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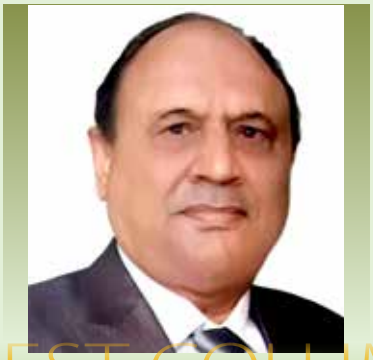
Cotton Exchange Building, 2nd Floor, Cotton Green, Mumbai - 400 033
Phone: 3006 3400 Fax: 2370 0337 Email: cai@caionline.in
www.caionline.in

Pink Bollworm - A Notorious Pest on Cotton



GUEST COLUMN

Dr. Brijender Mohan Vithal
Cotton Expert

Dr. Brijender Mohan Vithal has a Ph.D. Agric (Plant Breeding-Cotton) from Punjab Agriculture University (PAU) Ludhiana. He has been associated with cotton R&D activities for more than three decades. He has worked as a Senior Cotton Breeder with PAU, GM Production / Executive Director with National Seeds Corporation and Director, DOCD, Ministry of Agriculture (MOA). He was Officer on Special Duties (OSD) to look after activities related with Tech Mission on Cotton (TMC) in CCI Ltd during its pre-launch period. He joined CCI Ltd - TMC Cell (MMIII & IV) during 1999 and continued working there till the end of the TMC Project in December 2010. He is still associated with cotton through agencies like ISCI.

An article published in 'Economic Times' dated 13th August, 2018, mentioned that cotton farmers of Maharashtra and Telangana face potentially huge losses this year too, as the respective state agricultural departments have observed growing incidence of Pink Bollworm (PBW) infestation in parts of the two states. Along with the deficient rainfall, the pest has triggered concern among farmers.

Similarly, the crop season 2017, witnessed PBW attacks on cotton, especially in Maharashtra and also in Telangana, Andhra Pradesh and Karnataka. According to a study by the International Food Policy Research Institute, the adoption of Bt cotton was low till 2005. Between 2005-06 and 2016-17, India's cotton acreage and yields increased by a fifth. In 2017-18, while the area was bigger than last year, productivity was estimated to be 9% lower. Vijay Kumar, the then principal secretary in the Maharashtra agriculture department, said that around 80% of the area sown under cotton in the state was affected by PBW.

The Cotton Advisory Board (CAB) also lowered its cotton output estimates of 37.7 million bales to 37 million bales for 2017-18. This low production was largely attributed to PBW attack on the cotton crop. Further, this damage has also resulted in decline of about 4% area under cotton during the current year (2018-19), from that a year ago, at all India level; as per Union agriculture ministry's data.

The Federation of Seed Industry of India (FSII) is an association of research-based seed and seed technology companies that provide

high-performance and high-quality seeds. More than 10 of its member companies catered to around 40-45 per cent of the hybrid Bt cotton seeds in the 2017 kharif season. FSII in its report dated 16th January 2018, mentioned that it is very difficult to establish that yield loss, if any, is due to PBW attack. It is an established scientific fact that crop yields depend on multiple factors. It also said that a major factor for the possible resistance development in pink bollworm is due to non-adherence to the regulatory guideline of planting non-Bt refuge by farmers. It is also dependent on the quality of non Bt refuge seeds supplied by some seed companies. All these factors might have contributed to any possible yield losses.

Similar reports have been made available by different agencies during the last couple years that PBW has caused hazards and has become major pest even to Bt cotton crop. But no one is ready to own responsibility.

The following Information has been collected from different sources on various aspects of PBW. But since some of it too technical, efforts have been made to place said information in a simpler form, for our readers.

A Review on Pink Bollworm *(Pectinophora gossypiella- Saund)*

The cotton crop is attacked by 1326 species of insect pests throughout the world, of which about 130 different species of insects and mites devour cotton at different stages of crop growth in India. The Pink Bollworm (Pectinophora gossypiella - Saunders) was first recorded in India in 1842 and it spread to other countries of the world through cottonseeds. Pink Bollworm has assumed major pest status in recent years and has known to cause loss in seed cotton yield, oil content, loss in the normal opening of bolls, damage of locules and reduction in seed cotton yield. etc. PBW attack also lowers quantity and quality of both, lint (affecting fibre length, fibre bundle strength and micronaire) and seeds. It is one of the serious pests of cotton throughout the cotton growing parts of India.

