MON 89034 x 1507 x MON 88017 x 59122 maize

Genuity® SmartStax®

Insect protection and herbicide tolerance

Key Facts

Monsanto EMEA
and Dow AgroSciences
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Maize, a key crop

Today, maize is the largest cultivated crop in the world followed by wheat (*Triticum* sp.) and rice (*Oryza sativa* L.) in total global metric ton production. Following European discovery of the Americas where this crop is indigenous, maize was rapidly adopted in Europe, Africa and Asia. Today, it is one of the few intensively cultivated crops in European agriculture. Significant areas of production include the Danube basin from southwest Germany to the Black Sea and southern France through to the Po Valley of northern Italy.

As in other world areas, maize use in Europe is dominated by the demand for animal feed. Maize is also processed into valuable industrial and food products such as ethyl alcohol, maize meal, starch and sweeteners.

In 2011/12, the estimated area of maize harvested in the European Union (EU) was approximately 9.1 million hectares, with a production of around 68.09 million tons[1]. The EU is a large importer of maize, having imported in 2010/11 about 7.53 million tonnes of maize grain per year (the majority from Brazil, Ukraine and Serbia)[2].

What is MON 89034 x 1507 x MON 88017 x 59122?

MON 89034 x 1507 x MON 88017 x 59122 is a traditionally bred maize, produced by the crossing of four genetically modified (GM) maize lines: MON 89034, 1507, MON 88017 and 59122.

MON 89034 x 1507 x MON 88017 x 59122 combines the traits of agronomic interest from the four parental lines, *i.e.* protection against certain lepidopteran and coleopteran insect pests and tolerance to the glufosinate–ammonium and the glyphosate herbicides.

Insect protection

MON 89034 is a GM maize developed through *Agrobacterium*-mediated transformation to express two proteins: Cry1A.105 and Cry2Ab2 modified from the common soil bacteria *Bacillus thuringiensis*. These proteins protect the plants from feeding damage caused by the European corn borer (*Ostrinia nubilalis*) and other lepidopteran (moths and butterflies) insect pests.

1507 is a GM maize developed through the particle acceleration method and carries a gene coding for the Cry1F protein which provide protection against a broad spectrum of lepidopteran insect pests.

MON 88017 is a GM maize developed through *Agrobacterium*-mediated transformation to express the Cry3Bb1 protein modified from *Bacillus thuringiensis* subsp. *Kumamotoensis*. This protein is selective for coleopterans (Chrysomelidae) of the *Diabrotica* family (Siegfried, et al., 2005).

59122 is a GM maize developed through *Agrobacterium*-mediated transformation to express two proteins: Cry34Ab1 and Cry35Ab1 from the common soil bacteria *Bacillus thuringiensis*. The two proteins act together to provide protection against the larval stage of the corn root worm insect pests.

The combination of the Cry1A.105, Cry2Ab2, Cry1F, Cry3Bb1, Cry34Ab1 and Cry35Ab1 insecticidal proteins in a single plant provides improved insect control.

Herbicide tolerance

Together with the insecticidal proteins Cry1F or Cry34Ab1 and Cry35Ab1, 1507 and 59122 also express the phosphinothricin acetyltransferase (PAT) protein from *Streptomyces viridochromogenes*, a commonly occurring soil organism. PAT provides tolerance to the glufosinate-ammonium herbicide. Glufosinate inhibits glutamine synthase, which synthesizes glutamine from glutamic acid and ammonia. When this enzyme is inhibited, ammonia accumulates in the plant body and causes plant death. The PAT protein acetylates glufosinate to N-acetylglufosinate, which does not inhibit glutamine synthase and is thus not herbicidally active.

Together with the Cry3Bb1 protein, MON 88017 also expresses the 5-enolpyruvyl-shikimate-3-phosphate synthase (EPSPS) enzymes derived from the CP4 strain (CP4 EPSPS) of the common soil bacterium *Agrobacterium* sp. CP4 EPSPS provides tolerance to the glyphosate herbicide. Glyphosate (N-phosphonomethyl glycine) inhibits EPSPS (5-enolpruvylshikimate-3-phosphate synthase), an enzyme in the shikimate pathway involved in the production of aromatic amino acids. Inhibition of the production of aromatic amino acids, which are necessary for plant growth and development, causes the plant to die. The shikimate pathway is found in all plants but is not present in mammals and other animal species.

