活品質。

[1] ISAAA Brief 26-2013
[2] Indicus Analytics, 2007. Socio-economic appraisal of Bt cotton cultivation in India. Indicus Analytics Study.
[3] Graham Brookes and Peter Barfoot. Economic impact of GM crops: The global income and production effects 1996-2012. www.landesbioscience.com/journals/gmcrops/article/28098/
[4] www.ncga.com/news-and-resources/news-stories/article/2012/8/our-view-lies-damn-lies-and-statistics
[5] www.madehow.com/Volume-2/Tofu.html#ixzz3ERC318Na
[6] www.statcan.gc.ca/pub/96-325-x/2007000/article/10778-eng.htm#howto
[7] IFPRI tool: http://apps.harvestchoice.org/agritech-toolbox/
[8] http://ars.usda.gov/is/AR/archive/jul97/gcd0797.htm
[9] IFPRI tool: http://apps.harvestchoice.org/agritech-toolbox/

植物生技對我們的日常生活有何影響？

我們從早到晚都受惠於植物生物技術 – 從放在料理台上的食材到加入車子中的燃料，甚至是縫製您服裝用的布料。

[1] http://isaaa.org/resources/publications/pocketk/16/default.asp
[2] Graham Brookes and Peter Barfoot. Economic impact of GM crops: The global income and production effects 1996–2012. www.landesbioscience.com/journals/gmcrops/article/28098/
[3] www.ncga.com/news-and-resources/news-stories/article/2012/8/our-view-lies-damn-lies-and-statistics
[4] Barfoot P, Brookes G. Key global environmental impacts of genetically modified (GM) crop use 1996–2012. GM Crops and Food: Biotechnology in Agriculture and the Food Chain.
[5] http://www.tfl.gov.uk/cdn/static/cms/documents/technical-note-12-how-many-cars-are-there-in-london.pdf
[6] www.arborgen.com/biotech-trees/
[7] www.hawaiipapaya.com/rainbow.htm
[8] http://banana.aatf-africa.org/news/media/new-gm-banana-could-help-tackle-uganda%E2%80%99s-nutrition-challenges
[9] www.canolacouncil.org/oil-and-meal/canola-oil/health-benefits-of-canola-oil/
[10] www.plenish.com

一整天的生技貢獻

早上 7 點起床

早餐
自 1996 年起迄今，生物技術已經為糧食供應增加 2.31 噸玉米，相當於
707 億盒玉米片 – 等於是地球上每個人分到將近 100 盒[2,3]！

在公司
使用生技棱樹來製造環保紙張

可為後代子孫
保留天然林木[6]

開車上班
生技作物降低農田的碳排放量，減輕您開車對環境的影響。

單單在 2012 年生技作物省下的二氧化碳量，就相當於
將倫敦街上的汽車都拿掉長達五年時間[4,5]。

午餐時間
生物技術保護農民種植的木瓜不受致命病毒侵害。

是美國木瓜產業的救星[7]。

下午點心
生物技術強化香蕉為您的下午點心提供
更多必要維生素和礦物質[8]。

開車回家
生物技術增加玉米及大豆等作物生產，滿足生物燃料需求，讓您使用
更潔淨
環保的再生性能源。

晚餐
包括歐洲在內，世界各地都使用
生技玉米和大豆飼養家畜，為動物提供健康營養的蛋白質及熱量來源。

新的生技芥花籽和大豆種子產出
更健康的烹飪用油
含有更多 Omega-3 脂肪酸，無反式脂肪，且飽和脂肪含量低[9,10]。

蓄裝
全球生產的
70% 棉花
為生技棉花[1]。

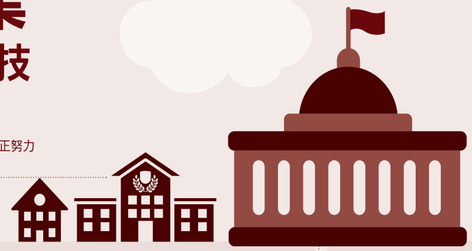
是否有公營事業單位從事植物生技研究？

是的，公營事業組織也正在發展突破性生技創新，盼能藉此因應氣候變遷，解決開發中地區營養不良問題，以改善糧食安全；這些計畫旨在造福農業社群並改善世界健康。

[1] http://www.hawaiipapaya.com/rainbow.htm
[2] http://banana.aatf-africa.org/news/media/new-gm-banana-could-help-tackle-uganda%E2%80%99s-nutrition-challenges
[3] http://www.goldenrice.org/
[4] IFPRI
[5] http://wema.aatf-africa.org/about-wema-project
[6] http://css.wsu.edu/people/faculty/diter-von-wettstein/developing-wheat-free-of-harmful-gluten-proteins/

