Biotech crop planting resumes high adoption in 2016

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ABSTRACT. The global area of biotech crops in 2016 increased from 179.7 million hectares to 185.1 million hectares, a 3% increase equivalent to 5.4 million hectares. Some 26 countries planted biotech crops, 19 of which were developing countries and seven were industrial. Information and data collected from various credible sources showed variations from the previous year. Fluctuations in biotech crop area (both increases and decreases) are influenced by factors including, among others, acceptance and commercialization of new products, demand for meat and livestock feeds, weather conditions, global market price, disease/pest pressure, and government’s enabling policies. Countries which have increased biotech crop area in decreasing order in 2016 were Brazil, United States of America, Canada, South Africa, Australia, Bolivia, Philippines, Spain, Vietnam, Bangladesh, Colombia, Sudan, Slovakia, and Costa Rica. Countries with decreased biotech area in decreasing order were China, India, Argentina, Paraguay, Uruguay, Mexico, Portugal, and Czech Republic, in decreasing incremental decrease in biotech area. Pakistan and Myanmar were the only countries with no change in biotech crop (cotton) planted. Information detailed in the paper including future crops and traits in each country could guide stakeholders in informed crafting of strategies and policies for increased adoption of biotech crops in the country.

KEYWORDS. biotech crops, biotech crop area, biotech traits, adoption rate, developing countries, industrial countries

INTRODUCTION

The 21 years of commercialization of biotech crops (1996 to 2016) had confirmed that biotech crops have delivered substantial agronomic, environmental, economic, health and social benefits to farmers and increasingly to the consumers. This rapid adoption of biotech
crops reflects the substantial multiple benefits realized by both large and small farmers in industrial and developing countries that have commercially grown biotech crops. In 21 years, biotech crops have been planted to an accumulated area of 2.1 billion hectares which contribute significantly to more than 7.6 billion people globally. Feeding the world population which is continuously increasing and predicted to be 10 billion in 2050 and 11.2 billion in 2100 is indeed a daunting task. It is estimated that the world will require some 50% to 70% increase in food production with dwindling resources of land, water, along with and environmental and agricultural challenges brought by climate change.

Benefits gained in the last 21 years through biotech crops also proves that conventional crop technology alone is not sufficient to feed the immense increase in population, but neither is biotechnology a panacea. The global scientific community adheres to the option that a balanced, safe and sustainable approach using the best of conventional crop technology such as well-adapted and agronomically desirable and high-yielding germplasm, and the best of biotechnology (GM and non-GM traits) to achieve sustainable intensification of crop productivity on the 1.5 billion hectares of cropland.

The more than 18 million farmers (up to 90% were small/poor farmers) in up to 26 countries who have planted biotech crops attest to the multiple benefits they derived in the last 21 years as follows:

- Increased productivity that contributes to global food, feed, and fiber security;
- Self-sufficiency on a nation’s arable land;
- Conserving biodiversity, precluding deforestation and protecting biodiversity sanctuaries;
- Mitigating challenges associated with climate change; and
- Improving economic, health, and social benefits for people.

Biotech crop area soared to 181.5 million hectares in 2014, the highest ever recorded from a marginal decrease in 2015 to 179.7 million hectares. In 2016, a 3% increase was achieved in global biotech crop hectarage equivalent to 5.4 million hectares (Table 1). Fluctuations in biotech crop hectarage of this order (both increases and decreases) are influenced by several factors including global commodity prices, demand for biofuels, livestock and poultry feeds, environmental stresses, disease/pest pressure, and local regulations, to name a few.

Some 26 countries planted biotech crops in 2016, and country adoption of biotech crops varies based on the factors discussed above. Hence, this paper attempts to discuss in detail biotech crop adoption in selected countries, including trends, crops and country situations affecting adoption, and future prospects. Country data and situations were obtained from large number of sources of approved biotech crops from both the public and private sectors in many countries throughout the world. Databases vary by country and include where available, government statistics, independent surveys, and estimates from commodity groups, seed associations and a range of proprietary databases.

