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Need for a Robust Desi Cotton Roadmap

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There was turbulence in the north and mild tremors across rest of the cotton farms in the country last year. In 2015, all the Bt-cotton Bollgard-II (BG-II) hybrids in north India without exception suffered to a variable extent from whiteflies and cotton leaf curl virus disease (CLCuD). Alarmingly, all the BG-II hybrids suffered from pink bollworm infestation to a variable extent all across central and south India. Production declined. Farmers protested. Monsanto openly threatened to go back home. Irrespective of their presence or absence in India, it is a fact now that the pink bollworm will continue to vandalise cotton especially in Gujarat and other parts of central and south India. It is clear that so far cotton in the country was riding on a Bt bubble waiting to burst. After having seen how the tiny worms tore into the all powerful BG-II, we need to seriously prepare a roadmap that would help us fight the bollworms without getting into the chemical quagmire like in the yester years. India cannot afford more bubbles; what we need is sustainable solutions for high yields. If the solutions have to be sustainable, they will have to essentially come from within the home.

Ideally, the country should have harvested a record yield because of the good monsoon all across the country except in Marathwada and north Karnataka. Though monsoon was erratic initially in Telangana, it recovered to normalcy by end of the season. But yields were 18% less than predicted.

Despite the prediction of a normal good monsoon for 2016-17, none of the cotton stakeholder agencies are having the courage to predict high yields. With the experiences faced last year, there is apprehension and many finger are crossed. What next? Is the question that everyone is asking.

A few technology proponents are proposing Bollgard-III as the solution to the current problems. The proposal of the three gene (Cry1Ac+Cry2Ab+VIP3A) based BG-III has actually little to offer to assure effective bollworm control. The 'BG-II resistant' pink bollworms may not even take 2-3 years to munch the new BG-III. Wide-strike (Cry1Ac+Cry1F) from Dow Agrosiences and Twinlink (Cry1Ab+Cry2Ae) from Bayer may not stand a strong chance before the pink bollworm since the worm is already resistant to the related Bt toxins Cry1Ac and the Cry2Ab. Pink bollworm is a late season pest that occurs after mid November in Central

and South India. Bolls formed during November and later are likely to get into the grip of the pink bollworm and may not contribute significantly to yields. Therefore it is unlikely that any of the currently listed Bt-cotton technologies may be able to combat the BG-II resistant pink bollworm. Any other unlisted technology, even if it gets into the country this year, may take at least another five years to be commercialised, after having completed all the regulatory requirements. The closest that we can get is to the BG-III which may be a bit better than the rest of all the Bt-cotton technologies that have completed field trials in India. But, before we consider that a new technology BG-III may give us any additional benefit, we must answer the basic question. Did Bollgard-II benefit India?

EXPERT'S Column



Dr. K.R. Kranthi

Bt-era is coming to an end

Data clearly show that Bollgard may have benefitted to some extent, but BG-II may not have conferred any additional benefit to the country. The single gene Cry1Ac based Bt-cotton Bollgard (BG) was introduced into India in 2002 in Central and South India and in 2006 in North India. Bt-cotton controlled the bollworms effectively and insecticide use decreased by 33.0%. During the period 2002-2007 yields increased by 67%. But, it would be incorrect to attribute the yield increase to Bt-cotton alone. During the five year period, fertilizer usage on cotton increased by 36%; area under hybrid cotton doubled; the irrigated cotton area in Gujarat doubled; a new seed treatment chemical imidacloprid 'Gaucho' effectively protected susceptible Bt-cotton hybrids from sap-sucking insect pests; at least six new effective insecticides were introduced to control sap-sucking insects and bollworms. Yields had already increased in North India even before the introduction of Bt-cotton in 2006. Interestingly, when the yields increased to the current levels of 490 kg lint per hectare in 2004, the non-Bt area in India was about 95% and there were just about three Bt-cotton hybrids that were available in the market. Nevertheless, to be fair to the Bt-cotton technology, it must be admitted that bollworm damage was arrested and yields were certainly protected by Cry1Ac to a good measure. But yield benefits were not just because of Bt-cotton.