公營事業研究提供生技解決方案

全球大學、政府機構和非營利組織都正努力為農民及消費者研發生技創新。



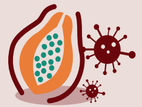
官方民間合作

透過官方民間合作機制，公營事業得以尋求民間企業共同進行合作計畫以解決當地問題，並為全球農民帶來更有助益的創新技術。

彩虹木瓜

具有與生俱來的植物病毒防護能力，**拯救 1700 萬美元的夏威夷木瓜產業免於覆滅**。今日，夏威夷的木瓜農因生技木瓜獲得豐碩收成[1]。

- 康乃爾大學、夏威夷大學與美國農業部農業研究服務處



耐旱玉米

將於 2017 年上市，其兼具傳統及生技特性，在旱災頻仍的非洲也能保障作物產能，屆時將能造福多達 3 億仰賴玉米為主要糧食的非洲人民[4,5]。

- 非洲有效用水玉米（WEMA）是非洲各國研究院與民間企業合作的計畫

富含維生素 A 香蕉

營養高達六倍，可**幫助 52% 五歲以下因缺乏維生素 A 而健康不佳的烏干達孩童**[2]。

- 烏干達國家農業研究組織（NARO）

無麩質小麥

經由生物技術研發，將使人們不再苦於因麩質（小麥中的一種蛋白質）引起的消化道問題；這項突破性創新將**為小麥過敏及麩質過敏人士提供更廣泛的安全糧食選擇**[6]。

- 華盛頓州立大學與民間企業合作

黃金稻米 富含 β 胡蘿蔔素及鐵質，

可望解決**開發中地區人民每年因缺乏維生素 A 而導致 50 萬人永久失明及 200 萬人死亡的問題**[3]。

- 蘇黎世聯邦理工學院、佛萊堡大學、德國與國際稻米研究院

有關上述創新的詳細資訊，請見：
彩虹木瓜： www.hawaiipapaya.com/rainbow.htm
富含維生素 A 香蕉：
http://banana.aatf-africa.org/news/media/new-gm-banana-could-help-tackle-uganda%E2%80%99s-nutrition-challenges

黃金稻米： www.goldenrice.org
WEMA： wema.aatf-africa.org/about-wema-project
無麩質小麥：
http://css.wsu.edu/people/faculty/diter-von-wettstein/developing-wheat-free-of-harmful-gluten-proteins/

未來生技作物發展趨勢？

植物生物技術已經為農民提供以往想像不到的農業創新，而未來的發展更是不可限量；產品開發管道中的生技種子將幫助農民減輕氣候變遷影響，並為全世界消費者解決營養不良及健康問題。

[1] http://croplife.org/wp-content/uploads/2014/09/Climate-Change-Brochure.pdf
[2] http://www.croplife.ca/plant-biotechnology/what-are-the-benefits
[3] http://www.danforthcenter.org/scientists-research/research-institutes/institute-for-international-crop-improvement/crop-improvement-projects/biocassava-plus
[4] http://biosorghum.org/abs.php http://gmoanswers.com/plant-biotechnology-research-can-be-found-more-just-private-sector-universities-government
[5] http://www.croplife.ca/plant-biotechnology/what-are-the-benefits
[6] http://www.okspecialtyfruits.com/arctic-apples/advantages-nonbrowning-apple

未來植物生技創新

從農田

生技種子創新將幫助農民克服日趨變異的氣候條件，持續生產安全且足量的糧食；陸續出現的新品種將幫助農民持續培養因應氣候變遷的能力，以達到提升產能、獲利性及永續性的目標。

氮素利用效率種子品種
可讓作物充分利用所施氮肥，改善作物生長，增加產量並減少碳排放[1]。

耐洪品種
可於極端潮濕的氣候中確保穩定產量。

耐旱
在酷旱中藉由有效用水保障收成並減少損失。

耐除草劑、耐疾病及耐害蟲種子的進步將提供更有效的病蟲害防治。

耐鹽及耐熱種子
可讓農民利用現在無法栽種作物的土地[2]。

這些技術
特別有益於開發中地區，
幫助農民克服因氣候變遷所產生的變異天氣和惡劣生長條件。

到餐桌

生物技術能為開發中地區提供生物強化糧食，解決營養不良問題。在工業國家消費者也能獲益於生技糧食創新，享有更營養、更優質、更便利的食物供應。

更加營養且產量豐饒的樹薯
是撒哈拉以南非洲 2.5 億人口的主要熱量來源，將協助改善營養不良現象[3]。

營養提升且更易消化的高粱
含有更多必需胺基酸和維生素，將可幫助數百萬賴之為主食的非洲人改善健康[4]。

具有抗病能力的種食
包括富含抗氧化物的番茄、高茄紅素含量的粉色果肉鳳梨、含有增量維生素 C、E 的玉米和大豆，以及能榨出健康食用油的種子[5]。

切片後不會變黑的蘋果和洋芋
更受食用者歡迎，促進健康並減少糧食浪費[6]。

植物生物技術未來發展不可限量

-- 從幫助農民提升產能並確保糧食安全的作物，到增進消費者飲食並降低健康風險的食物。

農民如何預先掌握害蟲抗藥性？

病蟲害一向是農民難以擺脫的噩夢。數千年來農民用盡一切方法對抗病蟲害、保護作物，但所有病蟲害都將反撲，並且演化出抵抗這些防治方法的能力；全球農田，包括生技、傳統和有機耕作田地都必須掌握害蟲抗藥能力的發展情況，並確保病蟲害防治方法的有效性。

預先掌握昆蟲抗藥性

所謂的抗性是指雜草、昆蟲或疾病經過演進，產生足以對抗農民病蟲害管理策略的能力。不論是傳統農業、生技農業或是有機農業，這是所有作物生產系統中必然發生的問題；但農民若是善用依據其農田及病蟲害狀況量身訂做的抗性管理計畫，就能延遲抗性產生的時間並發揮生物技術的效力。三種常用的抗性管理方法包括作物輪作、庇蟲種植及性狀混合。

庇蟲種植

種植耐蟲生技作物的農民通常會劃出庇蟲區域，也就是一塊或一條不含生技特性的作物。**庇蟲區域可確保留存一小部分不具抗性的昆蟲，預防病蟲害後代產生免疫能力。**若具有抗藥性的昆蟲誕生，其本身或後代還早會與不具抗性的昆蟲交配，因此達到延緩靠藥性出現的效果。

作物輪作

由於不同病蟲害攻擊的作物不同，因此**作物輪作能預防特定疾病或昆蟲的增長**為足以耐受防治方法。經由作物輪作，不同作物是以週期性的方式種植於同一片田地，限制抗性的發展。

這片玉米田明年將種植大豆，後年再換種另一種作物。

性狀混合

「性狀混合」可結合**同一種子中的多種特性，在同一植物中以不同方法防治病蟲害。**如果病蟲害對其中一種特性產生抵抗力，另一種特性就能消滅病蟲害，並去除昆蟲總體的抗性。