Global Biotech Crop Adoption in 2016

Of the total 26 countries cultivating biotech crops in 2016, 19 were developing and 7 were industrial countries. Eight of the top ten countries, each growing 1.0 million hectares or more of biotech crops, are developing countries, with Brazil, Argentina, India, Paraguay, Pakistan, China, South Africa, and Uruguay. Only two countries are industrial: USA and Canada. Burkina Faso did not plant biotech crops in 2016 due to farmers’ preference for a much better cotton germplasm with the insect resistant trait. Romanian farmers opted not to plant due to onerous reporting requirements of biotech crops area.

Eighteen biotech “mega countries” grew 50,000 hectares, or more of biotech crops. Notably, 14 of the 18 mega-countries are developing countries from Latin America, Asia and Africa. The high proportion of biotech mega countries in 2016, 18 out of 26 equivalent to 69% reflects the significant broadening, deepening and stabilizing in biotech crop adoption that has occurred within the group of more progressive mega-
countries adopting more than 50,000 hectares of biotech crops on all six continents.

Of the 26 countries that planted biotech crops, 12 (46%) were in the Americas, 8 (31%) in Asia, 4 (15%) in Europe, and 2 (8%) in Africa. On a hectare basis, of the 26 countries that planted biotech crops in 2016, 88% were in the Americas, 10% in Asia, 2% in Africa, and <1% in Europe.

Developing countries planted more biotech crops compared to industrial countries since 2012 (five years). Prior to 2011, industrial countries planted more than the developing countries, but by 2011, global area of biotech crops was evenly distributed between industrial and developing countries. Starting 2012, developing countries consistently increased in area, and by 2016, a difference of 14.1 million hectares between developing and industrial countries was achieved. Developing countries grew 54% of the global biotech area compared to 46% for industrial countries. Moreover, industrial countries increased by 3.5% in 2016, compared to 2015, while developing countries increased by 2.6%.

The 3.5% increase in industrial countries between 2015 and 2016 is due mainly to increases in the USA at 2%, Canada at 0.6% and Australia at 0.2%. Increases in developing countries, led by Brazil at 4.9% and South Africa at 0.4% contributed mainly to the 2.5% difference in 2015 and 2016. The trend for a higher share of global biotech crops in developing countries is likely to continue in the near, mid, and long-term, firstly, due to more countries from the southern hemisphere adopting biotech crops and traits, and secondly, expansion of area planted to biotech crops.

### Countries with High Adoption of Biotech Crops

The country having the largest year-over-year growth, by far, was Brazil with 4.9 million hectares, followed by the USA with 2 million hectares, Canada with 600,000 hectares, South Africa with 400,000 hectares and Australia with 200,000 hectares. Other countries with increased planting include Bolivia, Philippines, Spain, Vietnam, Costa Rica and Bangladesh.

### Brazil

Brazil is the second ranking country in area planted to biotech crops, next to the USA, but has the highest year-over-year growth in 2016. Biotech soybean, maize and cotton were planted on 49.1 million hectares, an increase of 11% from 2015. Biotech soybean has the greatest hectarage with 32.7 million hectares, a 7.5% increase in 2015; biotech maize was planted on 15.7 million hectares, a 16.1% increase from 2015; and biotech cotton was planted on 790,000 hectares, a 6.13% increase over 2015.

Biotech soybean planting increased despite concerns about the domestic economy and soybean areas shifting to the more profitable maize crop. High exports of soybean to leading markets China, Japan, and South Korea encouraged biotech soybean planting in Brazil. Maize was expected to become a more profitable crop than soybean in 2016, because of the high domestic maize prices. To support the livestock industry, the country had to import maize from Argentina, Paraguay and the USA. National Technical Biosafety Commission of Brazil (CTNBio, 2016) approved three US biotech events to allow importation of maize from the USA. It was also reported that the state of Mato Grosso expanded their maize ethanol production in 2016. The gain in hectares in cotton was obtained despite the economic crisis in Brazil brought by the devaluation of the Brazilian currency Real. According to USDA Brazil, “the Real depreciation resulted in significant gains for Brazilians farmers, as they were able to buy inputs using a stronger Real in the first half of 2015 but domestic prices were protected by a weaker Real they got while selling the crop in the second half. Since cotton is priced in U.S. dollars in the international market, the weaker exchange rate increased domestic cotton prices (more Reals per U.S. dollars). This exchange rate situation cushioned the overall decrease in global prices.”

