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Import and Commercialization of Transgenic Crops: An Indian Perspective

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Abstract: With the dramatic increase in the commercial cultivation of transgenic crops, concerns regarding their potential impacts on environment and human health are required to be addressed in a proper perspective. India has already reached a stage in the commercialization of transgenic crops that makes a strong collaboration between public and private sectors imperative to adequately address the biosafety issues. The National Bureau of Plant Genetic Resources (NBPGR) is a nodal organization under Indian Council of Agricultural Research (ICAR) for import and quarantine processing of transgenic planting material. Till date, 79 consignments of transgenic planting material comprising twelve crops with an array of transgenes have been imported from different countries through NBPGR for various public and private research institutions engaged in transgenic research.

This review article analyses and introspects the pattern of import in a range of crops for different traits over the last decade and attempts to understand the gap between the pace at which the transgenic crops are being imported by private and public sectors and their actual commercialization. Harnessing the optimum benefits of transgenic crops while sustaining our valuable biodiversity, hinges on systematic development, import and commercialization of transgenic crops alongwith strong public and private sector collaboration involving all stakeholders including the farmers and consumers.

Keywords: Transgenic crops, import, commercialization, national regulatory framework.

Introduction

Revolutionary advances in plant biotechnology over the past decade have enabled us to overcome all limitations associated with conventional

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hybridization making the entire global gene pool of plants, animals and microorganisms accessible for crop improvement. As the application of biotechnology promises holds immense potential for enriching agriculture in terms of increased yield, better nutritional quality and resistance to biotic and abiotic stresses and reduced post harvest losses. It is therefore no surprise that over the past merely thirteen years, the global area under cultivation of transgenic crops has multiplied manifold, viz. from 1.7 mha in 1996 to 125 mha in 2008.[1]

Such rapid development and commercialization of transgenic crops in recent years has also generated considerable apprehensions and concerns with regard to their potential impacts on the environment and consequently on the human and animal health. This calls for a systematic and scientific approach based upon comprehensive research data and a long term policy while harnessing this new technology. India has been able to develop appropriate biosafety regulations alongwith an institutionalized implementation framework to ensure an adequately effective evaluation of transgenic crops before the biosafety clearance is granted under Environment Protection Act, 1986. The Department of Biotechnology (DBT) is the nodal agency under the Ministry of Science and Technology, Government of India which deals with all aspects of transgenics. The National Bureau of Plant Genetic Resources (NBPGR) acts as a nodal agency under the Indian Council of Agricultural Research (ICAR), for the purpose of import as well as quarantine processing of transgenic planting material. Since 1997, almost 79 imports of transgenic planting material comprising twelve crops with an array of transgenes from different countries have been channeled for public and private sector organizations through NBPGR. India is presently at a juncture in terms of commercialization of transgenic crops that calls for a much greater public sector investment and involvement to ensure that this novel technology enables Indian agriculture to acquire the much needed cutting edge in global competitiveness. In addition, strong collaborations between public and private sectors alongwith involvement of farmers in a participatory mode at a massive scale would be necessary to facilitate an effective addressing of all issues related to transgenic crops and to achieve their countrywide adoption.

National Regulatory Framework for Transgenic Crops

India has already put in place an effective regulatory mechanism to monitor experiments in plant biotechnology as well as for biosafety assessment of transgenic plants since 1989, which has been updated from time to time. Under the provisions of the Environment Protection Act (EPA) of 1986, comprehensive rules for the manufacture, use, import, export and storage of hazardous microorganisms and genetically engineered (GE) organisms or cells were framed in the year 1989.[2]

Currently, the following competent committees are involved in the regulatory procedures pertaining to transgenics.[3]