這顆四倍性狀混合玉米種子提供四種不同的 天生病蟲害防治能力 – 兩種防治害蟲，兩種防治雜草 – 有效限制抗性產生。

抗性管理計畫不僅是用於保護生技作物，也是用於確保病蟲害防治方法能長久維持功效。雖然某些地區的生技農田確實出現抗性雜草和昆蟲，但藉由與植物科學產業合作實施抗性管理，農民已經成功將抗性圈限在小面積範圍中

植物生物技術 101 總結

防治影響產量的病蟲害
農民利用生物技術防治雜草及害蟲，確保安全、價格合理且供應充足的糧食收成。

提供更具效率的植物育種方法
生物技術幫助植物育種專家有效開發能滿足世界漸增糧食需求的作物。

確認安全性
衛生主管當局、科學專家及各國政府組織一致為生技作物的安全性背書(語意確認)。

增加採用
生技作物的種植遍及世界各地，並且已然成為農業領域中採用率增加最快的作物技術。

造福世界
植物生物技術推動農村進步，滿足糧食需求並照顧我們的地球，幫助世界成長。

與我們的日常生活息息相關
我們從早到晚都受惠於植物生物技術 – 從放在料理台上的食材到加入車子中的燃料，甚至是縫製您服裝用的布料。

突破性公營事業研究
公營事業組織正在發展突破性生技創新，盼能藉此因應氣候變遷，解決開發中地區營養不良問題，改善糧食安全。

精彩未來創新
目前正在研發中的生技種子將幫助農民減輕氣候變遷影響，並為全世界消費者解決營養不良及健康問題。

管理抗性
全球農田，包括生技、傳統和有機耕作田地，都必須掌握害蟲抗藥能力的發展情況，並確保病蟲害防治方法的有效性。

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CropLife INTERNATIONAL

Helping Farmers Grow

PLANT BIOTECHNOLOGY 101

Answering Your Questions

CropLife INTERNATIONAL

BIOTECH BASICS

Do you have questions about plant biotechnology? If you do, you're not alone. Many people find that they need to visit multiple sources or decipher scientific jargon for complete, accurate answers.

This booklet will answer many of your questions in one place. It is an easy-to-understand collection of infographics that will increase your knowledge of the basics of plant biotechnology and help you understand some of the more complex questions you often hear.

WHAT IS PLANT BIOTECHNOLOGY?

Plant biotechnology is a sophisticated breeding technology that allows plant breeders to precisely introduce beneficial traits into plants. Biotech crops approved for use today have been improved to help farmers tackle insects, disease and weeds in their fields and in the future could offer foods with higher vitamin levels, longer shelf life or the ability to grow even in the face of climate change.

Genetic modification (GM), genetic engineering (GE) and genetically modified organisms (GMO) are a few other terms that are also often used to refer to plant biotechnology.

Plant biotechnology will be a key tool to
HELP FARMERS PRODUCE
70% MORE FOOD
that will be required to feed this growing planet.

7 BILLION PEOPLE populated the world in 2012.

9 BILLION+ PEOPLE will populate the world in 2050.

TABLE OF CONTENTS

ABOUT CROPLIFE INTERNATIONAL

CropLife International is the voice of the global plant science industry. It champions the role of agricultural innovations in crop protection and plant biotechnology in supporting and advancing sustainable agriculture; helping farmers feed a growing population while looking after the planet; and progressing rural communities. The world needs farmers, and farmers need plant science. CropLife International is proud to be at the heart of helping farmers grow.

Still have questions? VISIT CROPLIFE.ORG TO LEARN MORE.

Why do farmers need to control weeds and insects?

The majority of weeds and insects are unwelcome in a farmer's field. Left uncontrolled they can reduce plant health, robbing a crop of yield and quality. This also impacts a farmer's bottom line. It's in everyone's best interest to limit weeds and insect pressure to help achieve a harvest of safe, affordable and abundant food.

[1] James, C. 2003. Global Review of Commercialized Transgenic Crops: 2002 Feature: Bt Maize. ISAAA Briefs No. 29. ISAAA: Ithaca, NY
[2] Oerke, E.C., 2006, "Crop losses to pests," Journal of Agricultural Science, vol. 144, pp. 31-43
[3] Graham Brookes and Peter Barfoot. Economic impact of GM crops: The global income and production effects 1996–2012. www.landesbioscience.com/journals/gmcrops/article/28098/

THE LIFE OF A CORN COB

PLANTING

A CORN PLANT WILL FACE CHALLENGES THROUGHOUT THE GROWING SEASON, BEGINNING WITH WEEDS, INSECTS AND DISEASES THREATENING THE CROP BEFORE IT EVEN HAS A CHANCE TO SPROUT.

Biotechnology can provide built-in protection against insects and weeds, giving a corn plant a strong, healthy start.

GROWING

Weeds compete with corn plants for nutrients, moisture, sunlight and space, and provide the ideal hiding place for pests and diseases.

INSECTS FEED ON CORN PLANTS, CAUSING DAMAGE AND TRANSMITTING DISEASE.

Herbicide-tolerant and insect-tolerant biotech traits can help eliminate weed and insect pressure, allowing a corn plant to reach its full potential.

HARVESTING

Insect damage lowers the quality of the corn crop, leading to smaller harvests and reduced income for farmers. Insect damage also creates mycotoxins (poisonous substances produced by fungi), which can reduce food quality and safety.[1]

WEED COMPETITION LEADS TO SMALLER COBS, WHICH REDUCES YIELDS.

Without the weed competition and insect damage that conventional crops face, biotech crops can reach their full yield and quality potential.

CONSUMING

UP TO 40% OF THE WORLD'S POTENTIAL CROP PRODUCTION IS LOST each year because of weeds, insects and diseases.[2]

BIOTECH CROPS ENABLE FARMERS TO PRODUCE MORE FOOD

SINCE 1996
biotech crops helped farmers produce
231 million tons more corn.[3]

This provides farmers with a higher income and better quality of life.