### United States of America

The biotech crop area in the USA increased by 3% or 2 million hectares – from 70.9 million hectares to 72.9 million hectares.
This 72.9 million hectares is comprised of 35.05 million hectares biotech maize (6% increase from 2015), 31.8 million hectares biotech soybean (1.7% decrease from 2015), 3.7 million hectares biotech cotton (10% increase from 2015), 620,000 hectares canola (5% increase from 2015), 472,000 hectares biotech sugar beet at 100% adoption similar to 2015, and 1.23 million hectares of biotech alfalfa.\(^7\)

A portfolio of biotech crops have been approved for commercialization in the USA since 1996 including creeping bent grass, flax, melon, papaya, plum, potato, rice, squash and tobacco.\(^8\) Small areas of biotech virus resistant squash (1,000 hectares) and papaya ringspot virus resistant papaya in Hawaii (some 1,000 hectares) continued to be grown in the USA in 2016. In addition, a new generation of economically important and consumer-friendly biotech products for improved nutrition, better-looking and reduced wastage were introduced in 2016. These include Innate\(^\text{TM}\) potato generation 1 with lower levels of acrylamide, a potential carcinogen and non-browning trait that reduces wastage. Russet Burbank, Ranger Russet and Atlantic potato varieties with the generation 1 traits were planted in 2015 at 160 hectares which increased to 2,500 hectares in 2016. Moreover, these three generation 1 varieties were improved to contain late blight resistance and designated thereafter as generation 2. These were approved for planting in 2016 and are expected to be in the farmers’ field in 2017.\(^9\)

The non-browning trait was also introduced in three apple varieties Golden, Granny, and Fuji with Arctic\(^\text{®}\) trademark, and approved for planting in 2016. Planting of 70,000 trees of Arctic\(^\text{®}\) Golden and Granny varieties in 2016 was completed, with plans for 300,000 and 500,000 trees for 2017 and 2018, respectively in North America.\(^10\)

The USA remains at the forefront of biotech/GM crops development and commercialization. As the major biotech crops soybean, maize, and cotton in the US reached its maximum adoption of 93%, new crops and traits have been developed and commercialized for consumer traits to reduce wastage and to improve taste and nutrition. Expansion of planted areas for these new crops and traits is expected as consumers realize the benefits and accompanying cost reduction of the technology.

Canada

Canada is fourth in world ranking of biotech crops, with an area of 11.55 million hectares, a 5% increase from 2015 of 10.95 million hectares, with an average adoption rate of 93%, similar to 2015. The four biotech crops grown in Canada in 2016 were canola (7.53 million hectares), soybean (2.08 million), maize (1.49 million) sugar beet (8,000 hectares with 100% adoption rate, and for the first time alfalfa (809 hectares). Total planting of these crops also increased by 5% from 11.74 million hectares (2015) to 12.38 million hectares. Similar to the USA, non-browning Arctic\(^\text{®}\) apples and Innate\(^\text{TM}\) potatoes with the generation 1 traits (reduced levels of reducing sugars, reduced acrylamide potential, and black spot bruising tolerance) have been approved for commercialization in 2017.\(^11\)

Biotech crop planting in Canada increased in 2016 following increases in the total area of canola, soybean, and maize.\(^12\) Canola Council of Canada actively pursues its Strategic Plan of producing 26 MMT canola by 2025 through yield improvement technologies. The increase in soybean area was due to its profitability and high oilseed prices.\(^13\) For maize, increased gasoline and ethanol and ethanol consumption due to lower gas prices provided incentive for maize planting. The introduction of low-lignin alfalfa on 800 hectares provided an opportunity for Canadian dairy farmers to benefit from the technology by reducing cost and increasing profit.\(^12\) Biotech soybean with high oleic acid and biotech maize with high lysine content have been available in the Canadian market for health-conscious public. The average adoption of biotech crops in Canada is 93%, similar to the US, Brazil, and Argentina. Increased adoption of biotech crops may come from introduction of new crops and traits such as the approval for commercialization of non-browning Arctic\(^\text{®}\) apple, the Innate\(^\text{TM}\) potatoes with four stacked traits and new herbicide tolerant stacked soybean.
South Africa

SA planted 2.66 million hectares of biotech crops comprised of maize (2.16 million hectares), soybean (494,000 hectares), and cotton (9,000 hectares) – a 16% increase from the reported biotech crop area of 2.29 million in 2015. Average biotech crop adoption increased marginally at 91% in 2016. The total area planted to maize, soybean, and cotton was 2.93 million hectares, a 15% increase from the previous report in 2015.

