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Technologies are breaking down –What next?

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From the year 2000, over the past fifteen years a few technologies made a huge difference to cotton production in India. But now, these technologies have either entered a stage of fatigue, or diminishing returns or near death. At this stage, it is important to take stock of what is failing, what lies in shambles and what needs to be done for tomorrow. It is widely acknowledged that the Bacillus thuringiensis (Bt) based genetically modified (GM) Bt-cotton technology and the new 'neonicotinoid' class of insecticides played a strong role in protecting cotton hybrids from insect pests, thereby resulting in higher cotton production during the past decade. Data show that the technology benefits are now fading. In this context it is also pertinent to examine the case of a prospective herbicide resistant GM technology that has suddenly become debatable because of a recent technological assessment and declaration by the WHO (World Health Organization). If technologies keep falling like cards, -where do we go from here?

EXPERT's Column

Dr K.R. Kranthi

TECHNOLOGY BREAK DOWN

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The bollworms, whiteflies and cotton leaf curl virus (CLCuV) are the most menacing. Thus far, until almost three to four years ago, there were a few technologies that were able to provide relief from these problems. But now these technologies are fatigued. New 'neonicotinoid' class of insecticides that were able to control the whiteflies have become ineffective. Whiteflies are able to survive almost all recommended insecticides, only to cause more damage by transmitting the dreaded leaf curl virus. Bt-cotton technology has thus far been effective in keeping bollworms under check, but recent reports from Gujarat and Maharashtra indicate that the efficacy of Bt-cotton will decline sooner than later. The leaf curl virus continues to evolve, resulting in new potent virulent strains such as the 'Multan' and 'Burewala' strains that break down the best of CLCuD-resistant cotton varieties. Because of the technologies breakdown, the bollworms, whiteflies and virus are laughing all the way. A new GM cotton technology called Roundup-Ready-Flex (RRFlex®) was just about to be approved for commercial cultivation in India. But a recent WHO declaration has pushed the technology into a fresh debate. If potent technologies continue to breakdown time and again, and with no new technologies in immediate sight, cotton production can end up at cross roads. Under the current predicament, it is time to ponder whether this is the correct road towards sustainability.

Breakdown of Bt-cotton: Are bollworms having the last laugh?

Is Bt-cotton unable to protect cotton crop from bollworm damage? Since the last week of July, there were several distress calls from Gujarat farmers informing of an outbreak like condition of the pink bollworm on Bollgard-II (BG-II) most of which was sown in May. BG-II has a potent combination of two Bt genes cry1Ac + cry2Ab. We sent teams from CICR to assess the situation. Indeed pink bollworm larvae were causing damage to flowers and tender bolls of Bt-cotton Bollgard-II in many parts of Gujarat. The pink bollworm was reported to be happily chewing up plant parts of BG-II in some of the fields, unaffected by the Bt-toxins present in the plants. While a few farmers were resorting to indigenous methods such as 'cow urine + calotropis + neem + butter milk etc., to control the pink bollworm menace on Bollgard-II, some farmers had uprooted their fields.

Also, over the past two years, there were stray reports of the American bollworm (Helicoverpa armigera) larvae surviving on bolls of BG-II in fields of Gujarat and Maharashtra. The two bollworm species (pink and American) are the most menacing. Bollgard-II is probably the most powerful of all technologies that have thus far been developed for bollworm control. Beyond doubt, Bt-cotton technology has been very effective in controlling bollworms and has so far efficiently protected an estimated 13.42% cotton yield loss in India over the past thirteen years during 2002 to 2014 (Kranthi, unpublished data). But at this point of time, when reports are piling up to show that bollworms are able to survive on Bollgard-II, is it time to ask if the technology is on the verge of breaking down? The question is, if the technology is unlikely to protect cotton crop from bollworm damage in the coming years –Where do we go from here? Is it -back to insecticides, or do we have any other back-up plans.

Breakdown of new insecticides: Sucking pests are marauding.

