



全球抗除草剂转基因作物转化事件分析

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摘要 本文根据国际农业生物技术应用服务组织(International Agricultural Biotechnology Application Service Organization, ISAAA)的相关数据,归纳总结了棉花(*Gossypium hirsutum*)、大豆(*Glycine max*)、油菜(*Brassica napus*)和玉米(*Zea mays*)这4种作物的抗除草剂转基因转化事件,以便为我国抗除草剂转基因作物的培育提供参考。经统计发现截止2017-05-21,全球抗除草剂的转基因棉花、大豆、油菜和玉米转化事件分别为39、28、32和201个。在这4种作物中,抗除草剂基因有19种,来源于16种生物,涉及到的除草剂共有9种;分别是草甘膦(glyphosate)、草铵膦(glufosinate)、咪唑啉酮类(imidazolinone)、2,4-D (2,4-dichlorophenoxy)、异噁唑草酮(isoxaflutole)、麦草畏(dicamba)、磺酰脲类(sulfonylurea)、硝磺草酮(mesotrione)和溴苯腈(bromoxynil)。单抗事件、多抗事件和复合抗性事件分别为25个、18个和257个,分别占抗除草剂总转化事件的8.3%、6%和85.7%。抗除草剂转化事件涉及的公司有8个,分别是先正达、孟山都公司、杜邦、拜耳作物科学、陶氏益农有限公司、巴斯夫、Genective S.A. 和美国斯泰恩种子农场股份有限公司。本文能为我国抗除草剂转基因作物的培育提供重要参考。

关键词 转基因, 抗除草剂, 转化事件, 棉花, 大豆, 玉米, 油菜

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Analysis on the Event of Global Herbicide Tolerant Transgenic Crops

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Abstract Based on the data from the International Agricultural Biotechnology Application Service Organization (ISAAA), the herbicide tolerance transgene events of 4 crops, including cotton (*Gossypium hirsutum*), soybean (*Glycine max*), canola (*Brassica napus*) and maize (*Zea mays*) were summarized. The aim is to provide important references for the development of herbicide tolerance transgenic crops in China. It was found that there were 328 herbicide tolerance transgene events by the end of 21 May 2017. These events are approved by the country concerned for direct consumption or as an additive or for cultivation. Herbicide tolerance transgene events of cotton, soybean, canola and maize were 39, 28, 32 and 201, respectively, accounted for 11.89%, 8.53%, 9.76% and 61.28% of the global herbicide tolerance transgenic events, respectively. Nineteen herbicide tolerance genes, which are derived from 16 kinds of organisms, involved in these herbicide tolerance events of these four crops. Seven out of 19 herbicide tolerance genes are derived

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from five plant genomes, including maize, arabidopsis (*Arabidopsis thaliana*), soybeans, tobacco (*Nicotiana tabacum* cv. Xanthi) and oats (*Avena sativa*), and the rest of 13 from microbial genomes. These 19 genes displayed tolerance to nine kinds of herbicides, which are glyphosate, glufosinate, imidazolinones, 2,4-dichlorophenoxy (2,4- D), isoxazalone, dicamba, sulfonyleureas, mesotrione and bromoxynil. Singular herbicide tolerance events, multi herbicide tolerance events, stacked gene events (herbicide tolerance and other trait, such as insect resistance) were 25, 18 and 257, respectively, which accounted for 8.3%, 6% and 85.7% of the total herbicide tolerance events of four crops. These events were developed by eight companies, namely Syngenta, Monsanto Company, DuPont, Bayer CropScience, Dow AgroSciences LLC, BASF, Genective S.A. and the Stein Seed Farm Inc.(USA). Compared to the above international situation, the most of the herbicide tolerance events are glyphosate tolerance, mainly from microorganisms in China. Therefore several suggestions are put forward for developing herbicide tolerance events scientifically in China. Firstly, it is suggested to focus on the development of herbicide tolerance transgene events which should be from plants, because plants have abundant herbicide tolerance genes and herbicide metabolic genes. Secondly, it is recommended to develop glufosinate tolerance transgene events due to characteristics of glufosinate, such as broad spectrum, low toxicity and high activity, environmental compatibility, and excellent weed control effects. Thirdly, other herbicides tolerance transgene events, such as 2,4- D, mesotrione, bromoxynil and isoxazolones should be developed. The single herbicide tolerance crop would lead to the evolution of herbicide resistance weeds due to overreliance on a single herbicide or group of herbicides that share the same mechanism of action or of metabolism. Transgenic crops carried double herbicide tolerance and even more herbicide tolerance genes allow to rotations of herbicides with different modes of action and different metabolic pathways, which are more likely to delay the evolution of herbicide resistant weeds than using herbicide of the same mode of action. Finally, it is suggested to cultivate the event with stacked traits, which could improve the economic value and ecological benefit of the transgenic crops.

Keywords Transgene, Herbicide tolerance, Transformation event, *Gossypium hirsutum*, *Glycine max*, *Brassica napus*, *Zea mays*

抗除草剂转基因作物是利用转基因生物技术, 将具有抗除草剂性状的基因通过根癌农杆菌(*Agrobacterium tumefaciens*)介导、基因枪等方法转入到作物的基因序列中, 使作物能表达对特定除草剂的抗性(向文胜等, 1998)。随着转基因工程的快速发展以及抗除草剂基因的获得, 抗除草剂转基因作物的转化事件数量明显增加。根据国际农业生物技术应用服务组织(International Agricultural Biotechnology Application Service Organization, ISAAA)提供的数据(<http://www.isaaa.org/gmapprovaldatabase/default.asp>, 通过高级查询所需的作物及作物转基因特性获得数据), 截止2017年5月21日, 共有328个抗除草剂转化事件(这些抗除草剂转化事件均被相关国家授权直接食用或作为添加剂或用于栽培), 其中棉花(*Gossypium hirsutum*)、大豆(*Glycine max*)、油菜(*Brassica napus*)和玉米(*Zea mays*)的抗除草剂转化事件300个, 占抗除草剂转化事件总数的91.46%。本文

根据ISAAA数据, 分析了全球棉花、大豆、油菜和玉米这4种作物的抗除草剂转化事件, 以期为我国抗除草剂转基因作物的培育提供参考。

1 全球四种作物抗除草剂转化事件分析

1.1 全球抗除草剂转基因棉花的转化事件

目前全球共有57个转基因棉花转化事件, 其中抗除草剂转化事件39个(表1), 占转基因棉花转化事件总数的68.4%。其他还有抗虫转化事件。所抗除草剂主要为草甘膦(glyphosate), 其次为草铵膦(glufosinate)和2, 4-D (2,4-dichlorophenoxy)以及麦草畏(dicamba)、磺酰脲类(sulfonyleurea)、溴苯腈(bromoxynil) (附表1)。

在39个抗除草剂的转基因棉花转化事件中, 独立转化事件共20个, 均是根癌农杆菌介导的转化事件。其中单一抗除草剂性状的转化事件有4个, 分

别是杜邦抗磺酰脲类除草剂的19-51a;拜耳作物科学抗草甘膦的GHB614和抗草铵膦的LLCotton25;孟山都公司抗草甘膦的MON1445、MON88913。除抗单一除草剂外,双抗除草剂的棉花转化事件有2个,分别是孟山都公司抗草铵膦和麦草畏的MON88701,陶氏益农公司抗草铵膦和2,4-D的81910。此外,还有抗除草剂及抗虫复合抗性的转化事件14个,如拜耳作物科学的抗草铵膦同时抗鳞翅目昆虫的GHB119、T303-3和T304-40等。

除独立转化事件外,还采用人工杂交的方法培育出19个抗除草剂转基因棉花事件。其中有1个双抗除草剂转化事件,即拜耳作物科学的抗草甘膦和草铵膦的GHB614×LLCotton25;三抗除草剂转化事件有1个,即孟山都公司的抗草甘膦、草铵膦和麦草畏的MON88701×MON88913。另外17个是抗除草剂和抗虫性状的转化事件,如孟山都公司的抗草甘膦、草铵膦和抗鳞翅目昆虫3006-210-23×281-24-236×MON1445和孟山都公司的抗草铵膦、麦草畏和抗鳞翅目害虫的转化事件MON88701×MON88913×MON15985等。

1.2 全球抗除草剂转基因大豆的转化事件

目前全球共有36个转基因大豆转化事件,其中抗除草剂转基因大豆转化事件28个(表1),占转基因大豆转化事件的77.8%。其他为抗虫和抗虫、改性油/脂肪酸或抗生素抗性的复合性状的转化事件。所抗除草剂主要为草铵膦和草甘膦,其次为抗咪唑啉酮类除草剂、2,4-D、麦草畏和异噁唑草酮以及硝磺草酮(附表2)。

28个抗除草剂转基因大豆转化事件中,独立转化事件17个。其中单一抗除草剂的事件有9个,包括孟山都公司抗草甘膦的MON89788和GTS40-3-2(401-3-2);拜耳作物科学抗草铵膦的A2704-12、A2704-21、A5547-127、A5547-35、W62和W98;巴斯夫的抗咪唑啉酮类的CV-127。除了单一抗除草剂外,还有6个多抗除草剂转化事件,分别是陶氏益农有限公司抗2,4-D和草铵膦的DAS68416-4;拜耳作物科学抗草甘膦和异噁唑草酮的FG72;孟山都公司抗草甘膦和麦草畏的MON87708;杜邦抗磺酰脲类和草甘膦的DP356043;拜耳作物科学与先正达抗草铵膦和硝磺草酮的SYHTØH2;陶氏益农公司抗草铵膦、草甘膦和2,4-D的DAS44406-6。另外还有2个复合性状的转化事件,即孟山都

公司抗草甘膦和改性油/脂肪酸的MON87705;拜耳作物科学抗草铵膦和抗生素抗性的GU262。

除独立转化事件外,还采用人工杂交的方法培育出11个抗除草剂转基因大豆事件。其中多抗除草剂转化事件有3个,包括孟山都公司抗草甘膦和麦草畏的MON87708×MON89788;拜耳作物科学草甘膦、草铵膦和异噁唑草酮的FG72×A5547-127;陶氏益农公司抗草甘膦、草铵膦和2,4-D的DAS68416-4×MON89788。具有抗除草剂及其他性状的复合性状转化事件有8个,分别是抗草甘膦和品质改良的MON87705×MON87708、MON87705×MON89788和MON87769×MON89788;抗草甘膦、麦草畏和品质改良的MON87705×MON87708×MON89788;抗草甘膦和抗虫的MON87701×MON89788;抗草甘膦、麦草畏和抗虫的MON87751×MON87701×MON87708。抗草甘膦、草铵膦、2,4-D和抗虫的DAS81419×DAS44406-6;抗草甘膦、磺酰脲类除草剂和品质改良的DP305423×GTS40-3-2。

1.3 全球抗除草剂转基因油菜的转化事件

目前全球共有39个转基因油菜转化事件,其中抗除草剂转基因油菜转化事件有32个(表1),占转基因油菜转化事件的82.1%。所抗除草剂主要为草甘膦和草铵膦,其次还有溴苯腈(附表3)。之外,还有其他性状的转化事件,如抗生素抗性、育性恢复及雄性不育等性状。

在32个抗除草剂转基因油菜转化事件中,独立转化事件有18个,其中单抗除草剂转化事件有7个,包括孟山都公司抗草甘膦的GT200(RT200)、GT73(RT73)和MON88302;杜邦抗草甘膦67349和61061;拜耳作物科学抗草铵膦的HCN28(T45)和抗溴苯腈的OXY-235。除了单一抗除草剂转化事件外,还有11个具有抗除草剂性状同时还具有其他性状的复合性状转化事件,如拜耳作物科学抗草铵膦和雄性不育的MS1(B91-4)、MS8;拜耳作物科学抗草铵膦和育性恢复的RF1(B93-101)、RF2(B94-2)、RF3;拜耳作物科学抗草铵膦和抗生素抗性的HCN10和HCN92;拜耳作物科学抗草铵膦、雄性不育和育性恢复的PHY14、PHY23、PHY35、PHY36。

除独立转化事件外,还采用人工杂交培育出14个抗除草剂转基因油菜事件。其中双抗除草剂转化事件有1个,即拜耳作物科学的HCN28×

MON88302。除了双抗除草剂转化事件,还有13个抗除草剂同时还具有其他性状的复合性状转化事件,如拜耳作物科学抗草铵膦、雄性不育和育性恢复的MS1×RF1(PGS1)、MS1×RF2(PGS2)、MS1×RF3、MS8×RF3;拜耳作物科学抗草铵膦、草甘膦和育性恢复的MON88302×RF3、RF1×MON88302、RF2×MON88302;杜邦抗草甘膦、草胺膦和育性恢复的73496×RF3;孟山都公司抗草甘膦和草胺膦、雄性不育和育性恢复的MON88302×MS8×RF3等。

1.4 全球抗除草剂转基因玉米的转化事件

目前全球共有229个转基因玉米转化事件,其中有201(表1)个抗除草剂转基因玉米转化事件,约占总转化事件总数的87.77%。其他还有抗虫转化事件;抗虫和甘露糖代谢功能性状的复合性状转化事件。所抗除草剂主要为草铵膦、草甘膦,其次是磺酰脲类除草剂、麦草畏以及2,4-D(附表4;附表5)。

在201个抗除草剂转基因玉米转化事件中,独立转化事件28个。其中单一抗除草剂有6个,分别是陶氏益农有限公司抗2,4-D的DAS40278;孟山都公司抗草甘膦的GA21、MON87427和NK603;美国斯泰恩种子农场股份有限公司抗草甘膦的HCEM485;Genective S.A抗草甘膦的VCO-Ø1981-5。除单一抗草甘膦、草铵膦和2,4-D外,还有3个双抗除草剂玉米事件,即杜邦抗草甘膦和抗磺酰脲类的98140;先正达抗草甘膦和草铵膦的MZHGOJG;孟山都公司抗草铵膦和麦草畏的MON87419。另外还有19个具有复合性状的转基

