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Diehn et al.(10) **Patent No.:** **US 8,575,434 B2**
(45) **Date of Patent:** **Nov. 5, 2013**(54) **MAIZE EVENT DP-004114-3 AND METHODS FOR DETECTION THEREOF**(75) Inventors: **Scott Diehn**, West Des Moines, IA (US);
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C07H 21/04 (2006.01)(52) **U.S. Cl.**
USPC **800/302**; 800/260; 800/279; 800/320.1;
800/265; 800/275; 536/23.71; 426/655; 426/615(58) **Field of Classification Search**
None
See application file for complete search history.(56) **References Cited**

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Primary Examiner — Anne Kubelik
Assistant Examiner — Jeffrey Bolland(57) **ABSTRACT**

The invention provides DNA compositions that relate to transgenic insect resistant maize plants. Also provided are assays for detecting the presence of the maize DP-004114-3 event based on the DNA sequence of the recombinant construct inserted into the maize genome and the DNA sequences flanking the insertion site. Kits and conditions useful in conducting the assays are provided.

28 Claims, 5 Drawing Sheets

Figure 1

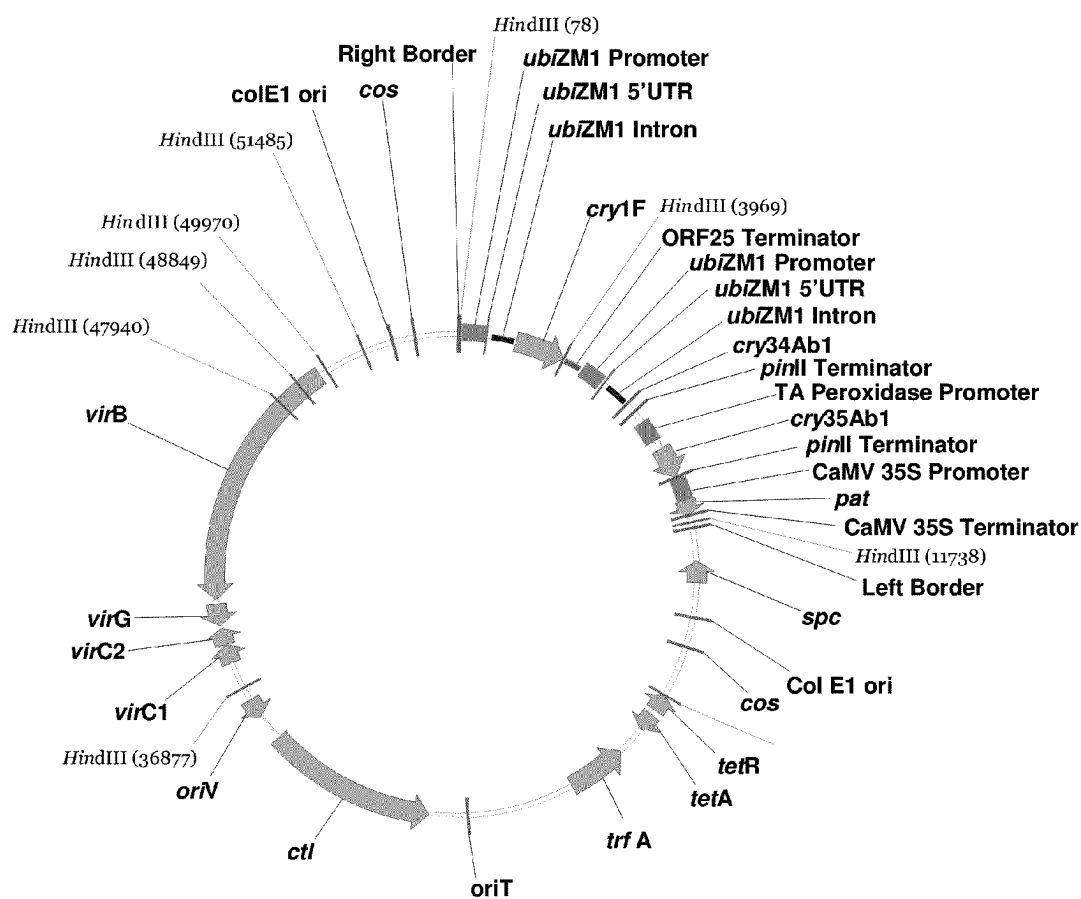


Figure 2

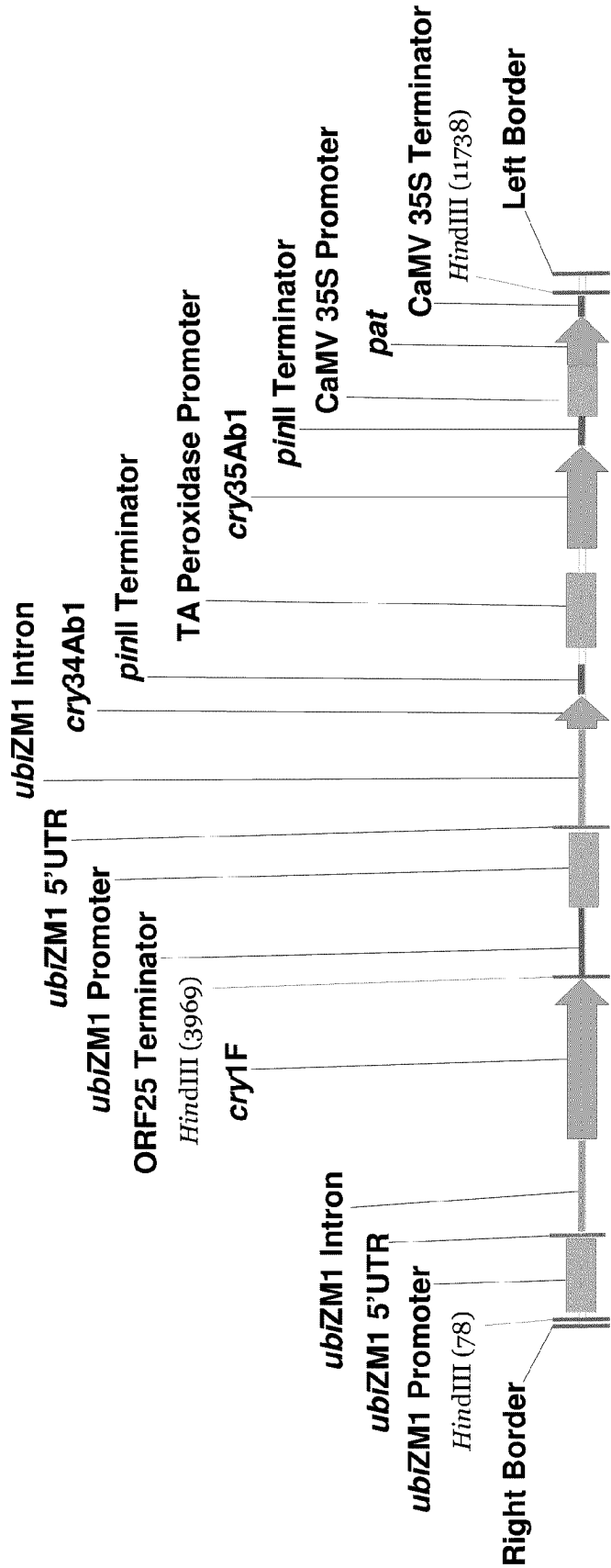


Figure 3

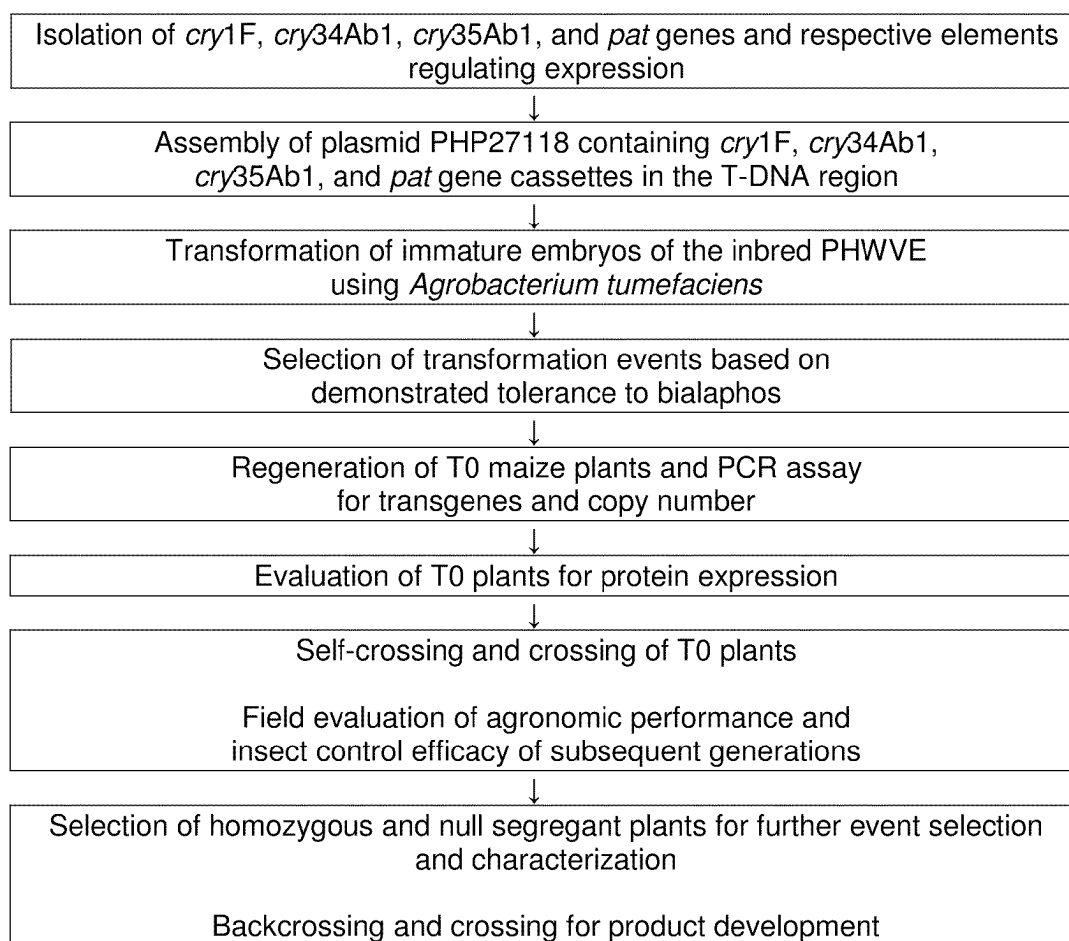


Figure 4

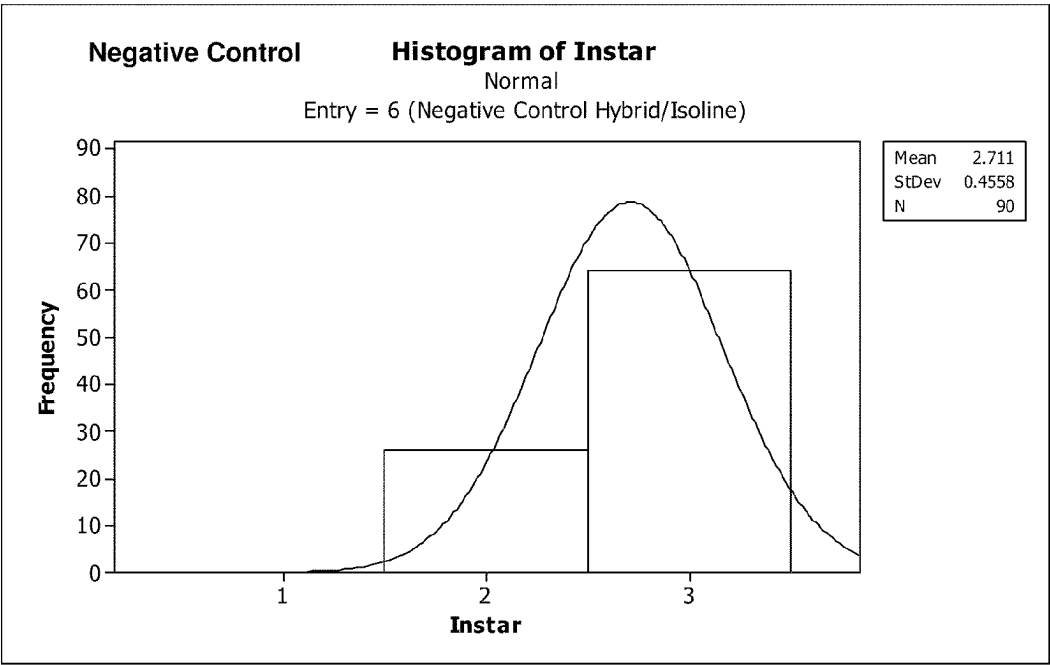
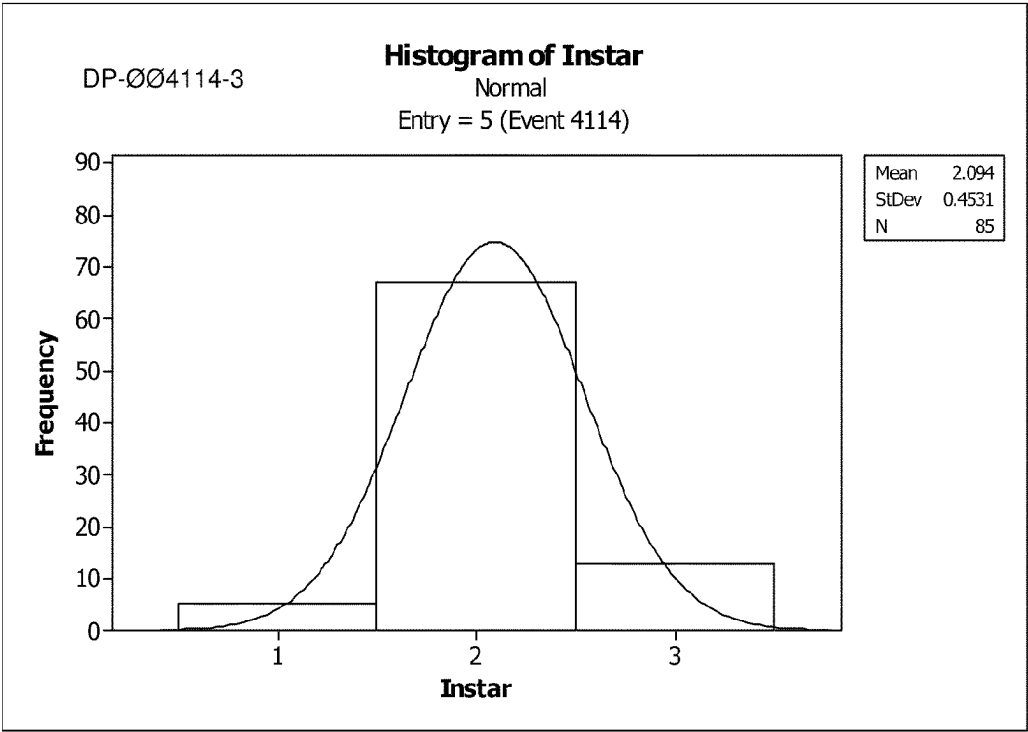
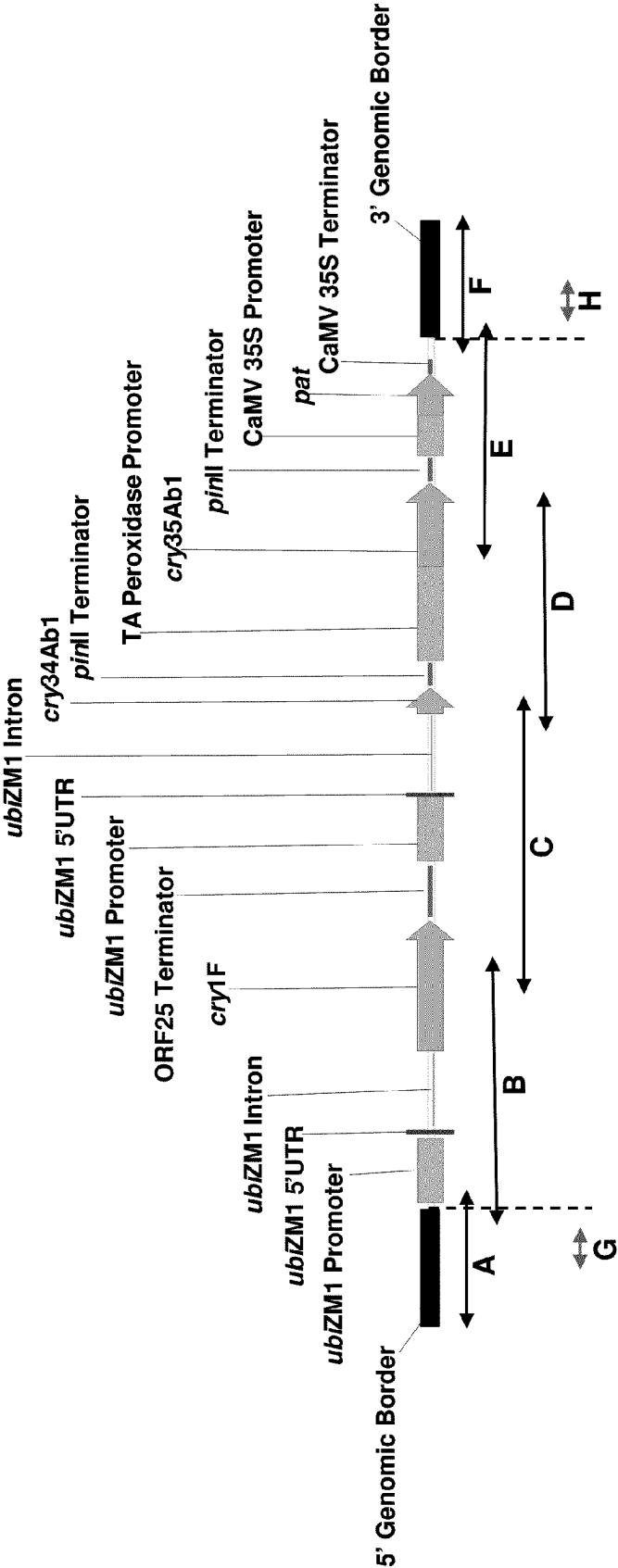


Figure 5



MAIZE EVENT DP-004114-3 AND METHODS FOR DETECTION THEREOF

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application No. 61/413,536, filed on Nov. 15, 2010 and U.S. Provisional Application No. 61/287,462, filed Dec. 17, 2009, the contents of which are herein incorporated by reference in their entirety.

FIELD OF INVENTION

Embodiments of the present invention relate to the field of plant molecular biology, specifically embodiment of the invention relate to DNA constructs for conferring insect resistance to a plant. Embodiments of the invention more specifically relate to insect resistant corn plant event DP-004114-3 and to assays for detecting the presence of corn event DP-004114-3 in a sample and compositions thereof.

BACKGROUND OF INVENTION

An embodiment of this invention relates to the insect resistant corn (*Zea mays*) plant DP-004114-3, also referred to as “maize line DP-004114-3,” “maize event DP-004114-3,” and “4114 maize,” and to the DNA plant expression construct of corn plant DP-004114-3 and the detection of the transgene/flanking insertion region in corn plant DP-004114-3 and progeny thereof.

Corn is an important crop and is a primary food source in many areas of the world. Damage caused by insect pests is a major factor in the loss of the world’s corn crops, despite the use of protective measures such as chemical pesticides. In view of this, insect resistance has been genetically engineered into crops such as corn in order to control insect damage and to reduce the need for traditional chemical pesticides. One group of genes which have been utilized for the production of transgenic insect resistant crops is the delta-endotoxin group from *Bacillus thuringiensis* (Bt). Delta-endotoxins have been successfully expressed in crop plants such as cotton, potatoes, rice, sunflower, as well as corn, and have proven to provide excellent control over insect pests. (Perlak, F. J. et al. (1990) *Bio/Technology* 8:939-943; Perlak, F. J. et al. (1993) *Plant Mol. Biol.* 22:313-321; Fujimoto, H. et al. (1993) *Bio/Technology* 11:1151-1155; Tu et al. (2000) *Nature Biotechnology* 18:1101-1104; PCT publication WO 01/13731; and Bing, J. W. et al. (2000) Efficacy of Cry1F Transgenic Maize, 14th Biennial International Plant Resistance to Insects Workshop, Fort Collins, Colo.).