Imidacloprid –one of the most potent insecticides released in recent times, is no longer effective as seed treatment in Bt-cotton. It is neither effective any longer as foliar spray. Whiteflies and leaf hoppers were exhibiting resistance from 2009 in India to the highly effective new class of insecticides called 'neonicotinoids'. Imidacloprid which belongs to the neonicotinoid class of insecticides was registered in India in 1993. The chemical was highly effective as seed treatment and foliar sprays at low concentrations in controlling leaf hoppers and whiteflies. Subsequently two more insecticides, thiomethoxam and acetamiprid were approved in 1999.

When imidacloprid (Gaucho®) was first used as seed treatment for cotton fifteen years ago, the resultant seedlings would resist sap-sucking pests for at least 75 to 80 days. 'Imidacloprid' is a strong systemic (absorbed and trans-located) chemical. When used for seed treatment, the chemical is absorbed by the seedlings through its initial growth and is trans-located through the tissues. Sap sucking pests suck the plant sap and get killed by imidacloprid. All the Bt-cotton hybrid seeds are treated with Gaucho because majority of the cotton hybrids are susceptible to leaf hoppers and whiteflies. I must mention here that there is a fairly strong genetic association of big boll size with leaf hopper susceptibility in majority of the cotton hybrids. In other words, if the bolls are big, the chances of leaf hopper susceptibility are also high. Farmers prefer big boll hybrids. Without imidacloprid seed treatment, these susceptible hybrids do not grow properly and yields are reduced because of stunted growth. Needless to mention, hybrid cotton technology wouldn't have been as successful as it has been, without the seed treatment technology. Imidacloprid played a significant role in protecting Bt-cotton hybrids from sap-sucking insects, thereby enhancing cotton yields. Over the past 14-15 years, leaf hoppers and whiteflies were exposed continuously to imidacloprid, thiomethoxam and acetamiprid, all belonging to the same chemical class called 'neonicotinoid', which are used either as seed treatment or foliar sprays. Because of the continuous exposure, whiteflies and leaf hoppers developed resistance to the neonicotinoid class of insecticides. Thus none of these insecticides is now able to kill the target insects, either as seed treatment or as foliar sprays. Since whiteflies are able to survive insecticides, they are able to transmit the leaf curl virus easily.

The neonicotinoid group of insecticides are now under global scrutiny. On the December 1, 2013, the European Food Safety Authority (EFSA) banned clothianidin, imidacloprid and thiamethoxam as seed treatment, soil application and foliar sprays for a period of two years in all the 28 member states of the European Union. The ban was enforced in view of the reports that these chemicals were highly toxic to honey bees, which were collecting pollen, nectar and guttation fluid from plants that developed from seeds treated with neonicotinoids. Foliar sprays had more severe effect. Though the regulatory system in India is yet to contemplate any action, the neonicotinoid class of chemicals may not be preferred by farmers and seed companies because of the reduced efficacy. So, is it the end of the road for imidacloprid and the also the other insecticides belonging to the neonicotinoid class? Also, because big boll hybrids are generally more susceptible to leaf hoppers and get affected the most by sucking pests, is it also a threat to big boll hybrid cottons as well?

A combined breakdown of Bt-cotton and

insecticides will mean victory of insects over technologies. Is there any fresh arsenal in sight that can help scientists and farmers win the war against insect pests?

The glyphosate question: Prospects of (GM) RRFlex cotton?

Glyphosate (Roundup® and other brands) is a chemical herbicide (kills weeds) that has broad spectrum activity on a wide range of weeds. It is the largest selling herbicide across the globe. Amongst GM crops, herbicide tolerant crops, mostly, resistance to glyphosate constitute 154 million hectares, which is 85% of the total area under GM crops. The glyphosate tolerant GM crops, cotton, maize, soybean and canola have been extensively cultivated across industrial countries over the past few years. Though India is yet to approve the commercial cultivation of glyphosate resistant RRFlex® (Roundup®-Ready) cotton, glyphosate was being increasingly used for weed control over the past 15-16 years to substitute the acute labour shortages in the country. Since the herbicide is toxic to conventional crops, the chemical was being carefully sprayed on weeds using hoods, to avoid any possible drift on the main crop plants. Until 1996, glyphosate was not used in the country. However, about 1.0 million litres were sprayed in 1998 and by 2010 the usage increased to almost 10.0 million litres. In India, glyphosate is used 30% on tea, 14% on cotton, 13% on sugarcane, 10% on paddy and 33% on vegetables and fruit orchards. These figures may change slightly from year to year, but the trend remains more or less the same.