[1] USDA - http://usda01.library.cornell.edu/usda/fas/worldag-production//2010s/2013/worldag-production-07-11-2013.pdf - (Accessed on November 13, 2013)

[2] EC – http://ec.europa.eu/agriculture/cereals/trade/cereals/2010-2011_en.pdf (Accessed on November 13, 2013)

More information on MON 89034, 1507, MON 88017 and 59122 can be obtained from the Center of Environmental Risk Assessment (CERA) and EuropaBio websites[3].

Worldwide plantings and regulatory status of MON 89034 x 1507 x MON 88017 x 59122

Genetically modified crops protected against insect pests and/or tolerant to a specific herbicide are commercialized in the US by Monsanto and/or Dow since 1996. In 2012, 170.3 million hectares of GM crops were grown worldwide, from which 43.7 million hectares were expressing stacked traits (James, 2012). Of the 159 million hectares of global maize planted in 2012, more than one-third (35%) or 55.1 million hectares were biotech maize (James, 2012).

MON 89034 x 1507 x MON 88017 x 59122 has already received regulatory approval for production in the United States and in Canada. In the US, MON 89034 x 1507 x MON 88017 x 59122 approval is covered by the parental maize events approval and by registration with the EPA. Importation of MON 89034 x 1507 x MON 88017 x 59122 and derived foods and feeds is approved in Japan, Korea, Mexico, Colombia, Philippines, South Africa and Taiwan.

A strict regulatory system for genetically modified crops

In the EU, the regulatory system for GM crops comprises several regulations and directives, including Directive 2001/18/EC for deliberate release of GMOs in the environment (repealing Directive 90/220/EEC) and Regulation (EC) No 1829/2003 on GM Food and Feed (replacing Regulation (EC) No 258/97 on novel foods and novel food ingredients for GM products).

Regulation (EC) No 1829/2003 includes procedures for the authorisation of deliberate release (cultivation and/or import, and processing), in addition to food and feed use, according to the "one door, one key" principle.

A regulation on traceability and labeling of GMOs and products produced from GMOs (Regulation (EC) No 1830/2003) entered into force on 18 April 2004.

A regulation laying down the methods of sampling and analysis for the official control of feed as regards presence of genetically modified material for which an authorization procedure is pending or the authorisation of which has expired (Commission regulation (EU) No 619/2011) entered into force on 24 June 2011.

Regulatory status of MON 89034 x 1507 x MON 88017 x 59122 in the EU

On 24 October 2008, Monsanto and Dow submitted an application for food and feed use of MON 89034 x 1507 x MON 88017 x 59122 maize[4] as any other maize (excluding cultivation) under Regulation (EC) No 1829/2003 to the European Food Safety Authority (EFSA), via the Czech Republic. This application was declared valid on 03 March 2009.

EFSA evaluated the application as well as additional information provided by Monsanto and Dow during the scientific review, scientific comments submitted by the Member States and relevant scientific publications. Furthermore, information from applications for placing on the market MON 89034, 1507, MON 88017 and 59122 were taken into account.

EFSA finalized the risk assessment and adopted a scientific opinion on 08 September 2010[5] for the placing on the market of insect resistant and herbicide tolerant genetically modified maize MON 89034 x 1507 x MON 88017 x 59122 and all sub-combinations of the individual events as present in its segregating progeny. In its scientific opinion EFSA concludes that "*the maize* MON 89034 x 1507 x MON 88017 x 59122 *is as safe as its conventional comparator and commercial maize varieties with respect to potential effects on human and animal health or the environment*"

The EFSA overall opinion, which fulfils the requirements of Articles 6 and 18 for the placing on the market of MON 89034 x 1507 x MON 88017 x 59122, was published on 27 September 2010.

Following the Commission's mandate of 01 February 2011 to EFSA requesting to complement the overall EFSA opinion to cover all sub-combinations of their single events independently of their origin, in addition to the higher stack MON 89034 x 1507 x MON 88017 x 59122, EFSA issued on 14 October 2011 a statement complementing the EFSA GMO Panel scientific opinion on maize MON 89034 x 1507 x MON 88017 x 59122 to cover all sub-combinations independently of their origin[6].

The updated EFSA overall opinion was published on 10 November 2011.