1. Recombinant DNA Advisory Committee (RDAC): has an advisory role and is constituted by the DBT to review the recent developments in biotechnology at national and international levels.
2. Institutional Biosafety Committee (IBSC): has an advisory and regulatory role and is constituted by the respective organizations involved in research on recombinant DNA technology. The committee reports to RCGM on regular basis.
3. Review Committee on Genetic Manipulation (RCGM): has the main regulatory role and is responsible for Biosafety Research Level I (BRL I) trials. RCGM has the following sub committee:
   - *Monitoring cum Evaluation Committee (MEC):* has a monitoring role under the direct supervision of RCGM. This committee designs field experiments as well as formats for collection and collation of scientific information on plants grown in containment as well as in the limited field trials in consultation with RCGM. The committee members undertake field visits and suggest remedial measures wherever required.
4. Genetic Engineering Approval Committee (GEAC): has a regulatory and approval role and functions under the Ministry of Environment and Forests. It is the regulatory authority for Biosafety Research Level II (BRL II) trials.
5. State Biotechnology Coordination Committee (SBCC): headed by the Chief Secretary of the respective state. This committee inspects, investigates and takes punitive actions in case of violations of the statutory provisions.

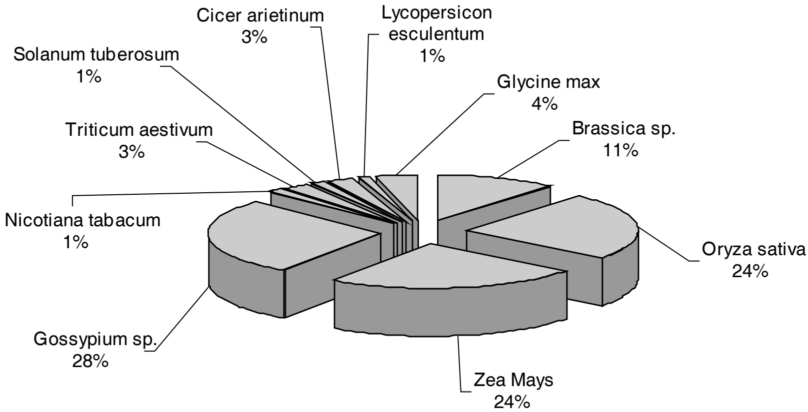
6. District Level Committee (DLC): headed by the District Collector to monitor the safety regulations in installations engaged in the use of genetically-modified organisms (GMOs) in research and applications.

The biosafety guidelines to monitor all experiments involving GM plants, both within the laboratory/greenhouse and outside were brought into force in 1990[4] by the Department of Biotechnology (DBT). These DBT guidelines have been updated in 1994[5] and thereafter in 1998[6], incorporating in particular the allergenicity and toxicity evaluation of the transgenic material. Revised guidelines for the conduct of confined field trials of GE plants have been put in place by India in 2008.[7] These guidelines summarize the information requirements and procedures used by the two regulatory committees, RCGM in DBT, Ministry of Science and Technology and GEAC in the Ministry of Environment and Forests (MoEF), that are responsible for evaluating and approving applications for confined field trials, Biosafety Research Level I (BRL I) and Biosafety Research Level II (BRL II) field trials, respectively.

The import of transgenics is governed by the provisions of Plant Quarantine (Regulation of Import into India) Order 2003 referred to as PQ Order effective from 1 January 2004. As per this order, NBPGR has been designated as the competent authority to issue import permits for import of seeds/planting materials by public and private sector agencies for research purposes. For importing the transgenic material an indentor has to submit the proposal through the IBSC to RCGM. NBPGR issues the import permit only after the import clearance is accorded by RCGM. Two documents, i.e. an import permit and phytosanitary certificate from the country of origin, are obligatory with every imported seed/plant consignment. Under the said regulations, the Director, NBPGR has been authorized to issue import permits and accept the imported materials from customs authorities for the purpose of its quarantine processing. Before releasing these to the indentor, NBPGR assigns exotic collection numbers or a national identity number to each accession of transgenic material so received by it through import.[8]