How is a biotech crop created?

For thousands of years, farmers and researchers used traditional breeding methods to develop many of the domesticated crops we enjoy today. In the past 100 years though, our global population tripled and plant breeders needed faster and more effective methods to meet the growing demands of our world. Biotechnology provided precise tools that enabled researchers to add a 'trait' or characteristic to a plant. These traits can make the crop heartier and healthier, add higher levels of vitamins, or provide a longer shelf-life after harvest – the opportunities are endless.

www.irs.gov/Businesses/Biotech-Industry-Overview---History-of-Industry
www.gmoanswers.com/explore
www.nature.com/scitable/knowledge/library/history-of-agricultural-biotechnology-how-crop-development-25885295
www.croplife.org/biotech-crop-development/

BIOTECH CROPS

AN IMPORTANT MILESTONE FOR AGRICULTURE AS IT CONTINUALLY IMPROVES TO KEEP PACE WITH THE GROWING DEMAND FOR FOOD.

FARMERS AND PLANT BREEDERS HAVE BEEN MODIFYING PLANT GENES FOR MORE THAN 10,000 YEARS in order to develop higher-yielding crops and foods with improved nutrition and taste. Plant breeding has evolved over centuries and biotechnology is a continuation of this time-tested process.

BC 8000
Simple selection: farmers select seed from top-performing plants. Many "modern" or familiar vegetables and fruits were domesticated through breeding programs.

Scientific discoveries dating back to the 1800s have paved the way for modern plant breeders to use molecular biology to remove the guesswork and imprecision of conventional breeding methods.

1700s
Cross-breeding: farmers and scientists cross-breed plants within a species (e.g. rutabagas are a cross between turnips and cabbage).

1940s
Seed breeding: plant breeders use radiation or chemicals to generate seeds with desirable traits. These random mutations lead to new and useful plant characteristics such as size, sweetness or color (e.g. red grapefruit).

1865
Scientist Gregor Mendel's pea-breeding experiments prove heredity and the field of genetics is "born."

1953
Scientists James Watson and Francis Crick discover the double helix structure of DNA.

1973
Scientists Stanley Cohen and Herbert Boyer perfect recombinant DNA development – the technique used to cut and paste DNA and reproduce the new DNA in bacteria. This signalled the birth of genetic engineering or modern biotechnology.

1980s
Insulin is the first approved product of modern biotechnology. Plant breeders apply new techniques of biotechnology to plants.

1996
First biotech staple crops are commercialized and available for planting.

1996-2013
Researchers introduce biotech corn, soybean, cotton, canola, papaya and more to farmers around the world.

2014 and beyond
Plant biotechnology continues to evolve with new techniques that will advance food production for farmers and meet the needs of consumers (e.g. genome editing, gene silencing, plastid transformation and inducible genes).

CREATING BIOTECH SEEDS

Plant biotechnology is the process of copying a gene for a desired trait (such as insect resistance) from one plant or organism and using it in another plant. Methods for achieving this are continually evolving, but one of the most common ways is:

1. IDENTIFICATION

Identify the gene or genetic material that will make the plant more nutritious, heartier or less susceptible to diseases or pests.

2. TRANSFERRING

Genetic researchers use a revolutionary method that utilizes agrobacterium, a natural organism discovered over 100 years ago, to pass on genes to plants. The agrobacterium acts like an automobile, carrying its passengers (the genes) into the seed, where they integrate into a precise area of the plant's genetic material.

The agrobacterium then exits the seed, leaving behind the new, beneficial trait.

3. PLANTING

The new seed is then tested for safety, reliability and effectiveness. Once it receives approval by regulators, farmers are able to plant and reap the benefits of this new technology.

Are biotech crops safe?

Yes. Health authorities, scientific experts and governments around the world have all found biotech crops to be one of the most rigorously tested products on the market with a proven safety record for our food and our health.

[1] Critical Reviews in Biotechnology, March 2014, Vol. 34, No. 1
[2] ISAAA Brief 46-2013
[3] Agricultural Biotechnology Council

BIOTECH CROP SAFETY IS OVERWHELMINGLY ENDORSED BY:

HEALTH AUTHORITIES

"No effects on human health have been shown as a result of the consumption of GM foods by the general population in the countries where they have been approved."
- WORLD HEALTH ORGANIZATION

WORLD HEALTH ORGANIZATION (WHO) • AMERICAN MEDICAL ASSOCIATION (AMA)
ROYAL SOCIETY OF MEDICINE (UK) • BRITISH MEDICAL ASSOCIATION • HEALTH CANADA

SCIENTIFIC EXPERTS

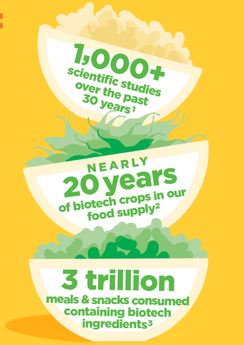
"The science is quite clear: crop improvement by the modern molecular techniques of biotechnology is safe."
- AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE (AAAS) • NATIONAL ACADEMIES OF SCIENCE OF MANY COUNTRIES
NETWORK OF AFRICAN SCIENCE ACADEMIES (NASAC) • EUROPEAN ACADEMIES SCIENCE ADVISORY COUNCIL (EASAC)
INTERNATIONAL COUNCIL FOR SCIENCE • PONTIFICAL ACADEMY OF SCIENCE

GOVERNMENT ORGANIZATIONS

"The use of more precise technology and the greater regulatory scrutiny probably makes GMOs even safer than conventional plants and foods."
- EUROPEAN COMMISSION

EUROPEAN COMMISSION • FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)
US-FDA • FOOD STANDARDS AUSTRALIA NEW ZEALAND • PHILIPPINES FOOD AND DRUG ADMINISTRATION
FRENCH FOOD SAFETY AGENCY • CANADIAN FOOD INSPECTION AGENCY
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT (USAID)



0 FOOD SAFETY OR HEALTH ISSUES[3]

Where are biotech crops grown?