因玉米转化事件,如杜邦抗草铵膦和抗虫性状的4114;陶氏益农有限公司与杜邦公司抗草铵膦和抗虫性状的59122等。

除独立转化事件外,还采用人工杂交的方法培育出173个抗除草剂的转基因玉米。双抗除草剂的仅有1个,即美国陶氏益农有限公司抗草甘膦和2,4-D的DAS40278×NK603;另外还有抗除草剂及其他性状的复合性状转化事件172个,如抗草甘膦、草铵膦、2,4-D和鞘翅目昆虫的59122×MON88017×DAS40278;抗草甘膦、草铵膦、磺酰脲类和抗鞘翅目昆虫的98140×59122;抗草甘膦、草铵膦和鞘翅目昆虫的59122×NK603和59122×NK603×MIR604;抗草甘膦、草铵膦和抗鳞翅目、鞘翅目昆虫的TC1507×59122×NK603;抗草铵膦、鳞翅目昆虫、改性α-淀粉酶同时具有甘露糖代谢功能的3272×Bt11、3272×Bt11×GA21、3272×Bt11×MIR604;抗草铵膦、抗鳞翅目和鞘翅目昆虫的TC1507×59122等。

2 独立转化事件涉及的抗除草剂基因

目前,抗除草剂转化事件所涉及的除草剂共有9种(类),分别是草甘膦、草铵膦、咪唑啉酮类(imidazolinone)、2,4-D、异噁唑草酮(isoxaflutole)、麦草畏、磺酰脲类、硝磺草酮(mesotrione)和溴苯腈(表2)。

抗草甘膦基因有7种,共涉及了29个独立转化事件和4种作物;这7种抗性基因分别是来源于根癌农杆菌株Cp4的5-烯醇丙酮酸莽草酸-3-磷酸合成酶(*Cp4-5-enolpyruvylshikimate-3-phosphate syn-*

表1 四种作物的抗除草剂性状的独立及非独立事件

Table 1 Independent and non-independent events of the herbicide-resistance of four crops

目标性状 Target traits	棉花 Cotton	大豆 Soybean	油菜 Canola	玉米 Maize	总计 Total
独立事件 Independent events					
单一抗除草剂 Single herbicide tolerance	4	9	7	6	26
双抗除草剂 Double herbicide tolerance	2	5	0	3	10
三抗除草剂 Three herbicides tolerance	0	1	0	0	1
复合性状 Stacked traits	14	2	11	19	46
非独立事件 Non-independent events					
单一抗除草剂 Single herbicide tolerance	0	0	0	0	0
双抗除草剂 Double herbicide tolerance	1	1	1	1	4
三抗除草剂 Three herbicides tolerance	1	2	0	0	3
复合性状 Stacked traits	17	8	13	172	210
总计 Total	39	28	32	201	300

thetase)基因(*cp4 epsps*); 来源于地衣芽胞杆菌(*Bacillus licheniformis*)的草甘膦N-乙酰转移酶(glyphosate N-acetyltransferase enzyme)基因(*gat4601*); 来源于地衣芽胞杆菌的草甘膦N-乙酰转移酶基因(*gat4621*); 来源于苍白杆菌(*Ochrobactrum anthropi* strain LBAA)的草甘膦氧化酶(glyphosate oxidase)基因(*goxv247*); 来源于土壤球形节杆菌(*Arthrobacter globiformis*)的改良 EPSP 合成酶(EPSPS 或 EPSPS ACE5)蛋白(modified 5-enol pyruvyl shikimate-3-phosphate synthase protein or EPSPS ACE5 pro-

tein)基因(*epsps grg23ace5*); 来源于玉米(*Zea mays*)的EPSPS 修饰合成酶(modified 5-enolpyruvylshikimate-3-phosphate synthase)基因(*mepsps*)和 双突变型 EPSPS 修饰合成酶(*2mepsps*) 基因。

抗草铵膦基因有 2 种, 涉及了抗除草剂独立转化事件 51 个和 4 种作物, 2 种抗性基因分别是来源于吸水链霉菌(*Streptomyces hygroscopicus*)的膦丝菌素 N-乙酰转移酶(phosphinothricin N-acetyltransferase)基因(*bar*)和来源于绿色产色链霉菌(*Streptomyces viridochromogenes*)的膦丝菌素 N-乙酰转移酶基

表 2 抗除草剂性状的基因来源和各基因的独立转化事件数量

Table 2 Source of genes for herbicide tolerance traits and independent event numbers of genes

性状 Traits	基因来源 Gene source	基因 Gene	棉花 Cotton	大豆 Soybeans	油菜 Canola	玉米 Maize	总计 Total
抗草甘膦 Glyphosate tolerance	根瘤农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	<i>cp4 epsps</i>	3	4	3	5	15
	地衣芽胞杆菌 <i>Bacillus licheniformis</i>	<i>gat4601</i>	0	1	0	0	1
	苍白杆菌 <i>Ochrobactrum anthropi</i> strain LBAA	<i>gat4621</i>	0	0	2	1	3
	土壤球形节杆菌 <i>Arthrobacter globiformis</i>	<i>goxv247</i>	0	0	2	1	3
	玉米 <i>Zea mays</i>	<i>epsps grg23ace5</i>	0	0	0	1	1
	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	<i>mepsps</i>	0	0	0	1	1
	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	<i>2mepsps</i>	1	2	0	2	5
抗草铵膦 Glufosinate tolerance	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	<i>bar</i>	5	2	11	6	24
	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	<i>pat</i>	1	8	1	17	27
抗咪唑啉酮类 Imidazolinone herbicides tolerance	拟南芥 <i>Arabidopsis thaliana</i>	<i>csr1-2</i>	0	1	0	0	1
抗 2,4-D 2,4-D tolerance	代尔夫特食酸菌 <i>Delftia acidovorans</i>	<i>aad-12</i>	1	2	0	0	3
	鞘氨醇杆菌 <i>Sphingobium herbicidovorans</i>	<i>aad-1</i>	0	0	0	1	1
抗异噁唑草酮 Isoxaflutole tolerance	荧光假单胞菌菌株 A32 <i>Pseudomonas fluorescens</i> strain A32	<i>hppdPF W336</i>	0	1	0	0	1
抗麦草畏 Dicamba tolerance	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	<i>dmo</i>	1	1	0	1	3
抗磺酰脲类 Sulfonylurea herbicide tolerance	大豆 <i>Glycine max</i>	<i>gm-hra</i>	0	1	0	0	1
	玉米 <i>Zea mays</i>	<i>zm-hra</i>	0	0	0	1	1
	烟草 <i>Nicotiana tabacum</i> cv. Xanthi	<i>S4-HrA</i>	1	0	0	0	1
抗硝磺草酮 Mesotrione Tolerance	燕麦 Oat <i>Avena sativa</i>	<i>avhppd-03</i>	0	1	0	0	1
抗溴苯腈 Oxynil tolerance	肺炎克雷伯氏菌亚种 <i>Klebsiella pneumoniae</i> subsp. <i>Ozaenae</i>	<i>bxn</i>	9	0	1	0	10

因(pat)。

抗咪唑啉酮类基因仅有1种,1个抗除草剂大豆转基因独立转化事件涉及该基因,该抗咪唑啉酮类基因来源于拟南芥(*Arabidopsis thaliana*)的改良乙酰乳酸合成酶大亚基(modified acetohydroxyacid synthase large subunit)基因(*csr1-2*)。

抗2,4-D的基因有2种,涉及抗除草剂独立转化事件4个和3种作物(棉花、大豆和玉米)。2种基因分别是来源于代尔夫特食酸菌(*Delftia acidovorans*)的芳氧基链烷酸酯双加氧酶12蛋白(aryloxyalkanoate di-oxygenase 12 protein)基因(*aad-12*)和来源于鞘氨醇杆菌(*Sphingobium herbicidovorans*)的芳氧基链烷酸酯双加氧酶1蛋白(aryloxyalkanoate di-oxygenase 1 protein)基因(*aad-1*)。

抗异噁唑草酮基因有1种,涉及的抗除草剂转基因大豆转化事件有1个。该基因来源于荧光假单胞菌菌株 A32(*Pseudomonas fluorescens* strain A32)的改良对羟苯基丙酮酸双加氧酶(modified p-hydroxyphenylpyruvate dioxygenase enzyme)基因(*hppdPF W336*)。

抗麦草畏基因来源于嗜麦芽寡养单胞菌菌株 DI-6(*Stenotrophomonas maltophilia* strain DI-6)的麦草畏单加氧酶(dicamba mono-oxygenase enzyme)基因(*dmo*)。3个转化事件和3种作物(棉花,大豆和玉米)涉及该基因。

抗磺酰脲类除草剂的基因有3种,包括来源于大豆的改良乙酰乳酸合成酶(modified acetolactate synthase enzyme)基因(*gm-hra*);来源于玉米的突变乙酰乳酸合成酶(acetolactate synthase enzyme)基因(*zm-hra*)和来源于烟草(*Nicotiana tabacum* cv. Xanthi)的突变乙酰乳酸合酶基因(*S4-HrA*)。这3种基因涉及到的抗除草剂转化事件有3个,涉及棉花、大豆和玉米3种作物。

抗硝磺草酮的基因包括来源于燕麦(*Avena sativa*)的对羟基苯丙酮酸双加氧酶(P-hydroxyphenylpyruvate dioxygenase)基因(*avhppd-03*)。该基因仅应用于1个抗除草剂转基因大豆独立转化事件中。

抗溴苯腈的基因包括来源于肺炎克雷伯氏菌亚种(*Klebsiella pneumoniae* subsp. *ozaenae*)的腈水解酶(nitrilase enzyme)基因(*bxn*)。9个抗除草剂转基因棉花转化事件和1个抗除草剂转基因油菜转化事件涉及该基因。

3 不同公司的抗除草剂转基因作物转化事件

目前抗除草剂转基因作物的公司主要有8个,分别是孟山都公司、拜耳作物科学、陶氏益农有限公司、杜邦、先正达、Genective S.A. 和美国斯泰恩种子农场股份有限公司。其中先正达的转化事件最多,高达84个,占全部抗除草剂转基因转化事件

表3 不同公司的抗除草剂转基因作物转化事件

Table 3 Events of herbicide-resistant transgenic crops from different companies

公司 Company	棉花 Cotton	大豆 Soybean	油菜 Canola	玉米 Maize	总计 Total
先正达 Syngenta	0	0	0	84	84
孟山都公司 Monsanto Company (including fully and partly owned companies)	21	11	4	40	76
拜耳作物科学 Bayer CropScience (including fully and partly owned companies)	11	9	24	3	47
杜邦 DuPont (Pioneer Hi-Bred International Inc.)	1	2	4	28	35
陶氏益农有限公司 Dow AgroSciences LLC	3	4	0	24	31
巴斯夫公司 Badische Anilin-und-Soda-Fabrik (BASF)	0	1	0	0	1
美国斯泰恩种子农场股份有限公司 Stine Seed Farm Inc (USA)	0	0	0	1	1
Genective S.A.	0	0	0	1	1
孟山都公司与陶氏益农有限公司 Monsanto Company and Dow AgroSciences LLC	2	0	0	10	12
陶氏益农有限公司与杜邦	0	0	0	7	7
Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)					
先正达与孟山都公司 Syngenta and Monsanto Company	1	0	0	1	2
孟山都公司与巴斯夫公司 Monsanto and BASF	0	0	0	1	1
孟山都公司与拜耳作物科学 Monsanto Company and Bayer CropScience	0	0	0	1	1
拜耳作物科学和先正达 Bayer CropScience and Syngenta	0	1	0	0	1
合计 Total	39	28	32	201	300

的28%，但该公司转化事件所涉及的作物仅有玉米，较为单一。其次是孟山都公司，拥有76个抗除草剂转化事件，占全部抗除草剂转基因转化事件的25.67%，所涉及的作物有棉花、大豆、油菜和玉米。另外是拜耳作物科学、杜邦和陶氏益农有限公司，它们的抗除草剂转化事件分别为：47个、35个和31个。巴斯夫公司、Genective S.A. 和美国斯泰恩种子农场股份有限公司都只有1个。其中拜耳作物科学和杜邦的抗除草剂转化事件均涉及了棉花、大豆、油菜和玉米这四种作物；陶氏益农公司涉及了棉花、大豆和玉米；巴斯夫公司仅涉及了大豆；Genective S.A. 和美国斯泰恩种子农场股份有限公司仅涉及了玉米。

另外，两家公司联合开发的转化事件有23个，占全部抗除草剂转化事件的7.67%。其中，包括孟山都公司与巴斯夫公司共有1个抗除草剂玉米转化事件；先正达与孟山都公司共有1个抗除草剂棉花转化事件和1个抗除草剂玉米转化事件；孟山都公司与陶氏益农公司共有10个抗除草剂玉米转化事件；陶氏益农公司与杜邦共有8个抗除草剂玉米转化事件；孟山都公司与拜耳作物科学的1个抗除草剂玉米转化事件；拜耳作物科学和先正达共有1个抗除草剂大豆转化事件。

4 我国抗除草剂转基因作物发展现状及建议

4.1 我国抗除草剂转基因作物的发展现状

目前国内研发的抗除草剂转基因作物主要是单一抗草甘膦性状，其次是抗草铵膦性状；另外还有抗咪唑啉酮类、磺酰脲类和溴苯腈的性状。

我国科研工作者已经获得一批稳定表达的单抗除草剂和具有抗虫抗除草剂复合性状的转基因棉花新材料。中山大学生物防治国家重点实验室及河南师范大学生命科学学院等单位将抗草甘膦突变基因5-烯醇丙酮酸莽草酸-3-磷酸合成酶M12(5-enolpyruvylshikimate-3-phosphate synthetase M12, *aroAM12*)导入到棉花中，获得了抗草甘膦的再生植株，并通过Southern及Western试验验证了该基因的导入，转化株对草甘膦具有很高的抗性(谢龙旭等, 2004)。刘锡娟等(2007)通过花粉管通道法转化棉花，获得了3株具有草甘膦抗性的转基因植株。冯艳(2009)以百棉1号为受体，通过农杆菌侵染棉花茎尖，获得了抗草铵膦转基因棉花植株。中国农