To better understand the havoc caused by the PBW, it is important to know its life history (different stages of life), carry over system, damaging stage, nature of damage it causes, symptoms on plants, its prediction criteria and control measures. It is also important to understand reasons for PBW occurrence on Bt cotton with Bollgard II. The following facts will prove illuminating:-

Life History of PBW

PBW like other boll worms has four stages, viz. egg, larvae, pupae and adult. It is the larval stage that damages the crop at its different stages. Adults contribute in increase of their population. See pictures below:

Late instar larvae (damaging stage)

Adult Pink Bollworm

Egg: Eggs are white when first laid but then turn orange, and later the larval head capsule is visible prior to hatching. Eggs hatch in about three to four days after they are laid. Eggs measure about 0.5 mm long and 0.25 mm wide.

Larvae: The mature larva is 10-12 mm long and has broad horizontal bands of red/pink colour. The larva turns pink in the fourth and final in stars of development only. The young larva is a tiny, white caterpillar with a dark brown head up to second in star. It becomes pinkish in third and fourth in star. The larval period lasts for about 10-14 days.

Pupae: The pupa is light brown and approximately 7 mm long. The pupal stage lasts for 7-10 days.

Adult: the adults are small, grayish brown, inconspicuous moths. The wing tips are conspicuously fringed. There is a time period of 2-3 days after emergence during which the

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female mates and prepares to lay eggs. Pre-oviposition period is about ten days. Adults may live for one to two months. The moths are about 7-10 mm with a wing span of 15-20 mm.

Carry Over

PBW remain in left over standing cotton throughout the year. About 35 per cent larva survive in the lower part of the heap in the leftover bolls of cotton stalks kept horizontally. The seed cotton carried to market yards acts as a source for the pest to spread. In the absence of cotton, or as a genetically pre-disposed condition, the pink bollworm undergoes hibernation for 6-8 months, until the next season.

Nature of Damage

After hatching, the young larva penetrates the ovaries of flowers or young bolls within two days of hatching. Larva prefer feeding on developing seeds and generally pupates inside the seeds and bolls. Affected bolls either open prematurely or get badly affected due to rotting. Fibre length and strength are lowered. Further, the cotton lint in the insect infested bolls gets damaged by secondary fungal infection

Symptoms

1. Rosette flowers: Flowers do not open fully. They get twisted.

2. Spots on green bolls: Black spots on green bolls may often be indicative of PBW damage. PBW damaged bolls often predispose the occurrence of secondary bacterial infection that results in the blackening of boll rind on the outside.

3. Stained lint in open bolls: This is a distinct symptom of damage. It occurs in the later stages of crop growth, once the damage is done.

Control Measures

The introduction of Bt cotton hybrids during 2002 and its wide spread cultivation (>95% area) in the country, has showed change in dynamics of the pests. The Pink Bollworm, once a serious problem for non Bt cotton especially in later stage of the crop has now become a major problem in Bt cotton hybrids, as has been mentioned in recent reports above. The damage starts appearing from flowering stage of the crop and inflicting damage, if unattended.

Integrated Pest Management (IPM)

Weather Conditions

Maximum temperature greater than 33°C, morning relative humidity less than 70 %, evening relative humidity greater than 40 % during the standard weeks of 40, 41 and 43, and less than 12°C minimum temperature between 48 and 49 respectively, result in PBW severity

Better Management Practices (BMPs):

Better Management Practices (BMPs) are agricultural practices which optimise the three pillars of sustainability:- social responsibility, environmental integrity and economic viability by binding together, the financial requirements for agriculture, such as high yield with environmental and social concerns, such as water and pesticide use. Thus, all efforts should be made to adopt BMPs to control PBW.

Biological Control:

Byproducts of excess pesticide use are; (a) resistance (b) emergence of secondary pests (c) health hazards (d) ground water contamination and (e) increase in production cost.

One way of reducing pesticide use in agricultural production is to use biological control organisms. To get maximum benefit from biological control of insects in cotton, farmers should establish the insect's natural enemies in their fields with minimum use of selective insecticides that have least impact on bio organisms. PBW has a number of parasitoids and predators. Mass rearing and release of various parasitoids from India include Trichogrammabrasiliensis (Ashm.), Braconkirkpatricki and Chelonusblackburni. Predatory mites Pyemotesventricosus (Newport) and P. herfsi (Oudemans) are widely reported as preying on and giving good control of long cycle larvae.