The expression of foreign genes in plants is known to be influenced by their location in the plant genome, perhaps due to chromatin structure (e.g., heterochromatin) or the proximity of transcriptional regulatory elements (e.g., enhancers) close to the integration site (Weising et al. (1988) *Ann. Rev. Genet.* 22:421-477). At the same time the presence of the transgene at different locations in the genome will influence the overall phenotype of the plant in different ways. For this reason, it is often necessary to screen a large number of events in order to identify an event characterized by optimal expression of an introduced gene of interest. For example, it has been observed in plants and in other organisms that there may be a wide variation in levels of expression of an introduced gene among events. There may also be differences in spatial or temporal patterns of expression, for example, differences in the relative expression of a transgene in various plant

tissues, that may not correspond to the patterns expected from transcriptional regulatory elements present in the introduced gene construct. For this reason, it is common to produce hundreds to thousands of different events and screen those events for a single event that has desired transgene expression levels and patterns for commercial purposes. An event that has desired levels or patterns of transgene expression is useful for introgressing the transgene into other genetic backgrounds by sexual outcrossing using conventional breeding methods. Progeny of such crosses maintain the transgene expression characteristics of the original transformant. This strategy is used to ensure reliable gene expression in a number of varieties that are well adapted to local growing conditions.

It would be advantageous to be able to detect the presence of a particular event in order to determine whether progeny of a sexual cross contain a transgene of interest. In addition, a method for detecting a particular event would be helpful for complying with regulations requiring the pre-market approval and labeling of foods derived from recombinant crop plants, for example, or for use in environmental monitoring, monitoring traits in crops in the field, or monitoring products derived from a crop harvest, as well as for use in ensuring compliance of parties subject to regulatory or contractual terms.

It is possible to detect the presence of a transgene by any nucleic acid detection method known in the art including, but not limited to, the polymerase chain reaction (PCR) or DNA hybridization using nucleic acid probes. These detection methods generally focus on frequently used genetic elements, such as promoters, terminators, marker genes, etc., because for many DNA constructs, the coding region is interchangeable. As a result, such methods may not be useful for discriminating between different events, particularly those produced using the same DNA construct or very similar constructs unless the DNA sequence of the flanking DNA adjacent to the inserted heterologous DNA is known. For example, an event-specific PCR assay is described in U.S. Pat. No. 6,395,485 for the detection of elite event GAT-ZM1. Accordingly, it would be desirable to have a simple and discriminative method for the identification of event DP-004114-3.

SUMMARY OF INVENTION

Embodiments of this invention relate to methods for producing and selecting an insect resistant monocot crop plant. More specifically, a DNA construct is provided that when expressed in plant cells and plants confers resistance to insects. According to one aspect of the invention, a DNA construct, capable of introduction into and replication in a host cell, is provided that when expressed in plant cells and plants confers insect resistance to the plant cells and plants. Maize event DP-004114-3 was produced by *Agrobacterium*-mediated transformation with plasmid PHP27118. This event contains the cry1F, cry34Ab1, cry35Ab1, and pat gene cassettes, which confer resistance to certain lepidopteran and coleopteran pests, as well as tolerance to phosphinothricin.

Specifically, the first cassette contains a truncated version of the cry1F gene from *Bacillus thuringiensis* var. *aizawai*. The insertion of the cry1F gene confers resistance to damage by lepidopteran pests. The Cry1F protein (SEQ ID NO: 1) is comprised of 605 amino acids and has a molecular weight of approximately 68 kDa. The expression of the cry1F gene is controlled by the maize polyubiquitin promoter (Christensen et al. (1992) *Plant Mol. Biol.* 118(4):675-89), providing constitutive expression of the Cry1F protein in maize. This region also includes the 5' untranslated region (UTR) and intron associated with the native polyubiquitin promoter. The termi-

nator for the cry1F gene is the poly(A) addition signal from Open Reading Frame 25 (ORF 25) of the *Agrobacterium tumefaciens* Ti plasmid pTi15955 (Barker et al. (1983) *Plant Mol. Biol.* 2:335-350).

The second cassette contains the cry34Ab1 gene isolated from *Bacillus thuringiensis* strain PS149B1 (U.S. Pat. Nos. 6,127,180; 6,624,145 and 6,340,593). The Cry34Ab1 protein (SEQ ID NO: 2) is 123 amino acid residues in length and has a molecular weight of approximately 14 kDa. The expression of the cry34Ab1 gene is controlled by a second copy of the maize polyubiquitin promoter with 5' UTR and intron (Christensen et al., 1992, supra). The terminator for the cry34Ab1 gene is the pinII terminator (Keil et al. (1986) *Nucleic Acids Res.* 14:5641-5650; An et al. (1989) *Plant Cell* 1:115-22).

The third gene cassette contains the cry35Ab1 gene, also isolated from *Bacillus thuringiensis* strain PS149B1 (U.S. Pat. Nos. 6,083,499; 6,548,291 and 6,340,593). The Cry35Ab1 protein (SEQ ID NO: 3) has a length of 383 amino acids and a molecular weight of approximately 44 kDa. Simultaneous expression of the Cry34Ab1 and Cry35Ab1 proteins in the plant confers resistance to coleopteran insects. The expression of the cry35Ab1 gene is controlled by the *Triticum aestivum* (wheat) peroxidase promoter and leader sequence (Hertig et al. (1991) *Plant Mol. Biol.* 16:171-174). The terminator for the cry35Ab1 gene is a second copy of the pinII terminator (Keil et al., 1986, supra; An et al., 1989, supra).

The fourth and final gene cassette contains a version of the phosphinothricin acetyl transferase gene from *Streptomyces viridochromogenes* (pat) that has been optimized for expression in maize. The pat gene expresses the phosphinothricin acetyl transferase enzyme (PAT) that confers tolerance to phosphinothricin. The PAT protein (SEQ ID NO: 4) is 183 amino acids residues in length and has a molecular weight of approximately 21 kDa. Expression of the pat gene is controlled by the promoter and terminator regions from the CaMV 35S transcript (Franck et al. (1980) *Cell* 21:285-294; Odell et al. (1985) *Nature* 313:810-812; Pietrzak, et al. (1986) *Nucleic Acids Res.* 14(14):5857-5868). Plants containing the DNA constructs are also provided.

According to another embodiment of the invention, compositions and methods are provided for identifying a novel corn plant designated DP-004114-3. The methods are based on primers or probes which specifically recognize the 5' and/or 3' flanking sequence of DP-004114-3. DNA molecules are provided that comprise primer sequences that when utilized in a PCR reaction will produce amplicons unique to the transgenic event DP-004114-3. The corn plant and seed comprising these molecules is an embodiment of this invention. Further, kits utilizing these primer sequences for the identification of the DP-004114-3 event are provided.

An additional embodiment of the invention relates to the specific flanking sequence of DP-004114-3 described herein, which can be used to develop specific identification methods for DP-004114-3 in biological samples. More particularly, the invention relates to the 5' and/or 3' flanking regions of DP-004114-3 which can be used for the development of specific primers and probes. A further embodiment of the invention relates to identification methods for the presence of DP-004114-3 in biological samples based on the use of such specific primers or probes.

According to another embodiment of the invention, methods of detecting the presence of DNA corresponding to the corn event DP-004114-3 in a sample are provided. Such methods comprise: (a) contacting the sample comprising DNA with a DNA primer set, that when used in a nucleic acid amplification reaction with genomic DNA extracted from

corn event DP-004114-3 produces an amplicon that is diagnostic for corn event DP-004114-3; (b) performing a nucleic acid amplification reaction, thereby producing the amplicon; and (c) detecting the amplicon.

According to another embodiment of the invention, methods of detecting the presence of a DNA molecule corresponding to the DP-004114-3 event in a sample, such methods comprising: (a) contacting the sample comprising DNA extracted from a corn plant with a DNA probe molecule that hybridizes under stringent hybridization conditions with DNA extracted from corn event DP-004114-3 and does not hybridize under the stringent hybridization conditions with a control corn plant DNA; (b) subjecting the sample and probe to stringent hybridization conditions; and (c) detecting hybridization of the probe to the DNA. More specifically, a method for detecting the presence of a DNA molecule corresponding to the DP-004114-3 event in a sample, such methods, consisting of (a) contacting the sample comprising DNA extracted from a corn plant with a DNA probe molecule that consists of sequences that are unique to the event, e.g. junction sequences, wherein said DNA probe molecule hybridizes under stringent hybridization conditions with DNA extracted from corn event DP-004114-3 and does not hybridize under the stringent hybridization conditions with a control corn plant DNA; (b) subjecting the sample and probe to stringent hybridization conditions; and (c) detecting hybridization of the probe to the DNA.

In addition, a kit and methods for identifying event DP-004114-3 in a biological sample which detects a DP-004114-3 specific region are provided.

DNA molecules are provided that comprise at least one junction sequence of DP-004114-3; wherein a junction sequence spans the junction between heterologous DNA inserted into the genome and the DNA from the corn cell flanking the insertion site, i.e. flanking DNA, and is diagnostic for the DP-004114-3 event.

According to another embodiment of the invention, methods of producing an insect resistant corn plant that comprise the steps of: (a) sexually crossing a first parental corn line comprising the expression cassettes of the invention, which confers resistance to insects, and a second parental corn line that lacks insect resistance, thereby producing a plurality of progeny plants; and (b) selecting a progeny plant that is insect resistant. Such methods may optionally comprise the further step of back-crossing the progeny plant to the second parental corn line to producing a true-breeding corn plant that is insect resistant.

A further embodiment of the invention provides a method of producing a corn plant that is resistant to insects comprising transforming a corn cell with the DNA construct PHP27118, growing the transformed corn cell into a corn plant, selecting the corn plant that shows resistance to insects, and further growing the corn plant into a fertile corn plant. The fertile corn plant can be self pollinated or crossed with compatible corn varieties to produce insect resistant progeny.

Another embodiment of the invention further relates to a DNA detection kit for identifying maize event DP-004114-3 in biological samples. The kit comprises a first primer which specifically recognizes the 5' or 3' flanking region of DP-004114-3, and a second primer which specifically recognizes a sequence within the foreign DNA of DP-004114-3, or within the flanking DNA, for use in a PCR identification protocol. A further embodiment of the invention relates to a kit for identifying event DP-004114-3 in biological samples, which kit comprises a specific probe having a sequence which corresponds or is complementary to, a sequence having between 80% and 100% sequence identity with a specific

region of event DP-004114-3. The sequence of the probe corresponds to a specific region comprising part of the 5' or 3' flanking region of event DP-004114-3.

The methods and kits encompassed by the embodiments of the present invention can be used for different purposes such as, but not limited to the following: to identify event DP-004114-3 in plants, plant material or in products such as, but not limited to, food or feed products (fresh or processed) comprising, or derived from plant material; additionally or alternatively, the methods and kits can be used to identify transgenic plant material for purposes of segregation between transgenic and non-transgenic material; additionally or alternatively, the methods and kits can be used to determine the quality of plant material comprising maize event DP-004114-3. The kits may also contain the reagents and materials necessary for the performance of the detection method.

A further embodiment of this invention relates to the DP-004114-3 corn plant or its parts, including, but not limited to, pollen, ovules, vegetative cells, the nuclei of pollen cells, and the nuclei of egg cells of the corn plant DP-004114-3 and the progeny derived thereof. The corn plant and seed of DP-004114-3 from which the DNA primer molecules provide a specific amplicon product is an embodiment of the invention.

The foregoing and other aspects of the invention will become more apparent from the following detailed description and accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1. Schematic diagram of plasmid PHP27118 with genetic elements indicated and Hind III restriction enzyme sites. Plasmid size is 54910 bp.

FIG. 2. Schematic diagram of the T-DNA indicating the cry1F, cry34Ab1, cry35Ab1, and pat genes (arrows) along with their respective regulatory elements. Hind III restriction enzyme sites within the T-DNA are indicated. The size of the T-DNA is 11978 bp.

FIG. 3. Schematic Diagram of the Transformation and Development of DP-004114-3.

FIG. 4. Western corn rootworm (WCRW) larvae developmental effects in the sub-lethal seedling assay employing maize hybrid seedlings in the same genetic background: DP-004114-3 maize with an isolate as a negative control. Results are based on three replicates. Graphic profiles show the percent of larvae in each of three instars at 17 days post egg hatch. A shift towards instar 3 indicates a decrease in efficacy.

FIG. 5. Schematic representation of the insert and genomic border regions sequenced in 4114 maize. The diagram indicates the PCR fragments generated from 4114 maize genomic DNA that were cloned and sequenced: fragments A through F. The vertical dash line represents the genomic border/insert junctions. Fragment G and H represent the 5' and 3' genomic border regions, respectively. Figure is not drawn to scale.

DETAILED DESCRIPTION

The following definitions and methods are provided to better define the present invention and to guide those of ordinary skill in the art in the practice of the present invention. Unless otherwise noted, terms are to be understood according to conventional usage by those of ordinary skill in the relevant art. Definitions of common terms in molecular biology may also be found in Rieger et al., *Glossary of Genetics: Classical and Molecular*, 5th edition, Springer-Verlag; New York, 1991;

and Lewin, *Genes V*, Oxford University Press: New York, 1994. The nomenclature for DNA bases as set forth at 37 CFR §1.822 is used.

The following table sets forth abbreviations used throughout this document, and in particular in the Examples section.

Table of Abbreviations

4114 maize	Maize containing event DP-004114-3
bp	Base pair
Bt	<i>Bacillus thuringiensis</i>
CaMV	Cauliflower mosaic virus
cry1F	cry1F gene from <i>Bacillus thuringiensis</i> var. <i>aizawai</i>
Cry1F	Protein from cry1F gene
cry34Ab1	cry34Ab1 gene from <i>Bacillus thuringiensis</i> strain PS149B1
Cry34Ab1	Protein from cry34Ab1
cry35Ab1	cry35Ab1 gene from <i>Bacillus thuringiensis</i> strain PS149B1
Cry35Ab1	Protein from cry35Ab1 gene
kb	Kilobase pair
kDa	KiloDalton
LB	Left T-DNA border
pat	phosphinothricin acetyl transferase gene
PAT	Protein from phosphinothricin acetyl transferase gene
PCR	Polymerase chain reaction
pinII	Proteinase inhibitor II gene from <i>Solanum tuberosum</i>
RB	Right T-DNA border
T-DNA	The transfer DNA portion of the <i>Agrobacterium</i> transformation plasmid between the Left and Right Borders that is expected to be transferred to the plant genome
UTR	Untranslated region
ECB	European corn borer (<i>Ostrinia nubilalis</i>)
FAW	Fall armyworm (<i>Spodoptera frugiperda</i>)
WCRW	western corn rootworm (<i>Diabrotica virgifera virgifera</i>)

Compositions of this disclosure include seed deposited as Patent Deposit No. PTA-11506 and plants, plant cells, and seed derived therefrom. Applicant(s) have made a deposit of at least 2500 seeds of maize event DP-004114-3 with the American Type Culture Collection (ATCC), Manassas, Va. 20110-2209 USA, on Nov. 24, 2010 and the deposits were assigned ATCC Deposit No. PTA-11506. These deposits will be maintained under the terms of the Budapest Treaty on the International Recognition of the Deposit of Microorganisms for the Purposes of Patent Procedure. These deposits were made merely as a convenience for those of skill in the art and are not an admission that a deposit is required under 35 U.S.C. §112. The seeds deposited with the ATCC on Nov. 24, 2010 were taken from the deposit maintained by Pioneer Hi-Bred International, Inc., 7250 NW 62nd Avenue, Johnston, Iowa 50131-1000. Access to this deposit will be available during the pendency of the application to the Commissioner of Patents and Trademarks and persons determined by the Commissioner to be entitled thereto upon request. Upon allowance of any claims in the application, the Applicant(s) will make available to the public, pursuant to 37 C.F.R. §1.808, sample(s) of the deposit of at least 2500 seeds of hybrid maize with the American Type Culture Collection (ATCC), 10801 University Boulevard, Manassas, Va. 20110-2209. This deposit of seed of maize event DP-004114-3 will be maintained in the ATCC depository, which is a public depository, for a period of 30 years, or 5 years after the most recent request, or for the enforceable life of the patent, whichever is longer, and will be replaced if it becomes nonviable during that period. Additionally, Applicant(s) have satisfied all the requirements of 37 C.F.R. §§1.801-1.809, including providing an indication of the viability of the sample upon deposit. Applicant(s) have no authority to waive any restrictions

imposed by law on the transfer of biological material or its transportation in commerce. Applicant(s) do not waive any infringement of their rights granted under this patent or rights applicable to event DP-004114-3 under the Plant Variety Protection Act (7 USC 2321 et seq.). Unauthorized seed multiplication prohibited. The seed may be regulated.

As used herein, the term “comprising” means “including but not limited to.”

As used herein, the term “corn” means *Zea mays* or maize and includes all plant varieties that can be bred with corn, including wild maize species.

As used herein, the term “DP-004114-3 specific” refers to a nucleotide sequence which is suitable for discriminatively identifying event DP-004114-3 in plants, plant material, or in products such as, but not limited to, food or feed products (fresh or processed) comprising, or derived from plant material.

As used herein, the terms “insect resistant” and “impacting insect pests” refers to effecting changes in insect feeding, growth, and/or behavior at any stage of development, including but not limited to: killing the insect; retarding growth; preventing reproductive capability; inhibiting feeding; and the like.

As used herein, the terms “pesticidal activity” and “insecticidal activity” are used synonymously to refer to activity of an organism or a substance (such as, for example, a protein) that can be measured by numerous parameters including, but not limited to, pest mortality, pest weight loss, pest attraction, pest repellency, and other behavioral and physical changes of a pest after feeding on and/or exposure to the organism or substance for an appropriate length of time. For example “pesticidal proteins” are proteins that display pesticidal activity by themselves or in combination with other proteins.

“Coding sequence” refers to a nucleotide sequence that codes for a specific amino acid sequence. As used herein, the terms “encoding” or “encoded” when used in the context of a specified nucleic acid mean that the nucleic acid comprises the requisite information to guide translation of the nucleotide sequence into a specified protein. The information by which a protein is encoded is specified by the use of codons. A nucleic acid encoding a protein may comprise non-translated sequences (e.g., introns) within translated regions of the nucleic acid or may lack such intervening non-translated sequences (e.g., as in cDNA).

“Gene” refers to a nucleic acid fragment that expresses a specific protein, including regulatory sequences preceding (5' non-coding sequences) and following (3' non-coding sequences) the coding sequence. “Native gene” refers to a gene as found in nature with its own regulatory sequences. “Chimeric gene” refers any gene that is not a native gene, comprising regulatory and coding sequences that are not found together in nature. Accordingly, a chimeric gene may comprise regulatory sequences and coding sequences that are derived from different sources, or regulatory sequences and coding sequences derived from the same source, but arranged in a manner different than that found in nature. “Endogenous gene” refers to a native gene in its natural location in the genome of an organism. “Foreign” refers to material not normally found in the location of interest. Thus “foreign DNA” may comprise both recombinant DNA as well as newly introduced, rearranged DNA of the plant. A “foreign” gene refers to a gene not normally found in the host organism, but that is introduced into the host organism by gene transfer. Foreign genes can comprise native genes inserted into a non-native organism, or chimeric genes. A “transgene” is a gene that has been introduced into the genome by a transformation

procedure. The site in the plant genome where a recombinant DNA has been inserted may be referred to as the “insertion site” or “target site”.

As used herein, “insert DNA” refers to the heterologous DNA within the expression cassettes used to transform the plant material while “flanking DNA” can exist of either genomic DNA naturally present in an organism such as a plant, or foreign (heterologous) DNA introduced via the transformation process which is extraneous to the original insert DNA molecule, e.g. fragments associated with the transformation event. A “flanking region” or “flanking sequence” as used herein refers to a sequence of at least 20 bp, preferably at least 50 bp, and up to 5000 bp, which is located either immediately upstream of and contiguous with or immediately downstream of and contiguous with the original foreign insert DNA molecule. Transformation procedures leading to random integration of the foreign DNA will result in transformants containing different flanking regions characteristic and unique for each transformant. When recombinant DNA is introduced into a plant through traditional crossing, its flanking regions will generally not be changed. Transformants will also contain unique junctions between a piece of heterologous insert DNA and genomic DNA, or two (2) pieces of genomic DNA, or two (2) pieces of heterologous DNA. A “junction” is a point where two (2) specific DNA fragments join. For example, a junction exists where insert DNA joins flanking DNA. A junction point also exists in a transformed organism where two (2) DNA fragments join together in a manner that is modified from that found in the native organism. “Junction DNA” refers to DNA that comprises a junction point. Two junction sequences set forth in this disclosure are the junction point between the maize genomic DNA and the 5' end of the insert as set forth in SEQ ID NO: 27, and the junction point between the 3' end of the insert and maize genomic DNA as set forth in SEQ ID NO: 28.