The introduction of Bollgard-II in 2006, ushered in a lot of uncertainty in Indian cotton. Yields were 554 kg lint per hectare in 2007 when the area under BG-II was negligible. Yields declined constantly to 504 kg/ha by 2012 as the area under BG-II increased every year from 0% in 2006 to reach a saturation point of 90% in 2012. For nine years after 2006, yields stagnated at 504-524 kg/ha with no perceptible benefit from the increase of area under BG-II. Disappointingly, the yields were stagnant despite 70% increased usage of fertilizers (Data source: Ministry of Agriculture, http://eands.dacnet.nic.in/Cost_of_Cultivation.htm). Alarming, the insecticide usage also increased by 92%, because of increase in sap-sucking insects on the BG-II hybrids. Insecticide use increased significantly from 0.5 kg per hectare to 0.97 kg per hectare, thereby resulting in rapid development of 'insecticide-resistance' in whiteflies and leaf hoppers. A whopping 734 Bollgard-II hybrids were approved to saturate the entire country's cotton area with Bollgard-II in just five years after its introduction. Majority of the new BG-II hybrids were highly susceptible to leaf hoppers and whiteflies. However hard one might search, there is no scientific evidence to show that BG-II may have actually conferred any additional benefit over Bollgard after 2006. If anything, yields declined and chemical usage (fertilizers and pesticides) increased significantly. Thus to sum up, there is no evidence

to show that the introduction of BG-II may have actually benefitted the Indian farmer.

BG-II was expected to delay resistance development of bollworms to Bt-cotton. However, the policy of deploying the Bt-technology in hybrids with cry genes in heterozygous condition, coupled with long duration of the hybrids, blew away the benefits into thin air. This policy brought the pink bollworm back as a major pest after 30 years of hiatus. The pink bollworm which was almost forgotten in India after 1980 appeared back in 2010. It is now highly resistant to Cry1Ac+Cry2Ab toxins of BG-II. This happened because of two major factors: firstly long duration (180 to 240 days) hybrids and secondly, the segregation of Bt toxins in seeds inside the bolls of Bt-cotton hybrid crop. Both these factors are unique to India. Pink bollworm is a late season pest. The main insect peaks occur when winter sets in. As long as the pink bollworms were susceptible to Bt toxins, it was easy to cultivate long duration Bt-cotton hybrids, but not any longer. In bolls of BG hybrid, about 25% of developing seeds do not contain Cry1Ac toxin and in bolls of BG-II hybrids, about 6.25% of seeds do not contain Bt toxin, while about 18.75% seeds have only Cry1Ac; 18.75% contain only Cry2Ab and the rest would have both toxins. This situation provides an ideal condition for an insect species that can survive only on developing seeds or floral parts. The pink bollworm is one such species which used these ideal conditions to develop resistance to Bt-cotton rapidly.

Clearly the pink bollworm will continue to damage Bt-cotton in the ensuing seasons. The damage will only increase with every progressing year. Pink bollworm will continue to be a major threat as long as late duration hybrids are cultivated. Another impending problem is the dreaded American bollworm. Indications are that it is likely to resurface any time in the next few seasons. With just the pink bollworm in action, cotton cultivation becomes uncertain. With the two major bollworms back in form, cotton cultivation would become miserable again with every possibility of the return of the chemical juggernauts.

What next after Bt-cotton?

With bollworm resistance to Bt-cotton, will Indian cotton survive? What next after Bt-cotton? This is one question that many have been asking, but few have answers. With bollworm resistance to Bt-cotton surfacing as a reality, the common concerns are: How will we be able to control bollworms? How can we get good yields? How can we get good quality cotton? Are we heading back to the era of chemical farming which was so uncertain?

As of now there are no solutions that are robust enough to immediately replace Bt-cotton hybrids.

However with careful planning, effective strategies can be developed.