业科学院棉花研究所构建了含有从高抗草甘膦的棉花突变株中克隆的*epsps*基因的植物表达载体，为进一步在棉花中转化奠定了基础(孙豹, 2014)。王霞等(2014)通过农杆菌介导法成功将G10-5-烯醇丙酮酸莽草酸-3-磷酸合成酶(G10-5-enolpyruvylshikimate-3-phosphate synthetase)基因(*G10aroA*)转入棉花。中国农业科学院生物技术研究所郭三堆研究团队获得了转基因抗草甘膦抗虫棉花材料，并已经进入环境释放阶段(郭三堆等, 2015)。

中国农科院作物研究所研发的来自于可变盐单胞菌(*Halomonas variabilis*)的G2-5-烯醇丙酮酸莽草酸-3-磷酸合成酶(G2-5-enolpyruvylshikimate-3-phosphate synthetase)的基因(*G2-aroA*)、甘氨酸-N酰基转移酶(*glycine-N-acyltransferase*)基因(*gat*)已经转入大豆中(邱丽娟等, 2017)。中国农科院作物研究所成功将抗草甘膦基因*aroA*和N-乙酰转移酶*gat*基因转入大豆中(荣非等, 2015)。中国农科院生物技术研究所于2015年申请了一种抗草甘膦转基因大豆及其制备方法和应用的专利，所转基因也是拥有自主知识产权的*aroA*基因以及草甘膦N-乙酰转移酶*gat*基因(邱丽娟等, 2015)。韩强(2015)利用农杆菌介导的大豆子叶节遗传转化方法，获得了携带草甘膦抗性基因*g10-epsps*和抗虫*Bt*基因的大豆转化植株。

中国科学院微生物研究所将抗溴苯腈基因*bxn*导入油菜，获得了抗溴苯腈转基因油菜(钟蓉等, 1997)。江苏省农业科学院筛选到了自然突变的咪唑啉酮类除草剂的甘蓝型油菜，把突变基因的核酸序列，命名为*BnALS1R*基因，应用杂交、回交植物常规育种方法将该基因导入其他油菜品种或品系，提高了目标品种或品系对抗咪唑啉酮类除草剂的耐受性。还以甘蓝型油菜抗磺酰脲类除草剂突变体为材料，获得突变体中的抗性基因，命名为*BnALS3R*基因，利用构建的植物表达载体将该基因导入无抗性的植物中，可提高转基因植物对磺酰脲类除草剂的抗性(浦惠明等, 2010; 胡茂龙等, 2013)。沈志成和高建华(2011)从耐辐射奇球菌(*Deinococcus radiodurans* R1)中分离出的Dein R1 EPSP合酶基因*G7*，并将经过人工改造得到的基因*G10*导入油菜，获得对草甘膦的抗性。

中国农业大学对*cp4 epsps*的密码子及编码框进行了改造，同时在优化后的*epsps*基因5'端增加了一个来源于高粱的叶绿体转运肽，整合了叶绿体信

号肽并经过密码子优化的基因命名为 *CC-MEP-SPS*, 将该基因转入玉米中, 获得了有自主知识产权的转基因抗草甘膦玉米 *CC-2* (赖锦盛等, 2012)。北京大北农科技集团股份有限公司研发的抗草甘膦和草铵膦的双抗转基因玉米 *DBN9877*, 抗草甘膦基因 5-烯醇丙酮酸莽草酸 3-磷酸合酶基因 (*epsps*) 是从土壤农杆菌菌株中分离得到的, 且可以通过优化密码子或者以其他方式改变编码; 抗草铵膦基因是膦丝菌素 N-乙酰基转移酶基因 (*pat*) (康越景等, 2015)。孙越等 (2015) 通过农杆菌介导的玉米茎尖遗传转化法将 5-烯醇式丙酮酸莽草酸-3-磷酸合酶基因 (5-enolpyruvyl-shikimate-3-phosphate synthase, *epsps*) 和杀虫蛋白基因 (*Bt*) *cryIACM* 转入了玉米, 并通过分子检测、草甘膦抗性筛选和田间接种亚洲玉米螟 (*Ostrinia furnacalis* (Guenée)) 试验筛选出了遗传稳定且抗亚洲玉米螟、抗除草剂草甘膦的转基因玉米株系。北京市农林科学院将玉米核酮糖二磷酸羧化酶小链基因 (ribulose biphosphate carboxylase small chain, *RBCS*) 叶绿体引导肽与 GenBank: GM718572.1 的 *epsps* 基因融合, 获得了融合序列的优化基因 *G23V-epsps*, 将该基因转入玉米中获得了具有高抗草甘膦特性的玉米品种 (姜志军等, 2016)。

4.2 我国抗除草剂转基因作物的研发策略

4.2.1 着重开发来源于植物的抗除草剂基因的转化事件

目前, 全球抗除草剂转基因棉花、大豆、油菜和玉米独立转化事件中所涉及的抗除草剂基因有 19 种, 基因来源于 16 种生物, 对 9 种 (类) 除草剂有抗性。其中微生物来源有 11 种, 涉及的抗除草剂基因有 12 种; 植物来源有 5 种, 涉及的抗除草剂基因有 8 种。在我国, 抗除草剂转基因作物的性状主要是抗草甘膦, 且主要来源于微生物。与微生物来源的抗草甘膦基因相比, 植物中有丰富的除草剂抗性基因和除草剂代谢基因资源, 因此建议着重开发来源于植物的抗除草剂基因转化事件。

4.2.2 加强培育转抗草铵膦基因及其他除草剂基因的转化事件

目前国际上抗草铵膦的棉花、大豆、油菜和玉米转化事件分别为 18、13、21 和 169 个, 占该类作物抗除草剂转化事件的 46.15%、46.42%、65.62% 和 84.08%。在我国, 尚未见报道有自主知识产权的抗

草铵膦基因的转化事件, 因此应加强抗草铵膦转化事件的培育, 这是由于草铵膦具有杀草谱广、低毒、活性高、在土壤中易降解、对作物安全、漂移小、用量少、环境相容性好和杀草迅速等特点。另外应加大培育抗其他除草剂的基因事件, 如抗 2,4-D、硝磺草酮、溴苯腈以及异噁唑草酮的转化事件。

4.2.3 加强培育多抗除草剂及复合性状的转化事件

随着转基因技术的发展, 多抗及复合性状的转基因作物的研发日益受到人们的重视, 通过 ISAAA 的数据可以看出, 目前国际上多抗除草剂转化事件在棉花、大豆、油菜和玉米中分别为 3、9、1 和 4 个, 占该类作物总抗除草剂转化事件的 7.69%、32.14%、3.12% 和 2%; 复合性状的转化事件分别为 26、9、21 和 186 个, 占该类作物总抗除草剂转化事件的 66.67%、32.14%、65.62% 和 92.54%。单一抗除草剂的作物在长期使用目标除草剂后, 田间杂草产生抗药性的可能性将大大增加, 那么该抗除草剂作物也将失去应用的价值。与抗单一除草剂的转基因作物相比, 具有双抗甚至多抗除草剂的转基因作物可以轮换除草剂的使用, 避免抗性杂草产生, 因此建议培育抗两种以上除草剂的转化事件, 另外还建议培育抗除草剂和抗虫的复合性状的转化事件, 提高转基因作物的经济价值和生态效益。

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附表 1~附表 5 见“《农业生物技术学报》官方网站”及“中国知网”本文数字版论文

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附表 1 39 个独立及非独立抗除草剂转基因棉花转化事件

Schedule 1 39 independent and non-independent herbicide tolerance transgenic cotton events

目标性状 Target traits	基因 Gene	基因来源 Gene source	产物及作用机制 Product and function	事件 Event	开发机构 Developer
抗磺酰脲类 Sulfonylurea herbicide tolerance	<i>S4-HrA</i>	烟草 <i>Nicotiana tabacum</i> cv. Xanthi	耐除草剂的乙酰乳酸合成酶 (ALS) Herbicide tolerant acetolactate synthase (ALS) enzyme 可使植物在磺酰脲类除草剂作用下合成必需氨基酸 Allows the plant to synthesize essential amino acids in the presence of sulfonylurea herbicides	19-51a	杜邦(先锋良种国际有限公司) DuPont (Pioneer Hi-Bred International Inc.)
抗溴苯腈 Oxynil tolerance	<i>bxn</i>	肺炎克雷伯氏菌亚种 <i>Klebsiella pneumoniae</i> subsp. <i>Ozaenae</i>	腈水解酶 Nitrilase enzyme 消除溴苯腈的除草活性 Eliminates herbicidal activity of oxynil herbicides	31707 31803 (BXN™ Plus Bollgard™ Cotton)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>Kurstaki</i> strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	31807 (BXN™ Plus Bollgard™ Cotton) 31808 (BXN™ Plus Bollgard™ Cotton)	
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection	42317 (BXN™ Plus Bollgard™ Cotton)	
抗 2,4-D	<i>aad-12</i>	代尔夫特食酸菌	芳氧基链烷酸酯二加氧酶 12 (AAD-12) 蛋白	81910	陶氏益农有限公

2,4-D tolerance 抗草铵膦 Glufosinate tolerance	<i>pat</i>	<i>Delftia acidovorans</i> 绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 催化 2,4-D 除草剂的侧链降解 Catalyzes the side chain degradation of 2,4-D herbicide 膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		司 Dow AgroSciences LLC
抗溴苯腈 Oxynil tolerance	<i>bxn</i>	肺炎克雷伯氏菌亚种 <i>Klebsiella pneumoniae</i> subsp. <i>Ozaenae</i>	腈水解酶 Nitrilase enzyme 消除溴苯腈的除草活性 Eliminates herbicidal activity of oxynil herbicides	BXN10211(10211) (BXN™ Cotton) BXN10215(10215) (BXN™ Cotton) BXN10222(10222) (BXN™ Cotton) BXN10224(10224) (BXN™ Cotton)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	GHB119	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ae</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>dakota</i>	<i>cry2Ae</i> δ-内毒素 <i>cry2Ae</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		

抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力, 从而增加对草甘膦除草剂的耐受性 decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide	GHB614 (GlyTol™)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	LLCotton25 (Fibermax™ Liberty Link™)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON1445 (Roundup Ready™ Cotton) MON1698 (Roundup Ready™ Cotton)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗生素抗性 Antibiotic resistance	<i>aad</i>	大肠杆菌 <i>Escherichia coli</i>	3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 耐氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin		

抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽寡养单胞菌菌株 DI-6 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 在酶反应中用麦草畏作为底物而具有对除草剂麦草畏（2-甲氧基-3,6-二氯苯甲酸）的耐受性 Confers tolerance to the herbicide dicamba (2-Methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction	MON88701	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合成酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力，从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON88913 (Roundup Ready™ Flex™ Cotton)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ab</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i>	Ry1Abδ-内毒素 cry1Ab delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	T303-3 T304-40	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性		
抗鳞翅目昆虫 Lepidopteran insect	<i>cry1F</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i>	cry1Fδ-内毒素 cry1F delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对	281-24-236× 3006-210-23× COT102×81910	陶氏益农有限公司 Dow AgroSciences

resistance			鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		LLC
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 <i>HD73</i> <i>Bacillus.thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗草铵膦 Glufosinate tolerance	<i>pat (syn)</i>	绿色产色链霉菌 <i>Dreptomyces</i> <i>viridochromogenes</i> strain Tu 494	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(<i>pat</i>) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>vip3A(a)</i>	苏云金芽孢杆菌 <i>AB88</i> <i>Bacillus thuringiensis</i> strain <i>AB88</i>	<i>VIP3A</i> 植物性杀虫蛋白 <i>VIP3A</i> vegetative insecticidal protein 通过选择性地破坏鳞翅目昆虫的中肠粘膜破坏进食 而赋予对鳞翅目昆虫抗性 Confers resistance to feeding damage caused by lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>aph4 (hpt)</i>	大肠杆菌 <i>Escherichia coli</i>	潮霉素-B 磷酸转移酶（ <i>hph</i> ）酶 Hygromycin-B phosphotransferase (<i>hph</i>) enzyme 对抗生素潮霉素 B 的抗性 Allows selection for resistance to the antibiotic hygromycin B		
抗 2,4-D 除草	<i>aad-12</i>	代尔夫特食酸菌	芳氧基链烷酸酯二加氧酶 12（ <i>AAD-12</i> ）		

剂 2,4-D tolerance		<i>Delftia acidovorans</i>	Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 催化 2,4-D 除草剂的侧链降解 Catalyzes the side chain degradation of 2,4-D herbicide		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草 剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	3006-210-23× 281-24-236× MON1445 (WideStrike™ Roundup Ready™ Cotton)	孟山都公司和陶 氏益农有限公司 Monsanto Company and Dow AgroSciences LLC
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cryIF</i>	苏云金芽孢杆菌变种 <i>Bacillus thuringiensis var. aizawai</i>	<i>cry1Fδ</i> -内毒素 <i>cry1F delta-endotoxin</i> 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cryIAc</i>	苏云金芽孢杆菌 Kurstaki 菌 株 HD73 <i>Bacillus thuringiensis subsp. kurstaki strain HD73</i>	<i>cry1Acδ</i> -内毒素 <i>cry1Ac delta-endotoxin</i> 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗草铵膦	<i>bar</i>	吸水链霉菌	膦丝菌素 N-乙酰转移酶		

Glufosinate tolerance		<i>Streptomyces hygroscopicus</i>	Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 antibiotics Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗生素抗性 Antibiotic resistance	<i>aad</i>	大肠杆菌 <i>Escherichia coli</i>	3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	3006-210-23 × 281-24-236 × MON88913 (Widestrike™ Roundup Ready Fle ×™ Cotton)	孟山都公司和陶氏益农有限公司 Monsanto Company and Dow AgroSciences LLC
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cryIF</i>	苏云金芽孢杆菌变种 <i>Bacillus thuringiensis</i> var. <i>aizawai</i>	<i>cry1Fδ</i> -内毒素 <i>cry1F delta</i> -endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫	<i>cryIAc</i>	苏云金芽孢杆菌 Kurstaki	<i>cry1Acδ</i> -内毒素		