Maize production in South Africa indicates the long term trend of producing more maize on less area with the use of more efficient and effective farming methods and practices. These are accompanied by the use of less marginal land in the maize production systems, better seed cultivars, and adoption of biotechnology. The country in partnership with Kenya, Mozambique, Tanzania and Uganda are developing biotech water efficient maize under the Water Efficient Maize for Africa (WEMA) project. Maize varieties with stacked drought tolerance and insect resistance were approved in June 2015 and seeds to become available in late 2017 to a limited number of smallholders.14,15

It is noteworthy that the increase in biotech crop planting in South Africa was spurred by increased planting of maize because of improved weather and water conditions at the last quarter of 2016 (Wynand van der Walt, personal communication). A slight decline in soybean planting on the other hand was due to drought during the beginning of the planting season. The 25% decrease in cotton area was due to low global price. There was an El Niño dry spell that persisted throughout late 2015 and into 2016, with entry of La Niña rains in late November. It is estimated that biotech crop area will increase in the coming year since rainfall came in late 2016 for most crops, and there was increased demand for maize for food and feed, and increased soybean oil capacity. Water deficiency that affects South Africa may be mitigated by the WEMA maize expected to be distributed widely to farmers by 2018. The decline in cotton planting was affected by low global prices.

Australia

Australia ranks 11th in the countries planting biotech crops with 852,000 hectares of biotech cotton and canola, a 29% increase from 658,000 hectares in 2015. This was comprised of 405,000 hectares cotton and 447,000 hectares canola. The adoption of biotech crops increased from 30% in 2015 to 36% in 2016. The increase in biotech area is mostly from biotech cotton which had a significant increase of 89% due to the introduction of Bollgard III/RR® Flex. A slight decrease in planting was observed in biotech canola, however, adoption rates increased from 22% to 23%. With the lifting of the biotech crops planting moratorium in Western Australia, farmers who are planting some 1.5 million conventional canola may shift to biotech in subsequent years.16 This will also open doors for the development and adoption of other biotech crops and traits. It is noteworthy that the South Australian (SA) grain growers have already petitioned the State Government to lift a similar moratorium imposed on them. The growers believe that they should have greater freedom freedom of choice to grow the crop varieties which best fit their farming systems, as well as coincide with the basic free market and right to farm principles.17

Other Countries with Some Increase in Biotech Area

Countries which increased biotech area of more than 500,000 hectares include Bolivia, Philippines, Spain, Vietnam and Bangladesh.

In Bolivia, biotech soybean area increased by 13% (150,000 hectares) in 2016 from 1.05 million hectares to 1.2 million hectares. This is notable since the area of total soybean area in the country declined from 1.31 million hectares in 2015 to 1.3 million hectares in 2016. Adoption of herbicide tolerant soybean however, increased to 91% (from 80%). Reduction in the total soybean planting was due to a historic and severe drought that affected major soybean growing areas in the country, and losses in crops affecting soybean growers
(132,000 families) in 131 municipalities. The drought hit early in 2016 in the lower elevated areas of Sta. Cruz and affected the winter soybean crop season. There is optimism that with developments in drought/stress tolerant biotech seeds. The government may consider approving other biotech crops of maize, cotton, and sugarcane. Currently, Bolivia only allows one biotech soybean event, GTS-40-3-2.

In the Philippines, 812,000 hectares of biotech maize were planted in 2016, a 16% increase (110,000 hectares) from the 702,000 hectares planted in 2015 due to favourable weather conditions, local demand for livestock and low feed stocks. This was comprised of 133,000 hectares herbicide tolerant maize and 679,000 hectares of IR/HT maize – IR (Bt) maize has not been planted since 2013. Adoption rates also increased from 63% in 2015 to 65% in 2016. Biotech maize has been planted since 2003 and the country is gearing up for the possible commercialization of products of public-private sector collaborations such as Golden Rice, Bt eggplant, virus resistant papaya and Bt cotton.