Transgenic lines have been imported on a regular basis through NBPGR, New Delhi ever since 1997. Twelve transgenic crops, namely *Brassica oleracea, B. juncea, B. napus, Cicer arietinum, Glycine max, Gossypium hirsutum, Lycopersicon esculentum, Nicotiana tabaccum, Oryza sativa, Solanum tuberosum, Triticum aestivum* and *Zea mays* have since been imported for

Figure 1: Crop-wise Import of Transgenic Planting Material



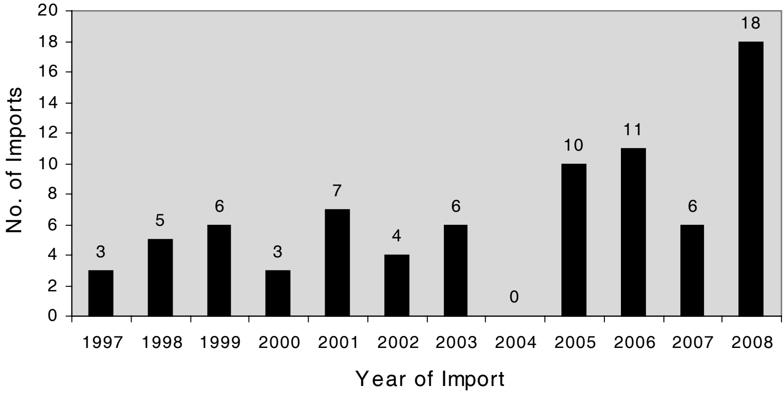
research purposes. Out of these imported transgenic crops, the maximum number of imports are in transgenic cotton followed by transgenic maize and transgenic rice (Annex 1, Figure 1). The predominant trait in these imported crops is for imparting resistance to lepidopteran insects followed by herbicide tolerance. Till date, a maximum number of transgenes have been introduced in rice including *AmA1* gene and ferritin genes for improved nutrition, *cry1Ac, cry1C, cry2A, cry19C* and *GFM-cry1A* genes for imparting resistance against lepidopteran insects, *cry1Ab* gene for resistance to stem borer, *cp4epsps* gene for herbicide tolerance, *Xa21* gene for resistance to bacterial leaf blight, *PR* genes for resistance to sheath borer, *bar* gene for resistance to glufosinate ammonium herbicide, *HAS, ScFv* & *AFP-AG* genes for nematode resistance and the genes for phytoene synthase, phytoene desaturase, and lycopene cyclase involved in the synthesis of â-carotene in the endosperm of golden rice. The other crops, i.e. Brassica spp., soybean, tomato, tobacco, chickpea, wheat and potato have also been imported with the transgenes/traits that can minimize crop damage through disease and pest resistant varieties, reduce the use of chemicals and enhance stress tolerance (Annex 1).

Since 2000, molecular characterization of the transgenic material is also being undertaken at NBPGR simultaneously with the quarantine processing, under an ICAR/ DBT project, in which a National Containment Facility of CL-4 level along with transgene testing laboratory for molecular evaluation of imported transgenic planting material has been established. All the imported transgenic planting material is regularly being tested for terminator technology alongwith checking for specific transgenes, promoters and selectable marker genes. The terminator cassette consists of three sets of genes, namely, repressor gene encoding repressor protein, *cre-recombinase* gene encoding recombinase enzyme and terminator (lethal gene) which codes for ribosome inhibiting protein (RIP). Lethal gene encoding RIP interferes in the synthesis of all proteins in the plant cell without being toxic to other organisms. The primers have been designed to amplify the 1031 bp sequence of *cre-recombinase* gene and are being used for PCR-based detection to check for the presence of this cassette in the imported transgenic material. So far, no positive results have been observed in the imported material tested for *cre recombinase* gene as the amplicon of 1031 bp is only amplified in positive control. The imported transgenic materials are also characterized for the specific transgenes, promoters, selectable markers and terminators by single or multiplex PCR for simultaneous detection of two or more genes.