For the ensuing 2016 season, some simple solutions that the Bt-cotton seed industry may consider to escape pink bollworm infestation are as follows:

1. Avoid Bt-hybrids of more than 180 day duration
2. Recommend Bt-hybrids that are tolerant to leaf hoppers in Central and South India and to leaf curl virus in North India
3. Develop Bt-cotton hybrids with homozygous condition of the cry genes

These strategies work in a better manner if sowing is done in time and with strict avoidance of excessive use of chemicals such as urea, neonicotinoids and insecticides such as monocrotophos, especially during pre-flowering period which results in prolonged vegetative phase, delayed maturity and prolonged crop duration.

Hybrid cotton has its own advantages of hybrid vigour with more bolls per plant, big boll size, superior length and strength. Hybrid plants are designed to produce more number of bolls at about 80-150 bolls per plant which invariably make them run into a longer duration. Application of excessive urea and a few insecticides of the neonicotinoid and the organophosphate group would extend the crop duration and severely disrupt natural enemy complexes in ecosystems thereby making it easy for the bollworms to attack and prosper. Moreover, long duration cotton results in a long flowering and fruiting window. Because of the hybrid vigour of foliage the crop exhausts the available nutrients in the vegetative stage itself, with very less left for the critical flowering and fruiting phase. The long duration pushes the 'flowering and fruiting' window into moisture and nutrient stress in rainfed regions which results in low yields. Literature shows that 80% of moisture and nutrients are needed by cotton plants at the flowering and fruiting phase, with 60% of this requirement for flowering. Under irrigated conditions water and nutrients can be provided during the late window of flowering and fruiting. But, the pink bollworm becomes an issue for long duration cotton, because it is a late season pest. So far, the long duration hybrids survived the pink bollworm due to the presence of Bt. It will be difficult now because of the pink bollworm resistance to BG-II.

Short duration varieties escape the pink bollworm. If sown early, in Central and South India, short duration early maturing varieties complete the narrow flowering window in August itself, even before the American bollworm starts its first peak infestation in early September. Thus it is possible to escape both the major bollworms with short duration varieties or hybrids. But, with the low

density of plants, short duration Bt-hybrids cannot give high yields and long duration hybrids come under pink bollworm attack. High density is not a viable option with hybrids because of high seed cost and also because of hybrid vigour which needs to be suppressed with chemicals.

Alternatively, a sustainable option is to rely on pure-line straight varieties. Though seemingly simple, a very robust solution is "Sucking pest tolerant, early maturing, compact varieties with good fibre quality short duration (<150 days) for rainfed and medium duration (<180 days) for irrigated".

Plant breeders may consider developing cotton varieties with the following attributes:

1. Short duration (140-150 days) cotton varieties for rainfed conditions
2. Medium duration (150-180 days) cotton varieties for irrigated conditions
3. Early maturing and synchronous flowering habit
4. Mandatory resistance/tolerance to leaf hoppers in Central and South India
5. Mandatory resistance/tolerance to leaf curl virus in North India

With just about the need for 8-10 bolls per plant in the high density planting systems, the attributes of big boll size, superior fibre quality, can be easily obtained with the pure line, short duration, early maturing varieties, which fit into high density planting. Why high density? Under high density of 1.1 to 2.5 lakh plants per hectare, high yields can be obtained with few bolls (8-10) per plant. This requires a narrow window of flowering and boll formation. Under rainfed conditions, the crop gets access to soil moisture and nutrients easily for the narrow window. With early sowing of early maturing short duration varieties, flowering of 8-10 flowers is completed by mid-August and the crop escapes American bollworm which start generally by end of August and peak in September and October. With short duration crop, harvest is completed before the end of November and pink bollworm appears after that time.

Strange as it may sound to many, Desi cotton will be the best bet as an alternative to Bt-cotton. All roads lead to home. Why then was the Desi cotton species *Gossypium arboreum* replaced completely with American cotton species *Gossypium hirsutum*? Because the Desi cotton bolls were small and the fibre was short, weak and coarse. The fibre was not suitable for machine spinning. The bolls of American cotton varieties were bigger and the fibre was relatively longer, stronger and finer. The fibre quality was suitable for machine spinning. The American cotton varieties responded to chemical fertilizers and were highly susceptible to insects and diseases.