In Spain, biotech maize Mon 810 (IR/Bt maize) was planted on 129,081 hectares, a 20% increase (21,000 hectares) from 107,749 hectares planted in 2015. The increased Bt maize area was due to abnormally high pressure from the European corn borer brought by the unusually warm conditions prevailing in summer 2015. The autonomous regions of Aragon and Catalonia had the largest share (70%) of biotech maize of Spain’s total biotech maize plantings, as the corn borer insect is endemic in these areas. The total area of maize in Spain declined from 392,000 hectares in 2015 to 361,100 hectares in 2016 due to poor crop margins, competition by other crops and unfavourable conditions (excessive rains) during the planting season.

In Vietnam, biotech maize commercialization started in 2015 at a minimal area of 3,500 hectares. In 2016, farmers adopted the technology quickly with a 10-fold (31,500 hectares) increase to 35,000 hectares of stacked IR/HT varieties. Four biotech maize events were approved for cultivation since 2015 including Bt11 x GA21, GA21, Mon8904 and NK603. Biotech maize was reported to increase productivity by as much as 25% compared to non-GM crops. This provides incentive for biotech maize farmers and future adopters. In addition, the need for an immediate source of livestock feeds where demand increases annually, and the government’s shift towards conversion of rice areas to maize paved the way for the commercialization of maize. Various field trials of biotech maize are being conducted in prime maize areas of the country. Moreover, with the enabling policies of the government, other biotech crops and traits may gain approval for planting in the country, including biotech cotton and soybean.

In Bangladesh, commercial planting of Bt brinjal/eggplant from 25 hectares in 2015 increased by 675 hectares to 700 hectares in 2016, planted by 2,500 farmers. Bt brinjal is the country’s first genetically modified crop that protects brinjal from the deadly fruit and shoot borer (FSB). The insect pest causes losses of up to 70% in commercial plantings. The large scale planting of IR (Bt) brinjal has resulted in a substantial reduction in insecticide applications and lowered the cost of producing a more bountiful harvest of blemish-free brinjal fruits. Experiments to-date showed that Bt brinjal increases yield by at least 30% and reduces the number of insecticide applications by 70–90%, resulting in a net economic benefit of US$1,868 per hectare over non-Bt brinjal. Biotech late blight resistant potato, Golden Rice and insect resistant cotton are in the various stages of field testing for future introduction in the country to address economic and nutrient-deficiency problem.

## Countries with Minimal Increases in Biotech Crop Area

Countries which increased biotech area of less than 500,000 hectare include Colombia, Honduras, Chile, Sudan, Slovakia and Costa Rica.

**Colombia** planted 110,000 hectares of biotech crops: 21,000 hectares (approx 24%) more
than in 2015 (89,000 hectares). This is comprised of 100,000 hectares of biotech maize and 9,800 hectares of biotech cotton. Increased biotech maize was due to a program to increase biotech maize hectares for the poultry industry. The global low cotton prices affected biotech cotton in the country.

**Honduras** planted 31,000 hectares of biotech maize 15% higher than 27,000 hectares (2015) at 100% adoption rate. The increased area of maize planting is due to unfavourable weather conditions and better market prices for biotech maize.

**Chile** has been producing biotech seeds for export since commercialization began in 1996 under strict field conditions for re-export outside the country. In 2016, the country grew 10,667 hectares of biotech crops comprised of 6,260 hectares IR/HT maize, 2,050 hectares HT soybean, and 2,357 hectares HT canola. In 2016, the area planted to biotech crops increased to 10,667 hectares which was a 15% increase (equivalent to 1,361 hectares) from the 9,306 hectares planted in 2015. This increased biotech crop area planted for seeds indicates the increased demand for planting materials in importing countries USA and Canada.

**Sudan’s** continuous research over the last five years resulted in approval of two new IR cotton hybrids in 2015, gradually increasing the biotech cotton area from an initial modest launch of 20,000 hectares in 2012 to 120,600 hectares in 2016, a slight (0.5%) increase from the 2015 reported area of 120,000 hectares. The rate of adoption of biotech cotton remained at 98%.