On 15th March 2015, the WHO (World health organization) declared glyphosate as a probable carcinogen under the category 2A. BG-II-RRFlex® cotton was expected to be resistant to the cotton bollworms and the herbicide glyphosate. Since labour shortages and wage hikes were affecting weeding operations, RRFlex® cotton technology was being considered as the nex-gen GM technology that could have a favourable impact on the cotton scenario in India. Regulatory testing for bio-safety and agronomic benefits was in the final stage in India and the technology was expected to be approved any time. The WHO declaration comes as a blow to the herbicide and the glyphosate resistant GM crops. It remains to be seen how the Indian regulatory system reacts to the recent developments and finally what impact it could have on chemical weed management in India.

Breakdown of natural resistance: Cotton leaf curl virus (CLCuV) is back

Reports are being received continuously over the past two weeks from the north, confirming heavy infestation of whitefly and leaf curl virus especially in late sown crop. More than 300 Bt-cotton hybrids were released and introduced into north India after 2006 by private seed companies and almost all of them are susceptible to CLCuD. The Bt-cotton hybrids replaced all the conventional varieties that were resistant to the CLCuD. Some of the resistant varieties that were developed earlier by the public sector institutions are now breaking down before whiteflies and the leaf curl virus. A variety called LRA-5166 (developed by CICR) was highly resistant to the leaf curl virus. Apart from being cultivated, LRA-5166 was commonly used as CLCuD-resistant source by plant breeders to develop new varieties and hybrids. Even LRA-5166 is breaking down.

The virus is transmitted by the whiteflies. Just a few insects can inject the virus into the plants. The severity of infection depends on weather conditions, strain of the virus and susceptibility of the variety. As the name suggests, the disease causes leaf curling. It cripples the plant and can be debilitating, depending on the severity of infection. Early stage of infestation distorts the leaves and stunts the crop, resulting in significant yield loss. So far the disease is restricted only to north India and Pakistan. The disease is not curable. Preventive methods can help in avoiding the disease. For more details on the CLCuV disease please see my article 'Cotton leaf curl virus time bomb' in the CAI 'Cotton statistics and News' published on 22nd April 2014.

The CLCuD was first reported in 1989 in India. There were two outbreaks in 1993 and 1996. Subsequently through its All India coordinated cotton improvement (AICCIP) programme, the CICR (Central Institute for Cotton Research) intensified efforts and identified CLCuD resistant varieties such as LRA-5166, RST9, RS875, RS810, RS2013, F1861, LH2076, H117, H1126 and resistant hybrids LHH144, CSH198, CSHH238 and CSHH243 which were popular in north India until the introduction of Bt-cotton hybrids in 2005. Prior to 2005, the entire area in north India was covered by public sector cotton varieties. For the development of these varieties, it was mandatory for AICCIP to approve only CLCuD resistant genotypes for cultivation in north India. The technology of CLCuD resistant varieties was coupled with several other strategies such as Desi cotton cultivation (Desi cottons varieties are immune to CLCuD), early sowing, clean cultivation etc., which resulted in virtual disappearance of the virus during 1998 to 2006. From 2007 onwards, CLCuD resurfaced again and is now causing havoc in Punjab, Haryana and Rajasthan. This is primarily because of the fact that several private seed companies started releasing Bt-cotton hybrids indiscriminately with scant regard to CLCuD reaction. These companies were not conscious to the fact that the virus could resurface any time in an epidemic form, even with the introduction of one or two susceptible hybrids. Lessons should have been learnt from the Pakistan situation where CLCuD had started in 1973 in their popular varieties

149-F and B-557. The disease became an epidemic with the introduction of highly susceptible varieties such as S12 and CIM-70 in 1988.