As used herein, “heterologous” in reference to a nucleic acid is a nucleic acid that originates from a foreign species, or, if from the same species, is substantially modified from its native form in composition and/or genomic locus by deliberate human intervention. For example, a promoter operably linked to a heterologous nucleotide sequence can be from a species different from that from which the nucleotide sequence was derived, or, if from the same species, the promoter is not naturally found operably linked to the nucleotide sequence. A heterologous protein may originate from a foreign species, or, if from the same species, is substantially modified from its original form by deliberate human intervention.

“Regulatory sequences” refer to nucleotide sequences located upstream (5' non-coding sequences), within, or downstream (3' non-coding sequences) of a coding sequence, and which influence the transcription, RNA processing or stability, or translation of the associated coding sequence. Regulatory sequences may include promoters, translation leader sequences, introns, and polyadenylation recognition sequences.

“Promoter” refers to a nucleotide sequence capable of controlling the expression of a coding sequence or functional RNA. In general, a coding sequence is located 3' to a promoter sequence. The promoter sequence consists of proximal and more distal upstream elements, the latter elements are often referred to as enhancers. Accordingly, an “enhancer” is a nucleotide sequence that can stimulate promoter activity and may be an innate element of the promoter or a heterologous element inserted to enhance the level or tissue-specificity of a promoter. Promoters may be derived in their entirety from a

native gene, or be composed of different elements derived from different promoters found in nature, or even comprise synthetic nucleotide segments. It is understood by those skilled in the art that different promoters may direct the expression of a gene in different tissues or cell types, or at different stages of development, or in response to different environmental conditions. Promoters that cause a nucleic acid fragment to be expressed in most cell types at most times are commonly referred to as "constitutive promoters". New promoters of various types useful in plant cells are constantly being discovered; numerous examples may be found in the compilation by Okamuro and Goldberg (1989) *Biochemistry of Plants* 15:1-82. It is further recognized that since in most cases the exact boundaries of regulatory sequences have not been completely defined, nucleic acid fragments of different lengths may have identical promoter activity.

The "translation leader sequence" refers to a nucleotide sequence located between the promoter sequence of a gene and the coding sequence. The translation leader sequence is present in the fully processed mRNA upstream of the translation start sequence. The translation leader sequence may affect numerous parameters including, processing of the primary transcript to mRNA, mRNA stability and/or translation efficiency. Examples of translation leader sequences have been described (Turner and Foster (1995) *Mol. Biotechnol.* 3:225-236).

The "3' non-coding sequences" refer to nucleotide sequences located downstream of a coding sequence and include polyadenylation recognition sequences and other sequences encoding regulatory signals capable of affecting mRNA processing or gene expression. The polyadenylation signal is usually characterized by affecting the addition of polyadenylic acid tracts to the 3' end of the mRNA precursor. The use of different 3' non-coding sequences is exemplified by Ingelbrecht et al. (1989) *Plant Cell* 1:671-680.

A "protein" or "polypeptide" is a chain of amino acids arranged in a specific order determined by the coding sequence in a polynucleotide encoding the polypeptide.

A DNA construct is an assembly of DNA molecules linked together that provide one or more expression cassettes. The DNA construct may be a plasmid that is enabled for self replication in a bacterial cell and contains various endonuclease enzyme restriction sites that are useful for introducing DNA molecules that provide functional genetic elements, i.e., promoters, introns, leaders, coding sequences, 3' termination regions, among others; or a DNA construct may be a linear assembly of DNA molecules, such as an expression cassette. The expression cassette contained within a DNA construct comprises the necessary genetic elements to provide transcription of a messenger RNA. The expression cassette can be designed to express in prokaryote cells or eukaryotic cells. Expression cassettes of the embodiments of the present invention are designed to express in plant cells.

The DNA molecules of embodiments of the invention are provided in expression cassettes for expression in an organism of interest. The cassette will include 5' and 3' regulatory sequences operably linked to a coding sequence. "Operably linked" means that the nucleic acid sequences being linked are contiguous and, where necessary to join two protein coding regions, contiguous and in the same reading frame. Operably linked is intended to indicate a functional linkage between a promoter and a second sequence, wherein the promoter sequence initiates and mediates transcription of the DNA sequence corresponding to the second sequence. The cassette may additionally contain at least one additional gene to be co-transformed into the organism. Alternatively, the

additional gene(s) can be provided on multiple expression cassettes or multiple DNA constructs.

The expression cassette will include in the 5' to 3' direction of transcription: a transcriptional and translational initiation region, a coding region, and a transcriptional and translational termination region functional in the organism serving as a host. The transcriptional initiation region (i.e., the promoter) may be native or analogous, or foreign or heterologous to the host organism. Additionally, the promoter may be the natural sequence or alternatively a synthetic sequence. The expression cassettes may additionally contain 5' leader sequences in the expression cassette construct. Such leader sequences can act to enhance translation.

It is to be understood that as used herein the term "transgenic" includes any cell, cell line, callus, tissue, plant part, or plant, the genotype of which has been altered by the presence of a heterologous nucleic acid including those transgenics initially so altered as well as those created by sexual crosses or asexual propagation from the initial transgenic. The term "transgenic" as used herein does not encompass the alteration of the genome (chromosomal or extra-chromosomal) by conventional plant breeding methods or by naturally occurring events such as random cross-fertilization, non-recombinant viral infection, non-recombinant bacterial transformation, non-recombinant transposition, or spontaneous mutation.

A transgenic "event" is produced by transformation of plant cells with a heterologous DNA construct(s), including a nucleic acid expression cassette that comprises a transgene of interest, the regeneration of a population of plants resulting from the insertion of the transgene into the genome of the plant, and selection of a particular plant characterized by insertion into a particular genome location. An event is characterized phenotypically by the expression of the transgene. At the genetic level, an event is part of the genetic makeup of a plant. The term "event" also refers to progeny produced by a sexual outcross between the transformant and another variety that include the heterologous DNA. Even after repeated back-crossing to a recurrent parent, the inserted DNA and flanking DNA from the transformed parent is present in the progeny of the cross at the same chromosomal location. The term "event" also refers to DNA from the original transformant comprising the inserted DNA and flanking sequence immediately adjacent to the inserted DNA that would be expected to be transferred to a progeny that receives inserted DNA including the transgene of interest as the result of a sexual cross of one parental line that includes the inserted DNA (e.g., the original transformant and progeny resulting from selfing) and a parental line that does not contain the inserted DNA.

An insect resistant DP-004114-3 corn plant can be bred by first sexually crossing a first parental corn plant consisting of a corn plant grown from the transgenic DP-004114-3 corn plant and progeny thereof derived from transformation with the expression cassettes of the embodiments of the present invention that confers insect resistance, and a second parental corn plant that lacks insect resistance, thereby producing a plurality of first progeny plants; and then selecting a first progeny plant that is resistant to insects; and selfing the first progeny plant, thereby producing a plurality of second progeny plants; and then selecting from the second progeny plants an insect resistant plant. These steps can further include the back-crossing of the first insect resistant progeny plant or the second insect resistant progeny plant to the second parental corn plant or a third parental corn plant, thereby producing a corn plant that is resistant to insects.

As used herein, the term "plant" includes reference to whole plants, plant organs (e.g., leaves, stems, roots, etc.),

seeds, plant cells, and progeny of same. Parts of transgenic plants understood to be within the scope of the invention comprise, for example, plant cells, protoplasts, tissues, callus, embryos as well as flowers, stems, fruits, leaves, and roots originating in transgenic plants or their progeny previously transformed with a DNA molecule of the invention and therefore consisting at least in part of transgenic cells, are also an embodiment of the present invention.

As used herein, the term "plant cell" includes, without limitation, seeds, suspension cultures, embryos, meristematic regions, callus tissue, leaves, roots, shoots, gametophytes, sporophytes, pollen, and microspores. The class of plants that can be used in the methods of the invention is generally as broad as the class of higher plants amenable to transformation techniques, including both monocotyledonous and dicotyledonous plants.

"Transformation" refers to the transfer of a nucleic acid fragment into the genome of a host organism, resulting in genetically stable inheritance. Host organisms containing the transformed nucleic acid fragments are referred to as "transgenic" organisms. Examples of methods of plant transformation include *Agrobacterium*-mediated transformation (De Blaere et al. (1987) *Meth. Enzymol.* 143:277) and particle-accelerated or "gene gun" transformation technology (Klein et al. (1987) *Nature* (London) 327:70-73; U.S. Pat. No. 4,945,050, incorporated herein by reference). Additional transformation methods are disclosed below.

Thus, isolated polynucleotides of the invention can be incorporated into recombinant constructs, typically DNA constructs, which are capable of introduction into and replication in a host cell. Such a construct can be a vector that includes a replication system and sequences that are capable of transcription and translation of a polypeptide-encoding sequence in a given host cell. A number of vectors suitable for stable transfection of plant cells or for the establishment of transgenic plants have been described in, e.g., Pouwels et al., (1985; Supp. 1987) *Cloning Vectors: A Laboratory Manual*, Weissbach and Weissbach (1989) *Methods for Plant Molecular Biology*, (Academic Press, New York); and Flevin et al., (1990) *Plant Molecular Biology Manual*, (Kluwer Academic Publishers). Typically, plant expression vectors include, for example, one or more cloned plant genes under the transcriptional control of 5' and 3' regulatory sequences and a dominant selectable marker. Such plant expression vectors also can contain a promoter regulatory region (e.g., a regulatory region controlling inducible or constitutive, environmentally- or developmentally-regulated, or cell- or tissue-specific expression), a transcription initiation start site, a ribosome binding site, an RNA processing signal, a transcription termination site, and/or a polyadenylation signal.

It is also to be understood that two different transgenic plants can also be mated to produce offspring that contain two independently segregating added, exogenous genes. Selfing of appropriate progeny can produce plants that are homozygous for both added, exogenous genes. Back-crossing to a parental plant and out-crossing with a non-transgenic plant are also contemplated, as is vegetative propagation. Descriptions of other breeding methods that are commonly used for different traits and crops can be found in one of several references, e.g., Fehr, in *Breeding Methods for Cultivar Development*, Wilcos J. ed., American Society of Agronomy, Madison Wis. (1987).

A "probe" is an isolated nucleic acid to which is attached a conventional detectable label or reporter molecule, e.g., a radioactive isotope, ligand, chemiluminescent agent, or enzyme. Such a probe is complementary to a strand of a target nucleic acid, in the case of the present invention, to a strand of

isolated DNA from corn event DP-004114-3 whether from a corn plant or from a sample that includes DNA from the event. Probes according to the present invention include not only deoxyribonucleic or ribonucleic acids but also polyamides and other probe materials that bind specifically to a target DNA sequence and can be used to detect the presence of that target DNA sequence.

"Primers" are isolated nucleic acids that are annealed to a complementary target DNA strand by nucleic acid hybridization to form a hybrid between the primer and the target DNA strand, then extended along the target DNA strand by a polymerase, e.g., a DNA polymerase. Primer pairs of the invention refer to their use for amplification of a target nucleic acid sequence, e.g., by PCR or other conventional nucleic-acid amplification methods. "PCR" or "polymerase chain reaction" is a technique used for the amplification of specific DNA segments (see, U.S. Pat. Nos. 4,683,195 and 4,800,159; herein incorporated by reference).

Probes and primers are of sufficient nucleotide length to bind to the target DNA sequence specifically in the hybridization conditions or reaction conditions determined by the operator. This length may be of any length that is of sufficient length to be useful in a detection method of choice. Generally, 11 nucleotides or more in length, 18 nucleotides or more, and 22 nucleotides or more, are used. Such probes and primers hybridize specifically to a target sequence under high stringency hybridization conditions. Probes and primers according to embodiments of the present invention may have complete DNA sequence similarity of contiguous nucleotides with the target sequence, although probes differing from the target DNA sequence and that retain the ability to hybridize to target DNA sequences may be designed by conventional methods. Probes can be used as primers, but are generally designed to bind to the target DNA or RNA and are not used in an amplification process.

Specific primers can be used to amplify an integration fragment to produce an amplicon that can be used as a "specific probe" for identifying event DP-004114-3 in biological samples. When the probe is hybridized with the nucleic acids of a biological sample under conditions which allow for the binding of the probe to the sample, this binding can be detected and thus allow for an indication of the presence of event DP-004114-3 in the biological sample. Such identification of a bound probe has been described in the art. In an embodiment of the invention the specific probe is a sequence which, under optimized conditions, hybridizes specifically to a region within the 5' or 3' flanking region of the event and also comprises a part of the foreign DNA contiguous therewith. The specific probe may comprise a sequence of at least 80%, between 80 and 85%, between 85 and 90%, between 90 and 95%, and between 95 and 100% identical (or complementary) to a specific region of the event.

Methods for preparing and using probes and primers are described, for example, in Sambrook et al., *Molecular Cloning: A Laboratory Manual*, 2nd ed., vol. 1-3, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y. 1989 (hereinafter, "Sambrook et al., 1989"); Ausubel et al. eds., *Current Protocols in Molecular Biology*, Publishing and Wiley-Interscience, New York, 1995 (with periodic updates) (hereinafter, "Ausubel et al., 1995"); and Innis et al., *PCR Protocols: A Guide to Methods and Applications*, Academic Press: San Diego, 1990. PCR primer pairs can be derived from a known sequence, for example, by using computer programs intended for that purpose such as the PCR primer analysis tool in Vector NTI version 6 (Informax Inc., Bethesda Md.); PrimerSelect (DNASTAR Inc., Madison, Wis.); and Primer (Version 0.5©, 1991, Whitehead Institute

for Biomedical Research, Cambridge, Mass.). Additionally, the sequence can be visually scanned and primers manually identified using guidelines known to one of skill in the art.

A "kit" as used herein refers to a set of reagents for the purpose of performing the method embodiments of the invention, more particularly, the identification of event DP-004114-3 in biological samples. The kit of the invention can be used, and its components can be specifically adjusted, for purposes of quality control (e.g. purity of seed lots), detection of event DP-004114-3 in plant material, or material comprising or derived from plant material, such as but not limited to food or feed products. "Plant material" as used herein refers to material which is obtained or derived from a plant.

Primers and probes based on the flanking DNA and insert sequences disclosed herein can be used to confirm (and, if necessary, to correct) the disclosed sequences by conventional methods, e.g., by re-cloning and sequencing such sequences. The nucleic acid probes and primers of the present invention hybridize under stringent conditions to a target DNA sequence. Any conventional nucleic acid hybridization or amplification method can be used to identify the presence of DNA from a transgenic event in a sample. Nucleic acid molecules or fragments thereof are capable of specifically hybridizing to other nucleic acid molecules under certain circumstances. As used herein, two nucleic acid molecules are said to be capable of specifically hybridizing to one another if the two molecules are capable of forming an anti-parallel, double-stranded nucleic acid structure.

A nucleic acid molecule is said to be the "complement" of another nucleic acid molecule if they exhibit complete complementarity. As used herein, molecules are said to exhibit "complete complementarity" when every nucleotide of one of the molecules is complementary to a nucleotide of the other. Two molecules are said to be "minimally complementary" if they can hybridize to one another with sufficient stability to permit them to remain annealed to one another under at least conventional "low-stringency" conditions. Similarly, the molecules are said to be "complementary" if they can hybridize to one another with sufficient stability to permit them to remain annealed to one another under conventional "high-stringency" conditions. Conventional stringency conditions are described by Sambrook et al., 1989, and by Haymes et al., In: *Nucleic Acid Hybridization, a Practical Approach*, IRL Press, Washington, D.C. (1985), departures from complete complementarity are therefore permissible, as long as such departures do not completely preclude the capacity of the molecules to form a double-stranded structure. In order for a nucleic acid molecule to serve as a primer or probe it need only be sufficiently complementary in sequence to be able to form a stable double-stranded structure under the particular solvent and salt concentrations employed.

In hybridization reactions, specificity is typically the function of post-hybridization washes, the critical factors being the ionic strength and temperature of the final wash solution. The thermal melting point (T_m) is the temperature (under defined ionic strength and pH) at which 50% of a complementary target sequence hybridizes to a perfectly matched probe. For DNA-DNA hybrids, the T_m can be approximated from the equation of Meinkoth and Wahl (1984) *Anal. Biochem.* 138:267-284: $T_m = 81.5^\circ \text{C} + 16.6 (\log M) + 0.41 (\% \text{GC}) - 0.61 (\% \text{form}) - 500/L$; where M is the molarity of monovalent cations, % GC is the percentage of guanosine and cytosine nucleotides in the DNA, % form is the percentage of formamide in the hybridization solution, and L is the length of the hybrid in base pairs. T_m is reduced by about 1°C . for each 1% of mismatching; thus, T_m , hybridization, and/or wash

conditions can be adjusted to hybridize to sequences of the desired identity. For example, if sequences with >90% identity are sought, the T_m can be decreased 10°C . Generally, stringent conditions are selected to be about 5°C . lower than the T_m for the specific sequence and its complement at a defined ionic strength and pH. However, severely stringent conditions can utilize a hybridization and/or wash at 1, 2, 3, or 4°C . lower than the T_m ; moderately stringent conditions can utilize a hybridization and/or wash at 6, 7, 8, 9, or 10°C . lower than the T_m ; low stringency conditions can utilize a hybridization and/or wash at 11, 12, 13, 14, 15, or 20°C . lower than the T_m .

Using the equation, hybridization and wash compositions, and desired T_m , those of ordinary skill will understand that variations in the stringency of hybridization and/or wash solutions are inherently described. If the desired degree of mismatching results in a T_m of less than 45°C . (aqueous solution) or 32°C . (formamide solution), it is preferred to increase the SSC concentration so that a higher temperature can be used. An extensive guide to the hybridization of nucleic acids is found in Tijssen (1993) *Laboratory Techniques in Biochemistry and Molecular Biology-Hybridization with Nucleic Acid Probes*, Part I, Chapter 2 (Elsevier, N.Y.); and Ausubel et al., eds. (1995) and Sambrook et al. (1989).

As used herein, a substantially homologous sequence is a nucleic acid molecule that will specifically hybridize to the complement of the nucleic acid molecule to which it is being compared under high stringency conditions. Appropriate stringency conditions which promote DNA hybridization, for example, 6x sodium chloride/sodium citrate (SSC) at about 45°C ., followed by a wash of 2xSSC at 50°C ., are known to those skilled in the art or can be found in Ausubel et al. (1995), 6.3.1-6.3.6. Typically, stringent conditions will be those in which the salt concentration is less than about 1.5 M Na ion, typically about 0.01 to 1.0 M Na ion concentration (or other salts) at pH 7.0 to 8.3 and the temperature is at least about 30°C . for short probes (e.g., 10 to 50 nucleotides) and at least about 60°C . for long probes (e.g., greater than 50 nucleotides). Stringent conditions may also be achieved with the addition of a destabilizing agent such as formamide. Exemplary low stringency conditions include hybridization with a buffer solution of 30 to 35% formamide, 1 M NaCl, 1% SDS (sodium dodecyl sulphate) at 37°C ., and a wash in 1x to 2xSSC (20xSSC=3.0 M NaCl/0.3 M trisodium citrate) at 50 to 55°C . Exemplary moderate stringency conditions include hybridization in 40 to 45% formamide, 1 M NaCl, 1% SDS at 37°C ., and a wash in 0.5x to 1xSSC at 55 to 60°C . Exemplary high stringency conditions include hybridization in 50% formamide, 1 M NaCl, 1% SDS at 37°C ., and a wash in 0.1xSSC at 60 to 65°C . A nucleic acid of the invention may specifically hybridize to one or more of the nucleic acid molecules unique to the DP-004114-3 event or complements thereof or fragments of either under moderately stringent conditions.

Methods of alignment of sequences for comparison are well known in the art. Thus, the determination of percent identity between any two sequences can be accomplished using a mathematical algorithm. Non-limiting examples of such mathematical algorithms are the algorithm of Myers and Miller (1988) *CABIOS* 4:11-17; the local homology algorithm of Smith et al. (1981) *Adv. Appl. Math.* 2:482; the homology alignment algorithm of Needleman and Wunsch (1970) *J. Mol. Biol.* 48:443-453; the search-for-similarity-method of Pearson and Lipman (1988) *Proc. Natl. Acad. Sci.* 85:2444-2448; the algorithm of Karlin and Altschul (1990) *Proc. Natl. Acad. Sci. USA* 87:2264, modified as in Karlin and Altschul (1993) *Proc. Natl. Acad. Sci. USA* 90:5873-5877.