Out of the 79 imports till date, 84.62 per cent have been imported by the private sector, whereas the public sector accounts for merely 15.38 per cent of the imports. The public sector has mainly confined to four transgenic crops, namely, *C. arientinum, N. tabacum, O. sativa* and *Solanum tuberosum* and the material has been imported from Australia, Canada, Philippines, Scotland, Switzerland, USA and Vietnam, while the private sector has imported eight transgenic crops, namely, *B. juncea, B. napus, B. oleracea, G. hirsutum, Glycine max, O. sativa, L. esculentum* and *Z. mays* from Belgium, Australia, China, Netherlands, Philippines, South Africa, UK and USA (Annex 1).

There has been no uniform trend in the import of transgenic planting material during the last twelve years. It is, however, noteworthy that maximum number of imports of transgenic planting material has been reported in the year 2008 (Figure 2). As the pace of developments in the research on transgenic crops is a prerequisite to their commercialization this needs to be substantially upscaled particularly, in the public sector to

Figure 2: Year-wise Import of Transgenic Planting Materials from 1997-2008



have commensurate results. Simultaneously, widespread public awareness needs to be generated regarding the perceived benefits/risks of transgenic crops. Further, there is a need for greater collaboration as well as cooperation between public and private sectors. This may also be achieved by developing networking and consortia within the public sector itself as well as between the public and private sector to collectively harness the benefits of transgenic crops.

Commercialization of Transgenic Crops in India

The global area under cultivation of transgenic crops has touched 125 mha in 2008, with 25 countries growing these biotech crops.[9] India being the largest cotton growing country in the world, Bt cotton was the first transgenic crop commercialized in 2002. By 2008, 280 hybrids of four events, i.e. MON 531, MON 15985, GFM-cry1A, Event 1 and one variety of BN-Bt (variety of Bikaneri Nerma) of Bt cotton have been commercially released[10] (Figures 3 & 4). Out of the five events commercialized, three events MON 531, MON 15985 (Maharashtra Hybrid Seeds Co. Ltd.) and GFM-cry1A (Nath Seeds Ltd.) have been imported in the years 1995, 2000 and 2002, respectively, whereas the other two events are indigenously developed, i.e. Event 1 developed in the year 2002 at IIT, Kharagpur using indigenous *cry1Ac* gene[11] and commercialized by J.K. Agrigenetics Ltd. while BN-Bt[12] was developed and commercialized by Central Institute of Cotton Research (CICR), Nagpur (Table 1).