On 10 June 2013, the European Commission presented the Draft Commission Implementing Decision authorizing the placing on the market of products containing, consisting of, or produced

[3] CERA - http://www.cera-gmc.org/?action=gm_crop_database and http://www.europabio.org/information-operators-product-information (Accessed on November 13, 2013)

[4] Since maize grain is the product of genetic segregation and reunion of genetic components according to Mendelian law, F_2 grain produced from MON 89034 × 1507 × MON 88017 × 59122 hybrid (F_1) seeds, will include a mixture of MON 89034 × 1507 × MON 88017 × 59122 and all combinations with fewer of these segregating events.

[5] EFSA – http://www.efsa.europa.eu/en/scdocs/scdoc/1781.htm (Accessed on November 13, 2013)

[6] EFSA - http://www.efsa.europa.eu/en/efsajournal/pub/2399.htm (Accessed on November 13, 2013)

from genetically modified maize MON 89034 x 1507 x MON 88017 x 59122 and not previously authorized sub-combinations, *independently from their origin*[7] to the Standing Committee on the Food Chain and Animal Health (SCFCAH) for a vote. After this vote, the draft decision was passed to the Appeal Committee who met for a vote on 11 July 2013. The Appeal Committee forwarded the draft decision to the European Commission with a recommendation for an approval. The authorization was finally granted by the European Commission on 06 November 2013[8].

Regulatory status of the parental lines

Approval of MON 89034 for import, food, feed and processing

On 14 December 2006, Monsanto submitted an application for food and feed uses, import and processing of MON 89034 under the Regulation (EC) No 1829/2003 on GM Food and Feed to the EFSA via the Netherlands. This application was declared valid by EFSA on 24 August 2007. EFSA evaluated the application as well as Monsanto's responses to comments and reasoned objections from certain Member States. EFSA finalized the risk assessment and adopted a scientific opinion on 03 December 2008, concluding that "*MON89034 is as safe as its non genetically modified counterpart with respect to potential effects on human and animal health or the environment*"[9]. The EFSA overall opinion, which fulfils the requirements of Articles 6 and 18 of Regulation (EC) No 1829/2003, was published on 18 December 2008. Subsequently, on 30 October 2009, MON 89034 maize was authorised by the European Commission for placing on the EU market for import, food and feed for 10 years (Commission Decision 2009/813/EC[10]).

Approval of 1507 maize import, processing and animal feed

Pioneer and Dow AgroSciences submitted the notification for 1507 maize import, processing and animal feed to the Dutch Competent Authority (CA) under Directive 90/220/EEC in November 2000 and updated it to meet the requirements of Directive 2001/18/EC on 6 November 2002. The Dutch CA issued a positive safety evaluation report on the notification in September 2003[11]. EFSA evaluated the notification and adopted a scientific opinion on 24 September 2004, concluding that '*1507 will not have an adverse effect on human and animal health or the environment in the context of its proposed use*'[12]. Subsequently, on 3 November 2005, 1507 maize was authorised by the European Commission for placing on the EU market for import, processing and animal feed use (Commission Decision 2005/772/EC). The final consent for placing on the market in accordance with Decision 2005/772/EC was granted by the Dutch CA on 16 March 2006 after approval of 1507 for food use[13].

Approval of1507 maize for food

Pioneer and Dow AgroSciences submitted the application for 1507 novel food use to the Dutch CA under Regulation (EC) No 258/97 in February 2001. The application received a positive safety evaluation by the Dutch CA in November 2003, but had to be updated to meet the requirements under Regulation (EC) No 1829/2003 before being forwarded to EFSA by the Dutch CA. The GMO Panel of EFSA evaluated the application and adopted a scientific opinion on 19 January 2005, concluding once more '*that 1507 maize will not have an adverse effect on human and animal health in the context of its proposed use*'[14]. Subsequently, on 3 March 2006, 1507 maize was authorised by the European Commission for placing on the EU market for food use (Commission Decision 2006/197/EC).