Computer implementations of these mathematical algorithms can be utilized for comparison of sequences to determine sequence identity. Such implementations include, but are not limited to: CLUSTAL in the PC/Gene program (available from Intelligenetics, Mountain View, Calif.); the ALIGN program (Version 2.0); the ALIGN PLUS program (version 3.0, copyright 1997); and GAP, BESTFIT, BLAST, FASTA, and TFASTA in the Wisconsin Genetics Software Package, Version 10 (available from Accelrys, 9685 Scranton Road, San Diego, Calif. 92121, USA). Alignments using these programs can be performed using the default parameters.

The CLUSTAL program is well described by Higgins and Sharp, *Gene* 73: 237-244 (1988); Higgins and Sharp, *CABIOS* 5: 151-153 (1989); Corpet, et al., *Nucleic Acids Research* 16: 10881-90 (1988); Huang, et al., *Computer Applications in the Biosciences* 8: 155-65 (1992), and Pearson, et al., *Methods in Molecular Biology* 24: 307-331 (1994). The ALIGN and the ALIGN PLUS programs are based on the algorithm of Myers and Miller (1988) *supra*. The BLAST programs of Altschul et al. (1990) *J. Mol. Biol.* 215:403 are based on the algorithm of Karlin and Altschul (1990) *supra*. The BLAST family of programs which can be used for database similarity searches includes: BLASTN for nucleotide query sequences against nucleotide database sequences; BLASTX for nucleotide query sequences against protein database sequences; BLASTP for protein query sequences against protein database sequences; TBLASTN for protein query sequences against nucleotide database sequences; and TBLASTX for nucleotide query sequences against nucleotide database sequences. See, Ausubel, et al., (1995). Alignment may also be performed manually by visual inspection.

To obtain gapped alignments for comparison purposes, Gapped BLAST (in BLAST 2.0) can be utilized as described in Altschul et al. (1997) *Nucleic Acids Res.* 25:3389. Alternatively, PSI-BLAST (in BLAST 2.0) can be used to perform an iterated search that detects distant relationships between molecules. See Altschul et al. (1997) *supra*. When utilizing BLAST, Gapped BLAST, PSI-BLAST, the default parameters of the respective programs (e.g., BLASTN for nucleotide sequences, BLASTX for proteins) can be used.

As used herein, "sequence identity" or "identity" in the context of two nucleic acid or polypeptide sequences makes reference to the residues in the two sequences that are the same when aligned for maximum correspondence over a specified comparison window. When percentage of sequence identity is used in reference to proteins it is recognized that residue positions which are not identical often differ by conservative amino acid substitutions, where amino acid residues are substituted for other amino acid residues with similar chemical properties (e.g., charge or hydrophobicity) and therefore do not change the functional properties of the molecule. When sequences differ in conservative substitutions, the percent sequence identity may be adjusted upwards to correct for the conservative nature of the substitution. Sequences that differ by such conservative substitutions are said to have "sequence similarity" or "similarity." Means for making this adjustment are well known to those of skill in the art. Typically this involves scoring a conservative substitution as a partial rather than a full mismatch, thereby increasing the percentage sequence identity. Thus, for example, where an identical amino acid is given a score of 1 and a non-conservative substitution is given a score of zero, a conservative substitution is given a score between zero and 1. The scoring of conservative substitutions is calculated, e.g., as implemented in the program PC/GENE (Intelligenetics, Mountain View, Calif.).

As used herein, "percentage of sequence identity" means the value determined by comparing two optimally aligned sequences over a comparison window, wherein the portion of the polynucleotide sequence in the comparison window may comprise additions or deletions (i.e., gaps) as compared to the reference sequence (which does not comprise additions or deletions) for optimal alignment of the two sequences. The percentage is calculated by determining the number of positions at which the identical nucleic acid base or amino acid residue occurs in both sequences to yield the number of matched positions, dividing the number of matched positions by the total number of positions in the window of comparison, and multiplying the result by 100 to yield the percentage of sequence identity.

Regarding the amplification of a target nucleic acid sequence (e.g., by PCR) using a particular amplification primer pair, "stringent conditions" are conditions that permit the primer pair to hybridize only to the target nucleic-acid sequence to which a primer having the corresponding wild-type sequence (or its complement) would bind and preferably to produce a unique amplification product, the amplicon, in a DNA thermal amplification reaction.

The term "specific for (a target sequence)" indicates that a probe or primer hybridizes under stringent hybridization conditions only to the target sequence in a sample comprising the target sequence.

As used herein, "amplified DNA" or "amplicon" refers to the product of nucleic acid amplification of a target nucleic acid sequence that is part of a nucleic acid template. For example, to determine whether a corn plant resulting from a sexual cross contains transgenic event genomic DNA from the corn plant of the invention, DNA extracted from the corn plant tissue sample may be subjected to a nucleic acid amplification method using a DNA primer pair that includes a first primer derived from flanking sequence adjacent to the insertion site of inserted heterologous DNA, and a second primer derived from the inserted heterologous DNA to produce an amplicon that is diagnostic for the presence of the event DNA. Alternatively, the second primer may be derived from the flanking sequence. The amplicon is of a length and has a sequence that is also diagnostic for the event. The amplicon may range in length from the combined length of the primer pairs plus one nucleotide base pair to any length of amplicon producible by a DNA amplification protocol. Alternatively, primer pairs can be derived from flanking sequence on both sides of the inserted DNA so as to produce an amplicon that includes the entire insert nucleotide sequence of the PHP27118 expression construct as well as the sequence flanking the transgenic insert. A member of a primer pair derived from the flanking sequence may be located a distance from the inserted DNA sequence, this distance can range from one nucleotide base pair up to the limits of the amplification reaction, or about 20,000 bp. The use of the term "amplicon" specifically excludes primer dimers that may be formed in the DNA thermal amplification reaction.

Nucleic acid amplification can be accomplished by any of the various nucleic acid amplification methods known in the art, including PCR. A variety of amplification methods are known in the art and are described, inter alia, in U.S. Pat. Nos. 4,683,195 and 4,683,202 and in Innis et al., (1990) *supra*. PCR amplification methods have been developed to amplify up to 22 Kb of genomic DNA and up to 42 Kb of bacteriophage DNA (Cheng et al., *Proc. Natl. Acad. Sci. USA* 91:5695-5699, 1994). These methods as well as other methods known in the art of DNA amplification may be used in the practice of the embodiments of the present invention. It is understood that a number of parameters in a specific PCR protocol may

need to be adjusted to specific laboratory conditions and may be slightly modified and yet allow for the collection of similar results. These adjustments will be apparent to a person skilled in the art.

The amplicon produced by these methods may be detected by a plurality of techniques, including, but not limited to, Genetic Bit Analysis (Nikiforov, et al. *Nucleic Acid Res.* 22:4167-4175, 1994) where a DNA oligonucleotide is designed which overlaps both the adjacent flanking DNA sequence and the inserted DNA sequence. The oligonucleotide is immobilized in wells of a microwell plate. Following PCR of the region of interest (using one primer in the inserted sequence and one in the adjacent flanking sequence) a single-stranded PCR product can be hybridized to the immobilized oligonucleotide and serve as a template for a single base extension reaction using a DNA polymerase and labeled ddNTPs specific for the expected next base. Readout may be fluorescent or ELISA-based. A signal indicates presence of the insert/flanking sequence due to successful amplification, hybridization, and single base extension.

Another detection method is the pyrosequencing technique as described by Winge (2000) *Innov. Pharma. Tech.* 00:18-24. In this method an oligonucleotide is designed that overlaps the adjacent DNA and insert DNA junction. The oligonucleotide is hybridized to a single-stranded PCR product from the region of interest (one primer in the inserted sequence and one in the flanking sequence) and incubated in the presence of a DNA polymerase, ATP, sulfurylase, luciferase, apyrase, adenosine 5' phosphosulfate and luciferin. dNTPs are added individually and the incorporation results in a light signal which is measured. A light signal indicates the presence of the transgene insert/flanking sequence due to successful amplification, hybridization, and single or multi-base extension.

Fluorescence polarization as described by Chen et al., (1999) *Genome Res.* 9:492-498 is also a method that can be used to detect an amplicon of the invention. Using this method an oligonucleotide is designed which overlaps the flanking and inserted DNA junction. The oligonucleotide is hybridized to a single-stranded PCR product from the region of interest (one primer in the inserted DNA and one in the flanking DNA sequence) and incubated in the presence of a DNA polymerase and a fluorescent-labeled ddNTP. Single base extension results in incorporation of the ddNTP. Incorporation can be measured as a change in polarization using a fluorometer. A change in polarization indicates the presence of the transgene insert/flanking sequence due to successful amplification, hybridization, and single base extension.

Taqman® (PE Applied Biosystems, Foster City, Calif.) is described as a method of detecting and quantifying the presence of a DNA sequence and is fully understood in the instructions provided by the manufacturer. Briefly, a FRET oligonucleotide probe is designed which overlaps the flanking and insert DNA junction. The FRET probe and PCR primers (one primer in the insert DNA sequence and one in the flanking genomic sequence) are cycled in the presence of a thermostable polymerase and dNTPs. Hybridization of the FRET probe results in cleavage and release of the fluorescent moiety away from the quenching moiety on the FRET probe. A fluorescent signal indicates the presence of the flanking/transgene insert sequence due to successful amplification and hybridization.

Molecular beacons have been described for use in sequence detection as described in Tyangi et al. (1996) *Nature Biotech.* 14:303-308. Briefly, a FRET oligonucleotide probe is designed that overlaps the flanking and insert DNA junction. The unique structure of the FRET probe results in it containing secondary structure that keeps the fluorescent and

quenching moieties in close proximity. The FRET probe and PCR primers (one primer in the insert DNA sequence and one in the flanking sequence) are cycled in the presence of a thermostable polymerase and dNTPs. Following successful PCR amplification, hybridization of the FRET probe to the target sequence results in the removal of the probe secondary structure and spatial separation of the fluorescent and quenching moieties. A fluorescent signal results. A fluorescent signal indicates the presence of the flanking/transgene insert sequence due to successful amplification and hybridization.

A hybridization reaction using a probe specific to a sequence found within the amplicon is yet another method used to detect the amplicon produced by a PCR reaction.

Maize event DP-004114-3 is effective against insect pests including insects selected from the orders Coleoptera, Diptera, Hymenoptera, Lepidoptera, Mallophaga, Homoptera, Hemiptera, Orthoptera, Thysanoptera, Dermaptera, Isoptera, Anoplura, Siphonaptera, Trichoptera, etc., particularly Coleoptera and Lepidoptera.

Insects of the order Lepidoptera include, but are not limited to, armyworms, cutworms, loopers, and heliothines in the family Noctuidae: *Agrotis ipsilon* Hufnagel (black cutworm); *A. orthogonia* Morrison (western cutworm); *A. segetum* Denis & Schiffmüller (turnip moth); *A. subterranea* Fabricius (granulate cutworm); *Alabama argillacea* Hübner (cotton leaf worm); *Anticarsia gemmatilis* Hübner (velvetbean caterpillar); *Aethis mindara* Barnes and McDunnough (rough skinned cutworm); *Earias insulana* Boisduval (spiny bollworm); *E. vittella* Fabricius (spotted bollworm); *Egira* (*Xylomyges*) *curialis* Grote (citrus cutworm); *Euxoa messoria* Harris (darksided cutworm); *Helicoverpa armigera* Hübner (American bollworm); *H. zea* Boddie (corn earworm or cotton bollworm); *Heliothis virescens* Fabricius (tobacco budworm); *Hypena scabra* Fabricius (green cloverworm); *Hyponeuma taltula* Schaus; (*Mamestra configurata* Walker (bertha armyworm); *M. brassicae* Linnaeus (cabbage moth); *Melanchra picta* Harris (zebra caterpillar); *Mocis latipes* Guenée (small mocis moth); *Pseudaletia unipuncta* Haworth (armyworm); *Pseudoplusia includens* Walker (soybean looper); *Richia albicosta* Smith (Western bean cutworm); *Spodoptera frugiperda* J E Smith (fall armyworm); *S. exigua* Hübner (beet armyworm); *S. litura* Fabricius (tobacco cutworm, cluster caterpillar); *Trichoplusia ni* Hübner (cabbage looper); borers, casebearers, webworms, coneworms, and skeletonizers from the families Pyralidae and Crambidae such as *Achroia grisella* Fabricius (lesser wax moth); *Amyelois transitella* Walker (naval orangeworm); *Anagasta kuehniella* Zeller (Mediterranean flour moth); *Cadra cautella* Walker (almond moth); *Chilo partellus* Swinhoe (spotted stalk borer); *C. suppressalis* Walker (striped stem/rice borer); *C. terrenellus* Pagenstecher (sugarcane stem borer); *Corcyra cephalonica* Stainton (rice moth); *Crambus caliginosellus* Clemens (corn root webworm); *C. teterrellus* Zincken (bluegrass webworm); *Cnaphalocrocis medinalis* Guenée (rice leaf roller); *Desmia funeralis* Hübner (grape leaf folder); *Diaphania hyalinata* Linnaeus (melon worm); *D. nitidalis* Stoll (pickleworm); *Diatraea flavipennella* Box; *D. grandiosella* Dyar (southwestern corn borer); *D. saccharalis* Fabricius (sugarcane borer); *Elasmopalpus lignosellus* Zeller (lesser cornstalk borer); *Eoreuma loftini* Dyar (Mexican rice borer); *Ephestia elutella* Hübner (tobacco (cacao) moth); *Galleria mellonella* Linnaeus (greater wax moth); *Hedylepta accepta* Butler (sugarcane leafroller); *Herpetogramma licarsialis* Walker (sod webworm); *Homoeosoma electellum* Hulst (sunflower moth); *Loxostege sticticalis* Linnaeus (beet webworm); *Maruca testulalis* Geyer (bean pod borer); *Orthaga thyrsalis* Walker (tea tree web moth); *Ostrinia nubi-*

lalis Hübner (European corn borer); *Plodia interpunctella* Hübner (Indian meal moth); *Scirpophaga incertulas* Walker (yellow stem borer); *Udea rubigalis* Guenée (celery leaf-tier); and leaf rollers, budworms, seed worms, and fruit worms in the family Tortricidae *Acleris gloverana* Walsingham (Western blackheaded budworm); *A. variana* Fernald (Eastern blackheaded budworm); *Adoxophyes orana* Fischer von Rösslerstamm (summer fruit tortrix moth); *Archips* spp. including *A. argyrospila* Walker (fruit tree leaf roller) and *A. rosana* Linnaeus (European leaf roller); *Argyrotaenia* spp.; *Bonagota salubricola* Meyrick (Brazilian apple leafroller); *Choristoneura* spp.; *Cochylis hospes* Walsingham (banded sunflower moth); *Cydia latiferreana* Walsingham (filbert-worm); *C. pomonella* Linnaeus (codling moth); *Endopiza viteana* Clemens (grape berry moth); *Eupoecilia ambiguella* Hübner (vine moth); *Grapholita molesta* Busck (oriental fruit moth); *Lobesia botrana* Denis & Schifferrmüller (European grape vine moth); *Platynota flavedana* Clemens (variegated leafroller); *P. stultana* Walsingham (omnivorous leafroller); *Spilonota ocellana* Denis & Schifferrmüller (eyespotted bud moth); and *Suleima helianthana* Riley (sunflower bud moth).

Selected other agronomic pests in the order Lepidoptera include, but are not limited to, *Alsophila pometaria* Harris (fall cankerworm); *Anarsia lineatella* Zeller (peach twig borer); *Anisota senatoria* J. E. Smith (orange striped oak-worm); *Antheraea pernyi* Guérin-Ménéville (Chinese Oak Silkworm); *Bombyx mori* Linnaeus (Silkworm); *Bucculatrix thurberiella* Busck (cotton leaf perforator); *Collas eurytheme* Boisduval (alfalfa caterpillar); *Datana integerrima* Grote & Robinson (walnut caterpillar); *Dendrolimus sibiricus* Tschetwerikov (Siberian silk moth); *Ennomos subsignaria* Hübner (elm spanworm); *Erannis tiliaria* Harris (linden looper); *Erechthias flavistriata* Walsingham (sugarcane bud moth); *Euproctis chrysorrhoea* Linnaeus (brown tail moth); *Harrisina americana* Guérin-Ménéville (grapeleaf skeletonizer); *Heliothis subflexa* Guenée; *Hemileuca oliviae* Cockrell (range caterpillar); *Hyphantria cunea* Drury (fall webworm); *Keiferia lycopersicella* Walsingham (tomato pinworm); *Lambdina fiscellaria fiscellaria* Hulst (Eastern hemlock looper); *L. fiscellaria lugubrosa* Hulst (Western hemlock looper); *Leucoma salicis* Linnaeus (satin moth); *Lymantria dispar* Linnaeus (gypsy moth); *Malacosoma* spp.; *Manduca quinquemaculata* Haworth (five spotted hawk moth, tomato hornworm); *M. sexta* Haworth (tomato hornworm, tobacco hornworm); *Operophtera brumata* Linnaeus (winter moth); *Orgyia* spp.; *Paleacrita vernata* Peck (spring cankerworm); *Papilio cresphontes* Cramer (giant swallowtail, orange dog); *Phryganidia californica* Packard (California oakworm); *Phyllocnistis citrella* Stainton (citrus leafminer); *Phyllonorycter blancardella* Fabricius (spotted tentiform leafminer); *Pieris brassicae* Linnaeus (large white butterfly); *P. rapae* Linnaeus (small white butterfly); *P. napi* Linnaeus (green veined white butterfly); *Platyptilia carduidactyla* Riley (artichoke plume moth); *Plutella xylostella* Linnaeus (diamond-back moth); *Pectinophora gossypiella* Saunders (pink bollworm); *Pontia protodice* Boisduval & Leconte (Southern cabbageworm); *Sabulodes aegrotata* Guenée (omnivorous looper); *Schizura concinna* J. E. Smith (red humped caterpillar); *Sitotroga cerealella* Olivier (Angoumois grain moth); *Telchin licus* Drury (giant sugarcane borer); *Thaumetopoea pityocampa* Schifferrmüller (pine processionary caterpillar); *Tineola bisselliella* Hummel (webbing clothesmoth); *Tuta absoluta* Meyrick (tomato leafminer) and *Yponomeuta padella* Linnaeus (ermine moth).

Of interest are larvae and adults of the order Coleoptera including weevils from the families Anthribidae, Bruchidae, and Curculionidae including, but not limited to: *Anthonomus*

grandis Boheman (boll weevil); *Cylindrocopturus adspersus* LeConte (sunflower stem weevil); *Diaprepes abbreviatus* Linnaeus (Diaprepes root weevil); *Hypera punctata* Fabricius (clover leaf weevil); *Lissorhoptrus oryzophilus* Kuschel (rice water weevil); *Metamasius hemipterus hemipterus* Linnaeus (West Indian cane weevil); *M. hemipterus sericeus* Olivier (silky cane weevil); *Sitophilus granarius* Linnaeus (granary weevil); *S. oryzae* Linnaeus (rice weevil); *Smicronyx fulvus* LeConte (red sunflower seed weevil); *S. sordidus* LeConte (gray sunflower seed weevil); *Sphenophorus maidis* Chittenden (maize billbug); *S. livis* Vaurie (sugarcane weevil); *Rhabdoscelus obscurus* Boisduval (New Guinea sugarcane weevil); flea beetles, cucumber beetles, rootworms, leaf beetles, potato beetles, and leafminers in the family Chrysomelidae including, but not limited to: *Chaetocnema ectypa* Horn (desert corn flea beetle); *C. pulicaria* Melsheimer (corn flea beetle); *Colaspis brunnea* Fabricius (grape colaspis); *Diabrotica barberi* Smith & Lawrence (northern corn rootworm); *D. undecimpunctata howardi* Barber (southern corn rootworm); *D. virgifera virgifera* LeConte (western corn rootworm); *Leptinotarsa decemlineata* Say (Colorado potato beetle); *Oulema melanopus* Linnaeus (cereal leaf beetle); *Phyllotreta cruciferae* Goeze (corn flea beetle); *Zygogramma exclamationis* Fabricius (sunflower beetle); beetles from the family Coccinellidae including, but not limited to: *Epilachna varivestis* Mulsant (Mexican bean beetle); chafers and other beetles from the family Scarabaeidae including, but not limited to: *Antitrogon parvulus* Britton (Childers cane grub); *Cyclocephala borealis* Arrow (northern masked chafer, white grub); *C. immaculata* Olivier (southern masked chafer, white grub); *Dermolepida albhirtum* Waterhouse (Greyback cane beetle); *Euethela humilis* rugiceps LeConte (sugarcane beetle); *Lepidiota frenchi* Blackburn (French's cane grub); *Tomarus gibbosus* De Geer (carrot beetle); *T. subtropicus* Blatchley (sugarcane grub); *Phyllophaga crinita* Burmeister (white grub); *P. latifrons* LeConte (June beetle); *Popillia japonica* Newman (Japanese beetle); *Rhizotrogus majalis* Razoumowsky (European chafer); carpet beetles from the family Dermestidae; wireworms from the family Elateridae; *Eleodes* spp.; *Melanotus* spp. including *M. communis* Gyllenhal (wireworm); *Conoderus* spp.; *Limonium* spp.; *Agriotes* spp.; *Ctenicera* spp.; *Aeolus* spp.; bark beetles from the family Scolytidae; beetles from the family Tenebrionidae; beetles from the family Cerambycidae such as, but not limited to, *Migdolus fryanus* Westwood (longhorn beetle); and beetles from the Buprestidae family including, but not limited to, *Aphanisticus cochinchinae seminulum* Obenberger (leaf-mining buprestid beetle).