**Slovakia** grew 138 hectares of biotech IR maize, an increase of 34 hectares or 33% over 2015. The increase of IR maize area in Slovakia may be attributed to corn borer infestation in the maize-growing areas of the country, similar to the infestation in Spain.20

**Costa Rica** planted 226 hectares of biotech crops, a 13% increase from 200 hectares in 2015. The 226 hectares was comprised of 14.8 hectares biotech pineapple with high antioxidants, less than one hectare HT soybean, and 210 hectares IR cotton. Similar to Chile, the country planted commercial biotech crops exclusively for export seed trade with biotech planting countries.

### Countries with Low Adoption of Biotech Crops

A few countries had decreased biotech crop plantings. The decreases were due to global low cotton prices such as in India, Argentina, Uruguay and Mexico, and high cotton reserves stocks particularly in China; low profitability in soybean and competition with maize in Paraguay and Uruguay; environmental stress (drought/submergence) in soybean planting in South Africa and Argentina, marginal decreases in the area of crop production for maize in Portugal, negative biotech perceptions in China and onerous reporting for biotech maize planting in Czech Republic. Countries with decreased biotech area are enumerated below.

**China**

China has been one of the leaders in planting IR (Bt) cotton since 1997, as well as small hectares of biotech papaya, poplar, and other vegetables. In 2016, IR (Bt cotton) was planted on 2.8 million hectares (~0.87 million hectares difference), virus resistant papaya on 8,500 hectares and some 543 hectares IR (Bt) poplar trees. The national area planted to cotton in China in 2016 was 2.92 million hectares compared to 3.8 million hectares in 2015, ~0.9 million hectares difference. Consistent with several other cotton growing areas including the US, the decrease in national cotton area in China was attributed to low cotton prices and high reserve stocks since 2015. This led to a decrease in total area of cotton planted, as well as the biotech cotton area. The adoption rate of biotech cotton planting also decreased from 96% in 2015 to 95% in 2016. Biotech crop prospects in the country depend on the expansion of biotech cotton area as the commodity price stabilizes. It is also apparent that with China’s increasing need for poultry and livestock feeds, biotech maize maybe
commercialized in the very near future. The government is committed to make China a strong biotech country disbursing funds for research and capacity building as well as the pending acquisition of Syngenta by ChemChina to strengthen its portfolio of biotech crops.\textsuperscript{23}

**India**

India for the first time in 14 years of insect resistant (IR, Bt) cotton planting (since 2002) has recorded a drop in area planted by 0.8 million hectare from 11.6 million hectares in 2015 to 10.8 million hectares in 2016, due to low global cotton prices. The percentage adoption however, increased to 96%, slightly higher than 95% adoption in 2015, distributed evenly among the ten major cotton growing states. Biosafety regulations in the country have been streamlined with revised guidelines on the monitoring of confined field trials of biotech crops. Biotech mustard expressing the barnase-barstar (HR) gene is under final review including public comments for environmental release in 2017. Mustard production and yields have remained stagnant for the past 20 years and it is hoped that the introduction of the biotech mustard can revive the mustard industry.\textsuperscript{24}

**Argentina**

Argentina planted 23.81 million hectares of biotech crops, 0.67 million hectares less than the 24.49 million hectares in 2015. Argentina maintained its ranking as the third largest producer of biotech crops in the world in 2016, after the USA and Brazil, covering 13% of the global biotech area. The 23.8 million hectares was comprised of 18.7 million hectares of biotech soybean, and an all time high of 4.74 million hectares of biotech maize and a reduced biotech cotton area of 0.38 million hectares due to low global cotton prices. Biotech soybean area was reduced by 2.4 million hectares from 24 million hectares in 2015 to 18.7 million hectares in 2016. This was due to greater competition from alternative crops such as maize and sunflower, as well as adverse weather conditions, crop damage and harvest delays that forced some producers to abandon planting wheat, jeopardizing the second cropping of soybean after wheat.\textsuperscript{25} With almost maximum adoption of biotech crops in Argentina of 97%, expansion of biotech crops commercialization can be achieved using new crops and traits. The development of drought tolerant soybean which is now in testing stage will allow utilization of marginal areas affected by drought. Also, adoption of virus resistant potato will be beneficial to farmers in increasing yield and reduction of production cost. The biotech virus resistant potato and the high oleic acid soybean cater well to farmers and consumers who are keen on reasonably priced and healthy food products.

