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Note on BT Cotton Adoption and Diffusion in India

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Abstract: *Genetically Modified (GM) crops were introduced in the middle of 1990s in USA and subsequently in other parts of the world. GM crops were launched mainly in Soybean, Cotton, Corn and canola crops. The main GM traits in which GM crops were released are (i) Insect resistance (IR), (ii) Herbicide tolerance (HT) and (iii) stacked traits of IR and HT. The GM traits commercialized so far, whether it is Insect resistance (IR) through Bacillus thuringiensis (Bt) genes, which make crop resistant to Lepidopteran pests or the HT trait, which aids in weed management of crops when specific herbicide "Roundup Ready" is used; are only "loss prevention" technologies, which enable realization of full genetic potential of already existing native traits of a plant variety (Thrall et al 2011)1. The spread of GM crops where ever they are released into environment is rapid as they enjoy advantage over natural biodiversity. Globally, in 2012, GM crops reached an area of 170 million ha in 30 countries, which is 100 fold increase of area in 1996 when GM crops were cultivate only in USA.*

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Spread of Bt cotton in India between 2002 – 03 and 2013-14

Year	#of Bt cotton events	#of Bt cotton hybrids	#of seed companies selling Bt cotton	Adoption of Bt cotton (Mha)	Total cotton area (Mha)	% of Bt cotton Area	# of Bt cottton farmers (Million)	% of Single Gene Bt cotton	% of double gene Bt cotton	Cotton production (M Bales)	Cotton yield (Kg/ha)
2002-03	1	3	1	0.05	7.7	1	0.05	100	-	13.6	302
2003-04	1	3	1	0.1	7.6	1	0.08	100	-	17.9	399
2004-05	1	4	1	0.5	8.9	6	0.3	100	-	24.3	463
2005-06	1	30	3	1.3	8.9	15	1.0	100	-	24.4	467
2006-07	4	62	15	3.8	9.2	42	2.3	96	4	28	521
2007-08	4	131	24	6.2	9.4	66	3.8	92	8	31.5	567
2008-09	5	274	30	7.6	9.4	81	5.0	73	27	29	525
2009-10	6	522	35	8.4	10.3	81	5.6	43	57	30.5	503
2010-11	6	780	35	9.4	11.0	85	6.2	30	70	31.2	475
2011-12	6	884	40	10.6	12.2	88	7.0	18	82	35.3	493
2012-13	6	1097	44	10.8	11.6	93	7.2	10	90	33.4	489
2013-14	6	1167	45	11.67	12.25	95	7.7	4	96	39	541

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Spread of Bt cotton in different cotton growing states in India between 2002 and 2014

State	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Maharashtra	25	30	200	607	1,840	2,800	3,130	3,396	3,710	3,960	3,995	3,860	3,950
A.P.	8	10	75	280	830	1,090	1,320	1,049	1,650	1,820	1,935	2,100	2,275
Gujarat	10	36	122	150	470	908	1,360	1,682	1,780	1,930	2,015	2,130	2,525
M.P	2	13	80	146	310	500	620	621	610	640	605	620	560
North Region	-	-	-	60	215	682	840	1,243	1,162	1,340	1,390	1,365	1,425
Karnataka	3	4	18	30	85	145	240	273	370	570	520	580	610
Tamil Nadu	2	7	5	27	45	70	90	109	110	220	220	194	110
Others	-	-	-	-	5	5	5	8	8	120	120	146	115
Total	**50**	**100**	**500**	**1300**	**3800**	**6200**	**7605**	**8381**	**9400**	**10600**	**10800**	**10990**	**11570**

Bt Cotton the only commercialized GM crop in India, was given clearance for biosafety and thereby safe release into environment in 2002. The details of Bt Cotton adoption in India as per ISAAA (Choudhary, B. and Gaur 2015) (Organization funded by Monsanto and other Biotech Trait developers) are given above. It can be clearly seen that the area under Bt cotton increased from nearly 1 mha in 2005 (5% of Cotton cultivated area) to 11 mha (85% of the Cotton cultivated area) in 2011 due to adoption of available Bt Cotton hybrids across the country by farmers though the yield remained almost the same between 450-500 kg per ha.

From an agro-ecological standpoint, in the initial years, once Bt Cotton is sown by a few farmers in a village, all the adjoining farmers have no choice but to adopt Bt Cotton. This is in view of the fact, the target pests (Boll worms) which now cannot thrive on Bt Cotton fields, move to adjacent non-BT Cotton fields, thereby significantly increasing the pest load in all surrounding non-Bt Cotton fields. . In such conditions, farmers are compelled to use higher quantity of pesticides to protect yield losses due to additional pest migration due to Bt Cotton adoption. This becomes highly uneconomical for non-Bt cotton farmers to continue growing non Bt Cotton or any other crop, which harbors the same target pests (eg: Pulses, vegetables, Corn, etc.) . The movement of pests from Bt Cotton or other GM crop fields to non- GM crop fields has been scientifically evaluated in many insect behavior and insect population dynamics assessment studies with respect to ovipositional (egg-laying) patterns, mating behaviors and buildup of insect population/pest load in a non-Bt crop or in refugia crop, to determine the ecological impact of Bt Cotton.

From an evolutionary paradigm based on Darwin's theory of natural selection and survival of fittest, the plant varieties with Bt trait, which has an adaptive advantage over non-Bt varieties, will proliferate in the environment, leading to a rapid spread of the only the varieties with the trait. Various studies show that insect movement, mating frequency, fecundity, and egg-laying pattern all contribute to buildup of pest load in non-Bt fields. This change in population dynamics and physiological response of insects to Bt toxin was also later used in Bt Refugia strategy for delaying of insect resistance against Bt Cotton. A few excerpts of relevant studies are reproduced below.

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"A number of studies using such models indicate that expression of toxins at very high levels could slow pest adaptation to a crawl if the ecology and genetics of the pest and cropping system fit specific assumptions. These assumptions relate to: (1) inheritance of resistance factors; (2) ecological costs of resistance factors; (3) behavioral response of larvae and admits to the toxins; (4) plant-to plant movement of larvae; (5) adult dispersal and mating behavior; and (6) distribution of host plants that do and do not produce the toxin(s)." (Annotated Bibliography 2003)

"Pest populations typically increase in fields of non-Bt crops or patches of wild hosts, which are source habitats, while fields of Bt crops are population sinks where populations decline. In particular, the refuge strategy adopted widely to delay resistance to Bt crops is based on the idea that susceptible insects. produced on non-Bt host plants near Bt crops will mate with resistant pests surviving on Bt crops (Yves Carriere, et al 2010)

The Cartagena protocol for biosafety which is built on the "precautionary principle" of Convention on biological diversity, governing the biosafety of GM crops, applies fundamental principles of evolution, ethics, and natural justice with respect to exercise of sovereign rights of a nation for approving GM crops.

The article-1 which describes the objective of Cartagena protocol is reproduced below .

(Cartagena protocol 2013)

"In accordance with the precautionary approach contained in Principle 15 of the Rio Declaration on Environment and Development, the objective of this Protocol is to contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movements."

The fact that plants with GM trait has a natural advantage over non-GM native varieties also comes out of the above statement in the Global convention.

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