Adults and immatures of the order Diptera are of interest, including leafminers *Agromyza parvicornis* Loew (corn blotch leafminer); midges including, but not limited to: *Contarinia sorghicola* Coquillett (sorghum midge); *Mayetiola destructor* Say (Hessian fly); *Neolasioptera murtfeldtiana* Felt, (sunflower seed midge); *Sitodiplosis mosellana* Géhin (wheat midge); fruit flies (Tephritidae), *Oscinella frit* Linnaeus (frit flies); maggots including, but not limited to: *Delia* spp. including *Delia platura* Meigen (seedcorn maggot); *D. coarctata* Fallen (wheat bulb fly); *Fannia canicularis* Linnaeus, *F. femoralis* Stein (lesser house flies); *Meromyza americana* Fitch (wheat stem maggot); *Musca domestica* Linnaeus (house flies); *Stomoxys calcitrans* Linnaeus (stable flies); face flies, horn flies, blow flies, *Chrysomya* spp.; *Phormia* spp.; and other muscoid fly pests, horse flies *Tabanus* spp.; bot flies *Gastrophilus* spp.; *Oestrus* spp.; cattle grubs *Hypoderma* spp.; deer flies *Chrysops* spp.; *Melophagus ovinus* Linnaeus (keds); and other *Brachycera*, mosquitoes

Aedes spp.; *Anopheles* spp.; *Culex* spp.; black flies *Prosimulium* spp.; *Simulium* spp.; biting midges, sand flies, sciarids, and other *Nematocera*.

Included as insects of interest are those of the order Hemiptera such as, but not limited to, the following families: Adelgidae, Aleyrodidae, Aphididae, Asterolecaniidae, Cercopidae, Cicadellidae, Cicadidae, Cixiidae, Coccidae, Coreidae, Dactylopiidae, Delphacidae, Diaspididae, Eriococcidae, Flatidae, Fulgoridae, Issidae, Lygaeidae, Margarodidae, Membracidae, Miridae, Orthetziidae, Pentatomidae, Phoenicococcidae, Phylloxeridae, Pseudococcidae, Psyllidae, Pyrrhocoridae and Tingidae.

Agronomically important members from the order Hemiptera include, but are not limited to: *Acrosternum hilare* Say (green stink bug); *Acyrtosiphon pisum* Harris (pea aphid); *Adelges* spp. (adelgids); *Adelphocoris rapidus* Say (rapid plant bug); *Anasa tristis* De Geer (squash bug); *Aphis craccivora* Koch (cowpea aphid); *A. fabae* Scopoli (black bean aphid); *A. gossypii* Glover (cotton aphid, melon aphid); *A. maidiradicis* Forbes (corn root aphid); *A. pomi* De Geer (apple aphid); *A. spiraeicola* Patch (spirea aphid); *Aulacaspis tegalensis* Zehntner (sugarcane scale); *Aulacorthum solani* Kaltentbach (foxglove aphid); *Bemisia tabaci* Gennadius (tobacco whitefly, sweetpotato whitefly); *B. argentifolii* Bellows & Perring (silverleaf whitefly); *Blissus leucopterus leucopterus* Say (chinch bug); *Blostomatidae* spp.; *Brevicoryne brassicae* Linnaeus (cabbage aphid); *Cacopsylla pyricola* Foerster (pear psylla); *Calocoris norvegicus* Gmelin (potato capsid bug); *Chaetosiphon fragaefolii* Cockerell (strawberry aphid); *Cimicidae* spp.; *Coreidae* spp.; *Corythuca gossypii* Fabricius (cotton lace bug); *Cyrtopeltis modesta* Distant (tomato bug); *C. notatus* Distant (suckfly); *Deois flavopicta* Stål (spittlebug); *Dialeurodes citri* Ashmead (citrus whitefly); *Diaphnocoris chlorionis* Say (honeysuckle plant bug); *Diuraphis noxia* Kurdjumov/Mordvilko (Russian wheat aphid); *Duplachionaspis divergens* Green (armored scale); *Dysaphis plantaginea* Paaserini (rosy apple aphid); *Dysdercus suturalis* Herrich-Schäffer (cotton stainer); *Dysmicoccus boninsis* Kuwana (gray sugarcane mealybug); *Empoasca fabae* Harris (potato leafhopper); *Eriosoma lanigerum* Hausmann (woolly apple aphid); *Erythroneura* spp. (grape leafhoppers); *Eumetopina flavipes* Muir (Island sugarcane planthopper); *Eurygaster* spp.; *Euschistus servus* Say (brown stink bug); *E. variolarius* Palisot de Beauvois (one-spotted stink bug); *Graptostethus* spp. (complex of seed bugs); and *Hyalopteris pruni* Geoffroy (mealy plum aphid); *Icerya purchasi* Maskell (cottony cushion scale); *Labopidicola allii* Knight (onion plant bug); *Laodelphax striatellus* Fallen (smaller brown planthopper); *Leptoglossus corculis* Say (leaf-footed pine seed bug); *Leptodictya tabida* Herrich-Schaeffer (sugarcane lace bug); *Lipaphis erysimi* Kaltentbach (turnip aphid); *Lygocoris pabulinus* Linnaeus (common green capsid); *Lygus lineolaris* Palisot de Beauvois (tarnished plant bug); *L. hesperus* Knight (Western tarnished plant bug); *L. pratensis* Linnaeus (common meadow bug); *L. rugulipennis* Poppius (European tarnished plant bug); *Macrosiphum euphorbiae* Thomas (potato aphid); *Macrosteles quadrilineatus* Forbes (aster leafhopper); *Magicalcada septendecim* Linnaeus (periodical cicada); *Mahanarva fimbriolata* Stål (sugarcane spittlebug); *M. posticata* Stål (little cicada of sugarcane); *Melanaphis sacchari* Zehntner (sugarcane aphid); *Melanaspis glomerata* Green (black scale); *Metopolophium dirhodum* Walker (rose grain aphid); *Myzus persicae* Sulzer (peach-potato aphid, green peach aphid); *Nasonovia ribisnigri* Mosley (lettuce aphid); *Nephotettix cincticeps* Uhler (green leafhopper); *N. nigropictus* Stål (rice leafhopper); *Nezara viridula* Linnaeus (southern green stink bug); *Nilaparvata lugens* Stål (brown

planthopper); *Nysius ericae* Schilling (false chinch bug); *Nysius raphanus* Howard (false chinch bug); *Oebalus pugnax* Fabricius (rice stink bug); *Oncopeltus fasciatus* Dallas (large milkweed bug); *Orthops campestris* Linnaeus; *Pemphigus* spp. (root aphids and gall aphids); *Peregrinus maidis* Ashmead (corn planthopper); *Perkinsiella saccharicida* Kirkaldy (sugarcane delphacid); *Phylloxera devastatrix* Pergande (pecan phylloxera); *Planococcus citri* Risso (citrus mealybug); *Plesiocoris rugicollis* Fallen (apple capsid); *Poecilocapsus lineatus* Fabricius (four-lined plant bug); *Pseudatomoscelis seriatus* Reuter (cotton fleahopper); *Pseudococcus* spp. (other mealybug complex); *Pulvinaria elongata* Newstead (cottony grass scale); *Pyrilla perpusilla* Walker (sugarcane leafhopper); *Pyrrhocoridae* spp.; *Quadraspidiotus perniciosus* Comstock (San Jose scale); *Reduviidae* spp.; *Rhopalosiphum maidis* Fitch (corn leaf aphid); *R. padi* Linnaeus (bird cherry-oat aphid); *Saccharicoccus sacchari* Cockerell (pink sugarcane mealybug); *Scaptocoris castanea* Perty (brown root stink bug); *Schizaphis graminum* Rondani (greenbug); *Sipha flava* Forbes (yellow sugarcane aphid); *Sitobion avenae* Fabricius (English grain aphid); *Sogatella furcifera* Horvath (white-backed planthopper); *Sogatodes oryzicola* Muir (rice delphacid); *Spanagonicus albobasatus* Reuter (whitemarked fleahopper); *Therioaphis maculata* Buckton (spotted alfalfa aphid); *Tinidae* spp.; *Toxoptera aurantii* Boyer de Fonscolombe (black citrus aphid); and *T. citricida* Kirkaldy (brown citrus aphid); *Trialeurodes abutiloneus* (bandedwinged whitefly) and *T. vaporariorum* Westwood (greenhouse whitefly); *Trioza diospyri* Ashmead (persimmon psylla); and *Typhlocyba pomaria* McAtee (white apple leafhopper).

Also included are adults and larvae of the order Acari (mites) such as *Aceria tosichella* Keifer (wheat curl mite); *Panonychus ulmi* Koch (European red mite); *Petrobia latens* Willer (brown wheat mite); *Steneotarsonemus bancrofti* Michael (sugarcane stalk mite); spider mites and red mites in the family Tetranychidae, *Oligonychus grypus* Baker & Pritchard, *O. indicus* Hirst (sugarcane leaf mite), *O. pratensis* Banks (Banks grass mite), *O. stickneyi* McGregor (sugarcane spider mite); *Tetranychus urticae* Koch (two spotted spider mite); *T. mcdanieli* McGregor (McDaniel mite); *T. cinnabarinus* Boissduval (carmine spider mite); *T. turkestanii* Ugarov & Nikolski (strawberry spider mite), flat mites in the family Tenuipalpidae, *Brevipalpus lewisi* McGregor (citrus flat mite); rust and bud mites in the family Eriophyidae and other foliar feeding mites and mites important in human and animal health, i.e. dust mites in the family Epidermoptidae, follicle mites in the family Demodicidae, grain mites in the family Glycyphagidae, ticks in the order Ixodidae, *Ixodes scapularis* Say (deer tick); *I. holocyclus* Neumann (Australian paralysis tick); *Dermacentor variabilis* Say (American dog tick); *Amblyomma americanum* Linnaeus (lone star tick); and scab and itch mites in the families Psoroptidae, Pyemotidae, and Sarcoptidae.

Insect pests of the order Thysanura are of interest, such as *Lepisma saccharina* Linnaeus (silverfish); *Thermobia domestica* Packard (firebrat).

Additional arthropod pests covered include: spiders in the order Araneae such as *Loxosceles reclusa* Gertsch & Mulaik (brown recluse spider); and the *Latrodectus mactans* Fabricius (black widow spider); and centipedes in the order Scutigeraomorpha such as *Scutigera coleoptrata* Linnaeus (house centipede). In addition, insect pests of the order Isoptera are of interest, including those of the termitidae family, such as, but not limited to, *Cornitermes cumulans* Kollar, *Cylindrotermes nordenskiöldi* Holmgren and *Pseudacanthotermes militaris* Hagen (sugarcane termite); as well as those in the

Rhinotermitidae family including, but not limited to *Heterotermes tenuis* Hagen. Insects of the order Thysanoptera are also of interest, including but not limited to thrips, such as *Stenchaetothrips minutus* van Deventer (sugarcane thrips).

Embodiments of the present invention are further defined in the following Examples. It should be understood that these Examples are given by way of illustration only. From the above discussion and these Examples, one skilled in the art can ascertain the essential characteristics of this invention, and without departing from the spirit and scope thereof, can make various changes and modifications of the embodiments of the invention to adapt it to various usages and conditions. Thus, various modifications of the embodiments of the invention, in addition to those shown and described herein, will be apparent to those skilled in the art from the foregoing description. Such modifications are also intended to fall within the scope of the appended claims.

The disclosure of each reference set forth herein is incorporated herein by reference in its entirety.

EXAMPLES

Example 1

Transformation of Maize by *Agrobacterium* Transformation and Regeneration of Transgenic Plants Containing the Cry1F, Cry34Ab1, Cry35Ab1 (Cry34/35Ab1) and Pat Genes

4114 maize was produced by *Agrobacterium*-mediated transformation with plasmid PHP27118. This event contains the cry1F, cry34Ab1, cry35Ab1, and pat gene cassettes, which confer resistance to certain lepidopteran and coleopteran pests.

Specifically, the first cassette contains a truncated version of the cry1F gene from Bt var. *aizawai*. The insertion of the cry1F gene confers resistance to damage by lepidopteran pests, including ECB and FAW. The Cry1F protein (SEQ ID NO: 1) is comprised of 605 amino acids and has a molecular weight of approximately 68 kDa. The expression of the cry1F gene is controlled by the maize polyubiquitin promoter (Christensen et al., 1992, supra), providing constitutive

expression of Cry1F protein in maize. This region also includes the 5' UTR and intron associated with the native polyubiquitin promoter. The terminator for the cry1F gene is the poly(A) addition signal from open reading frame 25 (ORF 25) of the *Agrobacterium tumefaciens* (*A. tumefaciens*) Ti plasmid pTi15955 (Barker et al., 1983, supra).

The second cassette contains the cry34Ab1 gene isolated from Bt strain PS149B1 (U.S. Pat. Nos. 6,127,180; 6,624,145 and 6,340,593). The Cry34Ab1 protein (SEQ ID NO: 2) is 123 amino acid residues in length and has a molecular weight of approximately 14 kDa. The expression of the cry34Ab1 gene is controlled by a second copy of the maize polyubiquitin promoter with 5' UTR and intron (Christensen et al., 1992, supra). The terminator for the cry34Ab1 gene is the pinII terminator (Keil et al., 1986, supra; An et al., 1989, supra).

The third gene cassette contains the cry35Ab1 gene, also isolated from Bt strain PS149B1 (U.S. Pat. Nos. 6,083,499; 6,548,291 and 6,340,593). The Cry35Ab1 protein (SEQ ID NO: 3) has a length of 383 amino acids and a molecular weight of approximately 44 kDa. Simultaneous expression of the Cry34Ab1 and Cry35Ab1 proteins in the plant confers resistance to coleopteran insects, including WCRW. The expression of the cry35Ab1 gene is controlled by the *Triticum aestivum* (wheat) peroxidase promoter and leader sequence (Hertig et al. 1991, supra). The terminator for the cry35Ab1 gene is a second copy of the pinII terminator (Keil et al. 1986, supra; An et al. 1989, supra).

The fourth and final gene cassette contains a version of pat from *Streptomyces viridochromogenes* that has been optimized for expression in maize. The pat gene expresses PAT, which confers tolerance to phosphinothricin (glufosinate-ammonium). The PAT protein (SEQ ID NO: 4) is 183 amino acids residues in length and has a molecular weight of approximately 21 kDa. Expression of the pat gene is controlled by the promoter and terminator regions from the CaMV 35S transcript (Franck et al., 1980, supra; Odell et al., 1985, supra; Pietrzak, et al., 1986, supra). Plants containing the DNA constructs are also provided. A description of the genetic elements in the PHP27118 T-DNA (set forth in SEQ ID NO: 5) and their sources are described further in Table 1.

TABLE 1

Genetic Elements in the T-DNA Region of Plasmid PHP27118			
Location on T-DNA (bp position)	Genetic Element	Size (bp)	Description
1 to 25	Right Border	25	T-DNA RB region from Ti plasmid of <i>A. tumefaciens</i>
26 to 76	Ti Plasmid Region	51	Non-functional sequence from Ti plasmid of <i>A. tumefaciens</i>
77 to 114	Polylinker Region	38	Region required for cloning genetic elements
115 to 1014	ubiZM1 Promoter	900	Promoter region from <i>Zea mays</i> polyubiquitin gene (Christensen et al., 1992, supra)
1015 to 1097	ubiZM1 5' UTR	83	5' UTR from <i>Zea mays</i> polyubiquitin gene. Id.
1098 to 2107	ubiZM1 Intron	1010	Intron region from <i>Zea mays</i> polyubiquitin gene. Id.
2108 to 2129	Polylinker Region	22	Region required for cloning genetic elements
2130 to 3947	cry1F Gene	1818	Truncated version of cry1F from Bt var. <i>aizawai</i>
3948 to 3992	Polylinker Region	45	Region required for cloning genetic elements
3993 to 4706	ORF 25 Terminator	714	Terminator sequence from <i>A. tumefaciens</i> pTi15955 ORF 25 (Barker et al., 1983, supra)
4707 to 4765	Polylinker Region	59	Region required for cloning genetic elements

TABLE 1-continued

Genetic Elements in the T-DNA Region of Plasmid PHP27118			
Location on T-DNA (bp position)	Genetic Element	Size (bp)	Description
4766 to 5665	ubiZM1 Promoter	900	Promoter region from <i>Zea mays</i> polyubiquitin gene (Christensen et al., 1992, supra)
5666 to 5748	ubiZM1 5' UTR	83	5' UTR from <i>Zea mays</i> polyubiquitin gene. Id.
5749 to 6758	ubiZM1 Intron	1010	Intron region from <i>Zea mays</i> polyubiquitin gene. Id.
6759 to 6786	Polylinker Region	28	Region required for cloning genetic elements
6787 to 7158	cry34Ab1 Gene	372	Synthetic version of cry34Ab1 encoding 14 kDa delta-endotoxin parasporal crystal protein from the nonmotile strain PS149B1 of Bt (Moellenbeck et al. (2001) Nature Biotech. 19: 668-672; Ellis et al. (2002) Appl. Env. Microbiol. 68(3): 1137-1145; Herman et al. (2002) Environ. Entomol. 31(2): 208-214.)
7159 to 7182	Polylinker Region	24	Region required for cloning genetic elements
7183 to 7492	pinII Terminator	310	Terminator region from <i>Solanum tuberosum</i> proteinase inhibitor II gene (Keil et al. 1986, supra; An et al. 1989, supra)
7493 to 7522	Polylinker Region	30	Region required for cloning genetic elements
7523 to 8820	TA Peroxidase Promoter	1298	Promoter from <i>Triticum aestivum</i> peroxidase including leader sequence (Hertig et al. 1991, supra)
8821 to 8836	Polylinker Region	16	Region required for cloning genetic elements
8837 to 9988	cry35Ab1	1152	Synthetic version of cry35Ab1 encoding a 44 kDa delta-endotoxin parasporal crystal protein from the nonmotile strain PS149B1 of Bt (Moellenbeck et al. 2001, supra; Ellis et al. 2002, supra; Herman et al. 2002, supra)
9989 to 10012	Polylinker Region	24	Region required for cloning genetic elements
10013 to 10322	pinII Terminator	310	Terminator region from <i>Solanum tuberosum</i> proteinase inhibitor II gene (Keil et al. 1986, supra; An et al. 1989, supra)
10323 to 10367	Polylinker Region	45	Region required for cloning genetic elements
10368 to 10897	CaMV 35S Promoter	530	35S promoter from CaMV (Franck et al., 1980, supra; Odell et al., 1985, supra; Pietrzak, et al., 1986, supra)
10898 to 10916	Polylinker Region	19	Region required for cloning genetic elements
10917 to 11468	pat Gene	552	Synthetic, plant-optimized phosphinothricin acetyltransferase coding sequence from <i>Streptomyces viridochromogenes</i> .
11469 to 11488	Polylinker Region	20	Region required for cloning genetic elements
11489 to 11680	CaMV35S Terminator	192	35S terminator from CaMV (Franck et al., 1980, supra; Pietrzak, et al., 1986, supra)
11681 to 11756	Polylinker Region	76	Region required for cloning genetic elements
11757 to 11953	Ti Plasmid Region	197	Non-functional sequence from Ti plasmid of <i>A. tumefaciens</i>
11954 to 11978	Left Border	25	T-DNA LB region from Ti plasmid of <i>A. tumefaciens</i>

Immature embryos of maize (*Zea mays* L.) were aseptically removed from the developing caryopsis nine to eleven days after pollination and inoculated with *A. tumefaciens* strain LBA4404 containing plasmid PHP27118 (FIG. 1), essentially as described in Zhao (U.S. Pat. No. 5,981,840, the contents of which are hereby incorporated by reference). The T-DNA region of PHP27118 is shown in FIG. 2. After three to six days of embryo and *Agrobacterium* co-cultivation on solid culture medium with no selection, the embryos were then transferred to a medium without herbicide selection but containing carbenicillin. After three to five days on this medium, embryos were then transferred to selective medium that was stimulatory to maize somatic embryogenesis and contained bialaphos for selection of cells expressing the pat transgene.