Biotech crops are grown worldwide, and have become one of the fastest-adopted crop technologies in the history of agriculture. Over 18 million farmers in 27 countries planted biotech crops – from maize to papaya – in 2013 and every year more growers are adopting the technology. In fact, the number of biotech crop hectares planted has increased 100-fold since the first commercialized seeds were sown in 1996. The world's largest maize and soybean exporters, United States, Brazil and Argentina, almost exclusively grow biotech crops. These trends are expected to continue as more countries embrace biotechnology.

[1] James, Clive. 2013. Global Status of Commercialized Biotech/GM Crops: 2013. ISAAA Brief No. 46. ISAAA: Ithaca, NY.

BIOTECH ADOPTION INCREASES ANNUALLY

FARMERS ARE FAST ADOPTERS

18 MILLION FARMERS GROW BIOTECH CROPS

90% of biotech growers live in developing countries where biotech crop benefits, such as better harvests and higher incomes, can transform rural communities.

NEARLY 100% of farmers replant biotech crops year after year.

5 billion people live in countries that are growing, eating or using biotech crops in their everyday lives.

COUNTRIES EMBRACE BIOTECH

27 COUNTRIES GROW BIOTECH CROPS*

63 COUNTRIES import biotech crops**

7 AFRICAN countries conduct biotech field trials***

9 ASIAN countries conduct biotech field trials****

BIOTECH ADOPTION IS HIGH

SOYBEAN

79% of global acres
95% adoption rate in U.S.
92% adoption rate in Brazil

CANOLA

24% of global acres
99% adoption rate in Australia
96% adoption rate in Canada

COTTON

70% of global acres
89% adoption rate in Sudan in just second year of planting
93% adoption rate in India

MAIZE

90%+ The percentage of biotech maize hectares in the U.S., Brazil and Argentina, helping them be the top 3 maize exporters worldwide

PAPAYA
75% adoption rate in Hawaii

SUGAR BEET
95% adoption rate in U.S.

* Argentina, Australia, Bolivia, Brazil, Burkina Faso, Canada, Chile, China, Columbia, Costa Rica, Cuba, Czech Republic, Honduras, India, Mexico, Myanmar, Paraguay, Pakistan, Philippines, Portugal,, Romania, Slovakia, South Africa, Spain, Sudan, U.S., Uruguay

** Argentina, Australia, Austria, Bangladesh, Belgium, Bolivia, Brazil, Bulgaria, Burkina Faso, Canada, Chile, China, Colombia, Costa Rica, Croatia, Cyprus, Czech Republic, Denmark, Egypt, Estonia, Finland, France, Germany, Greece, Honduras, Hungary, Indonesia, India, Iran, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Netherlands, Mexico, Myanmar, New Zealand, Norway, Pakistan, Panama, Paraguay, Philippines, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, South Africa, South Korea, Spain, Sweden, Taiwan, Thailand, Turkey, United Kingdom, U.S., Uruguay

*** Cameroon, Ghana, Kenya, Malawi, Nigeria, Uganda **** Bangladesh, China, India, Indonesia, Japan, Malaysia, Pakistan, Philippines, Vietnam

What are the benefits of biotech crops?

Plant biotechnology enables farmers worldwide to boost the profitability, productivity and sustainability of their farms. This helps create a better quality of life for their community by improving the local economy, provides consumers with high-quality nutritious crops and protects the natural environment around us.

[1] ISAAA Brief 26-2013
[2] Indicus Analytics, 2007. Socio-economic appraisal of Bt cotton cultivation in India. Indicus Analytics Study.
[3] Graham Brookes and Peter Barfoot. Economic impact of GM crops: The global income and production effects 1996–2012. www.landesbioscience.com/journals/gmcrops/article/28098/
[4] www.ncga.com/news-and-resources/news-stories/article/2012/8/our-view-lies-damn-lies-and-statistics
[5] www.madehow.com/Volume-2/Tofu.html#ixzz3ERC318Na
[6] www.statcan.gc.ca/pub/96-325-x/2007000/article/10778-eng.htm#howto
[7] IFPRI tool: http://apps.harvestchoice.org/agritech-toolbox/
[8] http://ars.usda.gov/is/AR/archive/jul97/gcd0797.htm
[9] IFPRI tool: http://apps.harvestchoice.org/agritech-toolbox/

PROGRESS RURAL COMMUNITIES

In 2013, biotech crops helped increase farm incomes and food security, while

alleviating poverty

for more than 65 million smallholder farmers

&

their family members through higher crop yields.[1]

In India, biotech cotton provides higher incomes and leads to

A BETTER QUALITY OF LIFE.

This includes improved access to telephone systems, drinking water and economic infrastructure as well as more maternal health care, higher school enrollment and increased vaccination rates.[2]

LOOK AFTER OUR PLANET

Biotech crops protect the environment.

Herbicide-tolerant crops reduce the need for tillage, keeping carbon in the soil.

NO-TILL FARMING PREVENTS ENOUGH CO_2 EMISSIONS – AT LEAST 3.2 MILLION TONS EACH YEAR – to offset home electricity use in the United States for nearly 3.5 years.[8]

PLANT BIOTECHNOLOGY HELPS OUR WORLD GROW

FEED A GROWING POPULATION

Biotech crops help meet the world's growing demand for food through increased crop productivity. Since 1996,

FARMERS HAVE ADDED

358 MILLION EXTRA TONS

TO OUR GLOBAL FOOD SUPPLY[3]

That's like providing every person on earth with

99 BOXES OF CORN FLAKES,[4] 125 SERVINGS OF TOFU,[5] AND A 14 OZ BOTTLE OF CANOLA OIL.[6]

In the future, advanced biotech traits like nitrogen-use efficiency will improve plant growth. This could **nearly double yields of irrigated maize in Latin America and Sub-Saharan Africa in 2050.[7]**

Nutrition-enhanced foods developed through biotechnology, from vitamin-A enriched bananas to sorghum with **higher levels of essential nutrients, could help the two billion malnourished people in developing regions.[9]**

By allowing farmers to grow more on less land,

123 MILLION HECTARES

of natural habitats were preserved between 1996 & 2012.[5]

How does plant biotech impact our daily lives?