**Paraguay**

Paraguay grew 3.52 million hectares of biotech crops comprising of 3.21 million hectares soybean, 0.31 million hectares maize, and 0.010 million hectares cotton. This compares with 3.63 million hectares biotech crops planted in 2015, a 3% decrease (0.11 million hectares) due to a marginal decrease in the area of production. Adoption of biotech crops was also reduced slightly by 1% in 2016. There was a marginal decrease in the area of crop planting, particularly soybean which has some competition with maize. An increase in the total maize area was observed due to the expansion of the pork industry. This is likely to continue in the next few years because maize prices will be relatively higher due to demand from Brazil and Chile.

**Uruguay**

Uruguay planted biotech soybean and maize on 1.3 million hectares, a 9% decrease (0.1 million hectares) from 1.4 million hectares in 2015. This is consistent with several other countries where a decrease in total plantings of the two crops is due to low domestic prices. The biotech crops planted in Uruguay were comprised of 1.23 million hectares biotech soybean and 60,000 hectares of biotech maize, with a 97% adoption rate, a 2% reduction from 2015. It is likely that once global prices become...
stable, biotech crop plantings will resume and be profitable to farmers. The impending cattle importation by Argentina is expected to boost biotech maize planting for silage, hay and grain feeds in Uruguay.26

**Mexico**

Mexico planted 101,000 hectares of biotech crops, down from 141,000 hectares in 2015, (a 40,000 hectares decrease). The 101,000 hectares were comprised of 97,000 hectares of biotech cotton (with an adoption rate of 98%) and 4,000 hectares of biotech soybean (2% adoption rate). Reduction in total and biotech cotton planting was due to low prices of cotton. On the other hand, reduction in soybean planting was due to the complications and dispute farmers had with Mayan Indians who needed to comply with the EU regulation of labelling the honey if GE pollen exceeds 0.9%.27 Mexico has vigilant scientists and experts that can address negative propaganda through strategic engagements with stakeholders and effective messaging to the general public. The current judicial decision to allow cultivation of biotech maize for experimental purposes may stir interest and positive shift for the development of biotechnology in the country.

**Portugal** had a reduced planting of IR (Bt) maize from 8,017 hectares in 2015 to 7,069 hectares in 2016, a 12% decrease (equivalent to 948 hectares). Maize area has been declining since 2014 and so has biotech maize area. Alentejo, the lead maize producer in the country occupying 47% of the total biotech maize area in 2016 had reduced planting by 32% (1,596

### TABLE 1. Global Area of Biotech Crops in 2015 and 2016: by Country (Million Hectares**).

| Country        | 2015 | %   | 2016 | %   | +/- | %   |
|----------------|------|-----|------|-----|-----|-----|
| 1  USA*        | 70.9 | 39  | 72.9 | 39  | 2.0 | 3%  |
| 2  Brazil*     | 44.2 | 25  | 49.1 | 27  | 4.9 | 11% |
| 3  Argentina   | 24.5 | 14  | 23.8 | 13  | -0.7| -3% |
| 4  Canada      | 11.0 | 6   | 11.56| 6   | 0.6 | 5%  |
| 5  India       | 11.6 | 6   | 10.8 | 6   | -0.8| -7% |
| 6  Paraguay*   | 3.6  | 2   | 3.6  | 2   | 0   | 0%  |
| 7  Pakistan*   | 2.9  | 2   | 2.9  | 2   | 0   | 0%  |
| 8  China*      | 3.7  | 2   | 2.8  | 2   | -0.9| -24%|
| 9  South Africa*| 2.3  | 1   | 2.7  | 1   | 0.4 | 17% |
| 10 Uruguay*    | 1.4  | 1   | 1.3  | 1   | -0.1| -7% |
| 11 Bolivia*    | 1.1  | 1   | 1.2  | 1   | 0.1 | 9%  |
| 12 Australia*  | 0.7  | <1  | 0.9  | <1  | 0.2 | 29% |
| 13 Philippines*| 0.7  | <1  | 0.8  | <1  | 0.1 | 14% |
| 14 Myanmar*    | 0.3  | <1  | 0.3  | <1  | 0   | 0   |
| 15 Spain*      | 0.1  | <1  | 0.1  | <1  | 0.1 | 0   |
| 16 Sudan*      | 0.1  | <1  | 0.1  | <1  | 0.1 | 0   |
| 17 Mexico*     | 0.1  | <1  | 0.1  | <1  | 0.1 | 0   |
| 18 Colombia*   | 0.1  | <1  | 0.1  | <1  | <0.1| <0.1|
| 19 Vietnam      | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 20 Honduras     | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 21 Chile        | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 22 Portugal     | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 23 Bangladesh*  | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 24 Costa Rica   | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 25 Slovakia     | <0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 26 Czech Republic|<0.1 | <1  | <0.1 | <1  | <0.1| <0.1|
| 27. Burkina Faso| 0.5  | <1  | —    | —   | —   | —   |
| 28. Romania     | <0.1 | <1  | —    | —   | —   | —   |
| Total          | 179.7| 100 | 185.1| 100 | 5.4 | 3.0 |