Figure 3: Year-wise Commercialization of Bt cotton hybrids

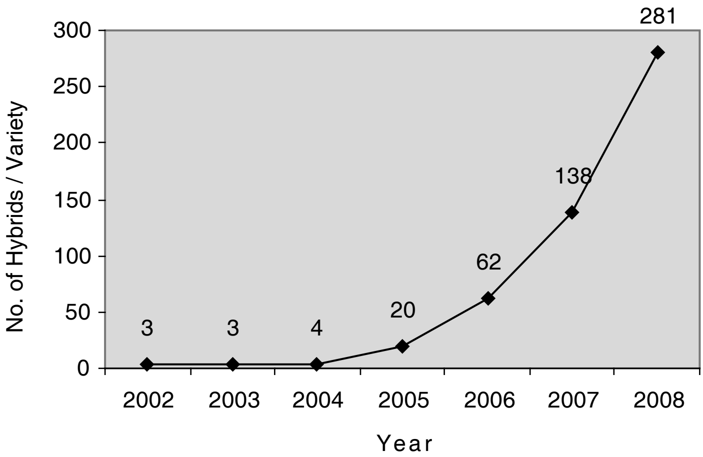


Figure 4: Commercially Released Hybrids/Variety of Bt Cotton from 2002-2008

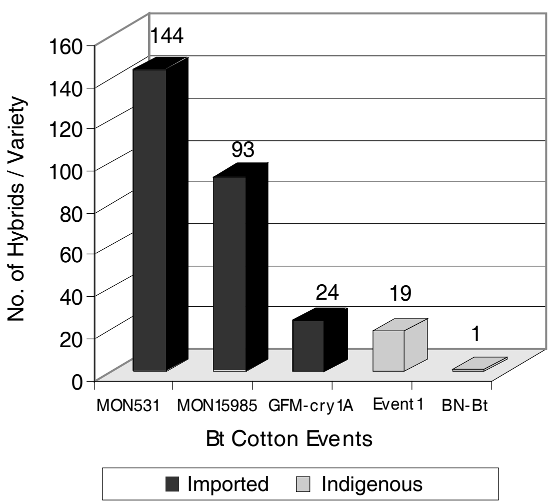


Table 1: Commercially Released Hybrids/ Variety of Bt cotton of the five events from 2002-July 2008

Year	MON 531	MON 15985	GFM-cry1A	Event 1	BN-Bt	Total
2002	3	-	-	-	-	3
2003	-	-	-	-	-	-
2004	1	-	-	-	-	1
2005	16	-	-	-	-	16
2006	24	7	3	8	-	42
2007	56	13	3	4	-	76
2008	44	73	18	7	1	143
Total	144	93	24	19	1	281

Source: *www.igmoris.nic.in*

In the year 2002, the permission for commercialization was given to three cotton hybrids only, whereas in year 2004 permission for commercialization was granted to one more hybrid followed by 16 hybrids of the same event. The year 2006 was the turning point when for the first time, 42 hybrids of four events of Bt cotton were permitted to grow commercially (Table 1). Later in the year 2007, 76 hybrids of these four events were allowed to grow commercially. In the year 2008 alone, 142 hybrids and one cotton variety of five events were commercialized.

Significantly, the highest number of imports in a year (18 imports) and the highest number of hybrids/ variety of Bt cotton given permission to grow commercially has been in the year 2008 which clearly shows that the transparent regulatory mechanism as well as advances in GM technology put in place by India are giving their promised results. Similarly, the area under cultivation of Bt cotton in India has dramatically increased from merely 29,000 hectares in 2002 to 7.6 million hectares in 2008 which clearly implies positive adoption of technology by the Indian farmers.

Interestingly from 1997 till date, 79 imports in 12 crops with more than 2 dozen traits with an array of diverse transgenes/ promoters/ markers have been made, yet only one transgenic crop, i.e. Bt cotton with an insect resistance trait with five different events has been commercialized. Evidently robust technology coupled with demonstrated viability of traits has played an overriding role in predominant adoption and commercialization in case of Bt cotton.

Concluding Remarks

There remains a critical gap between the pace at which the transgenic planting material is being imported by the private and public sector and its commercialization. The reasons for this may include:

1. Lack of single window system for issuance of different permits and clearances;
2. Relatively stringent regulatory mechanism prior to commercialization of transgenic crops;
3. Inadequate specialized manpower as well as research infrastructure for undertaking comprehensive risk assessment and management studies pertaining to the transgenic crops;
4. Inadequate generation of awareness about the benefits and risks of transgenic crops as well as the technology has acted as a serious handicap;
5. Lack of effective public private partnerships though lately there have been a few models which are working successfully.

To bridge this gap, it would be imperative to take up the development of GM crops in a mission - mode manner and different linkages need to be developed during generation of biosafety/ allergenicity and toxicity data. The biosafety studies should be conceptualized right in the beginning of the project at the stage of initial development of transgenics in the laboratory. All intellectual property rights related issues pertaining to transgenes/promoters/markers/constructs, etc. should be sought right in the beginning only so that such issues and disputes may not arise at later stages which may delay their commercialization. This will certainly require large scale investment in particular by the public sector in terms of developing specialized manpower, research infrastructure as well as putting in place dedicated public institutions and an authority for the purpose.