We benefit from plant biotechnology from morning until night – from the food we put on our kitchen table, to the fuel we put in our cars, to the fibers that make your favorite shirt.

[1] http://isaaa.org/resources/publications/pocketk/16/default.asp
[2] Graham Brookes and Peter Barfoot. Economic impact of GM crops: The global income and production effects 1996-2012. www.landesbioscience.com/journals/gmcrops/article/28098/
[3] www.ncga.com/news-and-resources/news-stories/article/2012/8/our-view-lies-damn-lies-and-statistics
[4] Barfoot P, Brookes G. Key global environmental impacts of genetically modified (GM) crop use 1996–2012. GM Crops and Food: Biotechnology in Agriculture and the Food Chain.
[5] http://www.tfl.gov.uk/cdn/static/cms/documents/technical-note-12-how-many-cars-are-there-in-london.pdf
[6] www.arborgen.com/biotech-tress/
[7] www.hawaiipapaya.com/rainbow.htm
[8] http://banana.aatf-africa.org/news/media/new-gm-banana-could-help-tackle-uganda%E2%80%99s-nutrition-challenges
[9] www.canolacouncil.org/oil-and-meal/canola-oil/health-benefits-of-canola-oil/
[10] www.plenish.com

BIOTECH THROUGHOUT THE DAY

7 AM WAKE UP

AT THE OFFICE

Biotech eucalyptus trees could soon be used as a sustainable paper source that

SAVES NATIVE FORESTS FOR FUTURE GENERATIONS.[6]

DRIVING TO WORK

Biotech crops mitigate the carbon impacts of your car by reducing on-farm emissions.

In 2012 alone, the amount of CO_2 saved by biotech crops was equal to

REMOVING EVERY SINGLE CAR FROM THE STREETS OF LONDON FOR FIVE YEARS.[4,5]

BREAKFAST

Since 1996, biotech has added 231 million more tons of corn to the food supply or enough corn for approximately

707 BILLION BOXES OF CORN FLAKES – that's nearly 100 boxes for every person on the planet![2,3]

GETTING DRESSED

70% OF COTTON produced worldwide is biotech.[1]

LUNCHTIME

Papayas developed through biotechnology are resistant to a deadly virus that would otherwise devastate a farmer's harvest.

IN THE UNITED STATES, THIS SAVED THE ENTIRE PAPAYA INDUSTRY.[7]

AFTERNOON SNACK

Bananas are being enhanced through biotechnology to provide

MORE ESSENTIAL VITAMINS

and minerals to your mid-afternoon snack.[8]

DRIVING HOME

Biotechnology increases production of crops such as corn and soybeans to meet biofuel demands, giving you access to

CLEANER, ENVIRONMENTALLY FRIENDLY SOURCES of renewable energy.

DINNER

Biotech corn and soybeans are

USED TO FEED LIVESTOCK ON EVERY CONTINENT, INCLUDING EUROPE,

offering the animals a healthy, nutritious source of protein and calories.

New biotech canola and soybean seeds produce new,

HEALTHIER COOKING OILS

with higher levels of omega-3 fatty acids, no trans-fat and lower saturated fat.[9,10]

Does the public sector conduct plant biotech research?

Yes, public sector organizations are developing ground-breaking biotech innovations that can help tackle climate change, fight malnutrition in developing regions, improve food security and more. These projects are poised to deliver incredible benefits to farming communities and improve the health of our world.

[1] http://www.hawaiipapaya.com/rainbow.htm
[2] http://banana.aatf-africa.org/news/media/new-gm-banana-could-help-tackle-uganda%E2%80%99s-nutrition-challenges
[3] http://www.goldenrice.org/
[4] IFPRI
[5] http://wema.aatf-africa.org/about-wema-project
[6] http://css.wsu.edu/people/faculty/diter-von-wettstein/developing-wheat-free-of-harmful-gluten-proteins/

PUBLIC SECTOR RESEARCH DELIVERS BIOTECH SOLUTIONS

Universities, government institutions and non-profits worldwide are working to develop new biotech innovations for farmers and consumers.

Rainbow papaya

with built-in protection against a devastating plant virus **saved the $17 million U.S. Hawaiian papaya industry from collapse.** Today, Hawaii's papaya farmers are flourishing as a result of biotech papaya.[1]

- CORNELL UNIVERSITY, UNIVERSITY OF HAWAII AND U.S. DEPARTMENT OF AGRICULTURE'S AGRICULTURAL RESEARCH SERVICE

Vitamin A-rich bananas

with six times the normal level of nutrients could one day **benefit 52% of Ugandan children under age five whose health suffers** from Vitamin A deficiencies. [2]

- UGANDAN NATIONAL AGRICULTURAL RESEARCH ORGANIZATION (NARO)

Golden rice,

which boasts high amounts of beta-carotene and iron, is expected to **significantly reduce Vitamin A deficiency in developing regions, which is responsible for 500,000 cases of irreversible blindness and up to 2 million deaths** each year. [3]

- SWISS FEDERAL INSTITUTE OF TECHNOLOGY, THE UNIVERSITY OF FREIBURG, GERMANY AND THE INTERNATIONAL RICE RESEARCH INSTITUTE

Public-Private Partnerships

Public-private partnerships offer a way for the public sector to pursue collaborative projects with the private sector, addressing local challenges and bringing greater innovation to our world's farmers.