August marks the beginning of a three month crucial phase for cotton in India. In north India, the main troublesome story starts in July itself when whiteflies mark their presence. These are small white insects of 1.2mm width. As mentioned in the previous passages, they transmit the dreaded leaf curl virus. It is widely known that the best way to control them is through eco-friendly strategies and habitat management. Many chemical insecticides are known to cause insect resurgence and outbreaks. Insecticides disrupt the naturally occurring biological control and some of them induce physiological changes in the insect which lead to outbreaks. Therefore it is extremely important to start with soft options such as neem oil based sprays. Under emergency conditions, soil application of systemic insecticides such as acephate or ethion is preferred. But, farmers want quick solutions. Many scientists and extension workers play to the gallery by recommending chemicals which may be acceptable to farmers but may have long term detrimental effects of the ecosystems. One chemical leads to the need for the next. Industry makes hay while the sun shines. More recommendations are made in a sequence subsequently, but this time by the pesticide dealers. Pesticides cocktails are sprayed. By September, whiteflies dominate and inject the entire region with the leaf curl virus. The crop gets battered. What comes out clearly at the end of every season is that 'everyone advises but nobody listens to anybody'. Finally technologies are overused and misused to the point that they become useless.

Clearly, the introduction of large number of Bt-cotton hybrids which are susceptible to whiteflies and CLCuD- in north India and discontinuation of CLCuD-resistant varieties has clearly aggravated the virus problem. But the issue is not just about susceptible Bt-cotton hybrids, over the past 4-5 years the whiteflies have developed high level of resistance to the most potent neonicotinoid class of insecticides. There are hardly any recommended chemicals available in the market except one or two newly introduced insecticides that are effective in controlling whiteflies. But, it is not insecticides that can give long term relief from the whiteflies and the virus. It is a set of policies, strategies, recommendations and implementation that together can have an impact. The disease can only get worse if the CICR recommendations are not taken seriously.

Conclusion

Technologies make a difference. Cotton is one of the few crops that have been tremendously influenced by technological breakthroughs. Technologies with genetic modification (GM); inter-specific and intra-specific hybrids and varieties; novel pesticides, management of diseases, insect and nematode pests, weeds, nutrients, soil, water and climatic aberrations; and mechanisation have contributed significantly to enhanced productivity. Harnessing the full potential of any technology for the longest possible time is an art. But, on the technology highway, it is not uncommon to see dead geese that laid golden eggs. It is sad to see epitaphs of some fabulous technologies which may have met their grave due to untimely death. Unfortunately, this happens more frequently in India than anywhere else. Sometimes this could be because, indiscriminate over-use, commercial considerations of industrial lobbies over-ride scientific opinion; nobody listens to anybody, at least in the agricultural sector and invariably the best technologies end up on the altar of 'overkill'. In this context it would be important to point out that, we must learn to respect our past, primarily because of the lessons that can be learnt from previous disasters. Remember 'those who forget history are condemned to repeat it'. It remains to be seen as to how many times we have to repeat history, as we suffer from memory loss; each time ending up with a bloody nose. Technologies are important, but they need to be sustainable. Sustainability and resilience can be ingrained into technologies only if they are developed in harmony with nature and in consonance with local ecology and environment.

As we mindlessly wander amongst ruins, with hopes to rebuild the falling citadels, again and again, it is worth remembering Rachel Carson who wrote the following passages in her book "Silent Spring" (Houghton Miffin, 1962) that created a storm 50 years ago. The storm continues still.

"The current vogue for poisons has failed utterly to take into account these most fundamental considerations. As crude a weapon as the cave man's club, the chemical barrage has been hurled against the fabric of life a fabric on the one hand delicate and destructible, on the other miraculously tough and resilient, and capable of striking back in unexpected ways. These extraordinary capacities of life have been ignored by the practitioners of chemical control who have brought to their task no "high-minded orientation," no humility before the vast forces with which they tamper."

"We stand now where two roads diverge. But unlike the roads in Robert Frost's familiar poem, they are not equally fair. The road we have long been travelling is deceptively easy, a smooth superhighway on which we progress with great speed, but at its end lies disaster. The other fork of the road the one "less travelled by" offers our last, our only chance to reach a destination that assures the preservation of our earth."

- Rachel Carson, 1962, Silent Spring.

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