The medium also contained carbenicillin to kill any remaining *Agrobacterium*. After six to eight weeks on the selective medium, healthy, growing calli that demonstrated resistance to bialaphos were identified. The putative transgenic calli were subsequently regenerated to produce T0 plantlets.

Samples were taken from the T0 plantlets for PCR analysis to verify the presence and copy number of the inserted cry1F, cry35Ab1, cry34Ab1, and/or pat genes. Maize event DP-004114-3 was confirmed to contain a single copy of the T-DNA (See Examples 2 and 3). In addition to this analysis, the T0 plantlets were analyzed for the presence of certain *Agrobacterium* binary vector backbone sequences by PCR (data not shown). Plants that were determined to be single copy for the inserted genes and negative for *Agrobacterium*

27

backbone sequences were selected for further greenhouse propagation. These selected T0 plants were screened for trait efficacy and protein expression by conducting numerous bioassays (See Example 5). The T0 plants meeting all criteria were advanced and crossed to inbred lines to produce seed for further testing. A schematic overview of the transformation and event development is presented in FIG. 3.

Example 2

Identification of Maize Event DP-004114-3

Genomic DNA from leaf tissue of test seed from 4114 maize and a control substance (seed from a non-genetically modified maize with a genetic background representative of the event background) was isolated and subjected to qualitative PCR amplification using a construct-specific primer pair. The PCR products were separated on an agarose gel to confirm the presence of the inserted construct in the genomic DNA isolated from the test seed, and the absence of the inserted construct in the genomic DNA isolated from the control seed. A reference standard (Low DNA Mass Ladder; Invitrogen Corporation Catalog #10380-012) was used to determine the PCR product size. The reliability of the construct-specific PCR method was assessed by repeating the experiment three times. The sensitivity of the PCR amplification was evaluated by various dilutions of the genomic DNA from 4114 maize.

Test and control leaf samples (V5-V7 leaf stage) were harvested from plants grown at the DuPont Experimental Station (Wilmington, Del.) from seed obtained from Pioneer Hi-Bred (Johnston, Iowa). Genomic DNA extractions from the test and control leaf tissues were performed using a standard urea extraction protocol.

Genomic DNA was quantified using the NanoDrop 1000 Spectrophotometer using ND-1000 V3.6 Software (Thermo-Scientific, Wilmington, Del.) and the Quant-iT PicoGreen® reagent (Invitrogen, Carlsbad, Calif.). DNA samples were visualized on an agarose gel to confirm quantitation values and to determine the DNA quality.

Genomic DNA samples isolated from leaf tissue of 4114 maize and control samples were subjected to PCR amplification (Roche High Fidelity PCR Master Kit, Roche Catalog #12140314001) utilizing a construct-specific primer pair (SEQ ID NOs: 7 and 8) which spans the maize ORF 25 terminator and the ubiquitin promoter (See FIG. 2), and allows for the unique identification of the inserted T-DNA in 4114 maize. A second primer set (SEQ ID NOs: 9 and 10) was used to amplify the endogenous maize invertase gene (GenBank accession number AF171874.1) as a positive control for PCR amplification. The PCR target site and size of the expected PCR product for each primer set are shown in Table 2. PCR reagents and reaction conditions are shown in Table 3. In this study, 50 ng of leaf genomic DNA was used in all PCR reactions.

TABLE 2

PCR Genomic DNA Target Site and Expected Size of PCR Products		
Primer Set	Target Site	Expected Size of PCR Product (bp)
SEQ ID NO: 7 & 8	Construct Specific T-DNA: ORF 25 terminator and ubiquitin promoter	287
SEQ ID NO: 9 & 10	Endogenous maize invertase gene	225

28

TABLE 3

PCR Reagents and Reaction Conditions					
PCR Reagents		PCR Reaction Conditions			
Reagent	Volume (μL)	Cycle Element	Temp (° C.)	Time (sec)	# Cycles
Template DNA (25 ng/μL)	2	Initial Denaturation	94	120	1
Primer 1 (10 μM)	2	Denaturation	94	10	35
Primer 2 (10 μM)	2	Annealing	65	15	
PCR Master Mix*	25	Elongation	68	60	1
ddH ₂ O	19	Final Elongation	68	420	
—	—	Hold Cycle	4	Until analysis	—

ddH₂O: double-distilled water

*Roche High Fidelity Master Mix

A PCR product of approximately 300 bp in size amplified by the construct-specific primer set (SEQ ID NOs: 7 and 8) was observed in PCR reactions using plasmid PHP27118 (10 ng) as a template and all 4114 maize DNA samples, but absent in all control maize samples and the no-template control. This experiment was repeated three times, and similar results were obtained. Results observed for DNA extracts from five 4114 maize plants and five control maize plants corresponded closely with the expected PCR product size (287 bp) for samples containing 4114 maize genomic DNA. A PCR product approximately 220 bp in size was observed for both 4114 maize and control maize samples following PCR reaction with the primer set (SEQ ID NOs: 9 and 10) for detection of the endogenous maize invertase gene. These results corresponded closely with the expected PCR product size (225 bp) for genomic DNA samples containing the maize endogenous invertase gene. The endogenous target band was not observed in the no-template control.

In order to assess the sensitivity of the PCR amplification, various concentrations of a single DNA sample from 4114 maize were diluted in non-genetically modified control DNA, resulting in 4114 maize DNA amounts ranging from 500 fg, 5 pg, 10 pg, 50 pg, 100 pg, 500 pg, 5 ng, and 50 ng (the total amount of genomic DNA in all PCR samples was 50 ng). Each dilution was subjected to PCR amplification as previously conducted. Based on this analysis, the limit of detection (LOD) was determined to be approximately 100 pg of 4114 maize DNA in 50 ng of total DNA, or 0.2% 4114 maize DNA.

In conclusion, qualitative PCR analysis utilizing a construct-specific primer set for 4114 maize confirmed that the test plants contained the inserted T-DNA from plasmid PHP27118, as evident by the presence of the construct-specific target band in all test plant samples analyzed, and the absence in the non-genetically modified control plants. This result was reproducible. Test and control plants both contained the endogenous maize invertase gene. The sensitivity of the analysis under the conditions described is approximately 100 pg of 4114 maize genomic DNA in 50 ng of total genomic DNA or 0.2% 4114 maize genomic DNA.

Example 3

Southern Blot Analysis of DP-004114-3 Maize for Integrity and Copy Number

Southern blot analysis was used to confirm the integrity and copy number of the inserted T-DNA from PHP27118 and to confirm the presence of the cry1F, cry34Ab1, cry35Ab1, and pat gene cassettes in 4114 maize.

Five individual plants from the T1 generation of 4114 maize were selected for Southern blot analysis. Young leaf material was harvested from the 4114 maize (test) and non-transgenic maize (control) plants and was immediately placed on dry ice. The frozen samples were lyophilized and genomic DNA was extracted from the test and control tissues using a CTAB extraction method.

Following restriction enzyme digestions as detailed below, the DNA fragments were separated on agarose gels, depurinated, denatured, and neutralized in situ, and transferred to a nylon membrane in 20×SSC buffer using the method as described for TURBOBLOTTER™ Rapid Downward Transfer System (Schleicher & Schuell). Following transfer to the membrane, the DNA was bound to the membrane by ultraviolet light crosslinking.

Integrity

The restriction enzyme Hind III was selected for Southern analysis of integrity, as there are three sites located within the T-DNA (FIG. 2). Approximately 1-3 µg of genomic DNA was digested with Hind III and separated by size on an agarose gel. As a positive control, approximately 15 pg of plasmid containing the PHP27118 T-DNA was spiked into a control plant DNA sample, digested and included on the agarose gel. A negative control was also included to verify background hybridization of the probe to the maize genome.

Four probes homologous to the cry1F, cry34Ab1, cry35Ab1, and pat genes on the PHP27118 T-DNA (for gene elements, see FIG. 2) were used for hybridization to confirm the presence of the genes. In order to develop the probes, fragments homologous to the cry1F, cry34Ab1, cry35Ab1, and pat genes were generated by PCR from plasmid containing the PHP27118 T-DNA, size separated on an agarose gel, and purified using a QIAquick® gel extraction kit (Qiagen). All DNA probes were subsequently generated from the fragments using the Rediprime™ II DNA Labeling System (Amersham) which performs random prime labeling with [³²P] dCTP.

The labeled probes were hybridized to the target DNA on the nylon membranes for detection of the specific fragments using the MiracleHyb® Hybridization Solution essentially as described by the manufacturer (Stratagene). Washes after hybridization were carried out at high stringency. Blots were exposed to X-ray film at -80° C. for one or more time points to detect hybridizing fragments.

Because the Hind III enzyme sites were known within the T-DNA, exact expected band sizes were determined for each of the probes (Table 4, FIG. 2). For an intact copy of the T-DNA, the cry1F probe was expected to hybridize to a fragment of 3891 bp. The cry34Ab1, cry35Ab1, and pat gene probes were expected to hybridize to a fragment of 7769 bp. Fragments from the test samples matching the expected sizes, as well as matching the bands in the plasmid control sample, would confirm the integrity of the inserted T-DNA and the presence of each gene.

The results of the Southern blot analysis with Hind III and the cry1F, cry34Ab1, cry35Ab1, and pat gene probes confirmed the expected fragment sizes and, thus, confirmed that the T-DNA inserted intact into each of the events and that each of the genes was present.

A band of approximately 4 kb was observed with the cry1F probe which is consistent with the expected fragment size. A similar fragment of approximately 4 kb was observed in the plasmid positive control lane, which was presumed to be the expected band of 3891 bp. Based on equivalent migration of the hybridizing band in the events to the band in the plasmid positive control, it was confirmed that the portion of the T-DNA containing cry1F had inserted intact in 4114 maize.

In the hybridization with the cry34Ab1 probe, a band of approximately 8 kb was observed in the event and also in the plasmid positive control. The hybridizing band in the plasmid positive control lane was presumed to be the expected band of 7769 bp. Because the hybridizing band in the event had migrated equivalently with this band, it was confirmed that this portion of the T-DNA containing cry34Ab1 was inserted intact.

Similarly, hybridizations with cry35Ab1 and pat hybridized to the same 7769 bp fragment in the plant and plasmid positive control as expected. These results confirmed that the portion of the T-DNA containing the cry35Ab1 and pat genes had inserted intact.

This Southern blot analysis confirms that 4114 maize contains an intact copy of the T-DNA from PHP27118 containing the cry1F, cry34Ab1, cry35Ab1, and pat genes.

TABLE 4

Summary of Expected and Observed Hybridization Fragments on Southern Blots for 4114 Maize DNA digested with Hind III

Probe	Expected Fragment Size from PHP27118 T-DNA (bp) ¹	Observed Fragment Size (kb) ²
cry1F	3891	~4
cry34Ab1	7769	~8
cry35Ab1	7769	~8
pat	7769	~8

¹Expected fragment sizes based on map of PHP27118 T-DNA (FIG. 2).

²All observed fragments migrated equivalently with the plasmid positive control and, therefore, were confirmed to represent the intact portion of the PHP27118 T-DNA.

Copy Number

The cry1F and pat probes were used in Southern blot hybridizations to evaluate the copy number of the insertions in 4114 maize.

The restriction enzyme Bcl I was selected for Southern analysis of copy number, as there is a single site located within the T-DNA (FIG. 2). Approximately 3 µg of genomic DNA from individual plants of the T1 generation of event 4114 was digested with Bcl I and separated by size on an agarose gel. A plasmid containing the PHP27118 T-DNA was spiked into a control plant DNA sample, digested and included on the agarose gel to serve as a positive hybridization control. Negative control maize DNA was also included to verify background hybridization of the probe to the maize genome. DNA Molecular Weight Marker VII, digoxigenin (DIG) labeled (Roche, Indianapolis, Ind.), was included on Bcl I blots as a size standard for hybridizing fragments.

Probes for the cry1F and pat genes were also labeled by a PCR reaction incorporating a digoxigenin (DIG) labeled nucleotide, [DIG-11]-dUTP, into the fragment. PCR labeling of isolated fragments was carried out according to the procedures supplied in the PCR DIG Probe Synthesis Kit (Roche).

The DIG-labeled probes were hybridized to the Bcl I Southern blots of the T1 generation of the 4114 event. Probes were hybridized to the target DNA for detection of the specific fragments using DIG Easy Hyb solution (Roche) essentially as described by manufacturer. Post-hybridization washes were carried out at high stringency. DIG-labeled probes hybridized to the bound fragments were detected using the CDP-Star Chemiluminescent Nucleic Acid Detection System (Roche). Blots were exposed to X-ray film at room temperature for one or more time points to detect

31

hybridizing fragments. Membranes were stripped of hybridized probe following the manufacturer's recommendation prior to hybridization with additional probes.

The restriction enzyme Bcl I, having a single restriction site within the T-DNA (FIG. 2), was selected to confirm the presence of a single PHP27118 T-DNA insertion in 4114 maize. The site for Bcl I is located at by 2546 of the T-DNA (FIG. 2) and will yield fragments of greater than about 2500 bp and 9400 bp for a single inserted T-DNA. Hybridization with the pat probe would indicate the number of copies of this element found in the event based on the number of hybridizing bands (e.g., one hybridizing band indicates one copy of the element). The pat probe would hybridize to the fragment of greater than 9400 bp. Because the Bcl I restriction enzyme site is within the cry1F gene, the cry1F probe is expected to hybridize to both fragments and result in two bands for a single T-DNA insertion (FIG. 2).

The results of the Southern blot analysis with Bcl I and the cry1F and pat gene probes for 4114 maize are summarized in Table 5.

TABLE 5

Summary of Expected and Observed Hybridization Fragments on Southern Blots for Bcl I digests of 4114 Maize			
Probe	Enzyme Digest	Expected Fragment Size from PHP27118 T-DNA (bp) ¹	Observed Fragment Size (kb) ²
cry1F	Bcl I	>2500 ³	~3.1
		>9400	>8.6
pat	Bcl I	>9400	>8.6

¹Expected fragment sizes based on map of PHP27118 T-DNA (FIG. 2).

²All observed fragment sizes are approximated based on the migration of the DIG VII molecular weight marker.

³Two fragments are expected with the cry1F probe due to the location of the Bcl I restriction site within the cry1F gene.

The results of the Southern blot analysis of 4114 maize with Bcl I digestion and the cry1F probe showed two bands as expected, one band of greater than 8.6 kb and a second band of approximately 3.1 kb. Two bands are expected for a single insertion due to the location of the Bcl I site within the cry1F gene, so these results indicate that there is a single copy of cry1F in 4114 maize. The results of the Southern blot analysis of 4114 maize with Bcl I digestion and the pat probe showed a single band of greater than 8.6 kb that matched the size of the larger cry1F band as expected. These results indicate that there is also a single insertion of the pat gene in maize event 4114.

As the cry34Ab1 and cry35Ab1 genes are located on the same fragment as the pat gene and part of the cry1F gene, and between the cry1F and pat genes on the T-DNA, by extension this also demonstrates that this event is likely to contain a single copy of each of these genes.

Example 4

Sequencing Characterization of Insert and Genomic Border Regions of Maize Event DP-004114-3

The sequence of the insert and genomic border regions was determined to confirm the integrity of the inserted DNA and to characterize the genomic sequence flanking the insertion site present in 4114 maize. In total, 16,752 bp of 4114 maize genomic sequence was confirmed, comprising 2,422 bp of the 5' genomic border sequence, 2,405 bp of the 3' genomic

32

border sequence, and 11,925 bp of inserted T-DNA from PHP27118. The inserted T-DNA in 4114 maize was found to have a 29 bp deletion on the Right Border (RB) end and a 24 bp deletion on the Left Border (LB) end. All remaining sequence is intact and identical to that of plasmid PHP27118. The 5' and 3' genomic border regions of 4114 maize were verified to be of maize origin by PCR amplification and sequencing of the genomic border regions from both 4114 maize and control maize plants.

Seed containing event DP-004114-3 was obtained from a T1S2 generation of 4114 maize. Control seed was obtained from a maize line that has a similar genetic background to 4114 maize but does not contain the cry1F, cry34Ab1, cry35Ab1, and pat gene cassettes. All seeds were obtained from Pioneer Hi-Bred International, Inc. (Johnston, Iowa). The Low DNA Mass Ladder (Invitrogen Corp., Carlsbad, Calif.) and the High DNA Mass Ladder (Invitrogen Corp.) were used for gel electrophoresis to estimate DNA fragment sizes on agarose gels.

The 4114 maize seed and the control seed were planted in growth chambers at the DuPont Experimental Station (Wilmington, Del.) to produce plant tissues used for this study. One seed was planted per pot, and the pot was uniquely identified. All plants were grown with light, temperature, and water regulated for healthy plant growth. Leaf samples were collected from the control and 4114 maize plants. For each individual plant, leaf material was collected in a pre-labeled bag, placed on dry ice, and then transferred to an ultra low freezer (<-55° C.) following collection. All samples were maintained frozen until tissue processing.

Genotype Confirmation Via Event-Specific PCR Analysis

A leaf sample was taken from all test and control plants for event-specific PCR analysis. DNA was extracted from each leaf sample using the Extract-N-Amp™ Plant PCR kit following the described procedure (Sigma-Aldrich, St. Louis, Mo.) for real-time PCR analysis.

Real-time PCR was performed on each DNA sample utilizing an ABI PRISM® 7500HT Sequence Detection System (Applied Biosystems, Inc., Foster City, Calif.). TaqMan® probe (Applied Biosystems, Inc.) and primer sets (Integrated DNA Technologies, Coralville, Iowa) were designed to detect a target sequence from 4114 maize. In addition, a second TaqMan® probe and primer set for a reference maize endogenous gene was used to confirm the presence of amplifiable DNA in each reaction. The analysis consisted of real-time PCR determination of qualitative positive/negative calls. The extracted DNA was assayed using TaqMan® Universal PCR Master Mix, No AmpErase® UNG (Applied Biosystems, Inc.).

Positive or negative determination for 4114 maize was based on comparison of the CT (threshold cycle) of the event-specific target PCR to that of the maize endogenous reference target. If the event and endogenous PCR targets amplified above CT threshold, then the plant was scored as positive for that event. If the endogenous target amplified and the event target did not, then the plant was scored as negative. If neither target amplified for a particular sample, then it was determined to be a poor quality DNA sample or failed run and the assay was repeated.

All 4114 maize plants were positive for the event-specific PCR and the PAT, Cry1F, and Cry34Ab1 proteins, whereas all the control maize plants were negative. The results are summarized in Table 6.

33

TABLE 6

Summary of Event-Specific PCR Analysis and Cry1F, Cry34Ab1, and PAT Protein Expression in 4114 Maize and Control Maize Plants				
4114 Maize Plant ID	Event-Specific PCR ¹	Cry1F ²	Cry34Ab1 ²	PAT ²
T-F-08-233C-1	+	+	+	+
T-F-08-233C-2	+	+	+	+
T-F-08-233C-3	+	+	+	+
T-F-08-233C-4	+	+	+	+
Control Maize Plant ID				
C-F-08-246C-1	-	-	-	-
C-F-08-246C-2	-	-	-	-

¹Summary of event-specific real time PCR assay for 4114 maize. Positive (+) indicates the presence of 4114 maize event. Negative (-) indicates the absence of 4114 maize event.

²Summary of Cry1F, Cry34Ab1, and PAT protein expression in 4114 maize and control maize plants using lateral flow devices. Positive (+) indicates the presence of the protein. Negative (-) indicates the absence of the protein.

DNA Sequencing

DNA fragments were cloned and submitted for sequencing at the Pioneer Crop Genetics Research sequencing facility (Wilmington, Del.). Sequencher™ software from Gene Codes Corporation (Ann Arbor, Mich.) was used to assemble the sequences. Sequence annotation was performed using Vector NTI 9.1.0 (Invitrogen Corp) by comparing the T-DNA insert sequences generated from 4114 maize with the sequences from the T-DNA region of plasmid PHP27118 (used for transformation to produce 4114 maize).

The T-DNA region of plasmid PHP27118, used to create 4114 maize, was sequenced and compared with the inserted T-DNA sequence in 4114 maize.

The sequence of the T-DNA region of plasmid PHP27118 was used to design primer pairs to characterize the inserted T-DNA in 4114 maize. Six overlapping PCR products were generated using genomic DNA from four different 4114 maize plants as template. These PCR products were cloned and sequenced.