*Biotech mega-countries growing 50,000 hectares or more.

**Rounded-off to the nearest hundred thousand or more.
hectares). This is due to a decline in total maize area, the tight crop margins of maize caused by its low market price in the country and water supply problem in Alentejo.28

**Czech Republic** planted only 75 hectares of biotech maize, compared to 922 hectares in 2015 (a difference of 847 hectares). Czech farmers have been growing biotech IR (Bt) maize since 2005 in increasing area from 250 hectares that peaked in 2008 at 8,380 hectares. The current decrease in biotech area is due to inconvenient and stringent reporting requirements for IR maize planting that resulted in less incentive for farmers and all stakeholders seeking to capture the benefits offered by IR maize.

**Pakistan** and **Myanmar** are the only two countries with no change in biotech crop area. Pakistan achieved optimal adoption of insect resistant IR (Bt) cotton varieties with adoption reaching 2.9 million hectares equivalent to 97% of the total 3 million hectares of cotton. The total cotton area was reduced from 3.12 million hectares to 3.00 million hectares due to global low prices of cotton. Even then, adoption of IR cotton increased from 93% in 2015 to 97% in 2016. This is indicative of farmer satisfaction with Bt technology that may be replicated with the adoption of biotech maize in the country.

Myanmar maintained the adoption of two insect resistant Bt cotton varieties on approximately 325,000 hectares, equivalent to an adoption rate of 93% of the 350,000 hectares of cotton grown in 2016. The two cotton varieties *Ngwe chi-6* and *Ngwe chi-9* were locally-developed and planted since 2006 by increasing number of small holder farmers.

**CONCLUSION**

The year 2016 is the 21st year of commercialization of biotech crops marked by a renewed increase in global area of 5.4 million hectares from 179.7 million hectares in 2015 to 185.1 million hectares in 2016. As discussed, fluctuations in biotech crop area in each country provided information on the country situations which influenced adoption and acceptance of biotech crops in the country. Some of the factors include global commodity prices, demand for biofuels, livestock and poultry feeds, environmental stresses, disease/pest pressure, and country regulations to name a few. This information could be the basis of biotech proponents in the academe, government and the industry in crafting strategies that will increase adoption and public acceptance of biotech crops. Possible expansion in biotech crops and traits detailed in some countries could also prepare stakeholders in future adoption and acceptance of these crops.

The year was also momentous since the global scientific community renewed its commitment to support biotech crops by releasing statements on the safety and productivity of biotech crops. The global community is assured that future generations can benefit more from wide choices of biotech crops with improved traits for high yield and nutrition that are ideally safe for consumption and the environment. However, as with any other technologies, there are challenges that limit adoption and acceptance of biotech crops. They include among other things: 1) regulatory barriers that limit scientific innovation and restrict technology development that would have benefited farmers and consumers; 2) the growing trade disruptions brought by asynchronous approvals and thresholds on low level presence (LLP) in GM crop trading countries; and 3) the need for continuous dialogue among all stakeholders for the expeditious understanding and appreciation of biotechnology, emphasizing benefits and safety. Overcoming these challenges is a daunting task that requires a cooperative partnership among the North and the South, East and West, and public and private sectors. Only through partnerships can we be assured that nutritious and sufficient food will be readily available on the table, stable supply of feed for our poultry and livestock, and accessible clothing and shelter for everyone.

**DISCLOSURE OF POTENTIAL CONFLICTS OF INTEREST**

No potential conflicts of interest were disclosed.
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