Therefore, systematic and planned development, import/ exchange and rapid commercialization of transgenic crops with due regard to biosafety issues pertaining to environment and human health followed by regular post release monitoring to evaluate the long-term impacts would be imperative to sustain the biodiversity while fully harnessing the benefits of transgenic crops.

Endnotes

[1] James (2008).
[2] GOI (1989).
[3] Mangal et.al (2003).
[4] GOI (1990).
[5] GOI (1994).
[6] GOI (1998).
[7] IGMORIS (2008).
[8] Tyagi (2007).
[9] James (2008).
[10] IGMORIS (2008a).
[11] Nayak *et al.*, (1997).
[12] Katageri *et al.*, (2007).

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Tyagi, V., D. Chand., I. P. Singh., S. P. Singh and S. Singh. (2007). "Guidelines for exchange of transgenic planting material", in Gurinder Jit Randhawa, Shashi Bhalla, V. C. Chalam and S. K. Sharma (eds): *Cartagena Protocol on Biosafety: Decisions to Diagnostics*, pp. 74-81, National Bureau of Plant Genetic Resources, New Delhi.

Annex 1: Cropwise details of transgenic planting material imported for research purposes through NBPGR

S. No.	Year of Import	Transgene	Trait	Country of export	Importer
Gossypium spp.					
1	1998	*cp4epsps*	Herbicide resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., New Delhi
2	1999	*cry X*	Insect resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., Jalna
3	2000	*cry X*	Insect resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., Jalna
4	2001	*vip-3A*	Insect resistance	USA	Syngenta India Pvt. Ltd., Pune
5	2002	*GFM cry1A*	Insect resistance	China	Nath Seeds Ltd., Aurangabad
6	2003	*cry 1F/ cry 1Ac*	Insect resistance	USA	De-nocil Crop Protection Pvt. Ltd., Mumbai
7	2003	*vip-3A*	Insect resistance	USA	Syngenta India Pvt. Ltd., Aurangabad
8	2005	*cry1Ac* (Event MON-531), *cryX (cry1Ac & cry2Ab*, Event 15985)	Insect resistance	USA	Proagro, PGS Ltd., Gurgaon
9	2005	*vip-3A* (cot 203 event)	Insect resistance	USA	Syngenta India Pvt. Ltd., Pune
10	2005	*Ascorbate peroxidase (APX)*	Hydrogen peroxide homeostasis during during cell fibre development	USA	Ankur Seeds Pvt. Ltd., Nagpur
11	2005	*cry1Ab*	Insect resistance	USA	Syngenta India Pvt. Ltd., Pune
12	2005	*cry1Ab*	Insect resistance	USA	Syngenta India Pvt. Ltd., Pune
13	2006	*cp4epsps*	Herbicide resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., Mumbai
14	2006	*35S-rol A, B & C and Mannosyl transferase*	Drought tolerance	China	Nath Seeds Ltd., Aurangabad
15	2006	*cry1Ac (Mon531)* & *cry2Ab* (Mon 15985)	Insect resistance	USA	Vikki's Agrotech Pvt. Ltd., Hyderabad
16	2006	*cp4epsps and cry1Ac & cry2Ab2* (MON 15985 X (MON 88913)	Insect resistance and herbicide resistance	USA	Emergent Genetics India Pvt. Ltd., Hyderabad