Sequencing of 5' and 3' Flanking Genomic Border Regions

Preliminary sequence characterization of the 5' and 3' flanking genomic border regions were carried out using several rounds of inverse PCR, (Silver and Keerikatte (1989) *J.*

34

Virol. 63: 1924; Ochman et al. (1988) *Genetics* 120:621-623; Triglia et al., (1988) *Nucl. Acids Res.* 16:8186) with primers anchored within various regions of the inserted T-DNA. Sequence information obtained from inverse PCR was subjected to BLASTn analysis and showed a match to the maize BAC clone AC211214 from the NCBI (National Center for Biotechnology Information) GenBank nucleotide database. This sequence was then used to design primers that spanned the 5' and 3' insert/genomic junctions in 4114 maize. The PCR products generated from four 4114 maize plants were cloned and sequenced to verify the 5' and 3' insert/genomic junctions and the genomic border regions.

In addition, to demonstrate that the identified 5' and 3' genomic border regions were of maize origin, PCR was performed on 4114 maize and control maize plants within the genomic regions. Each PCR fragment was directly sequenced to verify its identity of maize origin.

The T-DNA sequence information of plasmid PHP27118 was used to design primers to verify the inserted sequence in 4114 maize (Tables 7 and 8).

TABLE 7

PCR Primers Used to Characterize the Genomic Border Regions and Inserted T-DNA in 4114 Maize				
PCR Fragment	Primer Pair	Primer SEQ ID NOs:	Size (bp)	Amplified Region
A	09-0-3030/ 09-0-2787	11/12	2511	5' Genomic border region and insert
B	09-0-3036/ 09-0-3046	13/14	3622	Insert
C	09-0-2980/ 09-0-3045	16/15	4146	Insert
D	08-0-2463/ 08-0-2759	17/18	2713	Insert
E	09-0-2775/ 09-0-3083	19/20	3062	Insert
F	09-0-2799/ 09-0-3005	21/22	2612	3' Genomic border region and insert
G	09-0-3230/ 09-0-3229	23/24	257	5' Genomic border region
H	09-0-3231/ 09-0-3084	25/26	283	3' Genomic border region

TABLE 8

Sequence and Location of Primers Used For PCR Reactions.			
PCR Fragment	Primer (SEQ ID NO:)	Primer Sequence (5'-3')	Target Sequence Location (bp to bp) ¹
A	09-0-3030 (SID: 11)	GAGCATATCCAGCACCAGCTGGTACCAAG	1-29
	09-0-2787 (SID: 12)	GCAGGCATGCCCGCGGATA	2,511-2,493
B	09-0-3036 (SID: 13)	TGGTCTACCCGATGATGTGATTGGCC	1,994-2,019
	09-0-3046 (SID: 14)	CGAAGACAGGATCTGACAAGGTCCGATAG	5,615-5,587
C	09-0-3045 (SID: 15)	GACTTCATGAACCTTTGTTTGTGACTGCAGAGAC	5,414-5,414
	09-0-2980 (SID: 16)	CTCATGACTCAGGACTTGTGGC	9,559-9,538
D	08-0-2463 (SID: 17)	ATCAGCCTCTACTTCGAC	9,390-9,407
	08-0-2759 (SID: 18)	CTCCATGATCTTCGTCTCATGTG	12,102-12,080

TABLE 8-continued

Sequence and Location of Primers Used For PCR Reactions.			
PCR Fragment	Primer (SEQ ID NO:)	Primer Sequence (5'-3')	Target Sequence Location (bp to bp) ¹
E	09-0-2775	CACCAACTCCATCCAGAAGTGGC	11,481-
	(SID: 19)		11,503
	09-0-3083	GCCTTGCAATGGCGCAGTGAGAACCG	14,542-
	(SID: 20)		14,517
F	09-0-2799	CGGCGCGCCTCTAGTTGAAGACACGTT	14,141-
	(SID: 21)		14,167
	09-0-3005	CACTGGACTGAGCCGCACAGCTAAGGACAC	16,752-
	(SID: 22)		16,723
G	09-0-3230	GGAACATTGAGACTTGGGAGTCTGGACT	2,086-2,113
	(SID: 23)		
	09-0-3229	GAACAGGGTCCTCGAATCAAGGGCAGC	2,342-2,316
	(SID: 24)		
H	09-0-3231	CGGTTCTCACTGCGCCAATGCAAGGC	14,517-
	(SID: 25)		14,542
	09-0-3084	CATGACGACCATGAAGCAACATC	14,799-
	(SID: 26)		14,777

¹Location in sequence of 4114 Maize.

Bases 1-2,422 = 5' genomic border region

Bases 2,423-14,347 = insert

Bases 14,348-16,752 = 3' genomic border region.

To characterize the inserted T-DNA in 4114 maize, PCR primers were designed to amplify the T-DNA insert in six separate, overlapping PCR products as outlined in Table 7: fragments A through F (Positions indicated in FIG. 5). As expected, the predicted PCR products were generated only from 4114 maize genomic DNA samples, and were not present in the control maize samples. The six PCR products were cloned and sequenced. When comparing the sequence of the inserted T-DNA in 4114 maize to the T-DNA region of plasmid PHP27118 used to create 4114 maize, it was determined that there was a 29 bp deletion on the RB end, and a 24 bp deletion on the LB end. RB and LB termini deletions often occur in *Agrobacterium*-mediated transformation (Kim et al. (2007) *Plant J.* 51:779-791). All remaining sequence is intact and identical to that of plasmid PHP27118. The sequence of the insertion is presented in SEQ ID NO: 6.

To verify the additional 5' genomic border sequence, PCR was performed with a forward primer (SEQ ID NO: 11) in the 5' genomic border region and a reverse primer (SEQ ID NO: 12) within the inserted T-DNA. The resulting 2,511 bp PCR fragment A from 4114 maize genomic DNA samples was cloned and sequenced (FIG. 3). The 2,422 bp of the 5' genomic border region sequence is set forth in nucleotides 1-2,422 of SEQ ID NO: 6.

To verify the additional 3' genomic border sequence, PCR was performed with a forward primer (SEQ ID NO: 21) within the inserted T-DNA and a reverse primer (SEQ ID NO: 22) in the 3' genomic border region. The resulting 2,612 bp PCR fragment F from 4114 maize genomic DNA samples was cloned and sequenced (FIG. 3). The 2,405 bp of the 3' genomic border region sequence is set forth in nucleotides 14,348 to 16,752 of SEQ ID NO: 6.

In total, 16,752 bp of sequence from genomic DNA of 4114 maize were confirmed: 2,422 bp of the 5' genomic border sequence, 2,405 bp of the 3' genomic border sequence, and 11,925 bp comprising the inserted T-DNA.

To demonstrate that the identified 5' and 3' flanking genomic border sequences are of maize origin, PCR was

performed within the 5' and 3' genomic border regions (the primer pair set forth in SEQ ID NOs: 23 and 24 and the primer pair set forth in SEQ ID NOs: 25 and 26, respectively) on 4114 maize genomic DNA samples and control maize samples. The expected PCR fragment G (257 bp for the 5' genomic region) and PCR fragment H (283 bp for the 3' genomic region) were generated from both 4114 maize and control maize. These PCR products were cloned and sequenced, and the corresponding products from the 4114 maize and the control maize are identical, thus confirming that the sequences are of maize genomic origin.

Example 5

Insect Efficacy of Maize Event DP-004114-3

Efficacy data was generated on 4114 maize. Field testing compared 4114 maize in two genetic backgrounds to a negative control (isoline) in the same backgrounds. Efficacy testing included: first generation ECB (ECB1) foliage damage and second generation ECB (ECB2) stalk damage at four locations, WCRW root damage at three locations, and FAW foliar damage at one location. At each location, single-row plots were planted in a randomized complete block with three replications (20 kernels/plot×12 entries×3 replicates=1 experiment/location). All plants were tissue sampled after emergence to confirm the presence of the event by event-specific PCR. Any negatives were culled and each plot thinned to a target stand of 10-15 evenly spaced plants per plot.

For trials characterizing ECB1 damage, each plant was manually infested with approximately 100 ECB neonate larvae 3 times (300 larvae total) over approximately one week beginning at approximately the V5 growth stage. Approximately three weeks after the last successful infestation, leaf damage ratings (based on a 9-1 visual rating scale where 9 indicates no damage and 1 indicates maximum damage) were taken on 8 consecutive plants per plot (total of 24 plants per genetic background, per entry) and means were calculated for each treatment. First generation ECB foliar feeding results on 4114 maize are shown in Table 9.

37

TABLE 9

Efficacy of DP-004114-3 Maize Against First Generation ECB Larvae		
Location	Maize Line	Mean ECB1LF Damage Rating $\pm$ Standard Error ^{a,b}
York, NE	4114	9.0 $\pm$ 0.05 A
	1507 $\times$ 59122	9.0 $\pm$ 0.08 A
	Negative control	4.4 $\pm$ 0.09 B
Johnston, IA	4114	9.0 $\pm$ 0.00 A
	1507 $\times$ 59122	9.0 $\pm$ 0.00 A
	Negative control	4.5 $\pm$ 0.08 B
Mankato, MN	4114	9.0 $\pm$ 0.02 A
	1507 $\times$ 59122	9.0 $\pm$ 0.03 A
	Negative control	4.7 $\pm$ 0.11 B
Princeton, IL	4114	9.0 $\pm$ 0.00 A
	1507 $\times$ 59122	9.0 $\pm$ 0.00 A
	Negative control	5.5 $\pm$ 0.17 B

^aDamage ratings on individual plants were determined using the following visual rating scale: 9. No visible leaf injury or a small amount of pin or fine shot-hole type injury on a few leaves. 8. Small amount of shot-hole type lesions on a few leaves. 7. Shot-hole injury common on several leaves. 6. Several leaves with shot-hole and elongated lesions (Lesions <0.5" in length). 5. Several leaves with elongated lesions (Lesions 0.5" to 1.0" in length). 4. Several leaves with elongated lesions (Lesions >1.0" in length). 3. Long lesions (>1.0") common on about one-half the leaves. 2. Long lesions (>1.0") common on about two-thirds the leaves. 1. Most of the leaves with long lesions.

^bWithin a location, means with the same letter are not significantly different (Fisher's Protected LSD test, P > 0.05).

For trials characterizing ECB2 damage, the same plants infested above for ECB1 were manually infested again later in the growing season with approximately 100 ECB neonate larvae (300 larvae total) per plant 3 times over approximately one week beginning at the R1 growth stage, when approximately 50% of the plants were shedding pollen. At approximately 50-60 days after the last infestation, stalks of 8 consecutive plants per plot (total of 24 plants per genetic background, per entry) were split from the top of the 4th internode above the primary ear to the base of the plant. The total length of ECB stalk tunneling (ECBXCM) was then measured in centimeters and recorded for each plant. Tunnels 1 cm or less were considered entrance holes (larvae was not able to establish in the stalk) and were not included in the total cm of tunneling. Means (total cm of tunneling) were calculated for each treatment. The ECB2 stalk feeding results for 4114 maize are shown in Table 10.

TABLE 10

Efficacy of DP-004114-3 Maize Against Second Generation ECB Larvae		
Location	Maize Line	Mean ECB $\times$ CM (tunnel length, cm) $\pm$ Standard Error ^b
York, NE	4114	0.9 $\pm$ 0.27 B
	1507 $\times$ 59122	0.4 $\pm$ 0.12 B
	Negative control	22.6 $\pm$ 1.83 A
Mankato, MN	4114	1.3 $\pm$ 0.30 B
	1507 $\times$ 59122	0.7 $\pm$ 0.18 B
	Negative control	31.3 $\pm$ 2.19 A
Johnston, IA	4114	1.1 $\pm$ 0.26 B
	1507 $\times$ 59122	0.3 $\pm$ 0.11 B
	Negative control	33.0 $\pm$ 2.51 A
Princeton, IL	4114	0.8 $\pm$ 0.22 B
	1507 $\times$ 59122	0.1 $\pm$ 0.07 B
	Negative control	10.0 $\pm$ 0.94 A

^bWithin a location, means with the same letter are not significantly different (Fisher's Protected LSD test, P > 0.05).

Root damage caused by WCRW was also investigated. Plants at approximately the V2 growth stage were manually infested with approximately 500 WCRW eggs applied into the soil on each side of the plant (1,000 eggs/plant total).

38

Additionally, plots were planted in fields that had a high probability of containing a natural infestation of WCRW. Plant roots were evaluated at approximately the R2 growth stage. Five consecutive plants per plot (total 45 plants per genetic background, per entry) were removed from the plot and washed with pressurized water. The root damage was rated using the 0-3 node injury scale (CRWNIS) (Oleson, et al. (2005) *J. Econ. Entomol.* 98(1):1-8) and means were calculated for each treatment. Mean root damage ratings from WCRW feeding are shown in Table 11.

TABLE 11

Efficacy of DP-004114-3 Maize Against WCR Larvae		
Location	Maize Line	Mean CRWNIS score $\pm$ Standard Error ^{b,c}
Johnston, IA	4114	0.1 $\pm$ 0.01 B
	1507 $\times$ 59122	0.1 $\pm$ 0.02 B
	Negative Control	0.5 $\pm$ 0.09 A
Mankato, MN	4114	0.1 $\pm$ 0.02 B
	1507 $\times$ 59122	0.1 $\pm$ 0.01 B
	Negative Control	1.1 $\pm$ 0.11 A
Rochelle, IL	4114	0.3 $\pm$ 0.04 B
	1507 $\times$ 59122	0.1 $\pm$ 0.01 B
	Negative Control	1.3 $\pm$ 0.18 A

^bDamage ratings on individual plant root masses were determined using 0-3 Node Injury Scale (Oleson et al. 2005, supra).

^cWithin a location, means with the same letter are not significantly different (Fisher's Protected LSD test, P > 0.05).

For the FAW efficacy testing, individual plants were manually infested with approximately 75 neonates at approximately the V5 growth stage. Leaves were scored for damage on 8 consecutive plants per plot (total of 24 plants per genetic background, per entry) (FAWLF based on a 9-1 visual rating scale where 9 indicates no damage and 1 indicates maximum damage approximately two weeks after the last successful inoculation and means were calculated for each treatment. Mean damage ratings characterizing FAW foliar feeding on DP-004114-3 are shown in Table 12.

TABLE 12

Efficacy of DP-004114-3 Maize Against FAW Larvae		
Location	Maize Line	Mean FAWLF Damage Rating $\pm$ Standard Error ^{a,b}
Johnston, IA	4114	8.9 $\pm$ 0.06 BC
	1507 $\times$ 59122	9.0 $\pm$ 0.00 A
	Negative control	2.1 $\pm$ 0.08 D

^aDamage ratings on individual plants were determined using the following visual rating scale: 9. No damage to pinhole lesions present on whorl leaves. 8. Pinholes and small circular lesions present on whorl leaves. 7. Small circular lesions and a few small elongated (rectangular shaped) lesions up to 0.5" in length present on whorl and furl leaves. 6. Several small elongated lesions 0.5" to 1" in length on a few whorl and furl leaves. 5. Several large elongated lesions greater than 1" in length present on a few whorl and furl leaves and/or a few small to mid-sized uniform to irregular shaped holes (basement membrane consumed) in whorl and furl leaves. 4. Several large elongated lesions present on several whorl and furl leaves and/or several large uniform to irregular shaped holes in whorl and furl leaves. 3. Many elongated lesions of all sizes present on several whorl leaves plus several large uniform to irregular shaped holes in whorl and furl leaves. 2. Many elongated lesions of all sizes present on most whorl and furl leaves plus many mid to large-sized uniform to irregular shaped holes in whorl and furl leaves. 1. Whorl and furl leaves almost totally destroyed.

^bWithin a location, means with the same letter are not significantly different (Fisher's Protected LSD test, P > 0.05).

In addition to field efficacy studies, 4114 maize was evaluated in the lab-based sub-lethal seedling assay (SSA) (U.S. Publication No. 2006/0104904 the contents of which is hereby incorporated by reference). The SSA allowed for a comparison of the efficacy of 4114 maize to an unprotected control (near isoline) without the confounding effects of the field environment. The SSA technique involves exposing a population of neonate WCRW to maize seedlings containing either one of the 4114 maize events or non-transgenic (nega-

tive control) maize seedlings. Larvae were exposed for a period of 17 days from the date of initial egg hatch. The experimental unit for the SSA was a single plastic container with dimensions of 23×30×10 cm (Pactiv Corp., Lake Forest, Ill.). Entries were arranged in a randomized complete block with 3 replications per entry. For each entry, SSA setup involved placing 115 kernels into each container with 225 mL of a 1% thiophanate-methyl fungicide solution and 1000 mL of Metro-Mix 200 plant growth media (Scotts-Sierra Horticultural Products Company, Marysville, Ohio). Immediately after adding the Metro-Mix, WCRW eggs were infested onto the surface of each container at a rate of 1,000 eggs per container. WCRW eggs were pre-incubated at 25° C. so that initial egg hatch was timed to occur 5-7 days after container setup. Infested containers were held in a walk-in environmental chamber with settings of 25° C., 65% relative humidity, and 14:10 light:dark cycle. Larvae were extracted from the containers 17 days post-egg hatch using a Bursell funnel system. A random subsample of 30 larvae per container were selected and their head capsules measured under a dissecting microscope to categorize each into 1 of 3 instars. Data collected includes the age structure of the larval population determined from the number of larvae in each of three potential instars. Histograms that graphically displayed the age distribution of larvae for each entry were plotted and visually compared as shown in FIG. 4.

The pest spectrum for 4114 maize is provided in Table 13.

TABLE 13

Insect Pests That Are Controlled or Suppressed by DP-004114-3 Maize Expressing Cry1F, Cry34Ab1, and Cry35Ab1		
Scientific Name	Common Name	Insect Order
<i>Ostrinia nubilalis</i>	European corn borer (ECB)	Lepidoptera
<i>Helioverpa zea</i>	Corn earworm (CEW)	Lepidoptera
<i>Spodoptera frugiperda</i>	Fall armyworm (FAW)	Lepidoptera
<i>Diatraea grandiosella</i>	Southwestern corn borer (SWCB)	Lepidoptera
<i>Richia albicosta</i>	Western bean cutworm (WBCW)	Lepidoptera
<i>Agrotis ipsilon</i>	Black cutworm (BCW)	Lepidoptera
<i>Elasmopalpus lignosellus</i>	Lesser corn stalk borer (LCSB)	Lepidoptera
<i>Diatraea crambidoides</i>	Southern corn stalk borer (SCSB)	Lepidoptera
<i>Diabrotica virgifera</i>	Western corn rootworm (WCRW)	Coleoptera
<i>Diabrotica virgifera</i>	Mexican corn rootworm (MCR)	Coleoptera
<i>Diabrotica zeae</i>	Northern corn rootworm (NCR)	Coleoptera
<i>Diatraea saccharalis</i>	Sugarcane borer (SCB)	Coleoptera

Example 6

Protein Expression and Concentration

Generation of Plant Material

4114 maize from the PHNAR×BC3F3 generation was grown in five locations in the United States and Canada. Each site employed a randomized complete block design containing four blocks, with each block separated by a buffer distance of at least 36 inches (0.9 m). Each entry was planted in 2-row plots bordered on each side by 1 row of border seed.

Leaf Tissue Collection and Processing

One leaf tissue sample was collected in each block at the V9 stage. All samples were collected from impartially selected, healthy, representative plants for each event. Each leaf sample was obtained by selecting the youngest leaf that had emerged at least 8 inches (20 cm, visible tissue) from the whorl. If this leaf was damaged or otherwise unhealthy, the

next leaf below it was sampled. The leaf was pruned (cut) from the plant approximately 8 inches (20 cm) from the leaf tip. The leaf sample (including midrib) was cut into ≤1 inch (2.5 cm) pieces and placed in a 50-ml sample vial. The samples were then placed on dry ice until transferred to a freezer (≤−10° C.). Samples were shipped frozen and stored at ≤−10° C. upon arrival. All tissue samples were lyophilized, under vacuum, until dry. The lyophilized leaf samples were finely homogenized in preparation for analysis. Samples were stored frozen between processing steps.

Protein Concentration Determinations

Concentrations of the Cry1F, Cry34Ab1, Cry35Ab1, and PAT proteins were determined using specific quantitative ELISA methods.

Protein Extraction

Aliquots of processed leaf tissue samples were weighed into 1.2 mL tubes at the target weight of 10 mg. Each sample analyzed for Cry1F, Cry34Ab1, Cry35Ab1, and PAT protein concentrations was extracted in 0.6 mL of chilled PBST (Phosphate Buffered Saline plus Tween-20). Following centrifugation, supernatants were removed, diluted, and analyzed.