S. No	Name	Year	Institution	Duration days	Ginning percent	Fibre length (mm)	Bundle Strength	Mic value	Counts
1	G. Cot. Hy DH 9	1990	GAU, Surat	180-200	34	31	23	4.7	20
2	PHA 46	1996	MAU, Parbhani	180	34	29	22	5	40
3	Parbani Turab	2004	MAU, Parbhani	150-160	38.1	28	22	4.5	40s
4	DLSa 17	2009	UAS, Dharwad	145-150	38	27.5	22	4.5	30
5	PA 183 (Sawata)	1996	MAU, Parbhani	150-160	38.3	27	20.5	4.6	30
6	Pawan ADB 332	1981	ANGRAU	170	38	27	23	4.4	30
7	PA 402 (Vinayak)	2005	MAU, Parbhani	160-170	38.4	27	21.5	4.6	40
8	Rohini (NA 48)	1985	MAU, Nanded	175	38	26-27	46	4	30

Insecticides were essential for good yields. The American cotton hybrids respond more to fertilizers and need more pesticides for protection against a range of insect pests and diseases, because of the high levels of susceptibility. Of course, the American cotton varieties can also be tailored for sustainability, but Desi varieties provide the necessary resilience and robustness that are needed for long term sustainability of high yields with low production costs and least chemical inputs. Unfortunately, historically, there was very less effort on breeding good quality Desi varieties. Many of the varieties were of long duration bearing coarse fibre. It is only now that some excellent short duration varieties with outstanding fibre qualities have been developed. A combination of short staple and long staple short duration Desi varieties can certainly make a huge difference to cotton farming in the country.

India's future is in DESI cotton: The Desi cotton species *Gossypium arboreum* is resistant to drought, climate extremes, insects and diseases. It has the resilience to grow without chemical fertilizers and pesticides. The Desi *Gossypium arboreum* species has all the necessary answers for Indian cotton. We now have Desi varieties with long, medium and short staple fibres. Phule Dhanwantary is an excellent short staple short duration variety, which has been doing wonderfully well in Vidarbha for high yields under high density planting almost without any chemical inputs. Efforts are being made to develop long staple Desi varieties with architecture and duration similar to that of Phule Dhanwantary. Indian plant breeders have done a brilliant job in developing Desi varieties with excellent quality fibre as can be seen from the above table.

Additionally, there are four varieties developed by MAU Parbhani. PA 812, 785, PA 778 and PA 740 which have outstanding fibre qualities of 30-32 mm fibre length, 30 g/tex (HVI mode) with fine micronaire and other fibre attributes equivalent or better than the fibre of any best American cotton variety or hybrid developed in India thus far.

In my article "Long Live Swadesi Cotton" in CAI Cotton Statistics & News Vol. No. 20, August 2013, I had concluded that 'It is for sure that, if India has to move towards sustainable cotton cultivation, Desi cotton provides the answers not just for sustainability but for a vision towards India's global leadership that can happen through focused efforts and sound planning.' There were mixed responses, with most on them on the two extremes. However, last month I was pleasantly surprised when a senior colleague who in August 2013 had scoffed at the idea of Desi cotton returning back, called me to ask if 'at this point of time, can we explore the option of Desi cotton?'. He was worried at the crumbling of all the American cotton hybrids to the 'Cotton Leaf Curl Virus Disease' in many parts of North India in 2015. However much we may look at the possible sustainable alternatives after Bt-cotton, for high yields with low production cost and least chemical inputs, all roads seem to lead to Desi cotton varieties.

*"All that is gold does not glitter,
Not all those who wander are lost;
The old that is strong does not wither,
Deep roots are not reached by the frost.*

*From the ashes a fire shall be woken,
A light from the shadows shall spring;
Renewed shall be blade that was broken,
The crownless again shall be king."*

— J.R.R. Tolkien, *The Fellowship of the Ring*

It may be that I am obsessed with Desi cotton to the extent that, when I first read this beautiful poem, each line reminded me only of Desi cotton. The last line 'The crownless again shall be king' is the most apt for it. I firmly believe that the unheralded crownless 'Desi cotton' shall soon be the King to lead India towards durable economic profitability and ecological prosperity.

(The views expressed in this column are of the author and not that of Cotton Association of India)