Annex: 1 continued

Annex: 1 continued

17	2006	*cp4epsps* (MON88913)	Herbicide resistance	USA	Emergent Genetics India Pvt. Ltd., Hyderabad
18	2008	*cry1Ac, cry2Ab*	Insect resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
19	2008	*cp4epsps*	Herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
20	2008	*2mepsps*	Herbicide resistance	USA	Bayer Bioscience Pvt. Ltd., New Delhi
21	2008	*bar, cry1Ab, cry2Ae*	Insect resistance and glufosinate ammonium herbicide resistance	USA	Bayer Bioscience Pvt. Ltd., New Delhi
22	2008	*cry1Ac, cry2Ab, epsps*	Insect resistance and herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
Oryza sativa					
23	1997	*ama1*	High nutritional value	Philippines	JNU, New Delhi
24	1998	*basta*	Herbicide resistance	USA	CCMB, Hyderabad
25	1999	*cry1Ac*	Insect resistance		Monsanto Genetics India Pvt. Ltd., Jalna
26	1999	*cry 1 A (b)/*	Insect resistance	UK	Proagro, PGS Ltd., Gurgaon
27	2000	*cry19C and bar*	Insect resistance and herbicide resistance	Belgium	Hybrid Rice International, Gurgaon
28	2001	*Xa –21, cry1 Ab, PR*	Bacterial pathogen Xanthomonas oryzae resistance and insect resistance	Switzerland	DRR, Hyderabad
29	2001	*crtl (phytoene desaturase and lcy (lycopene cyclase)*	Beta-carotene biosynthesis in seeds	Switzerland	DRR, Hyderabad
30	2002	*cry1A(b), bar*	Insect resistance and glufosinate ammonium herbicide resistance	Belgium	Hybrid Rice International, Gurgaon
31	2002	*Xa –21*	Bacterial pathogen *Xanthomonas oryzae* esistance	Philippines	Maharashtra Hybrid Seeds Co. Ltd., Hyderabad
32	2003	*psy, crtl and 1cy*	Beta-carotene biosynthesis in seeds	Vietnam	DRR, Hyderabad

Annex: 1 continued

Annex: 1 continued

33	2003	*HAS and bar/ ScFv and AFP-AG*	Nematode resistance	Germany	Maharashtra Hybrid Seeds Co. Ltd., Mumbai
34	2005	*psy, crtl*	Beta-carotene biosynthesis in seeds	USA	IARI, New Delhi
35	2006	*GFM cry1A (cry1Ab-1Ac)*	Insect resistance	China	Nath Seeds Ltd., Aurangabad
36	2007	*cp4epsps*	Herbicide resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., Mumbai
37	2007	*bar/ cry1C/ cry1Ab*	Insect resistance and glufosinate ammonium herbicide resistance	Belgium	Bayer Biosciemce Pvt. Ltd., New Delhi
38	2008	*cry1Ca, bar*	Insect resistance and glufosinate ammonium herbicide resistance	Belgium	Bayer Biosciemce Pvt. Ltd., New Delhi
39	2008	*ferritin*	Improved nutrition	Philippines	Rice Research Station, West Bengal
40	2008	*cry1Ac, cry2A & cry1C*	Insect resistance	China	Pioneer Overseas Corp., Hyderabad
41	2008	*cry1Ab, cry1C & bar*	Insect resistance and glufosinate ammonium herbicide resistance	Belgium	Bayer Biosciemce Pvt. Ltd., New Delhi
42	2008	α-*amylase*	Improved nutrition	USA	Pioneer Hi Bred International, Inc.
Zea mays					
43	1998	*cry1Ab*	Insect resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., New Delhi
44	2001	*cry1Ab*	Insect resistance	USA	Syngenta India Pvt. Ltd., Pune.
45	2003	*cp4epsps*	Herbicide resistance	South Affrica	Monsanto Genetics India Pvt. Ltd., Mumbai
46	2005	*cry1Ab*	Insect resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
47	2005	*cry1A(b)* {Event MON 810}	Insect resistance	Philippines	Monsanto Genetics India Pvt. Ltd., Mumbai
48	2005	*cry1A(b)* {Event MON 810}	Insect resistance	Philippines	Monsanto Genetics India Pvt. Ltd., Mumbai
49	2006	*cry1A(b)* {Event MON 810}	Insect resistance	Philippines	Monsanto Genetics India Pvt. Ltd., Mumbai