Botanical Control:

As per reports available, application of botanicals, NSE 5%, Azadirachtin 1500 parts per million (ppm) and neem oil 1% proved to be the most effective. Neem oil at 1.5 and 2% and neem seed water extract at 2 and 3% resulted in significantly lower damage than control

Chemical Control:

The first application of Indoxacarb 15.8 EC @ 0.0079%, Emamectin benzoate 5 SC @

0.0025% or Spinosad 45 SC @ 0.014% at 75 DAS (days after sowing) and second application at 15 days after first spray was found economical and effective in managing pink bollworm in Bt cotton. Other chemicals like Cyfluthrin, spinosad and indoxacarb were reported as being effective in controlling PBW. Both, Thiodicarb 70 SP (750 g active ingredient (a.i.) /ha) as well as profenophos 50 EC (500 g a.i. /ha) effectively controlled PBW. As per other reports, even deltamethrin 1% EC + triazophos 35% EC at the rate of 360 g a.i./ha was the best followed by triazophos 40 EC (400 g a.i./ ha), deltamethrin 10 EC (25 g a.i./ha), thiodicarb 75 SG (562 g a.i./ha) and lamdacyhalothrin 5 EC (25 g a.i./ha) for the control of PBW. Thiamethoxam 25% WDG (40 g/ ha) was the most effective insecticide followed by chlorantraniliprole 20% SC and spinetoram 12% SC for the control of PBW.

Cultural Control:

Cultural control measures of PBW play a key role in keeping down the number of PBW carry-over between cotton crops. Maintenance of host free period during off-season is a must to ensure a pink boll worm free next season. Effective measures of prevention of pink bollworm damage include:-

A. Actions during post- harvest, off-season and pre planting periods:-

- Allowing cattle grazing of the left-over green bolls on the plant at the end of crop season
- Timely crop termination to maintain closed season
- Clean cultivation and destruction of crop residues (fallen leaves, twigs etc.) before the onset of season
- Avoiding stacking of cotton stalks for fuel purpose over long periods
- Summer deep ploughing to expose the pupae of the surviving larvae
- Selecting varieties with early maturity while planning for the next season,
- Drying of seeds under sun for 6-8 hours and sowing of acid de-linted seeds are effective and economical to prevent the carryover of pink bollworm to the next cotton season
- Cent per cent mortality was observed when seeds were exposed for 20 min at 48.9°C temperature
- Avoiding late sowing

B. Actions during the cropping season:-

Care must be taken to monitor PBW infestation on the crop during crop season. This can be done easily through:-

- Adequate planting of refuge in Bt-cotton fields
- The use of gossyplure pheromone baited traps that attract the males. Once a few male moths are found in the traps, it is an indication of the incidence starting in the bolls of the cotton plants
- One approach to PBW suppression is to trap most of the male moths in the crop ecosystem by using a large number of pheromone traps (@ 20 nos./ha) so that mating is disrupted and the population development is arrested. For this method to be effective, traps should be placed over many fields over larger areas
- Since the damage and stages of PBW are not visible, the decision of insecticidal spray can be made, looking at the male catches in the traps. If the moth catches exceed eight per trap for three consecutive days, an insecticidal spray in the field is recommended.
- When much of the bolls on the plants are 20-25 days old between October end and November, insecticidal protection is a must. In the absence of pheromone traps, assessment of PBW damage should be based on destructive sampling (boll cracking method) and chemical spray should be taken up when two live larvae are found in 20 medium sized green bolls sampled per acre
- Pyrethroids can be used against PBW during this period
- The open bolls on the plants should be harvested before the spray, as there is likelihood of aphid resurgence. When there is resurgence of aphids that would affect the quality of cotton, it is recommended to spray any one organo phosphorus insecticides. This takes care of pinkies as well as stainers resulting in the harvest of quality cotton.

These practices, if adopted on field-to-field basis over large areas of cotton growing regions by the cultivators, would largely bring down the attack of PBW in the ensuing season. All other management strategies such as pheromone traps, PB rope, botanicals, bio-agents and insecticides, alone and with integration, can be effective for controlling PBW.

Efforts to Reduce PBW Resistance in Other Parts of the World

As per reports available, scientists from the U.S. and China have discovered that by hybridising genetically-engineered cotton with conventional cotton, reduced the resistance of the pink bollworm. Details of the 11-year study that tested more than 66,000 pink bollworm caterpillars from China's Yangtze River Valley are published in the Proceedings of the National Academy of Sciences.