Determination of Cry1F, Cry34Ab1 and PAT Protein Concentration

The Cry1F, Cry34Ab1 and PAT ELISA kits employed were obtained from EnviroLogix, Inc. (Portland, Me.), and the Cry35Ab1 ELISA kit employed was obtained from Acadia BioScience, LLC (Portland, Me.). The ELISA method for each of these four proteins utilized a sequential “sandwich” format to determine the concentration of the protein in sample extracts. Standards (analyzed in triplicate wells) and diluted sample extracts (analyzed in duplicate wells) were incubated in plate pre-coated with an antibody specific to a single protein chosen from Cry1F, Cry34Ab1, Cry35Ab1 or PAT. Following incubation, unbound substances were washed from the plate. A different specific antibody for the respective selected protein, conjugated to the enzyme horseradish peroxidase (HRP), was added to the plate and incubated. Then, unbound substances were washed from the plate leaving the bound protein “sandwiched” between the antibody coated on the plate and the antibody-HRP conjugate. Detection of the bound antibody-protein complex was accomplished by the addition of substrate, which generated a colored product in the presence of HRP. The reaction was stopped with an acid solution and the optical density (OD) of each well was determined using plate reader. An average of the results from duplicate wells was used to determine the concentration of the Cry1F, Cry34Ab1, Cry35Ab1 or PAT protein in ng/mg sample dry weight.

Calculations for Determining Protein Concentrations

SoftMax® Pro software was used to perform the calculations required to convert the OD values obtained by the plate reader to protein concentrations.

1. Standard Curve

A standard curve was included on each ELISA plate. The equation for the standard curve was generated by the software, which used a quadratic fit to relate the mean OD values obtained for the standards to the respective standard concentration (ng/mL). The quadratic regression equation was applied as follows:

$$y=Cx^2+Bx+A$$

where x=known standard concentration and y=relative mean absorbance value (OD).

2. Sample Concentration

Interpolation of the sample concentration (ng/ml) was accomplished by solving for x in the above equation using values for A, B, and C determined by the standard curve.

$$\text{Sample Concentration (ng/mL)} = \frac{-B + \sqrt{B^2 - 4C(A - \text{sampleOD})}}{2C}$$

e.g. Curve Parameters: A=0.0476, B=0.4556, C=-0.01910, and sample OD=1.438

$$\begin{aligned} \text{Sample Concentration} &= \frac{-0.4556 + \sqrt{0.4556^2 - 4(-0.01910)(0.0476 - 1.438)}}{2(-0.01910)} \\ &= 3.6 \text{ ng/mL} \end{aligned}$$

Sample concentration values were adjusted for the dilution factor expressed as 1:N

Adjusted Concentration=Sample Concentration×Dilution Factor

e.g. Sample Concentration=3.6 ng/mL and Dilution Factor=1:10

Adjusted Concentration=3.6 ng/mL×10=36 ng/mL

Adjusted sample concentration values were converted from ng/mL to ng/mg sample weight as follows:

ng/mg Sample Weight=ng/mL×Extraction Volume (mL)/Sample Weight (mg)

e.g. Concentration=36 ng/mL, Extraction Volume=0.60 mL, and

Sample Weight=10.0 mg

ng/mg Sample Weight=36 ng/mg×0.60 mL/10.0 mg=2.2 ng/mg

3. Lower Limit of Quantitation (LLOQ)

The LLOQ, in ng/mg sample weight, was calculated as follows:

$$LLOQ = \frac{\text{Reportable Assay LLOQ} \times \text{Extraction Volume}}{\text{Sample Target Weight}}$$

e.g. for PAT in leaf: reportable assay LLOQ=2.3 ng/mL, extraction volume=0.6 mL, and sample target weight=10 mg

$$LLOQ = \frac{2.3 \text{ ng/mL} \times 0.6 \text{ mL}}{10 \text{ mg}} = 0.14 \text{ ng/mg sample weight}$$

Results

The proteins Cry1F, Cry34Ab1, Cry35Ab1, and PAT were detected in V9 leaf tissue of 4114 maize at the concentrations set forth in Table 14 below.

TABLE 14

Protein Concentrations in 4114 Maize				
Protein concentration in ng/mg dry weight*				
	Cry1F	Cry34Ab1	Cry35Ab1	PAT
Mean ± SD	9.7 ± 2.5	26 ± 3.1	33 ± 3.1	9.8 ± 3.3
Range	5.3-14	22-31	28-39	4.8-15

*The LLOQ for Cry1F and PAT was 0.14 ng/mg Dry Weight; the LLOQ for Cry34Ab1 and Cry35Ab1 were 0.16 ng/mg Dry Weight

Having illustrated and described the principles of the present invention, it should be apparent to persons skilled in the art that the invention can be modified in arrangement and detail without departing from such principles. We claim all modifications that are within the spirit and scope of the appended claims.

All publications and published patent documents cited in this specification are incorporated herein by reference to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

SEQUENCE LISTING

<160> NUMBER OF SEQ ID NOS: 28

<210> SEQ ID NO 1

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<223> OTHER INFORMATION: Cry1F

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20 25 30

Pro Leu Asp Ile Ser Leu Ser Leu Thr Arg Phe Leu Leu Ser Glu Phe
35 40 45

Val Pro Gly Val Gly Val Ala Phe Gly Leu Phe Asp Leu Ile Trp Gly
50 55 60

Phe Ile Thr Pro Ser Asp Trp Ser Leu Phe Leu Leu Gln Ile Glu Gln

-continued

65	70	75	80
Leu Ile Glu Gln Arg Ile Glu Thr Leu Glu Arg Asn Arg Ala Ile Thr	85	90	95
Thr Leu Arg Gly Leu Ala Asp Ser Tyr Glu Ile Tyr Ile Glu Ala Leu	100	105	110
Arg Glu Trp Glu Ala Asn Pro Asn Asn Ala Gln Leu Arg Glu Asp Val	115	120	125
Arg Ile Arg Phe Ala Asn Thr Asp Asp Ala Leu Ile Thr Ala Ile Asn	130	135	140
Asn Phe Thr Leu Thr Ser Phe Glu Ile Pro Leu Leu Ser Val Tyr Val	145	150	155
Gln Ala Ala Asn Leu His Leu Ser Leu Leu Arg Asp Ala Val Ser Phe	165	170	175
Gly Gln Gly Trp Gly Leu Asp Ile Ala Thr Val Asn Asn His Tyr Asn	180	185	190
Arg Leu Ile Asn Leu Ile His Arg Tyr Thr Lys His Cys Leu Asp Thr	195	200	205
Tyr Asn Gln Gly Leu Glu Asn Leu Arg Gly Thr Asn Thr Arg Gln Trp	210	215	220
Ala Arg Phe Asn Gln Phe Arg Arg Asp Leu Thr Leu Thr Val Leu Asp	225	230	235
Ile Val Ala Leu Phe Pro Asn Tyr Asp Val Arg Thr Tyr Pro Ile Gln	245	250	255
Thr Ser Ser Gln Leu Thr Arg Glu Ile Tyr Thr Ser Ser Val Ile Glu	260	265	270
Asp Ser Pro Val Ser Ala Asn Ile Pro Asn Gly Phe Asn Arg Ala Glu	275	280	285
Phe Gly Val Arg Pro Pro His Leu Met Asp Phe Met Asn Ser Leu Phe	290	295	300
Val Thr Ala Glu Thr Val Arg Ser Gln Thr Val Trp Gly Gly His Leu	305	310	315
Val Ser Ser Arg Asn Thr Ala Gly Asn Arg Ile Asn Phe Pro Ser Tyr	325	330	335
Gly Val Phe Asn Pro Gly Gly Ala Ile Trp Ile Ala Asp Glu Asp Pro	340	345	350
Arg Pro Phe Tyr Arg Thr Leu Ser Asp Pro Val Phe Val Arg Gly Gly	355	360	365
Phe Gly Asn Pro His Tyr Val Leu Gly Leu Arg Gly Val Ala Phe Gln	370	375	380
Gln Thr Gly Thr Asn His Thr Arg Thr Phe Arg Asn Ser Gly Thr Ile	385	390	395
Asp Ser Leu Asp Glu Ile Pro Pro Gln Asp Asn Ser Gly Ala Pro Trp	405	410	415
Asn Asp Tyr Ser His Val Leu Asn His Val Thr Phe Val Arg Trp Pro	420	425	430
Gly Glu Ile Ser Gly Ser Asp Ser Trp Arg Ala Pro Met Phe Ser Trp	435	440	445
Thr His Arg Ser Ala Thr Pro Thr Asn Thr Ile Asp Pro Glu Arg Ile	450	455	460
Thr Gln Ile Pro Leu Val Lys Ala His Thr Leu Gln Ser Gly Thr Thr	465	470	475
Val Val Arg Gly Pro Gly Phe Thr Gly Gly Asp Ile Leu Arg Arg Thr	485	490	495

-continued

Ser Gly Gly Pro Phe Ala Tyr Thr Ile Val Asn Ile Asn Gly Gln Leu
500 505 510

Pro Gln Arg Tyr Arg Ala Arg Ile Arg Tyr Ala Ser Thr Thr Asn Leu
515 520 525

Arg Ile Tyr Val Thr Val Ala Gly Glu Arg Ile Phe Ala Gly Gln Phe
530 535 540

Asn Lys Thr Met Asp Thr Gly Asp Pro Leu Thr Phe Gln Ser Phe Ser
545 550 555 560

Tyr Ala Thr Ile Asn Thr Ala Phe Thr Phe Pro Met Ser Gln Ser Ser
565 570 575

Phe Thr Val Gly Ala Asp Thr Phe Ser Ser Gly Asn Glu Val Tyr Ile
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Asp Arg Phe Glu Leu Ile Pro Val Thr Ala Thr Leu Glu
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 <222> LOCATION: (0)...(0)
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Thr Ser Pro Thr Asn Val Ala Asn Asp Gln Ile Lys Thr Phe Val Ala
35 40 45

Glu Ser Asn Gly Phe Met Thr Gly Thr Glu Gly Thr Ile Tyr Tyr Ser
50 55 60

Ile Asn Gly Glu Ala Glu Ile Ser Leu Tyr Phe Asp Asn Pro Phe Ala
65 70 75 80

Gly Ser Asn Lys Tyr Asp Gly His Ser Asn Lys Ser Gln Tyr Glu Ile
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Leu Phe Pro Ile Asp Asp Asp Gln Tyr Ile Ile Thr Ser Tyr Ala Ala
50 55 60

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 Gly Ser Ser Tyr Val Ile Gln Ser Asp Asn Gly Lys Val Leu Thr Ala
 100 105 110
 Gly Thr Gly Gln Ala Leu Gly Leu Ile Arg Leu Thr Asp Glu Ser Ser
 115 120 125
 Asn Asn Pro Asn Gln Gln Trp Asn Leu Thr Ser Val Gln Thr Ile Gln
 130 135 140
 Leu Pro Gln Lys Pro Ile Ile Asp Thr Lys Leu Lys Asp Tyr Pro Lys
 145 150 155 160
 Tyr Ser Pro Thr Gly Asn Ile Asp Asn Gly Thr Ser Pro Gln Leu Met
 165 170 175
 Gly Trp Thr Leu Val Pro Cys Ile Met Val Asn Asp Pro Asn Ile Asp
 180 185 190
 Lys Asn Thr Gln Ile Lys Thr Thr Pro Tyr Tyr Ile Leu Lys Lys Tyr
 195 200 205
 Gln Tyr Trp Gln Arg Ala Val Gly Ser Asn Val Ala Leu Arg Pro His
 210 215 220
 Glu Lys Lys Ser Tyr Thr Tyr Glu Trp Gly Thr Glu Ile Asp Gln Lys
 225 230 235 240
 Thr Thr Ile Ile Asn Thr Leu Gly Phe Gln Ile Asn Ile Asp Ser Gly
 245 250 255
 Met Lys Phe Asp Ile Pro Glu Val Gly Gly Gly Thr Asp Glu Ile Lys
 260 265 270
 Thr Gln Leu Asn Glu Glu Leu Lys Ile Glu Tyr Ser His Glu Thr Lys
 275 280 285
 Ile Met Glu Lys Tyr Gln Glu Gln Ser Glu Ile Asp Asn Pro Thr Asp
 290 295 300
 Gln Ser Met Asn Ser Ile Gly Phe Leu Thr Ile Thr Ser Leu Glu Leu
 305 310 315 320
 Tyr Arg Tyr Asn Gly Ser Glu Ile Arg Ile Met Gln Ile Gln Thr Ser
 325 330 335
 Asp Asn Asp Thr Tyr Asn Val Thr Ser Tyr Pro Asn His Gln Gln Ala
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65	70	75 80
Asn Ala Tyr Asp Trp Thr Val Glu Ser Thr Val Tyr Val Ser His Arg		
85	90	95
His Gln Arg Leu Gly Leu Gly Ser Thr Leu Tyr Thr His Leu Leu Lys		
100	105	110
Ser Met Glu Ala Gln Gly Phe Lys Ser Val Val Ala Val Ile Gly Leu		
115	120	125
Pro Asn Asp Pro Ser Val Arg Leu His Glu Ala Leu Gly Tyr Thr Ala		
130	135	140
Arg Gly Thr Leu Arg Ala Ala Gly Tyr Lys His Gly Gly Trp His Asp		
145	150	155 160
Val Gly Phe Trp Gln Arg Asp Phe Glu Leu Pro Ala Pro Pro Arg Pro		
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Val Arg Pro Val Thr Gln Ile		
180		

<210> SEQ ID NO 5
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 <223> OTHER INFORMATION: Complete sequence of the T-DNA region of
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 <400> SEQUENCE: 5

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<213> ORGANISM: Artificial Sequence

<220> FEATURE:

<223> OTHER INFORMATION: The complete sequence of the insert and flanking regions of event DP-004114-3

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26

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83

What is claimed is:

1. A DNA construct comprising: a first, second, third and fourth expression cassette, wherein said first expression cassette in operable linkage comprises:

- (a) a maize ubiquitin promoter;
- (b) a 5' untranslated exon of a maize ubiquitin gene;
- (c) a maize ubiquitin first intron;
- (d) a Cry1F encoding DNA molecule; and
- (e) a poly(A) addition signal from ORF 25 terminator;

said second expression cassette in operable linkage comprises:

- (1) a maize ubiquitin promoter;
- (2) a 5' untranslated exon of a maize ubiquitin gene;
- (3) a maize ubiquitin first intron;
- (4) a Cry34Ab1 encoding DNA molecule; and
- (5) a PinII transcriptional terminator;

said third expression cassette in operable linkage comprises;

- (i) a wheat peroxidase promoter;
- (ii) a Cry35Ab1 encoding DNA molecule; and
- (iii) a PinII transcriptional terminator; and

said fourth expression cassette in operable linkage comprises;

- (a) a CaMV 35S promoter;
- (b) a pat encoding DNA molecule; and
- (c) a 3' transcriptional terminator from CaMV 35S;

wherein the four cassettes are flanked by SEQ ID NO: 27 at the 5' end and SEQ ID NO: 28 at the 3' end.

2. A plant comprising the DNA construct of claim 1.

3. A plant of claim 2, wherein said plant is a corn plant.

4. A plant comprising the sequence set forth in SEQ ID NO: 6.

5. A corn plant comprising the genotype of the corn event DP-004114-3 deposited with American Type Culture Collection (ATCC) under Accession No. PTA-11506, wherein said genotype comprises the DNA construct of claim 1.

6. A corn plant comprising the genotype of the corn event DP-004114-3, wherein a representative sample of seed of said corn event has been deposited with American Type Culture Collection (ATCC) with Accession No. PTA-11506.

7. A plant parts of the plant comprising the corn event of claim 6.

8. A seed comprising corn event DP-004114-3, wherein said seed comprises the DNA construct of claim 1, wherein a representative sample of corn event DP-004114-3 seed has been deposited with American Type Culture Collection (ATCC) with Accession No. PTA-11506.

9. A corn plant, or part thereof, grown from the seed of claim 8.

10. A transgenic seed produced from the corn plant of claim 9, wherein the seed comprises corn event DP-004114-3.

11. A transgenic corn plant, or part thereof, grown from the seed of claim 10.

12. An isolated nucleic acid molecule comprising a nucleotide sequence selected from the group consisting of SEQ ID NO: 6; SEQ ID NO: 27; SEQ ID NO: 28, and full length complements thereof.

13. An amplicon comprising the nucleic acid sequence selected from the group consisting of SEQ ID NO: 27, SEQ ID NO: 28 and full length complements thereof.

14. A biological sample derived from corn event DP-004114-3 plant, tissue, or seed, wherein said sample comprises a nucleotide sequence selected from the group consisting of SEQ ID NO: 27 and SEQ ID NO: 28, or the complement thereof, wherein said nucleotide sequence is detectable in said sample using a nucleic acid amplification or nucleic

84

acid hybridization method, wherein a representative sample of said corn event DP-004114-3 seed has been deposited with American Type Culture Collection (ATCC) with Accession No. PTA-11506.

15. The biological sample of claim 14, wherein said biological sample comprise plant, tissue, or seed of transgenic corn event DP-004114-3.

16. The biological sample of claim 15, wherein said biological sample is a DNA sample extracted from the transgenic corn plant event DP-004114-3, and wherein said DNA sample comprises one or more of the nucleotide sequences selected from the group consisting of SEQ ID NO: 27, SEQ ID NO: 28, and the complement thereof.

17. The biological sample of claim 16, wherein said biological sample is selected from the group consisting of corn flour, corn meal, and cereals manufactured in whole or in part to contain corn by-products.

18. An extract derived from corn event DP-004114-3 plant, tissue, or seed and comprising a nucleotide sequence selected from the group consisting of SEQ ID NO: 27 and SEQ ID NO: 28 or the complement thereof, wherein a representative sample of said corn event DP-004114-3 seed has been deposited with American Type Culture Collection (ATCC) with Accession No. PTA-11506.

19. The extract of claim 18, wherein said nucleotide sequence is detectable in said extract using a nucleic acid amplification or nucleic acid hybridization method.

20. The extract of claim 19, further comprising a composition selected from the group consisting of corn flour, corn meal, corn syrup, corn oil, corn starch, and cereals manufactured in whole or in part to contain corn by-products, wherein said composition comprises a detectable amount of said nucleotide sequence.

21. A method of producing hybrid corn seeds comprising: (a) planting seeds of a first inbred corn line comprising the DNA construct of claim 1 and seeds of a second inbred line having a genotype different from the first inbred corn line;

(b) cultivating corn plants resulting from said planting until time of flowering;

(c) emasculating said flowers of plants of one of the corn inbred lines;

(d) sexually crossing the two different inbred lines with each other; and

(e) harvesting the hybrid seed produced thereby.

22. The method according to claim 21, wherein the plants of the first inbred corn line are the female parents.

23. The method according to claim 21, wherein the plants of first inbred corn line are the male parents.

24. A method for producing a corn plant resistant to lepidopteran pests comprising:

(a) sexually crossing a first parent corn plant with a second parent corn plant, wherein said first or second parent corn plant comprises event DP-004114-3 DNA, deposited under Accession No. PTA-11506 with American Type Culture Collection (ATCC), thereby producing a plurality of first generation progeny plants;

(b) selecting a first generation progeny plant that is resistant to lepidopteran insect infestation;

(c) selfing the first generation progeny plant, thereby producing a plurality of second generation progeny plants; and

(d) selecting from the second generation progeny plants, a plant that is resistant to lepidopteran pests;

wherein the second generation progeny plants comprise the DNA construct according to claim 1.

25. The method of claim 21 further comprising backcross-
ing the second generation progeny plant of step (d) that com-
prises corn event DP-004114-3 DNA, deposited under Acces-
sion No. PTA-11506 with American Type Culture Collection
(ATCC), to the parent plant that lacks the corn event 5
DP-004114-3 DNA, thereby producing a backcross progeny
plant that is resistant to at least western corn rootworm.

26. A method for producing a corn plant resistant to at least
corn rootworm, said method comprising:

- (a) sexually crossing a first parent corn plant with a second 10
parent corn plant, wherein said first or second parent
corn plant is a corn event DP-004114-3, deposited under
Accession No. PTA-11506 with American Type Culture
Collection (ATCC), plant, thereby producing a plurality
of first generation progeny plants; 15
- (b) selecting a first generation progeny plant that is resis-
tant to at least corn rootworm infestation;
- (c) backcrossing the first generation progeny plant of step
(b) with the parent plant that lacks corn event
DP-004114-3 DNA, thereby producing a plurality of 20
backcross progeny plants; and
- (d) selecting from the backcross progeny plants, a plant
that is resistant to at least corn rootworm infestation;
wherein the selected backcross progeny plant of step (d)
comprises SEQ ID NO: 6. 25

27. The method according to claim 21, wherein the plants
of the first inbred corn line are the female parents or male
parents.

28. Hybrid seed produced by the method of claim 21.

* * * * *