Approval of MON 88017 for import, food, feed and processing

On 04 October 2005, Monsanto submitted an application for food and feed uses, import and processing of MON 88017 under the Regulation (EC) No 1829/2003 on GM Food and Feed to the EFSA via the Czech Republic. This application was declared valid by EFSA on 11 January 2007. EFSA evaluated the application as well as Monsanto's additional information, scientific comments submitted by the Member States and relevant scientific publications. EFSA finalized the risk assessment and adopted a scientific opinion on 21 April 2009, concluding that "*MON 88017 is as safe as its non genetically modified counterpart with respect to potential effects on human and animal health or the environment.*"[15]. The EFSA overall opinion, which fulfils the requirements of Articles 6 and 18 of Regulation (EC) No 1829/2003, was published on 06 May 2009. Subsequently, on 30 October 2009, MON 88017 maize was authorised by the European Commission for placing on the EU market for import, food and feed for 10 years (Commission Decision 2009/814/EC[16]).

[7] Four related GM maizes combining three different single GM events (MON 89034 × 1507 × MON 88017, MON 89034 × 1507 × 59122, MON 89034 × MON 88017 × 59122, 1507 × MON 88017 × 59122) and four related GM maizes combining two different single GM events (MON 89034 x 1507, MON 89034 x 59122, 1507 x MON88017, MON 88017 x 59122)

[8] EUR-LEX - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:302:0047:0052:EN:PDF (Accessed on November 13, 2013)

[9] EFSA - http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902216540.htm (Accessed on November 13, 2013)

[10] EUR-LEX - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:289:0021:0024:EN:PDF (Accessed on July 24, 2013)

[11] JRC - http://gmoinfo.jrc.ec.europa.eu/csnifs/C-NL-00-10_AssessmentReport.pdf (Accessed on July 24, 2013)

[12] EFSA - http://www.efsa.europa.eu/en/scdocs/doc/124.pdf (Accessed on November 13, 2013)

[13] EUR-LEX - http://eur-lex.europa.eu/LexUriServ/site/en/oj/2005/l_291/l_29120051105en00420044.pdf (Accessed on November 13, 2013)

[14] EFSA - http://www.efsa.europa.eu/en/scdocs/scdoc/182.htm (Accessed on November 13, 2013)

[15] EFSA - http://www.efsa.europa.eu/EFSA/efsa_locale-1178620753812_1211902517555.htm (Accessed on November 13, 2013)

[16] EUR-LEX - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:289:0025:0028:EN:PDF (Accessed on November 13, 2013)

Approval of 59122 for import, food, feed and processing

In January 2005, Pioneer and Dow AgroSciences submitted an application for food and feed uses, import and processing of 59122 under the Regulation (EC) No 1829/2003 on GM Food and Feed to the EFSA via the Netherlands. This application was declared valid by EFSA on 16 September 2005. The EFSA evaluated the application as well as Pioneer and Dow AgroSciences's responses to comments and reasoned objections from certain Member States. EFSA adopted a scientific opinion on 23 March 2007, concluding that "*maize 59122 is unlikely to have any adverse effect on human and animal health or on the environment in the context of its intended uses."*[17] The EFSA overall opinion, which fulfils the requirements of Articles 6 and 18 of Regulation (EC) No 1829/2003, was published on 30 March 2007. Subsequently, on 24 October 2007, 59122 maize was authorised by the European Commission for placing on the EU market for import, food and feed for 10 years (Commission Decision 2007/702/EC)[18].

Traceability, labelling, unique identifier

Once authorised for commercialisation, operators importing, handling or using MON 89034 x 1507 x MON 88017 x 59122 grain and derived foods and feeds in the EU are required to be aware of the legal obligations regarding traceability and labelling of these products, laid down in Regulation (EC) No 1830/2003 and in the conditions of placing on the market of the consent.

The unique identifier for MON 89034 × 1507 × MON 88017 × 59122 is MON-89Ø34-3 × DAS-Ø15Ø7-1 × MON-88Ø17-3 × DAS-59122-7.

In August 2008, MON 89034 × 1507 × MON 88017 × 59122 samples of food and feed and control samples were provided to the Joint Research Centre (JRC), acting as the European Union Reference Laboratory (EURL). The EURL considers that the detection methods validated on the parental lines, MON 89034, 1507, MON 88017 and 59122, show a comparable performance when applied to MON 89034 x 1507 x MON 88017 x 59122. The detection methods for MON 89034, 1507, MON 88017 and 59122 had been previously validated by the EURL and were published at the EURL website[19]. The validation report for MON 89034 x 1507 x MON 88017 x 59122, prepared by the EURL in collaboration with the ENGL, was published on 04 August 2010 on the same website.