The ingenious strategy used in China entails interbreeding Bt cotton with non-Bt cotton, then crossing the resulting first-generation hybrid offspring and planting the second-generation hybrid seeds. This generates a random mixture within fields of 75 percent Bt cotton plants side-by-side with 25 percent non-Bt cotton plants.

Because cotton can self-pollinate, the first-generation hybrids must be created by the tedious and costly hand pollination of each flower, however, hybrids of the second generation and all subsequent generations can be obtained readily via self-pollination. So, the hybrid mix and its benefits can be maintained in perpetuity. The hybrid plants tend to have higher yield than the parent plants, and the second-generation hybrids cost less, so it's a market-driven choice for immediate advantages, and it promotes sustainability.

A great thing about this hybrid seed mix strategy is that we don't have to worry about growers' compliance or regulatory issues. It works for millions of farmers in the Yangtze River Valley. Whether it works elsewhere remains to be determined.

Reasons for PBW Occurrence on Bollgard II:

1. Physiological processes
   a) Defective solubilisation,
   b) Deficient proteolytic activation,
   c) Over-proteolysis (i.e. degradation of toxin),
   d) Sequestration of toxin molecules by non-functional binding sites,
   e) Defects in functional binding sites,
   f) Defective pore formation, and
   g) Enhanced cellular repair, etc.
2. Inadequate planting of refuge and more cultivation of Bt-cotton.
3. PBW is mono-phagous in nature.
4. Large scale planting of unapproved (illegal) Bt-cotton.
5. Lack of field monitoring due to Bt cotton.
6. Pest is concealed in nature.
7. Natural enemies are very few.
8. Less use of insecticides. The amount of spray fluid varies more with the canopy size than with the crop age. It is recommended that power sprayers be used against bollworm management through insecticides. Normally 200-300 liters /ha of water should be used for a crop that had attained eight to sixteen nodes.

Bt technology significantly transformed the fortunes of the cotton value chain. The experience of the last 15 years (2002-17) is testimony to its adoption even by small and marginal farmers. Any technology, though, gets obsolete with time and requiring replacement, including with upgraded versions. The development of resistance breakdown of Bt cotton to PBW is no doubt, a cause for concern. But it only underscores the importance of a long-term policy framework that supports research and allows new farm technologies into the market.

Courtesy Cotton India 2018 (Aurangabad)

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

UPCOUNTRY SPOT RATES

(Rs./Qtl)

Sr. No.	Growth	Standard Descriptions with Basic Grade & Staple in Millimetres based on Upper Half Mean Length [By law 66 (A) (a) (4)] Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	Spot Rate (Upcountry) 2018-19 Crop October 2019 7th	8th	9th	10th	11th	12th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	- -	H	- -	- -	- -	- -
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	- -		- -	- -	- -	- -
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	8998 (32000)		8998 (32000)	8998 (32000)	8998 (32000)	8998 (32000)
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	10320 (36700)	O	10320 (36700)	10320 (36700)	10320 (36700)	10320 (36700)
5	M/M (P)	ICS-104	Fine	24mm	4.0 – 5.5	4%	23	10826 (38500)		10826 (38500)	10826 (38500)	10826 (38500)	10826 (38500)
6	P/H/R (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	- -	L	- -	- -	- -	- -
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	10517 (37400)		10517 (37400)	10517 (37400)	10376 (36900)	10376 (36900)
8	P/H/R	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	- -		- -	- -	- -	- -
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	26	10686 (38000)	I	10686 (38000)	10686 (38000)	10573 (37600)	10573 (37600)
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	10911 (38800)		10911 (38800)	10911 (38800)	10798 (38400)	10798 (38400)
11	P/H/R	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	- -	D	- -	- -	- -	- -
12	M/M(P)/ SA/TL	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	11557 (41100)		11557 (41100)	11614 (41300)	11473 (40800)	11501 (40900)
13	GUJ	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	11445 (40700)		11417 (40600)	11445 (40700)	11360 (40400)	11389 (40500)
14	M/M(P)/ SA/TL/K	ICS-105	Fine	29mm	3.5 – 4.9	3.5%	28	11726 (41700)	A	11726 (41700)	11782 (41900)	11670 (41500)	11698 (41600)
15	GUJ	ICS-105	Fine	29mm	3.5 – 4.9	3.5%	28	11614 (41300)		11585 (41200)	11614 (41300)	11529 (41000)	11557 (41100)
16	M/M(P)/SA/ TL/K/O	ICS-105	Fine	30mm	3.5 – 4.9	3%	29	12035 (42800)	Y	12035 (42800)	12035 (42800)	11951 (42500)	11979 (42600)
17	M/M(P)/SA/ TL/K /TN/O	ICS-105	Fine	31mm	3.5 – 4.9	3%	30	12148 (43200)		12148 (43200)	12148 (43200)	12063 (42900)	12092 (43000)
18	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.9	3%	31	12513 (44500)		12513 (44500)	12513 (44500)	12429 (44200)	12429 (44200)
19	M/M(P)/ K/TN	ICS-107	Fine	34mm	3.0 - 3.8	3.5%	33	14904 (53000)		14904 (53000)	14904 (53000)	14904 (53000)	14904 (53000)