<p>Lepidopteran insect resistance</p> <p>抗草铵膦 Glufosinate tolerance</p>	<p><i>bar</i></p>	<p>菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73</p> <p>吸水链霉菌 <i>Streptomyces hygroscopicus</i></p>	<p>cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p> <p>膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation</p>		
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<p><i>cry1Ac</i></p>	<p>苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73</p>	<p>cry1Acδ-内毒素 cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>	<p>3006-210-23 × 281-24-236 × MON88913 × COT102</p>	<p>陶氏益农有限公司 Dow AgroSciences LLC</p>
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<p><i>vip3A(a)</i></p>	<p>苏云金芽孢杆菌 AB88 <i>Bacillus thuringiensis</i> strain AB88</p>	<p>VIP3A 植物性杀虫蛋白 VIP3A vegetative insecticidal protein 通过选择性地破坏鳞翅目昆虫的中肠粘膜破坏进食而赋予对鳞翅目昆虫抗性 Confers resistance to feeding damage caused by lepidopteran insects by selectively damaging their midgut lining</p>	<p>(Widestrike™ × Roundup Ready Fle×™ × VICOT™ Cotton)</p>	
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<p><i>cry1F</i></p>	<p>苏云金芽孢杆菌变种 <i>Bacillus thuringiensis</i> var. <i>aizawai</i></p>	<p>cry1Fδ-内毒素 cry1F delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>		
<p>抗生素抗性 Antibiotic</p>	<p><i>aph4 (hpt)</i></p>	<p>大肠杆菌</p>	<p>潮霉素-B 磷酸转移酶 (hph) 酶 Hygromycin-B phosphotransferase(hph) enzyme</p>		

resistance 抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	<i>Escherichia coli</i> 根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	对抗生素潮霉素 B 的抗性 Allows selection for resistance to the antibiotic hygromycin B 5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草 剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces</i> <i>viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by		
抗溴苯腈 Oxynil tolerance	<i>Bxn</i>	肺炎克雷伯氏菌亚种 <i>Klebsiella pneumoniae</i> subsp. <i>ozaenae</i>	腈水解酶 Nitrilase enzyme 消除溴苯腈除草剂的除草活性 (如溴苯腈) Eliminates herbicidal activity of oxynil herbicides (eg. Bromoxynil)	31807 × 31808	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗草甘膦 Glyphosate	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS)	COT102 × COT67B ×	先正达和孟山都 公司公司

tolerance)	strain CP4	enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON88913 (VIPCOT™ Roundup Ready FleX™ Cotton)	Syngenta and Monsanto Company
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>vip3A(a)</i>	苏云金芽孢杆菌 <i>AB88</i> <i>Bacillus thuringiensis</i> strain AB88	VIP3A 植物性杀虫蛋白 VIP3A vegetative insecticidal protein 通过选择性地破坏鳞翅目昆虫的中肠粘膜破坏进食而赋予对鳞翅目昆虫的抗性 Confers resistance to feeding damage caused by lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ab</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Acδ</i> -内毒素 <i>cry1Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>aph4 (hpt)</i>	大肠杆菌 <i>Escherichia coli</i>	潮霉素-B 磷酸转移酶 (hph) 酶 Hygromycin-B phosphotransferase(hph) enzyme 对抗生素潮霉素 B 的抗性 Allows selection for resistance to the antibiotic hygromycin B		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>)	根癌农杆菌菌株 <i>CP4</i> <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby	COT102 × MON15985 × MON88913 (Bollgard® III × Roundup Ready™ FleX™)	孟山都公司 Monsanto Company (including fully and partly owned companies)

抗鳞翅目昆虫 Lepidopteran insect resistance	<i>vip3A(a)</i>	苏云金芽孢杆菌 AB88 <i>Bacillus thuringiensis</i> strain AB88	conferring increased tolerance to glyphosate herbicide VIP3A 植物性杀虫蛋白 VIP3A vegetative insecticidal protein 通过选择性地破坏鳞翅目昆虫的中肠粘膜破坏进食 而赋予对鳞翅目昆虫抗性 Confers resistance to feeding damage caused by lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>aph4 (hpt)</i>	大肠杆菌 <i>Escherichia coli</i>	潮霉素-B 磷酸转移酶 (hph) 酶 Hygromycin-B phosphotransferase(hph) enzyme 对抗生素潮霉素 B 的抗性 Allows selection for resistance to the antibiotic hygromycin B		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>Kumamotoensis</i>	<i>cry2Ab</i> δ-内毒素 <i>cry2Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme		

<p>resistance</p> <p>抗生素抗性 Antibiotic resistance</p> <p>抗生素抗性 Antibiotic resistance</p>	<p><i>aad</i></p> <p><i>uidA</i></p>	<p>transposon</p> <p>大肠杆菌 <i>Escherichia coli</i></p> <p>大肠杆菌 <i>Escherichia coli</i></p>	<p>可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection 3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin</p> <p>β-D-葡糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进 行筛选 Produces blue stain on treated transformed tissue, which allows visual selection</p>		
<p>抗草甘膦 Glyphosate tolerance</p> <p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<p><i>cp4 epsps</i> (<i>aroA:CP4</i>)</p> <p><i>vip3A(a)</i></p>	<p>根癌农杆菌菌株 <i>CP4</i> <i>Agrobacterium tumefaciens</i> strain CP4</p> <p>苏云金芽孢杆菌 AB88 <i>Bacillus thuringiensis</i> strain AB88</p>	<p>5-烯醇丙酮尿嘧啶-3-磷酸合成酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草 剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide</p> <p>VIP3A 植物性杀虫蛋白 VIP3A vegetative insecticidal protein 通过选择性地破坏鳞翅目昆虫的中肠粘膜破坏进食 而赋予对鳞翅目昆虫抵抗 Confers resistance to feeding damage caused by lepidopteran insects by selectively damaging their midgut lining</p> <p>潮霉素-B 磷酸转移酶 (hph) 酶</p>	<p>COT102 × MON15985 × MON88913 × MON88701 (n/a)</p>	<p>孟山都公司 Monsanto Company (including fully and partly owned companies)</p>

抗生素抗性 Antibiotic resistance	<i>aph4</i> (<i>hpt</i>)	大肠杆菌 <i>Escherichia coli</i>	Hygromycin-B phosphotransferase(hph) enzyme 对抗生素潮霉素 B 的抗性 Allows selection for resistance to the antibiotic hygromycin B		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i>	<i>cry2Ab</i> δ-内毒素 <i>cry2Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗生素抗性 Antibiotic resistance	<i>aad</i>	大肠杆菌 <i>Escherichia coli</i>	3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin		
抗生素抗性 Antibiotic	<i>uidA</i>	大肠杆菌 <i>Escherichia coli</i>	B-D-葡萄糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进		

resistance			行筛选 Produces blue stain on treated transformed tissue, which allows visual selection		
抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba(2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力, 从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide	GHB614 × LLCotton25 (GlyTol™ Liberty Link™)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		

抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	GHB614 × LLCotton25 × MON15985	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>Kumamotoensis</i>	<i>cry2Ab</i> δ-内毒素 <i>cry2Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对 鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力，从而增加对草甘膦除草 剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素		

<p>抗生素抗性 Antibiotic resistance</p>	<i>aad</i>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection</p> <p>3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin</p>		
<p>抗生素抗性 Antibiotic resistance</p>	<i>uidA</i>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>B-D-葡糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进行筛选 Produces blue stain on treated transformed tissue, which allows visual selection</p>		
<p>抗草甘膦 Glyphosate tolerance</p>	<i>2mepsps</i>	<p>玉米 <i>Zea mays</i></p>	<p>5-烯醇丙酮酸莽草酸-3-磷酸合酶 (双突变型) 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力, 从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide</p>	<p>GHB614 × T304-40 × GHB119 (GlytoI™ × Twinlink™)</p>	<p>拜耳作物科学 Bayer CropScience (including fully and partly owned companies)</p>
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<i>cry1Ab</i>	<p>苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i></p>	<p>cry1Abδ-内毒素 cry1Ab delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>		
<p>抗鳞翅目昆虫 Lepidopteran</p>	<i>cry2Ae</i>	<p>苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp.</p>	<p>cry2Aeδ-内毒素 cry2Ae delta-endotoxin</p>		

insect resistance 抗草铵膦 Glufosinate tolerance	<i>bar</i>	<i>dakota</i> 吸水链霉菌 <i>Streptomyces hygrosopicus</i>	通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining 膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力，从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide	GHB614 × T304-40 × GHB119 × COT102 (Glytol™ × Twinlink™ × VICOT™ Cotton)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ab</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. kurstak	<i>cry1Ab</i> δ-内毒素 <i>cry1Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ae</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. Dakota	<i>cry2Ae</i> δ-内毒素 <i>cry2Ae</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		

抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>vip3A(a)</i>	苏云金芽孢杆菌 AB88 <i>Bacillus thuringiensis</i> strain AB88	VIP3A 植物性杀虫蛋白 VIP3A vegetative insecticidal protein 通过选择性地破坏鳞翅目昆虫的中肠粘膜破坏进食而赋予对鳞翅目昆虫抗性 Confers resistance to feeding damage caused by lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>aph4 (hpt)</i>	大肠杆菌 <i>Escherichia coli</i>	潮霉素-B 磷酸转移酶 (hph) 酶 Hygromycin-B phosphotransferase(hph) enzyme 对抗生素潮霉素 B 的抗性 Allows selection for resistance to the antibiotic hygromycin B		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	LLCotton25 × MON15985 (Fiberma × TM Liberty Link TM Bollgard II TM)	拜耳作物科学 (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	cry1Acδ-内毒素 cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		

抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i>	<i>cry2Abδ</i> -内毒素 <i>cry2Ab delta-endotoxin</i> 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗生素抗性 Antibiotic resistance	<i>uidA</i>	大肠杆菌 <i>Escherichia coli</i>	β -D-葡糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进行筛选 Produces blue stain on treated transformed tissue, which allows visual selection		
抗生素抗性 Antibiotic resistance	<i>aad</i>	大肠杆菌 <i>Escherichia coli</i>	3“(9) -O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin		

抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON15985 × MON1445 (Roundup Ready™ Bollgard II™ Cotton)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i>	<i>cry2Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>uidA</i>	大肠杆菌 <i>Escherichia coli</i>	β-D-葡糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进行筛选 Produces blue stain on treated transformed tissue, which allows visual selection		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 Allows transformed plants to metabolize neomycin and		

<p>抗生素抗性 Antibiotic resistance</p>	<p><i>aad</i></p>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>kanamycin antibiotics during selection 3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin</p>		
<p>抗草甘膦 Glyphosate tolerance</p>	<p><i>cp4 epsps (aroA:CP4)</i></p>	<p>根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4</p>	<p>5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide</p>	<p>MON531 × MON1445 (Roundup Ready™ Bollgard™ Cotton)</p>	<p>孟山都公司 Monsanto Company (including fully and partly owned companies)</p>
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<p><i>cry1Ac</i></p>	<p>苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73</p>	<p>cry1Acδ-内毒素 cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>		
<p>抗生素抗性 Antibiotic resistance</p>	<p><i>nptII</i></p>	<p>大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon</p>	<p>新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection</p>		
<p>抗生素抗性 Antibiotic resistance</p>	<p><i>aad</i></p>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside</p>		

			antibiotics such as spectinomycin and streptomycin		
抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction	MON88701 × MON88913	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygrosopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	根癌农杆菌菌株 <i>CP4 Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		

抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction	MON88701 × MON88913 × MON15985	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力，从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	cry1Ac δ -内毒素 cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素抗生素		

<p>resistance</p> <p>抗生素抗性 Antibiotic resistance</p>	<p><i>aad</i></p>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection</p> <p>3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin</p>		
<p>抗生素抗性 Antibiotic resistance</p>	<p><i>uidA</i></p>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>B-D-葡糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进行筛选 Produces blue stain on treated transformed tissue, which allows visual selection</p>		
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<p><i>cry2Ab2</i></p>	<p>苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i></p>	<p>cry2Abδ-内毒素 cry2Ab delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>		

抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	根癌农杆菌菌株 <i>CP4</i> <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON88913 × MON15985 (Roundup Ready™ Fle×™ Bollgard II™ Cotton)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i>	<i>cry2Abδ</i> -内毒素 <i>cry2Ab delta</i> -endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 <i>Kurstaki</i> 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	<i>cry1Acδ</i> -内毒素 <i>cry1Ac delta</i> -endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>uidA</i>	大肠杆菌 <i>Escherichia coli</i>	β-D-葡萄糖苷酸酶 (GUS) 酶 Beta-D-glucuronidase (GUS) enzyme 在经处理的转化组织上产生蓝色, 可以用肉眼观察进行筛选 Produces blue stain on treated transformed tissue, which allows visual selection		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichia coli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and		

<p>抗生素抗性 Antibiotic resistance</p>	<i>aad</i>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>kanamycin antibiotics during selection 3“(9)-O-氨基糖苷腺苷酰基转移酶 3“(9)-O-aminoglycoside adenylyltransferase enzyme 抗氨基糖苷类抗生素如奇霉素和链霉素 Allows selection for resistance to aminoglycoside antibiotics such as spectinomycin and streptomycin</p>		
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<i>cry1Ab</i>	<p>苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kurstak</i></p>	<p><i>cry1Ab</i>δ-内毒素 <i>cry1Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>	<p>T304-40 × GHB119 (TwinLink™ Cotton)</p>	<p>拜耳作物科学 Bayer CropScience (including fully and partly owned companies)</p>
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p>	<i>cry2Ae</i>	<p>苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>Dakota</i></p>	<p><i>cry2Ae</i>δ-内毒素 <i>cry2Ae</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p>		
<p>抗草铵膦 Glufosinate tolerance</p>	<i>bar</i>	<p>吸水链霉菌 <i>Streptomyces hygroscopicus</i></p>	<p>膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation</p>		

附表 2 28 个独立及非独立抗除草剂转基因大豆转化事件

Schedule 2 28 independent and non-independent herbicide tolerance transgenic soybeans events

目标性状 Target traits	基因 Gene	基因来源 Gene source	产物及作用机制 Product and function	事件 Event	开发机构 Developer
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON89788 (Genuity® Roundup Ready 2 Yield™) GTS40-3-2(401-3-2) (Roundup Ready™ soybean)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby	MON87705 (Vistive Gold™)	孟山都公司 Monsanto Company (including fully and partly owned companies)