[17] EFSA - http://www.efsa.europa.eu/en/scdocs/doc/470.pdf (Accessed on November 213, 2013)

[18] EUR-LEX - http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:285:0042:0046:EN:PDF (Accessed on November 13, 2013)

[19] JRC - http://gmo-crl.jrc.ec.europa.eu/StatusOfDossiers.aspx (Accessed on November 13, 2013).

Food, feed and environmental safety of MON 89034 x 1507 x MON 88017 x 59122

Food and feed safety

MON 89034 x 1507 x MON 88017 x 59122 is a traditionally bred maize, produced by the crossing of four GM maize lines: MON 89034, 1507, MON 88017 and 59122. The safety assessment was essentially carried out in two steps:

- Demonstration that the characteristics of the parental single-trait lines are maintained in MON 89034 x 1507 x MON 88017 x 59122.
- Assessment based on that of the parental single-trait lines.

Molecular analysis of the DNA inserts present in MON 89034 x 1507 x MON 88017 x 59122 confirmed that the insert structures of the parental single-traits were retained. Also, Cry1A.105, Cry2Ab2, Cry1F, PAT, Cry3Bb1, CP4 EPSPS, Cry34Ab1 and Cry35Ab1 protein levels in forage and grain of MON 89034 x 1507 x MON 88017 x 59122 were comparable to the levels in the corresponding single-trait maize (MON 89034, 1507, MON 88017 and 59122).

The conclusions of safety for the Cry1A.105, Cry2Ab2, Cry1F, PAT, Cry3Bb1, CP4 EPSPS, Cry34Ab1 and Cry35Ab1 proteins, as already demonstrated in the context of the MON 89034, 1507, MON 88017 and 59122 maize lines, remain applicable when these proteins are produced in combination in MON 89034 x 1507 x MON 88017 x 59122. It is unlikely that interactions between these proteins would occur that would raise any safety concerns[20].

Compositional and phenotypic/agronomic analyses showed that there are no biologically relevant differences in the characteristics of MON 89034 x 1507 x MON 88017 x 59122 as compared with its conventional counterpart and that the composition fell within the range of non-GM maize varieties, except that MON 89034 x 1507 x MON 88017 x 59122 expressed the Cry1A.105, Cry2Ab2, Cry1F, PAT, Cry3Bb1, CP4 EPSPS, Cry34Ab1 and Cry35Ab1 proteins.

Additionally, the food and feed safety of MON 89034 x 1507 x MON 88017 x 59122 was established through:

- The long history of safe use of Cry proteins (Betz, et al., 2000), CP4 EPSPS and PAT proteins in general;
- The evaluation of CP4 EPSPS activity and its homology to EPSPS proteins present in a diversity of plants, including those used for foods;
- The rapid digestibility of the introduced proteins in *in vitro* digestive models;

[20] EFSA – http://www.efsa.europa.eu/en/scdocs/scdoc/1781.htm (Accessed on November 13, 2013)

- The lack of toxicity or allergenicity of the introduced proteins, as demonstrated with bioinformatics as well as *in vitro* and *in vivo* safety studies of the proteins;
- A large margin of safety resulting from the low dietary exposure to the introduced proteins.

In conclusion, MON 89034 x 1507 x MON 88017 x 59122 was shown to be as safe and nutritious as the parental lines and the conventional maize control.

Environmental safety

The environmental safety of MON 89034 x 1507 x MON 88017 x 59122 was established through extensive laboratory and field testing of plant tissue or purified Cry1A.105, Cry2Ab2, Cry1F, PAT, Cry3Bb1, CP4 EPSPS, Cry34Ab1 and Cry35Ab1 proteins, and with a wide range of non-target species. No adverse effects have been observed in non-target species exposed to Cry1A.105, Cry2Ab2, Cry1F, PAT, Cry3Bb1, CP4 EPSPS, Cry34Ab1 and Cry35Ab1 proteins. In addition, these proteins are expected to degrade rapidly in the environment. Furthermore, agronomic, morphological and pest susceptibility data have been recorded in multiple field trials conducted in major maize growing regions. Results from these trials confirm that MON 89034 x 1507 x MON 88017 x 59122 is phenotypically equivalent to conventional maize except for its protection against corn borer and target coleopterans and its tolerance to glufosinate-ammonium and glyphosate.