Drought-tolerant maize

with conventional and biotech traits that help farmers in drought-prone Africa maximize crop production will be available in 2017, **benefiting more than 300 million Africans who depend on maize as their main food source.** [4,5]

- WATER EFFICIENT MAIZE FOR AFRICA (WEMA), A COLLABORATION BETWEEN AFRICAN NATIONAL RESEARCH INSTITUTES AND THE PRIVATE SECTOR

Gluten-free wheat

developed through biotechnology will one day benefit people who suffer digestive problems triggered by gluten (a protein found in wheat). This breakthrough innovation will **help provide individuals with wheat allergies and Celiac disease with a wider range of safe food choices.** [6]

- PARTNERSHIP BETWEEN WASHINGTON STATE UNIVERSITY AND THE PRIVATE SECTOR

For more info about each of these innovations, visit:
Rainbow Papaya: www.hawaiipapaya.com/rainbow.htm
Vitamin A-Rich Bananas: http://banana.aatf-africa.org/news/media/new-gm-banana-could-help-tackle-uganda%E2%80%99s-nutrition-challenges
Golden Rice: www.goldenrice.org
WEMA: wema.aatf-africa.org/about-wema-project
Gluten-Free Wheat: http://css.wsu.edu/people/faculty/diter-von-wettstein/developing-wheat-free-of-harmful-gluten-proteins/

What are some biotech crops of the future?

Plant biotechnology has already provided farmers with agricultural innovations they never thought possible. The future promises even greater advancements. Biotech seeds in the product development pipeline will help farmers better weather climate change and provide consumers worldwide with solutions to fight malnutrition and health issues.

[1] http://croplife.org/wp-content/uploads/2014/09/Climate-Change-Brochure.pdf
[2] http://www.croplife.ca/plant-biotechnology/what-are-the-benefits
[3] http://www.danforthcenter.org/scientists-research/research-institutes/institute-for-international-crop-improvement/crop-improvement-projects/biocassava-plus
[4] http://biosorghum.org/abs.php http://gmoanswers.com/plant-biotechnology-research-can-be-found-more-just-private-sector-universities-government
[5] http://www.croplife.ca/plant-biotechnology/what-are-the-benefits
[6] http://www.okspecialtyfruits.com/arctic-apples/advantages-nonbrowning-apple

FUTURE PLANT BIOTECH INNOVATIONS

FROM FARM

Biotech seed innovations will help farmers continually produce a safe and bountiful harvest in the face of increasingly volatile weather conditions. New varieties on the horizon will help farmers continue to build resilience to climate change, resulting in increased productivity, profitability and sustainability.

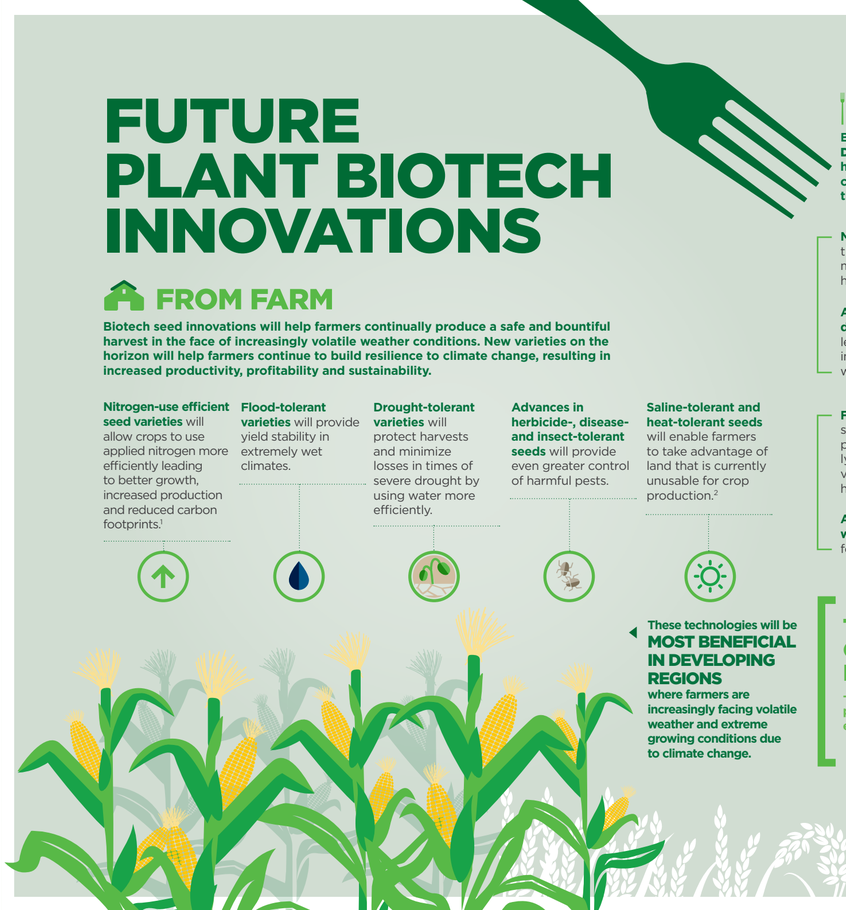
Nitrogen-use efficient seed varieties will allow crops to use applied nitrogen more efficiently leading to better growth, increased production and reduced carbon footprints.[1]

Flood-tolerant varieties will provide yield stability in extremely wet climates.

Drought-tolerant varieties will protect harvests and minimize losses in times of severe drought by using water more efficiently.

Advances in herbicide-, disease- and insect-tolerant seeds will provide even greater control of harmful pests.

Saline-tolerant and heat-tolerant seeds will enable farmers to take advantage of land that is currently unusable for crop production.[2]



These technologies will be MOST BENEFICIAL IN DEVELOPING REGIONS where farmers are increasingly facing volatile weather and extreme growing conditions due to climate change.