<p>改性油/脂肪酸 Modified oil/ fatty acid</p>	<p><i>fat1-A</i> (<i>sense and antisense segments</i>)</p>	<p>大豆 <i>Glycine max</i></p>	<p>conferring increased tolerance to glyphosate herbicide</p> <p>产生非功能性酶（通过 RNA 干扰抑制 FATB 酶或酰基-酰基载体蛋白硫酯酶的产生） No functional enzyme is produced (production of FATB enzymes or acyl-acyl carrier protein thioesterases is suppressed by RNA interference)</p> <p>降低饱和脂肪酸向质体外的转运,从而提高它们的去饱和作用,降低饱和脂肪酸的水平并提高 18: 1 油酸的水平 Decreases the transport of saturated fatty acids out of the plastid, thereby increasing their availability to desaturation to 18:1 oleic acid; reduces the levels of saturated fatty acids and increases the levels of 18:1 oleic acid</p>		
<p>改性油/脂肪酸 Modified oil/ fatty acid</p>	<p><i>fad2-1A</i> (<i>sense and antisense</i>)</p>	<p>大豆 <i>Glycine max</i></p>	<p>产生非功能性酶（通过 RNA 干扰抑制 Δ-12 去饱和酶的产生） No functional enzyme is produced (production of delta-12 desaturase enzyme is suppressed by RNA interference)</p> <p>降低 18:1 油酸的去饱和作用到 18:2 亚油酸; 增加单不饱和油酸的水平并降低种子中饱和脂肪亚油酸的水平 Reduces desaturation of 18:1 oleic acid to 18:2 linoleic acid; increases the levels of monounsaturated oleic acid and decreases the levels of saturated linoleic acid in the seed</p>		
<p>抗草铵膦 Glufosinate tolerance</p>	<p><i>pat</i></p>	<p>绿色产色链霉菌 <i>Streptomyces viridochromogenes</i></p>	<p>膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性</p>	<p>A2704-12 A2704-21 A5547-127</p>	<p>拜耳作物科学 Bayer CropScience (including fully</p>

			Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	A5547-35 Liberty Link™ soybean	and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	GU262 Liberty Link™ soybean	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗生素抗性 Antibiotic resistance	<i>bla</i>	大肠杆菌 <i>Escherichia coli</i>	β-内酰胺酶 Beta lactamase enzyme 解除 β-内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	W62 W98 Liberty Link™ soybean	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗咪唑啉酮类 Sulfonylurea herbicide tolerance	<i>csr1-2</i>	拟南芥 <i>Arabidopsis thaliana</i>	改良乙酰乳酸合成酶大亚基 Modified acetohydroxyacid synthase large subunit 对咪唑啉酮除草剂产生抗性 Confers tolerance to imidazolinone herbicides	CV-127 Cultivance	巴斯夫 BASF
抗 2,4-D 2,4-D tolerance	<i>aad-12</i>	代尔夫特食酸菌 <i>Delftia acidovorans</i>	芳氧基链烷酸酯双加氧酶蛋白 12 (AAD-12) Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 催化 2, 4-D 侧链降解 Catalyzes the side chain degradation of 2,4-D herbicide	DAS68416-4 Enlist™ Soybean	陶氏益农有限公司 Dow AgroSciences LLC
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		

抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 降低对草甘膦的结合亲和力, 从而增加对草甘膦除草剂的耐受性 Catalyzes the side chain degradation of 2,4-D herbicide	FG72 (FGØ72-2, FGØ72-3)	拜耳作物科学 Bayer CropScience and MS Technologies LLC
抗异恶唑草酮 Isoxaflutole tolerance	<i>hppdPF W336</i>	荧光假单胞菌菌株 A32 <i>Pseudomonas fluorescens</i> strain A32	改良的对羟苯基丙酮酸双加氧酶 Modified p-hydroxyphenylpyruvate dioxygenase (hppd) enzyme 通过降低除草剂生物反应的特异性而增强除草剂抗性 Confers tolerance to HPPD-inhibiting herbicides (such as isoxaflutole) by reducing the specificity for the herbicide's bioactive constituent		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i>	根癌农杆菌 CP4 菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON87708 Genuity® Roundup Ready™ 2 Xtend™	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 在酶反应中用麦草畏作为底物而具有对除草剂麦草畏（2-甲氧基-3,6-二氯苯甲酸）的耐受性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction		
抗磺酰脲类 Sulfonylurea herbicide	<i>gm-hra</i>	大豆 <i>Glycine max</i>	改良乙酰乳酸合成酶（ALS） Modified acetolactate synthase (ALS) enzyme 赋予磺酰脲类除草剂的应用耐受性	DP356043 (Optimum GAT™)	杜邦 DuPont (Pioneer Hi-Bred

tolerance 抗草甘膦 Glyphosate tolerance	<i>gat4601</i>	地衣芽孢杆菌 <i>Bacillus licheniformis</i>	Confers tolerance to applications of sulfonylurea – based herbicides 草甘膦 N-乙酰转移酶的酶 Glyphosate N-acetyltransferase enzyme 催化草甘膦失活，赋予草甘膦除草剂耐受性 Catalyzes the inactivation of glyphosate, conferring tolerance to glyphosate herbicides		International Inc.)
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	DAS44406-6	陶氏益农有限公司 Dow AgroSciences LLC
抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 降低对草甘膦的结合亲和力，从而增加对草甘膦除草剂的耐受性 Catalyzes the side chain degradation of 2,4-D herbicide		
抗 2,4-D 2,4-D tolerance	<i>aad-12</i>	代尔夫特食酸菌 <i>Delftia acidovorans</i>	芳氧基链烷酸酯二加氧酶 12（AAD-12）蛋白 Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 催化 2,4-D 除草剂的侧链降解 Catalyzes the side chain degradation of 2,4-D herbicide		

抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	SYHTØH2	拜耳作物科学和 先正达 Bayer CropScience and Syngenta
抗硝磺草酮 Mesotrione tolerance	<i>avhppd-03</i>	燕麦 Oat (<i>Avena sativa</i>)	对羟基苯丙酮酸双加氧酶 P-hydroxyphenylpyruvate dioxygenase 硝磺草酮除草剂耐受性 Tolerance to mesotrione herbicide		
抗 2,4-D 2,4-D tolerance	<i>aad-12</i>	代尔夫特食酸菌 <i>Delftia acidovorans</i>	芳氧基链烷酸酯二加氧酶 12 (AAD-12) 蛋白 Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 催化 2,4-D 除草剂的侧链降解 Catalyzes the side chain degradation of 2,4-D herbicide	DAS68416-4 × MON89788	陶氏益农有限公 司 Dow AgroSciences LLC
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草 剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗 2,4-D 2,4-D tolerance	<i>aad-12</i>	代尔夫特食酸菌 <i>Delftia acidovorans</i>	芳氧基链烷酸酯双加氧酶 12 (AAD-12) 蛋白 Aryloxyalkanoate di-oxygenase 12 (AAD-12) protein 催化 2,4-D 除草剂的侧链降解 Catalyzes the side chain degradation of 2,4-D herbicide	DAS81419 × DAS44406-6	陶氏益农有限公 司 Dow AgroSciences LLC

抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力, 从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. Kurstaki strain HD73	<i>cry1Ac</i> δ-内毒素 <i>cry1Ac</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1F</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> var. <i>Aizawai</i>	<i>cry1F</i> δ-内毒素 <i>cry1F</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗磺酰脲类 Sulfonylurea herbicide tolerance	<i>gm-hra</i>	大豆 <i>Glycine max</i>	改良乙酰乳酸合成酶（ALS）酶 Modified acetolactate synthase (ALS) enzyme 赋予磺酰脲类除草剂应用的耐受性 Confers tolerance to applications of sulfonylurea – based herbicides	DP305423 × GTS 40-3-2	杜邦 DuPont (Pioneer Hi-Bred International Inc.)

改性油/脂肪酸 Modified oil/ fatty acid	<i>gm-fad2-1</i> (<i>partial</i> <i>sequence</i>)	大豆 <i>Glycine max</i>	合成非功能性酶(编码 ω-6 去饱和酶的内源性 <i>fad2-1</i> 基因的表达被部分 <i>gm-fad2-1</i> 基因片段抑制) No functional enzyme is produced (expression of the endogenous <i>fad2-1</i> gene encoding omega-6 desaturase enzyme was suppressed by the partial <i>gm-fad2-1</i> gene fragment) 阻止油酸形成亚油酸(通过沉默 <i>fad2-1</i> 基因)并允许油酸在种子中的积累 Blocks the formation of linoleic acid from oleic acid (by silencing the <i>fad2-1</i> gene) and allows accumulation of oleic acid in the seed		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力,从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (双突变型) 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力,从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide	FG72 × A5547-127 (n/a)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗异恶唑草酮 Isoxaflutole tolerance	<i>hppdPF</i> W336	荧光假单胞菌菌株 A32 <i>Pseudomonas fluorescens</i> strain A32	改良的对羟苯基丙酮酸双加氧酶 Modified p-hydroxyphenylpyruvate dioxygenase (<i>hppd</i>) enzyme 通过降低除草剂生物反应的特异性而增强除草剂抗性		

抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	Confers tolerance to HPPD-inhibiting herbicides (such as isoxaflutole) by reducing the specificity for the herbicide's bioactive constituent 膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗鳞翅目昆虫 Lepidopteran insect resistance 抗草甘膦 Glyphosate tolerance	<i>cry1Ac</i> <i>cp4 epsps (aroA:CP4)</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73 根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	cry1Ac δ -内毒素 cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining 5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力,从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON87701 × MON89788 (Intacta™ Roundup Ready™ 2 Pro)	孟山都公司 Monsanto Company (including fully and partly owned companies)
改性油/脂肪酸 Modified oil/ fatty acid	<i>fad2-1A (sense and antisense)</i>	大豆 <i>Glycine max</i>	产生非功能性酶（通过 RNA 干扰抑制 Δ -12 去饱和酶的产生） No functional enzyme is produced (production of delta-12 desaturase enzyme is suppressed by RNA interference) 降低 18:1 油酸的去饱和作用到 18:2 亚油酸; 增加单不饱和油酸的水平并降低种子中饱和脂肪亚油酸的水平 Reduces desaturation of 18:1 oleic acid to 18:2 linoleic acid; increases the levels of monounsaturated oleic acid	MON87705 × MON87708	孟山都公司 Monsanto Company (including fully and partly owned companies)

<p>改性油/脂肪酸 Modified oil/ fatty acid</p>	<p><i>fat1-A</i> (<i>sense and antisense segments</i>)</p>	<p>大豆 <i>Glycine max</i></p>	<p>and decreases the levels of saturated linoleic acid in the seed</p> <p>产生非功能性酶（通过 RNA 干扰抑制 FATB 酶或酰基-酰基载体蛋白硫酯酶的产生） No functional enzyme is produced (production of FATB enzymes or acyl-acyl carrier protein thioesterases is suppressed by RNA interference)</p> <p>降低饱和脂肪酸向质体外的转运,从而提高它们的去饱和作用,降低饱和脂肪酸的水平并提高 18:1 油酸的水平 Decreases the transport of saturated fatty acids out of the plastid, thereby increasing their availability to desaturation to 18:1 oleic acid; reduces the levels of saturated fatty acids and increases the levels of 18:1 oleic acid</p>		
<p>抗麦草畏 Dicamba tolerance</p>	<p><i>dmo</i></p>	<p>嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6</p>	<p>麦草畏单加氧酶 Dicamba mono-oxygenase enzyme</p> <p>用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction</p>		
<p>改性油/脂肪酸 Modified oil/ fatty acid</p>	<p><i>fad2-1A</i> (<i>sense and antisense</i>)</p>	<p>大豆 <i>Glycine max</i></p>	<p>产生非功能性酶（通过 RNA 干扰抑制 Δ-12 去饱和酶的产生） No functional enzyme is produced (production of delta-12 desaturase enzyme is suppressed by RNA interference)</p> <p>降低 18:1 油酸的去饱和作用到 18:2 亚油酸; 增加单不饱和和油酸的水平并降低种子中饱和脂肪亚油酸的水平</p>	<p>MON87705 × MON87708 × MON89788</p>	<p>孟山都公司 Monsanto Company (including fully and partly owned companies)</p>

<p>改性油/脂肪酸 Modified oil/ fatty acid</p>	<p><i>fat1-A</i> (<i>sense and antisense segments</i>)</p>	<p>大豆 <i>Glycine max</i></p>	<p>Reduces desaturation of 18:1 oleic acid to 18:2 linoleic acid; increases the levels of monounsaturated oleic acid and decreases the levels of saturated linoleic acid in the seed</p> <p>产生非功能性酶（通过 RNA 干扰抑制 FATB 酶或酰基-酰基载体蛋白硫酯酶的产生） No functional enzyme is produced (production of FATB enzymes or acyl-acyl carrier protein thioesterases is suppressed by RNA interference)</p> <p>降低饱和脂肪酸向质体外的转运,从而提高它们的去饱和作用,降低饱和脂肪酸的水平并提高 18: 1 油酸的水平 Decreases the transport of saturated fatty acids out of the plastid, thereby increasing their availability to desaturation to 18:1 oleic acid; reduces the levels of saturated fatty acids and increases the levels of 18:1 oleic acid</p>		
<p>抗草甘膦 Glyphosate tolerance</p>	<p><i>cp4 epsps</i> (<i>aroA:CP4</i>)</p>	<p>根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4</p>	<p>5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme</p> <p>降低对草甘膦的结合亲和力,从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide</p>		
<p>抗麦草畏 Dicamba tolerance</p>	<p><i>dmo</i></p>	<p>嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6</p>	<p>麦草畏单加氧酶 Dicamba mono-oxygenase enzyme</p> <p>用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction</p>		

抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草 剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON87705 × MON89788	孟山都公司 Monsanto Company (including fully and partly owned companies)
改性油/脂肪 酸 Modified oil/ fatty acid	<i>fad2-1A</i> (<i>sense and</i> <i>antisense</i>)	大豆 <i>Glycine max</i>	产生非功能性酶 (通过 RNA 干扰抑制 Δ-12 去饱和 酶的产生) No functional enzyme is produced (production of delta-12 desaturase enzyme is suppressed by RNA interference) 降低 18:1 油酸的去饱和作用到 18:2 亚油酸; 增加单 不饱和油酸的水平并降低种子中饱和脂肪亚油酸的 水平 Reduces desaturation of 18:1 oleic acid to 18:2 linoleic acid; increases the levels of monounsaturated oleic acid and decreases the levels of saturated linoleic acid in the seed		
改性油/脂肪 酸 Modified oil/ fatty acid	<i>fatb1-A</i> (<i>sense and</i> <i>antisense</i> <i>segments</i>)	大豆 <i>Glycine max</i>	产生非功能性酶 (通过 RNA 干扰抑制 FATB 酶或酰 基-酰基载体蛋白硫酯酶的产生) No functional enzyme is produced (production of FATB enzymes or acyl-acyl carrier protein thioesterases is suppressed by RNA interference) 降低饱和脂肪酸向质体外的转运, 从而提高它们的去 饱和作用, 降低饱和脂肪酸的水平并提高 18: 1 油酸 的水平 Decreases the transport of saturated fatty acids out of the plastid, thereby increasing their availability to desaturation to 18:1 oleic acid; reduces the levels of		

			saturated fatty acids and increases the levels of 18:1 oleic acid		
抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction	MON87708 × MON89788	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1A.105</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. Kumamotoensis	<i>cry1a.105</i> 蛋白包括 <i>cry1Ab</i> , <i>cry1F</i> 和 <i>cry1Ac</i> 蛋白 <i>cry1A.105</i> protein which comprises the <i>cry1Ab</i> , <i>cry1F</i> and <i>cry1Ac</i> proteins 通过选择性地破坏中肠内膜, 赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	MON87751 × MON87701 × MON87708 × MON89788	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry2Ab2</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. Kumamotoensis	<i>cry2Abδ</i> -内毒素 <i>cry2Ab delta</i> -endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		

<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p> <p>抗麦草畏 Dicamba herbicide</p> <p>抗草甘膦 Glyphosate tolerance</p>	<p><i>cry1Ac</i></p> <p><i>dmo</i></p> <p><i>cp4 epsps (aroA:CP4)</i></p>	<p>苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73</p> <p>嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6</p> <p>根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4</p>	<p><i>cry1Ac</i>δ-内毒素 <i>cry1Ac delta-endotoxin</i> 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p> <p>麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction</p> <p>5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide</p>		
<p>改性油/脂肪酸 Modified oil/fatty acid</p> <p>改性油/脂肪</p>	<p><i>Pj.D6D</i></p> <p><i>Nc.Fad3</i></p>	<p>报春花 <i>Primula juliae</i></p> <p>粗糙链孢霉</p>	<p>Δ6 去饱和酶蛋白 Delta 6 desaturase protein 使某些内源性脂肪酸去饱和, 导致生成了含有 ω-3 脂肪酸的十八碳四烯酸 (SDA) Desaturates certain endogenous fatty acids resulting in the production of stearidonic acid (SDA), an omega-3 fatty acid</p> <p>Δ15 去饱和酶蛋白 Delta 15 desaturase protein</p>	<p>MON87769× MON89788</p>	<p>孟山都公司 Monsanto Company (including fully and partly owned companies)</p>

酸 Modified oil/ fatty acid		<i>Neurospora crassa</i>	使某些内源性脂肪酸去饱和，导致生成了含有 ω -3 脂肪酸的十八碳四烯酸（SDA） Desaturates certain endogenous fatty acids resulting in the production of stearidonic acid (SDA), an omega-3 fatty acid		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps</i> (<i>aroA:CP4</i>)	根癌农杆菌菌株 CP4 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力，从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		

附表 3 32 个独立及非独立抗除草剂转基因油菜转化事件表

Schedule 3 32 independent and non-independent herbicide tolerancetransgenic canola events table

目标性状 Target traits	基因 Gene	基因来源 Gene source	产物及作用机制 Product and function	事件 Event	开发机构 Developer
抗草甘膦 Glyphosate tolerance	<i>gat4621</i>	地衣芽孢杆菌 <i>Bacillus licheniformis</i>	草甘膦 N-乙酰转移酶 Glyphosate N-acetyltransferase enzyme 催化草甘膦的失活，赋予对草甘膦除草剂的耐受性 Catalyzes the inactivation of glyphosate, conferring tolerance to glyphosate herbicides	67349 61061 (Optimum®Glyc nola)	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草甘膦	<i>cp4</i>	根癌农杆菌株	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS）	GT200(RT200)	孟山都公司

Glyphosate tolerance	<i>epsps(aroA:CP4)</i>	<i>Agrobacterium tumefaciens</i> strain CP4	5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	(RoundupReady™Canola) GT73(RT73) (RoundupReady™Canola)	Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>goxv247</i>	苍白杆菌 <i>Ochrobactrum anthropi</i> strain LBAA	草甘膦氧化酶 Glyphosate oxidase 通过将草甘膦降解成氨基甲基磷酸 (AMPA) 和乙醛酸来赋予对草甘膦除草剂的耐受性 Confers tolerance to glyphosate herbicides by degrading glyphosate into aminomethylphosphonic acid (AMPA) and glyoxylate		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	HCN10(Topas19/2) (LibertyLink™Independence™) HCN92(Topas19/2) (LibertyLink™Innovator™)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichiacoli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗草铵膦 Glufosinate tolerance	<i>pat(syn)</i>	衍生自绿色链霉菌株系 Tu 494 合成形式的 <i>pat</i> 基因 <i>Synthetic form of pat gene derived from Streptomyces viridochromogenes</i> strain Tu494	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	HCN28(T45) (InVigor™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)

抗草甘膦 Glyphosate tolerance	<i>cp4 epsps(aroA :CP4)</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON88302 (TruFlex™Round upReady™Canola)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	MS1(B91-4) (InVigor™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
雄性不育基因 Male sterility	<i>barnase</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸 (rnase) 酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther	RF1(B93-101) (InVigor™Canola)	
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichiacoli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection	RF2(B94-2) (InVigor™Canola)	
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	MS8 (InVigor™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
			芽孢杆菌核糖核酸 (rnase) 酶	RF3 (InVigor™Canola)	

雄性不育基因 Male sterility	<i>barnase</i>	解淀粉芽孢杆菌 <i>Bacillus samyloliquefaciens</i>	barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther		
抗溴苯腈 Oxynil herbicide tolerance	<i>bxn</i>	肺炎克雷伯氏菌亚种 <i>Klebsiellapneumoniae</i> subsp. Ozaenae	腈水解酶 Nitrilase enzyme 消除溴苯腈除草剂的除草活性（如溴苯腈） Eliminates herbicidal activity of oxynil herbicides (eg. Bromoxynil)	OXY-235 (Navigator™Cano la)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	PHY14 PHY23 PHY35 PHY36	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
雄性不育基因 Male sterility	<i>barnase</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸（rnase）酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther		
育性恢复 Fertility restoration	<i>barstar</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性	HCN92× MON88302 (LibertyLink™Inn	拜耳作物科学 Bayer CropScience (including fully

<p>抗生素抗性 Antibiotic resistance</p>	<p><i>nptII</i></p>	<p>大肠杆菌 Tn5 转座子 <i>Escherichiacoli</i> Tn5 transposon</p>	<p>Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation</p> <p>新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection</p>	<p>ovator™ × TruFle × ™RoundupReady ™Canola)</p>	<p>and partly owned companies)</p>
<p>抗草铵膦 Glufosinate tolerance</p>	<p><i>bar</i></p>	<p>吸水链霉菌 <i>Streptomyces hygroscopicus</i></p>	<p>膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation</p>	<p>MS8 × RF3 (InVigor™Canola)</p>	<p>拜耳作物科学 Bayer CropScience (including fully and partly owned companies)</p>
<p>雄性不育基因 Male sterility</p>	<p><i>barnase</i></p>	<p>解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i></p>	<p>芽孢杆菌核糖核酸（rnase）酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther</p>		
<p>育性恢复 Fertility restoration</p>	<p><i>barstar</i></p>	<p>解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i></p>	<p>芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum</p>		

抗草甘膦 Glyphosate tolerance	<i>gat4601</i>	地衣芽孢杆菌 <i>Bacilluslicheniformis</i>	草甘膦 N-乙酰转移酶 Glyphosate N-acetyltransferase enzyme 催化草甘膦的失活，赋予对草甘膦除草剂的耐受性 Catalyzes the inactivation of glyphosate, conferring tolerance to glyphosate herbicides	73496×RF3 MON88302×RF3	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
育性恢复 Fertility restoration	<i>barstar</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum		
抗草铵膦 Glufosinate tolerance	<i>pat(syn)</i>	衍生自绿色链霉菌 Tu494 株系的合成形式的 <i>pat</i> 基因 <i>Synthetic form of pat gene derived from Streptomyces viridochromogenes strain Tu494</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	HCN28× MON88302 (InVigor™× TruFle× ™RoundupReady ™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens strain CP4</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力，从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		

抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON88302×MS8×RF3 (InVigor™×TruFle×™RoundupReady™Canola)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
雄性不育基因 Male sterility	<i>barnase</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸 (rnase) 酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther		
育性恢复 Fertility restoration	<i>barstar</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps(aroA:CP4)</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性	MS1×MON88302 (InVigor™×TruFle×™RoundupReady™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)

抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide 膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
雄性不育基因 Male sterility	<i>barnase</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸（rnase）酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichiacoli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	MS1 × RF1(PGS1) (InVigor™Canola) MS1 × RF2(PGS2) (InVigor™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
雄性不育基	<i>barnase</i>	解淀粉芽孢杆菌	芽孢杆菌核糖核酸（rnase）酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不		

因 Male sterility		<i>Bacillus amyloliquefaciens</i>	育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther	MS1×RF3 (Invigor™Canola)	
育性恢复 Fertility restoration	<i>barstar</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichiacoli</i> Tn5 transposon	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps(aroA:CP4)</i>	根癌农杆菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MS8×MON88302 (InVigor™×TruFle×™RoundupReady™Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i> <i>barnase</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation 芽孢杆菌核糖核酸 (rnase) 酶 barnase ribonuclease (rnase) enzyme		

雄性不育基因 Male sterility		解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	MS8×RF3×GT73(RT73)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
雄性不育基因 Male sterility	<i>barnase</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸（rnase）酶 barnase ribonuclease (rnase) enzyme 通过干扰花药绒毡层细胞中的 RNA 产生导致雄性不育 Causes male sterility by interfering with RNA production in the tapetum cells of the anther		
育性恢复 Fertility restoration	<i>barstar</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌株 <i>Agrobacteriumtumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力，从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		

抗草甘膦 Glyphosate tolerance	<i>goxv247</i>	苍白杆菌 <i>Ochrobactrum anthropi</i> strain LBAA	草甘膦氧化酶 Glyphosate oxidase 通过将草甘膦降解为氨基甲基磷酸 (AMPA) 和乙醛酸来赋予对草甘膦除草剂的耐受性 Confers tolerance to glyphosate herbicides by degrading glyphosate into aminomethylphosphonic acid (AMPA) and glyoxylate		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps(aroA:CP4)</i>	根癌农杆菌菌株 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 降低对草甘膦的结合亲和力, 从而赋予对草甘膦除草剂更高的耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	RF1 × MON88302 (InVigor™ × TruFle × RoundupReady Canola)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	RF2 × MON88302 (InVigor™ × TruFle × RoundupReady Canola)	
育性恢复 Fertility restoration	<i>barstar</i>	解淀粉芽孢杆菌 <i>Bacillus amyloliquefaciens</i>	芽孢杆菌核糖核酸酶抑制剂 barnase ribonuclease inhibitor 通过抑制芽孢杆菌核糖核酸酶对绒毡层的抑制作用来恢复生育力 Restores fertility by repressing the inhibitory effect of barnase on tapetum		
抗生素抗性 Antibiotic	<i>nptII</i>	大肠杆菌 Tn5 转座子 <i>Escherichiacoli</i> Tn5	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme		

resistance		transposon	可使转化植物在筛选时代谢新链丝菌素和卡那霉素 抗生素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		
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附表 4 28 个独立抗除草剂转基因玉米转化事件

Schedule 4 28 independent herbicide tolerance transgenic maize events

目标性状 Target traits	基因 Gene	基因来源 Gene source	产物及作用机制 Product and function	事件 Event	开发机构 Developer
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抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1F</i>	苏云金芽孢杆菌变种 <i>Bacillus thuringiensis</i> var. Aizawai	<i>cry1F</i> δ-内毒素 <i>cry1F</i> delta-endotoxin 通过选择性地破坏中肠内膜赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	4114	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗鞘翅目昆虫 Coleopteran insect resistance	<i>cry34Ab1</i>	苏云金芽孢杆菌菌株 <i>PS149B1</i> <i>Bacillus thuringiensis</i> strain <i>PS149B1</i>	<i>cry34ab1</i> δ-内毒素 <i>cry34Ab1</i> delta-endotoxin 通过选择性地破坏中肠内膜赋予对鞘翅目昆虫特别是玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining		
抗鞘翅目昆虫 Coleopteran insect resistance	<i>cry35Ab1</i>	苏云金芽孢杆菌菌株 <i>PS149B1</i> <i>Bacillus thuringiensis</i> strain <i>PS149B1</i>	<i>cry35ab1</i> δ-内毒素 <i>cry35Ab1</i> delta-endotoxin 通过选择性地破坏中肠内膜赋予对鞘翅目昆虫特别是玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces</i> <i>viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(<i>pat</i>) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		

抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	59122 (Herculex™ RW)	陶氏益农有限公司和杜邦 Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)
抗鞘翅目昆虫 Coleopteran insect resistance	<i>cry34Ab1</i>	苏云金芽孢杆菌菌株 PS149B1 <i>Bacillus thuringiensis</i> strain PS149B1	<i>cry34ab1δ</i> -内毒素 <i>cry34Ab1</i> delta-endotoxin 通过选择性地破坏中肠内膜，赋予对鞘翅目昆虫特别是玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining		
抗鞘翅目昆虫 Coleopteran insect resistance	<i>cry35Ab1</i>	苏云金芽孢杆菌菌株 PS149B1 <i>Bacillus thuringiensis</i> strain PS149B1	<i>cry35ab1δ</i> -内毒素 <i>cry35Ab1</i> delta-endotoxin 通过选择性地破坏中肠内膜，赋予对鞘翅目昆虫特别是醚根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	676 678 680	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
雄性不育基因 Male sterility	<i>dam</i>	大肠杆菌 <i>Escherichia coli</i>	DNA 腺嘌呤甲基化酶 DNA adenine methylase enzyme 通过干扰功能花药和花粉的产生导致雄性不育 Confers male sterility by interfering with the production of functional anthers and pollen		

抗磺酰脲类 Sulfonylurea herbicide tolerance	<i>zm-hra</i>	玉米 <i>Zea mays</i>	耐除草剂的乙酰乳酸合成酶 (ALS) Herbicide tolerant acetolactase synthase (als) enzyme 赋予耐乙酰乳酸合成酶抑制剂类除草剂如磺酰脲类和咪唑啉酮 Confers tolerance to acetolactate synthase-inhibiting herbicides such as sulfonylurea and imidazolinone	98140 (Optimum™ GAT™)	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草甘膦 Glyphosate tolerance	<i>gat4621</i>	地衣芽孢杆菌 <i>Bacillus licheniformis</i>	草甘膦 N-乙酰转移酶的酶 Glyphosate N-acetyltransferase enzyme 催化草甘膦失活，赋予草甘膦除草剂耐受性 Catalyzes the inactivation of glyphosate, conferring tolerance to glyphosate herbicides		
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ab</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i>	<i>cry1Ab</i> δ-内毒素 <i>cry1Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	Bt10 (Bt10)	先正达 Syngenta
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces</i> <i>viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(<i>pat</i>) enzyme 通过乙酰化消除草铵膦 (膦丝菌素) 的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗生素抗性 Antibiotic resistance	<i>bla</i>	大肠杆菌 <i>Escherichia coli</i>	β-内酰胺酶 Beta lactamase enzyme 解除 β-内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin		

抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	Bt11 (X4334CBR, X4734CBR) (Agrisure™ CB/LL)	先正达 Syngenta
抗鳞翅目昆 虫 Lepidopteran insect resistance	<i>cry1Ab</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. Kurstaki	<i>cry1Ab</i> δ-内毒素 <i>cry1Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠内膜来赋予 对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗鳞翅目昆 虫 Lepidopteran insect resistance	<i>cry1Ab</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i>	<i>cry1Ab</i> δ-内毒素 <i>cry1Ab</i> delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠内膜来赋予 对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	Bt176 (176) (NaturGard KnockOut™, Maximizer™)	先正达 Syngenta
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗生素抗性 Antibiotic resistance	<i>bla</i>	大肠杆菌 <i>Escherichia coli</i>	B-内酰胺酶 Beta lactamase enzyme 解除 β -内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin		

抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	CBH-351 (Starlink™ Maize)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry9C</i>	苏云金芽孢杆菌亚种 <i>Bacillus thuringiensis</i> subsp. <i>tolworthi</i> strain BTS02618A	cry9Cδ-内毒素 cry9C delta endotoxin 通过选择性地破坏中肠内膜，赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining		
抗生素抗性 Antibiotic resistance	<i>bla</i>	大肠杆菌 <i>Escherichia coli</i>	B-内酰胺酶 Beta lactamase enzyme 解除 β-内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin		
抗 2,4-D 2,4-D tolerance	<i>aad-1</i>	衍生自鞘氨醇杆菌中合成形式的 <i>aad-1</i> 基因 Synthetic form of the <i>aad-1</i> gene from <i>Sphingobium herbicidovorans</i>	芳基脂肪酸双加氧酶 1 (AAD-1) 蛋白 Aryloxyalkanoate dioxygenase 1 (AAD-1) protein 通过侧链降解和降解芳氧苯氧丙酸类除草剂的 R 异构体解毒 2,4-D 除草剂 Detoxifies 2,4-D herbicide by side-chain degradation and degrades the R-enantiomers of aryloxyphenoxypropionate herbicides	DAS40278 (Enlist™ Maize)	陶氏益农有限公司 Dow Agro Sciences LLC
抗鳞翅目昆虫 Lepidopteran insect resistance	<i>cry1Ac</i>	苏云金芽孢杆菌 Kurstaki 菌株 HD73 <i>Bacillus thuringiensis</i> subsp. <i>kurstaki</i> strain HD73	cry1Acδ-内毒素 cry1Ac delta-endotoxin 通过选择性地破坏鳞翅目昆虫的中肠粘膜来赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining	DBT418 (Bt Xtra™ Maize)	孟山都公司 Monsanto Company (including fully and partly owned companies)

抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗虫 Insect resistance	<i>pinII</i>	马铃薯 <i>Solanum tuberosum</i>	蛋白酶抑制蛋白 Protease inhibitor protein 通过降低叶片的可消化性和营养品质来提高对昆虫天敌的抵御能力 Enhances defense against insect predators by reducing the digestibility and nutritional quality of the leaves		
抗生素抗性 Antibiotic resistance	<i>bla</i>	大肠杆菌 <i>Escherichia coli</i>	B-内酰胺酶 Beta lactamase enzyme 解除 β -内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin		
抗草铵膦 Glufosinate tolerance	<i>bar</i>	吸水链霉菌 <i>Streptomyces hygroscopicus</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	DLL25 (B16)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗生素抗性 Antibiotic resistance	<i>bla</i>	大肠杆菌 <i>Escherichia coli</i>	β -内酰胺酶 Beta lactamase enzyme 解除 β -内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin		

抗草甘膦 Glyphosate tolerance	<i>mepsps</i>	玉米 <i>Zea mays</i>	EPSP 合成酶 (EPSPS) 修饰 Modified 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 使得对草甘膦产生抗性 Confers tolerance to glyphosate herbicides	GA21 (Roundup Ready™ Maize, Agrisure™GT)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶 (双突变型) 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力, 从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide	HCEM485	美国斯泰恩种子农场股份有限公司 Stine Seed Farm, Inc (USA)
抗草甘膦 Glyphosate tolerance	<i>goxv247</i>	人苍白杆菌 <i>Ochrobactrum anthropi</i> strain LBAA	草甘膦氧化酶 Glyphosate oxidase 将草甘膦降解为氨基磷酸 (AMPA) 和乙醛酸 Confers tolerance to glyphosate herbicides by degrading glyphosate into aminomethylphosphonic acid (AMPA) and glyoxylate	MON832 (Roundup Ready™ Maize)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇式丙酮酸莽草酸-3-磷酸合成酶 (EPSPS) 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) enzyme 可降低与草甘膦的结合力而获得草甘膦耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗生素抗性 Antibiotic resistance	<i>nptII</i>	大肠杆菌 <i>Escherichia coli</i>	新链丝菌素磷酸转移酶 II 酶 Neomycin phosphotransferase II enzyme 可使转化植物在筛选时代谢新链丝菌素和卡那霉素 Allows transformed plants to metabolize neomycin and kanamycin antibiotics during selection		

抗鞘翅目昆虫 Coleopteran insect resistance	<i>cry3Bb1</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i>	Δ-内毒素 cry3Bb1 cry3Bb1 delta endotoxin 通过选择性地破坏中肠内膜，赋予对鞘翅目昆虫特别是玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining	MON87411	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇式丙酮酸莽草酸-3-磷酸合成酶 (EPSPS) (EPSPS) enzyme 可降低与草甘膦的结合力而获得草甘膦耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide		
抗鞘翅目昆虫 Coleopteran insect resistance	<i>dvsnf7</i>	西玉米根虫 <i>Western Corn Rootworm (Diabrotica virgifera virgifera)</i>	含有 WCR snf7 基因的 240bp 片段的双链 RNA 转录物 Double-stranded RNA transcript containing a 240 bp fragment of the WCR snf7 gene RNA 干扰导致下调靶向 Snf7 基因的功能，导致西方玉米根虫死亡率。 RNA interference resulting to down-regulation of the function of the targeted Snf7 gene leading to Western Corn Rootworm mortality.		
抗麦草畏 Dicamba tolerance	<i>dmo</i>	嗜麦芽窄食单胞菌 <i>Stenotrophomonas maltophilia</i> strain DI-6	麦草畏单加氧酶 Dicamba mono-oxygenase enzyme 用麦草畏作为酶反应底物而获得耐麦草畏除草剂的抗性 Confers tolerance to the herbicide dicamba (2-methoxy-3,6-dichlorobenzoic acid) by using dicamba as substrate in an enzymatic reaction	MON87419 (n/a)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦	<i>pat</i>	绿色产色链霉菌	膦丝菌素 N-乙酰转移酶		

Glufosinate tolerance		<i>Streptomyces viridochromogenes</i>	Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇式丙酮酸莽草酸-3-磷酸合成酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 可降低与草甘膦的结合力而获得草甘膦耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON87427 (Roundup Ready™ Maize) NK603 (Roundup Ready™ 2 Maize)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance	<i>cp4 epsps (aroA:CP4)</i>	根癌农杆菌 <i>Agrobacterium tumefaciens</i> strain CP4	5-烯醇式丙酮酸莽草酸-3-磷酸合成酶（EPSPS） 5-enolpyruvulshikimate-3-phosphate synthase (EPSPS) enzyme 可降低与草甘膦的结合力而获得草甘膦耐受性 Decreases binding affinity for glyphosate, thereby conferring increased tolerance to glyphosate herbicide	MON88017 (YieldGard™ VT™ Rootworm™ RR2)	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗鞘翅目昆虫 Coleopteran insect resistance	<i>cry3Bb1</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>kumamotoensis</i>	Δ-内毒素 cry3Bb1 cry3Bb1 delta endotoxin 通过选择性地破坏中肠内膜，赋予对鞘翅目昆虫特别是玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining		
抗草甘膦 Glyphosate tolerance	<i>2mepsps</i>	玉米 <i>Zea mays</i>	5-烯醇丙酮酸莽草酸-3-磷酸合酶（双突变型） 5-enolpyruvyl shikimate-3-phosphate synthase enzyme (double mutant version) 降低对草甘膦的结合亲和力，从而增加对草甘膦除草剂的耐受性 Decreases binding affinity for glyphosate, thereby increasing tolerance to glyphosate herbicide	MZHG0JG (n/a)	先正达 Syngenta

抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗鞘翅目昆 虫 Coleopteran insect resistance	<i>cry3Bb1</i>	苏云金芽孢杆菌 <i>Bacillus thuringiensis</i> subsp. <i>Kumamotoensis</i>	Δ-内毒素 cry3Bb1 cry3Bb1 delta endotoxin 通过选择性地破坏中肠内膜，赋予对鞘翅目昆虫特 别玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm by selectively damaging their midgut lining	MZIR098	先正达 Syngenta
抗鞘翅目昆 虫 Coleopteran insect resistance	<i>mcry3A</i>	衍生自苏云金芽孢杆菌粉甲变 种的合成形式的 <i>cry3A</i> 基因 Synthetic form of <i>cry3A</i> gene from <i>Bacillus thuringiensis</i> subsp. <i>tenebrionis</i>	修饰 cry3Aδ-内毒素 Modified cry3A delta-endotoxin 通过选择性地破坏中肠内膜，赋予对鞘翅目昆虫特 别玉米根叶甲的抗性 Confers resistance to coleopteran insects particularly corn rootworm pests by selectively damaging their midgut lining		
抗草铵膦 Glufosinate tolerance	<i>pat</i>	绿色产色链霉菌 <i>Streptomyces viridochromogenes</i>	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation		
抗草铵膦 Glufosinate tolerance	<i>pat (syn)</i>	绿色链霉菌 Tu 494 株系 <i>Streptomyces viridochromogenes</i> strain Tu 494	膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(pat) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation	T14 (Liberty Link™ Maize) T-25 (Liberty Link™ Maize)	拜耳作物科学 Bayer CropScience (including fully and partly owned companies)

<p>抗生素抗性 Antibiotic resistance</p>	<i>bla</i>	<p>大肠杆菌 <i>Escherichia coli</i></p>	<p>B-内酰胺酶 Beta lactamase enzyme 解除 β -内酰胺类抗生素的毒素，如氨苄西林 Detoxifies beta lactam antibiotics such as ampicillin</p>		
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p> <p>抗草铵膦 Glufosinate tolerance</p>	<p><i>cry1Fa2</i></p> <p><i>pat</i></p>	<p>衍生自苏云金芽孢杆菌的合成形式的 <i>cry1F</i> 基因 <i>synthetic form of cry1F gene derived from Bacillus thuringiensis var. Aizawai</i></p> <p>绿色产色链霉菌 <i>Streptomyces viridochromogenes</i></p>	<p><i>cry1F</i> 改性蛋白 Modified <i>cry1F</i> protein 通过选择性地破坏中肠内膜，赋对抗鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p> <p>膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase(<i>pat</i>) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation</p>	<p>TC1507 (Herculex™ I, Herculex™ CB)</p>	<p>陶氏益农有限公司 Dow Agro Sciences LLC</p>
<p>抗鳞翅目昆虫 Lepidopteran insect resistance</p> <p>抗草铵膦 Glufosinate tolerance</p>	<p><i>cry1Fa1</i></p> <p><i>bar</i></p>	<p>衍生自变种苏云金芽孢杆菌的合成形式的 <i>cry1F</i> 基因 <i>synthetic form of cry1F gene from Bacillus thuringiensis var. aizawai</i></p> <p>吸水链霉菌 <i>Streptomyces hygroscopicus</i></p>	<p><i>cry1F</i> 改性蛋白 Modified <i>cry1F</i> protein 通过选择性地破坏中肠内膜，赋予对鳞翅目昆虫的抗性 Confers resistance to lepidopteran insects by selectively damaging their midgut lining</p> <p>膦丝菌素 N-乙酰转移酶 Phosphinothricin N-acetyltransferase (<i>pat</i>) enzyme 通过乙酰化消除草铵膦（膦丝菌素）的除草活性 Eliminates herbicidal activity of glufosinate (phosphinothricin) herbicides by acetylation</p>	<p>TC6275</p>	<p>陶氏益农有限公司 Dow Agro Sciences LLC</p>
<p>抗草甘膦 Glyphosate tolerance</p>	<p><i>epsps</i> <i>grg23ace5</i></p>	<p>土壤球形节杆菌 soil bacterium <i>Arthrobacter globiformis</i></p>	<p>改良 EPSP 合成酶（EPSPS）蛋白或 EPSPS ACE5 蛋白 Modified 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) protein or EPSPS ACE5 protein 赋予对草甘膦除草剂的抗性</p>	<p>VCO-Ø1981-5</p>	<p>Genective S.A.</p>