MON 89034 x 1507 x MON 88017 x 59122, the benefits

MON 89034 x 1507 x MON 88017 x 59122 will benefit both farmers and the environment.

Its potential benefits combine the benefits provided by parental lines: MON 89034 and 1507, which confer protection against certain lepidopteran insect pests; MON 88017 and 59122, which confer protection against certain coleopteran pests; MON 88017, which additionally confers tolerance to glyphosate and 1507 and 59122, which additionally confer tolerance to glufosinate-ammonium.

The benefits of MON 89034 x 1507 x MON 88017 x 59122 include:

- Multiple modes-of-action to help protect plants above and below the ground: i) Protected roots to enable the best nutrient and water uptake ii) Protected shoots to enhance photosynthesis and grain production. In addition, insect resistance has a much lower likelihood when plants present dual and triple modes of protection. The use of unique multiple modes-of-action provides the enhanced insect protection—while maintaining long-term durability of the trait technology. Overall, the product provides substantial economic benefits to growers by limiting yield losses from corn rootworm and lepidopteran insect pests as well as from weed pressure.
- The industry's first reduced refuge system for both above and below ground insect protection. Refuge percentage is reduced from 20% to 5%, the lowest in the US Corn Belt. Efficacy data, analyses, and modeling support the combined use of the Cry3Bb1 and Cry34/35Ab1 proteins for refuge reduction for corn rootworm, and the use of Cry1A.105, Cry2Ab2, and Cry1F proteins for lepidopteran control with multiple modes of insecticidal action. This multiple dose product with a 5% refuge has significantly greater durability than a single dose product with a 20% refuge.
- A method to control corn borers, other lepidopteran pests of maize and corn rootworm, compatible with integrated pest management (IPM) approaches, that offers improved pest control and higher yields, while at the same time being safe for humans and the environment. This is combined with a successful broad-spectrum weed control option that allows over-the-top applications of glufosinate-ammonium and/or glyphosate in maize on an "as needed basis"
- Better control of fall armyworm (*Spodoptera* sp.) and corn earworm (*Helicoverpa zea*) compared to the first generation insect protected maize, MON 810 (MON 89034 and 1507 have a wider spectrum of activity);
- An effective insect resistance management tool for lepidopteran insect pests due to the presence of three insecticidal proteins, Cry1A.105, Cry2Ab2 and Cry1F;
- Decreased occurrence of fungal mycotoxins associated with adverse health effects, as a result of lower damage to maize plants by lepidopteran pests (Bakan, et al., 2002; Brookes, 2008; de la Campa, et al., 2005; Munkvold, 2003; Wu, 2006);
- Negligible to no risks for adverse effects on beneficial, non-target organisms when compared to fields treated with conventional pesticides or with untreated controls, attributed to the reduction in insecticide use, low toxicity of glyphosate and compatibility with conservation tillage practices (Ammann, 2003; Fawcett and Towery, 2002; Giesy, et al., 2000; Lozzia, 1999; Orr and Landis, 1997; Pilcher, et al., 1997; Reyes, 2005).
- Control of a wide spectrum of weeds using a smaller number of herbicides. This is particularly important since a number of active ingredients are being re-assessed for toxicological and environmental safety under Directive 91/414/EEC. Glyphosate has already been approved under this directive and can provide an environmentally sustainable, flexible, and profitable alternative to existing weed control programs (Dewar, 2009); [

- Increased benefits for farmers linked to the reduced exposure to insecticides, ease of use and handling, time and labor savings, as well as better pest control (Brookes and Barfoot, 2008; Marra, et al., 2002)
- Resource conservation linked to reduced insecticide and herbicide use, *e.g.* less diesel fuel consumed in the manufacture and delivery of insecticides, less water used for insecticide application, conservation of aviation fuel and reduced use of insecticide containers (Carpenter, et al., 2002; Phipps and Park, 2002)[21];
- An excellent fit with reduced tillage systems, which are linked to many environmental advantages including improved soil and water quality, reduced soil erosion and runoff, improved wildlife habitat and reduced fuel use and C_{O2} emissions (Fawcett and Towery, 2002; Phipps and Park, 2002);

References

Ammann, K. 2003. Biodiversity and agricultural biotechnology - A review of the impact of agricultural biotechnology on biodiversity. Botanischer Garten Bern: 1-54.