TO FORK

Biotechnology will play an important role in providing DEVELOPING REGIONS with biofortified foods that help tackle malnutrition. In INDUSTRIAL COUNTRIES, consumers will also benefit from biotech food innovations that enhance nutrition, quality and convenience.

More nutritious and higher yielding cassava, the primary source of calories for over 250 million people in Sub-Saharan Africa, will help to reduce malnutrition.[3]

A nutrient-rich and more easily digestible sorghum, containing increased levels of essential amino acids and vitamins, will improve the health of millions of people in Africa who rely on the staple as their primary diet.[4]

Foods with disease-fighting properties such as tomatoes rich in antioxidants, pink-fleshed pineapples with higher levels of lycopene, corn and soybeans with increased vitamin C and E, and oilseeds that produce heart-healthy oils.[5]

Apples and potatoes that don't brown when sliced, leading to increased consumption for better health and less food waste.[6]

THE FUTURE POTENTIAL OF PLANT BIOTECHNOLOGY IS LIMITLESS

– from crops that enable farmers to maximize productivity and ensure food security to foods that enhance consumer diets and reduce health risks.

How do farmers stay ahead of pest resistance?

Pests have always been a fact of life for farmers. For thousands of years, they have adopted countless methods to fight them off and protect their crops. However, all pests will inevitably fight back and can develop resistance to these methods. Farms around the world, from biotech to conventional to organic, must work to manage potential resistance and ensure technologies that control yield-robbing pests remain effective.

STAYING AHEAD OF PEST RESISTANCE

Resistance is when a weed, insect or disease evolves to withstand the farmer's pest management strategy. It is inevitable and happens in every crop production system – from conventional to biotech to organic. Farmers are able to delay the onset of resistance and maximize the effectiveness of the technology by implementing resistance management plans tailored to their field and pest pressures. Three common approaches to resistance management include: crop rotation, refuge planting and stacked traits.

CROP ROTATION

Because different pests attack different crops, **CROP ROTATION PREVENTS A BUILDUP OF CERTAIN DISEASES OR INSECTS** that can become tolerant to the control method. Through crop rotation, a different crop is planted in a field periodically, limiting the development of resistance.

This corn field will be planted with soybeans next year and a different crop the following year.

REFUGE PLANTING

Farmers who plant insect-tolerant biotech crops often plant a refuge area – a block or strip of crop without the biotech trait. **REFUGE PREVENTS FUTURE GENERATIONS OF PESTS FROM BUILDING IMMUNITY BY ENSURING A SMALL PROPORTION OF INSECTS WITHOUT RESISTANCE ARE ALWAYS PRESENT.** If a resistant insect is born, it or its offspring will eventually mate with a non-resistant insect thereby delaying the onset of resistance.

STACKED TRAITS

"Stacked traits" can incorporate **MULTIPLE TRAITS IN THE SAME SEED, PROVIDING DIFFERENT METHODS TO CONTROL PESTS WITHIN ONE PLANT.** If a pest becomes resistant to one of traits, another trait can eliminate the pest and remove its resistance from the insect population.

This quadruple-stacked corn seed provides four different built-in pest controls – two for insects and two for weeds – so farmers can limit resistance well into the future.

RESISTANCE MANAGEMENT PLANS ARE AN ESSENTIAL WAY TO ENSURE NOT JUST A BIOTECH CROP, HOWEVER ANY METHOD OF ELIMINATING PESTS CAN REMAIN EFFECTIVE LONG INTO THE FUTURE. RESISTANT WEEDS AND INSECTS HAVE BEEN FOUND ON BIOTECH FIELDS IN CERTAIN PARTS OF THE WORLD, BUT BY WORKING HAND-IN-HAND ON RESISTANCE MANAGEMENT WITH THE PLANT SCIENCE INDUSTRY, FARMERS HAVE SUCCESSFULLY LIMITED RESISTANCE TO A SMALL NUMBER OF ACRES.

PLANT BIOTECHNOLOGY 101 SUMMARY

CONTROLLING YIELD-ROBBING PESTS

Farmers control weeds and insects with the help of biotechnology to help achieve a successful harvest of safe, affordable and abundant food.

DELIVERING MORE EFFECTIVE PLANT BREEDING METHODS

Biotechnology provides precise tools that enable plant breeders to effectively develop crops that help meet the growing demands of our world.

CONFIRMING SAFETY

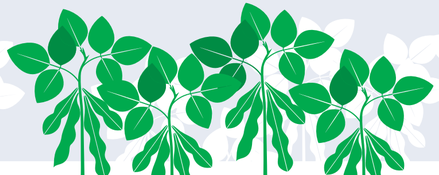
Health authorities, scientific experts and government organizations overwhelmingly endorse biotech crop safety.

INCREASING ADOPTION

Biotech crops are grown worldwide, and have been one of the fastest-adopted crop technologies in the history of agriculture.

BENEFITING OUR WORLD

Plant biotechnology helps our world grow by contributing to progress in rural communities, feeding a growing population, and looking after our planet.



IMPACTING OUR DAILY LIVES

We benefit from plant biotechnology from morning until night – from the food we put on our kitchen table, to the fuel we put in our cars, to the fibers that make your favorite shirt.

GROUNDBREAKING PUBLIC SECTOR RESEARCH

Public sector organizations are developing groundbreaking biotech innovations that can help tackle climate change, fight malnutrition in developing regions, improve food security and more.

EXCITING FUTURE INNOVATIONS

Biotech seeds now being developed will help farmers better weather climate change and provide consumers worldwide with solutions to fight malnutrition and health issues.

MANAGING RESISTANCE

Farmers around the world, from conventional to biotech to organic, work to manage potential resistance to ensure technologies that control yield-robbing pests remain effective.

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