		Confers tolerance to glyphosate herbicides	
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附表5 173个非独立抗除草剂转基因玉米转化事件

Schedule 5 173 non-independent herbicide tolerance transgenic maize events

目标性状 Target traits	事件 Event	开发机构 Developer
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 改性 α-淀粉酶 Modified alpha amylase 甘露糖代谢 Mannose metabolism	3272 × Bt11	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 改性 α-淀粉酶 Modified alpha amylase 甘露糖代谢 Mannose metabolism	3272 × Bt11 × GA21	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 改性 α-淀粉酶 Modified alpha amylase 甘露糖代谢 Mannose metabolism	3272 × Bt11 × MIR604	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 改性 α-淀粉酶 Modified alpha amylase	3272 × BT11 × MIR604 × GA21	先正达 Syngenta

甘露糖代谢 Mannose metabolism		
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 多个抗虫性 Multiple insect resistance 改性 α -淀粉酶 Modified alpha amylase 甘露糖代谢 Mannose metabolism	3272 × Bt11 × MIR604 × TC1507 × 5307 × GA21	先正达 Syngenta
抗草甘膦 Glyphosate tolerance 改性 α -淀粉酶 Modified alpha amylase 甘露糖代谢 Mannose metabolism	3272 × GA21	先正达 Syngenta
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 改性 α -淀粉酶 Modified alpha amylase 甘露糖代谢 Mannose metabolism	3272 × MIR604 × GA21	先正达 Syngenta
抗草甘膦 Glyphosate tolerance 多个抗虫性 Multiple insect resistance	5307 × GA21	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 多个抗虫性 Multiple insect resistance 甘露糖代谢 Mannose metabolism	5307 × MIR604 × Bt11 × TC1507 × GA21 5307 × MIR604 × Bt11 × TC1507 × GA21 × MIR162	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗 2,4-D 除草剂 2,4-D tolerance	59122 × DAS40278	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance	59122 × GA21	先正达 Syngenta
	59122 × MON88017	孟山都公司和陶氏益农有限公司 Monsanto Company and Dow

		AgroSciences LLC
	59122 × NK603 59122 × NK603 × MIR604	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
	MON87427 × 59122 MON87427 × MON88017 × 59122	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草铵膦 Glufosinate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 甘露糖代谢 Mannose metabolism	59122 × MIR604	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 甘露糖代谢 Mannose metabolism	59122 × MIR604 × GA21	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 甘露糖代谢 Mannose metabolism	59122 × MIR604 × TC1507 Bt11 × 59122 × MIR604 Bt11 × 59122 × MIR604 × TC1507 BT11 × MIR162 × MIR604 Bt11 × MIR604 Bt11 × MIR604 × TC1507 MIR604 × TC1507	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 甘露糖代谢 Mannose metabolism	59122 × MIR604 × TC1507 × GA21 Bt11 × 59122 × MIR604 × GA21 BT11 × 59122 × MIR604 × TC1507 × GA21 Bt11 × MIR162 × MIR604 × GA21 BT11 × MIR604 × GA21	先正达 Syngenta
	TC1507 × 59122 × MON810 × MIR604 × NK603 TC1507 × MIR604 × NK603	杜邦 DuPont (Pioneer Hi-Bred International Inc.)

抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance	59122 × MON810 59122 × MON810 × MIR604 TC1507 × 59122 × MON810 TC1507 × 59122 × MON810 × MIR604 TC1507 × MON810 × MIR604	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
	Bt11 × 59122 Bt11 × 59122 × TC1507 BT11 × MIR162 × MIR604 × TC1507	先正达 Syngenta
	MON89034 × 59122 MON89034 × TC1507 × 59122	孟山都公司和陶氏益农有限公司 Monsanto Company and Dow AgroSciences LLC
	TC1507 × 59122	陶氏益农有限公司和杜邦 Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance	59122 × MON810 × NK603 59122 × MON810 × NK603 × MIR604 TC1507 × 59122 × MON810 × NK603 TC1507 × 59122 × NK603 × MIR604 TC1507 × MON810 × NK603 × MIR604	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
	59122 × TC1507 × GA21 Bt11 × MIR162 × MIR604 × TC1507 × GA21 Bt11 × 59122 × GA21 Bt11 × 59122 × TC1507 × GA21 MIR162 × MIR604 × TC1507 × GA21 MIR604 × TC1507 × GA21	先正达 Syngenta

	MON87427 × MON89034 × 59122 MON87427 × MON89034 × MON88017 × 59122 MON87427 × MON89034 × TC1507 × 59122 MON87427 × MON89034 × TC1507 × MON87411 × 59122 MON87427 × MON89034 × TC1507 × MON88017 MON87427 × MON89034 × TC1507 × MON88017 × 59122 MON87427 × TC1507 × 59122 MON87427 × TC1507 × MON88017 MON87427 × TC1507 × MON88017 × 59122 TC1507 × MON88017	孟山都公司 Monsanto Company (including fully and partly owned companies)
	MON89034 × 59122 × MON88017 MON89034 × TC1507 × MON88017 MON89034 × TC1507 × MON88017 × 59122 TC1507 × 59122 × MON88017	孟山都公司和陶氏益农有限公司 Monsanto Company and Dow AgroSciences LLC
	TC1507 × 59122 × NK603	陶氏益农有限公司和杜邦 Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗 2,4-D 除草剂 2,4-D tolerance	59122 × MON88017 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗磺酰脲类 Sulfonylurea herbicide tolerance	98140 × 59122	陶氏益农有限公司和杜邦 Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗磺酰脲类 Sulfonylurea herbicide tolerance	98140 × TC1507	陶氏益农有限公司和杜邦 Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)

抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗磺酰脲类 Sulfonylurea herbicide tolerance	98140 × TC1507 × 59122	陶氏益农有限公司和杜邦 Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 多抗性 Multiple insect resistance	Bt11 × 5307 TC1507 × 5307	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 多抗性 Multiple insect resistance	Bt11 × 5307 × GA21 Bt11 × MIR162 × 5307 × GA21 Bt11 × MIR162 × TC1507 × 5307 × GA21 MIR162 × TC1507 × 5307 × GA21 TC1507 × 5307 × GA21	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance	Bt11 × GA21 Bt11 × MON89Ø34 × GA21 Bt11 × TC1507 × GA21	先正达 Syngenta
	MON87427 × MON89034 × TC1507 MON87427 × TC1507	孟山都公司 Monsanto Company (including fully and partly owned companies)
	MON89034 × TC1507 × NK603 TC1507 × NK603	孟山都公司和陶氏益农有限公司 Monsanto Company and Dow AgroSciences LLC
	TC1507 × GA21 TC1507 × MON810 × NK603	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 甘露糖代谢 Mannose metabolism	Bt11 × MIR162 Bt11 × MIR162 × MON89034 Bt11 × MIR162 × TC1507 MIR162 × TC1507	先正达 Syngenta
抗草铵膦 Glufosinate tolerance	Bt11 × MIR162 × 5307	先正达

抗鳞翅目昆虫 Lepidopteran insect resistance 多抗虫性 Multiple insect resistance	Bt11 × MIR162 × TC1507 × 5307 Bt11 × TC1507 × 5307 MIR162 × TC1507 × 5307	Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 甘露糖代谢 Mannose metabolism	Bt11 × MIR162 × GA21 Bt11 × MIR162 × MON89034 × GA21 Bt11 × MIR162 × TC1507 × GA21 MIR162 × TC1507 × GA21	先正达 Syngenta
	MON89034 × TC1507 × NK603 × MIR162 MON89034 × TC1507 × NK603 × MIR162	陶氏益农有限公司 Dow Agro Sciences LLC
	TC1507 × MIR162 × NK603 TC1507 × MON810 × MIR162 × NK603	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草铵膦 Glufosinate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗鳞翅目昆虫 Lepidopteran insect resistance 多抗虫性 Multiple insect resistance	BT11 × MIR162 × MIR604 × 5307 BT11 × MIR162 × MIR604 × TC1507 × 5307 Bt11 × MIR604 × 5307 Bt11 × MIR604 × TC1507 × 5307 MIR162 × MIR604 × TC1507 × 5307 MIR604 × TC1507 × 5307	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗鳞翅目昆虫 Lepidopteran insect resistance 多抗虫性 Multiple insect resistance	Bt11 × MIR162 × MIR604 × 5307 × GA21 Bt11 × MIR162 × MIR604 × MON89034 × 5307 × GA21 Bt11 × MIR604 × 5307 × GA21 MIR162 × MIR604 × TC1507 × 5307 × GA21 MIR604 × TC1507 × 5307 × GA21	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance	Bt11 × TC1507	先正达 Syngenta
	MON89034 × TC1507	孟山都公司和陶氏益农有限公司 Monsanto Company and Dow AgroSciences LLC
	TC1507 × MON810	陶氏益农有限公司和杜邦

		Dow AgroSciences LLC and DuPont (Pioneer Hi-Bred International Inc.)
抗草甘膦 Glyphosate tolerance 抗 2,4-D 除草剂 2,4-D tolerance	DAS40278 × NK603	陶氏益农有限公司 Dow Agro Sciences LLC
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance	MON87427 × MON89034 × NK603 MON89034 × NK603 NK603 × MON810 GA21 × MON810	孟山都公司 Monsanto Company (including fully and partly owned companies)
	MON87427 × MON89034	孟山都公司和巴斯夫 Monsanto and BASF
	MON89034 × GA21 MIR162 × MON89034 × GA21	先正达 Syngenta
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗生素耐药性 Antibiotic resistance	GA21 × T25	先正达 Syngenta
	NK603 × T25	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 多个抗虫性 Multiple insect resistance	MIR162 × 5307 × GA21	先正达 Syngenta
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 甘露糖代谢 Mannose metabolism	MIR162 × GA21 MIR162 × NK603	先正达 Syngenta
	MON810 × MIR162 × NK603	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
	MON87427 × MON89034 × MIR162 × NK603	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗鳞翅目昆虫 Lepidopteran insect resistance	MIR162 × MIR604 × 5307 × GA21	先正达 Syngenta

多个抗虫性 Multiple insect resistance		
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗鳞翅目昆虫 Lepidopteran insect resistance 甘露糖代谢 Mannose metabolism	MIR162 × MIR604 × GA21	先正达 Syngenta
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 多个抗虫性 Multiple insect resistance	MIR604 × 5307 × GA21	先正达 Syngenta
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 甘露糖代谢 Mannose metabolism	MIR604 × GA21	先正达 Syngenta
	MIR604 × NK603	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance	MON810 × MON88017 MON87427 × MON89034 × MON88017 MON89034 × MON88017	孟山都公司 Monsanto Company (including fully and partly owned companies)
	MON810 × NK603 × MIR604	杜邦 DuPont (Pioneer Hi-Bred International Inc.)
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 抗生素耐药性 Antibiotic resistance	MON863 × MON810 × NK603	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗生素耐药性 Antibiotic resistance	MON863 × NK603	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance	MON87427 × MON88017	孟山都公司 Monsanto Company (including fully and partly owned companies)

抗草甘膦 Glyphosate tolerance 抗虫 Insect resistance 抗生素抗性 Antibiotic resistance	MON87427 × NK603	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗旱 Drought stress tolerance	MON87460 × MON88017	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 抗生素耐药性 Antibiotic resistance 抗旱 Drought stress tolerance	MON87460 × MON89034 × MON88017	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗生素耐药性 Antibiotic resistance 抗旱 Drought stress tolerance	MON87460 × MON89034 × NK603	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗生素耐药性 Antibiotic resistance 抗旱 Drought stress tolerance	MON87460 × NK603	孟山都公司 Monsanto Company (including fully and partly owned companies)
抗草甘膦 Glyphosate tolerance 抗鞘翅目昆虫 Coleopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON88017 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × 59122 × DAS40278 MON89034 × TC1507 × 59122 × DAS40278 TC1507 × 59122 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草甘膦 Glyphosate tolerance 抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × 59122 × MON88017 × DAS40278 MON89034 × TC1507 × MON88017 × 59122 × DAS40278 MON89034 × TC1507 × MON88017 × DAS40278 TC1507 × 59122 × MON88017 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC

	TC1507 × MON88017 × DAS40278	
抗鳞翅目昆虫 Lepidopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × MON88017 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × NK603 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × TC1507 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗 2, 4-D 2,4-D tolerance	MON89034 × TC1507 × NK603 × DAS40278 TC1507 × NK603 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗 2, 4-D 2,4-D tolerance 甘露糖代谢 Mannose metabolism	MON89034 × TC1507 × NK603 × MIR162 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗鞘翅目昆虫 Coleopteran insect resistance 甘露糖代谢 Mannose metabolism	NK603 × MON810 × 4114 × MIR604 TC1507 × MON810 × MIR604 × NK603	先正达和孟山都公司公司 Syngenta and Monsanto Company 杜邦 DuPont (Pioneer Hi-Bred International Inc.)

抗生素耐药性 Antibiotic resistance		
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗生素耐药性 Antibiotic resistance	T25 × MON810	孟山都公司和拜耳作物科学 Monsanto Company and Bayer CropScience
抗草铵膦 Glufosinate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 抗 2, 4-D 2,4-D tolerance	TC1507 × DAS40278	陶氏益农有限公司 Dow Agro Sciences LLC
抗草铵膦 Glufosinate tolerance 抗草甘膦 Glyphosate tolerance 抗鳞翅目昆虫 Lepidopteran insect resistance 甘露糖代谢 Mannose metabolism 抗生素耐药性 Antibiotic resistance	TC1507 × MON810 × MIR162	杜邦 DuPont (Pioneer Hi-Bred International Inc.)