(Note: Figures in bracket indicate prices in Rs./Candy)

UPCOUNTRY SPOT RATES

(Rs./Qtl)

Sr. No.	Growth	Grade Standard	Grade	Staple	Micronaire	Gravimetric Trash	Strength /GPT	Spot Rate (Upcountry) 2019-20 Crop October 2019					
								7th	8th	9th	10th	11th	12th
1	P/H/R	ICS-101	Fine	Below 22mm	5.0 – 7.0	4%	15	10770 (38300)	H	10770 (38300)	10770 (38300)	10770 (38300)	10770 (38300)
2	P/H/R (SG)	ICS-201	Fine	Below 22mm	5.0 – 7.0	4.5%	15	10882 (38700)		10882 (38700)	10882 (38700)	10882 (38700)	10882 (38700)
3	GUJ	ICS-102	Fine	22mm	4.0 – 6.0	13%	20	- -		- -	- -	- -	- -
4	KAR	ICS-103	Fine	23mm	4.0 – 5.5	4.5%	21	- -	O	- -	- -	- -	- -
5	M/M (P)	ICS-104	Fine	24mm	4.0 – 5.5	4%	23	- -		- -	- -	- -	- -
6	P/H/R (SG)	ICS-202	Fine	27mm	3.5 – 4.9	4.5%	26	10432 (37100)	L	10179 (36200)	10292 (36600)	10236 (36400)	10320 (36700)
7	M/M(P)/ SA/TL	ICS-105	Fine	26mm	3.0 – 3.4	4%	25	- -		- -	- -	- -	- -
8	P/H/R	ICS-105	Fine	27mm	3.5 – 4.9	4%	26	10545 (37500)		10292 (36600)	10432 (37100)	10376 (36900)	10461 (37200)
9	M/M(P)/ SA/TL/G	ICS-105	Fine	27mm	3.0 – 3.4	4%	26	- -	I	- -	- -	- -	- -
10	M/M(P)/ SA/TL	ICS-105	Fine	27mm	3.5 – 4.9	3.5%	26	- -		- -	- -	- -	- -
11	P/H/R	ICS-105	Fine	28mm	3.5 – 4.9	4%	27	10629 (37800)	D	10376 (36900)	10489 (37300)	10432 (37100)	10517 (37400)
12	M/M(P)/ SA/TL	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	- -		- -	- -	- -	- -
13	GUJ	ICS-105	Fine	28mm	3.5 – 4.9	3.5%	27	- -		- -	- -	- -	- -
14	M/M(P)/ SA/TL/K	ICS-105	Fine	29mm	3.5 – 4.9	3.5%	28	- -	A	- -	- -	- -	- -
15	GUJ	ICS-105	Fine	29mm	3.5 – 4.9	3.5%	28	- -		- -	- -	- -	- -
16	M/M(P)/SA/ TL/K/O	ICS-105	Fine	30mm	3.5 – 4.9	3%	29	- -	Y	- -	- -	- -	- -
17	M/M(P)/SA/ TL/K /TN/O	ICS-105	Fine	31mm	3.5 – 4.9	3%	30	- -		- -	- -	- -	- -
18	SA/TL/K/ TN/O	ICS-106	Fine	32mm	3.5 – 4.9	3%	31	- -		- -	- -	- -	- -
19	M/M(P)/ K/TN	ICS-107	Fine	34mm	3.0 - 3.8	3.5%	33	- -		- -	- -	- -	- -

(Note: Figures in bracket indicate prices in Rs./Candy)