Annex: 1 continued

Annex: 1 continued

50	2006	*cry1Ab* (MON 810), *cp4epsps* (NK- 603)	Insect resistance and herbicide resistance	South Africa	Monsanto Genetics India Pvt. Ltd., Mumbai
51	2006	*cp4epsps*	Herbicide resistance	South Africa	Monsanto Genetics India Pvt. Ltd., Mumbai
52	2007	*gat (glyphosphate -N-acetyl transferase gene)*	Glyphosate resistance	USA	Metahelix Life Sciences Pvt. Ltd., Bangalore
53	2007	*cp4epsps*	Herbicide resistance	Philippines	Monsanto Genetics India Pvt. Ltd., New Delhi
54	2007	*cp4epsps*	Herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., New Delhi
55	2008	*cry1A.105, cry2Ab2*	Insect resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
56	2008	*Modified epsps*	Herbicide resistance	Philippines	Syngenta India Pvt. Ltd., Pune
57	2008	*epsps, cry1A.105*	Insect resistance and herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
58	2008	*gus*	Reporter gene	USA	Dupont Seed Pvt. Ltd.
59	2008	*cry1F and cry1Ab*	Insect resistance	USA	University of Agricultural Sciences, GKVK campus, Bangalore
60	2008	*Control elements*	Insect resistance	USA	Dupont India Pvt. Ltd., Hyderabad
61	2008	*cry1F*	Insect resistance	USA	Dow Agrosciences India Pvt. Ltd, Mumbai
Brassica spp.					
Brassica oleracea var. *capitata* & var. *botrytis*					
62	1997	*cry 9C*	Insect resistance	Belgium	Proagro Seed Pvt. Ltd., Gurgaon.
63	2006	*cry1Ba & cry1Ca*	Insect resistance	Netherlands	Nunhems India Pvt. Ltd., Gurgaon
64	2006	*cry1Ba & cry1Ca*	Insect resistance	Netherlands	Nunhems India Pvt. Ltd., Gurgaon
Brassica juncea					
65	1997	*barnase,*	Male sterility	Belgium	Proagro, PGS Ltd., Gurgaon
66	1999	*barnase, bar*	Male sterility	Belgium	Proagro, PGS Ltd., Gurgaon
67	2000	*bar, barstar, barnase*	Male sterility and restoration of male fertility & glufosinate ammonium herbicideresistance	Australia	Proagro, PGS Ltd., Gurgaon

Annex: 1 continued

Annex: 1 continued

68	2001	*bar, barstar, barnase*	Male sterility and restoration of male fertility & glufosinate ammonium herbicideresistance	Belgium	Proagro, PGS Ltd., Gurgaon
Brassica napus					
69	1999	*osmades-1, bar*	Reduced apical dominance & male sterility	Belgium	Proagro, PGS Ltd., Gurgaon
Triticum aestivum					
70	2003	*HAS and bar/ ScFv and AFP-AG*	Nematode resistance	Germany	Maharashtra Hybrid Seeds Co. Ltd., Mumbai
71	2007	*epsps*	Herbicide resistance	USA	Maharashtra Hybrid Seeds Co. Ltd., Mumbai
Glycine max					
72	1998	*cp4epsps*	Herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., New Delhi
73	1998	*cp4epsps*	Herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., Mumbai
74	1999	*cp4epsps*	Herbicide resistance	USA	Monsanto Genetics India Pvt. Ltd., Indore
Cicer arietinum					
75	2001	*Bean alpha-amylase inhibitor*	Insect resistance	Scotland	ICRISAT, Patancharu
76	2001	*Bean alpha-amylase inhibitor*	Insect resistance	Australia	Assam Agrigultural University, Jorhat
Nicotiana tabacum					
77	2002	*Alternate oxidase(AoX)*		Canada	University of Hyderabad, Hyderabad
Solanum tuberosum					
78	*2005*	RB	Late blight resistance	*USA*	CPRI, Shimla
Lycopersicon esculentum					
79	2008	*Arabidopsis vacuolar H+ pyrophosphatase (AVP1)*	Increased salt and drought tolerance	USA	Bejo Sheetal Seeds Pvt. Ltd., Jalna