Bakan, B., D. Mecion, D. Richard-Molard and B. Cahagnier. 2002. Fungal growth and *Fusarium* Mycotoxin content in isogenic traditional maize and genetically modified maize grown in France and Spain. J. Agric. Food Chem. 50: 728-731.

Betz, F.S., B.G. Hammond and R.L. Fuchs. 2000. Safety and advantages of *Bacillus thuringiensis*-protected plants to control insect pests. Reg. Toxicology and Pharmacology 32: 156-173.

Brookes, G. 2008. The impact of using GM insect resistant maize in Europe since 1998. Int. J Biotechnology 10: 148-166.

Brookes, G. and P. Barfoot. 2008. Global impact of biotech crops: socio-economic and environmental effects, 1996-2006. AgBioForum 11: 21-38.

Carpenter, J.E., A. Felsot, T. Goode, M. Hammig, D. Onstad and S. Sankula. 2002. Comparative environmental impacts of biotechnology-derived and traditional soybean, corn, and cotton crops. Council for Agricultural Science and technology: 1-189.

De La Campa, R., D.C. Hooker, J.D. Miller, A.W. Schaafsma and B.G. Hammond. 2005. Modeling effects of environment, insect damage, and *Bt* genotypes on fumonisin accumulation in maize in Argentina and the Philippines. Mycopathologia 159: 539-552.

Dewar, A. 2009. Weed control in glyphosate-tolerant maize in Europe. Pest Management Science 65: 1047-1058.

Fawcett, R. and D. Towery. 2002. Conservation tillage and plant biotechnology: how new technologies can improve the environment by reducing the need to plow. Report of the Conservation Technology Information Center (CTIC): 1-24.

Giesy, J.P., S. Dobson and K.R. Solomon. 2000. Ecotoxicological risk assessment for Roundup® herbicide. Rev. Environ. Contam. Toxicol. 167: 35-120.

James, C. 2012. Global status of commercialized biotech/GM crops: 2012. ISAAA Brief 44.

Lozzia, G.C. 1999. Biodiversity and structure of ground beetle assemblages (Coleoptera Carabidae) in Bt corn and its effects on non target insects. Boll. Zool. agr. Bioche. 31: 37-58.

Marra, M., P. Pardey and J. Alston. 2002. The payoffs to agriculture biotechnology - an assessment of the evidence. Environmental and Production Technology Division (EBTD) of the International Food Policy Research Institute (IFPRI) 87: 1-57.

Munkvold, G.P. 2003. Cultural and genetic approaches to managing mycotoxins in maize. Annu. Rev. Phytopathol. 41: 99-116.

Orr, D.R. and D.A. Landis. 1997. Oviposition of European corn borer (Lepidoptera: Pyralidae) and impact of natural enemy populations in transgenic versus isogenic corn. J. Econ. Entomol. 90: 905-909.

Phipps, R.H. and J.R. Park. 2002. Environmental benefits of genetically modified crops: global and European perspectives on their ability to reduce pesticide use. Journal of animal and feed sciences 11: 1-18.

Pilcher, C.D., J.J. Obrycki, M.E. Rice and L.C. Lewis. 1997. Preimaginal development, survival and field abundance of insect predators on transgenic *Bacillus thuringiensis* Corn. Biological Control 26: 446-454.

Reyes, S.G. 2005. Wet season population abundance of *Micraspis discolor* (Fabr.) (Coleoptera: Coccinellidae) and *Trichomma cnaphalocrosis* Uchida (Hymenoptera: Ichnuemonidae) on three transgenic corn hybrids in two sites in the Philippines. Asian Life Sciences 14: 217-224.

Siegfried, B., T. Vaughn and T. Spencer. 2005. Baseline susceptibility of western corn rootworm (Coleoptera: Crysomelidae) to Cry3Bb1*Bacillus thuringiensis* toxin. Journal of Economic Entomology 98: 1320-1324.

Wu, F. 2006. Mycotoxin reduction in Bt corn: potential economic, health, and regulatory impacts. Transgenic Research 15: 277-289.

[21] National Corn Growers Association and US Grain Council (NCGA & USG). Agriculture Biotechnology Reference Guide: http://www.ncga.com/files/guide.pdf (Accessed on November 13, 2013)