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Farmers' friendly scouting technique for *Helicoverpa armigera* (Hubner) in Bt cotton hybrids

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Abstract : *Bt* transgenic cotton appears to be a new strategy for the management of cotton bollworms. Bollgard cotton is ideally suited to IPM as the level of control of *Helicoverpa* sp. provided by the plant is usually sufficient to dramatically reduce the need to spray for this pest, especially during the early season. With the introduction of *Bt* cotton hybrids for commercial cultivation in India, it becomes imperative to develop a farmers' friendly rapid scouting technique as an alternative to know the appropriate time for taking up the protective measures by working out the level of square/ boll damage in the simplest way. Studies were made to know the allometric relationship between the square/ boll damage in the whole plant, with the square / boll damage in two-third of the plant. The results of the field studies conducted in the farmers' holdings during *Kharif* 2003 revealed that if scouting on square / boll damage is taken between 45 and 60 days sowing (DAS), on top two-third of the plant (t_2) the equation *viz.*, $t_3 = 1.2761\ t_1^{\ 07492}$ and $t_3=1.1413\ t_2^{\ 0.8731}$, could be used to arrive the square /boll damage of the whole plant, respectively. After 60 days scouting could be carried out only at top two-third portion of the plant. If it is taken up between 60 and 75 DAS, the equation *viz.*, $t_3= 1.2100\ t_2^{\ 0.8990}$, would fit to the best to find out the relative square / boll damage of the whole plant. The allometric relationships of the relative square /boll damage between top two-third and the whole plant, during 75 to 90 DAS would fit very well with the equation, $t_3 = 1.3160t_2^{\ 08964.}$

Key words: Scouting, Helicoverpa armigera, Bt cotton, Allometric model.

Indroduction

Cotton, *Gossypium hirsutum* L., the king of fibre crop, widely cultivated in India is being ravaged by several insect pests contributing to drastic reduction in yield levels and as many as 1326 insect and mite pests all over the world (Hargreaves, 1948) and about 200 in India (Anonymous, 1981) have been documented. The pesticide usage on cotton is both extensive and intensive. This is evident from the fact that 48 per cent of the pesticide consumption is by cotton alone (Balakrishnan, 1982).On a global scale, the cotton bollworm, *Helicoverpa armigera* (Hubner) referred to as American bollworm, cotton bollworm, gram pod borer, tomato fruit borer is of major importance and damages a wide variety crops (Jayaraj, 1990). Its predilection for the harvestable flowering parts of high value crops especially cotton (Uthamasamy *et al.,* 1990) confers high economic and socio-economic cost in higher input farming practices.

The major pests impacting cotton growers in India, the country with the largest acreage

Table 1. Allometric models describing the relationship of square / boll damage in *Bt* cotton hybrids.

Crop stage	Functional model t_3 Vs t_1	r^2	Functional model t_3 Vs t_1	r^2
57 DAS	$t_3 = 1.2761\ t_1^{0.7492}$	0.8378	$t_3 = 1.1413\ t_2^{0.8731}$	0.9137
63 DAS	$t_3 = 1.9828\ t_1^{0.3677}$	0.6176	$t_3 = 1.2100\ t_2^{0.8990}$	0.9403
72 DAS	$t_3 = 2.1999\ t_1^{0.2666}$	0.5761	$t_3 = 1.3330\ t_2^{0.6490}$	0.8484
80 DAS	$t3 = 10.0182\ t_1^{0.0842}$	0.0585	$t_3 = 1.3160 t_2^{0.8964}$	0.8681
87 DAS	$t_3 = 1.4208\ t_1^{0.3148}$	0.3486	$t3 = 1.1054\ t_2^{1.2071}$	0.9900

of cotton in the world (Murugan *et al.,* 2003), are the bollworms predominantly, *Helicoverpa armigera,* for the control of which insecticides worth around Rs. 1,200 crores are used annually. In spite of this, farmers are suffering huge losses. Their yield has reduced, income has dropped and debts have increased (Perlak *et al.,* 1990). Though integrated pest management (IPM) with major emphasis on biological control and other non-chemical methods is strongly recommended, it cannot be able to generate confidence among the farmers due to lack of any powerful tool that can match the temporal efficacy of a chemical insecticide (World Bank, 1990). In this context, bollworm resistant transgenic plants appear to provide the needed stability and strength to IPM especially in crops like cotton.

Bollworm resistant transgenic cotton plants had been produced based on insecticidal crystal proteins, from the soil bacterium, *Bacillus thuringiensis* and was released for commercial cultivation in USA during 1999. Subsequently, in India "Bollgard" the *Bt* gene of Monsanto (Dhar, 1996) was introduced into the Indian cotton hybrids by Maharashtra Hybrid Seed Company (MAHYCO) Limited, Mumbai appears to be the first transgenic crop after being approved by the Department of Biotechnology, Ministry of Science and Technology, Government of India.

Transgenic cotton is grown on over 1.3 million hectares (m.ha) an increase of 43% over the area of 3.7m. ha in 6 countries around the world during 1999. The fact that millions of cotton farmers in both industrial and developing countries opted for Bt cotton speaks volumes of confidence and trust; farmers have in its ability to help them in tackling the bollworm problem (James, 1999 and 2000)

Significant variations in insecticidal activity of *Bt* cotton on Bollworms at different stages, the growing season and among different parts of the plant were recorded (Zaho, 2000). Hence the crop growth and pest incidence in Bt cotton should be monitored carefully, so that appropriate control measures can be initiated immediately when the pest load crosses the economic threshold level (ETL). In India, the ETL for bollworm damage is fixed as 10 per cent square and boll damage, for which a minimum

of randomly selected twenty plants should be scouted to arrive the boll damage (Ragupathy *et al.,* 1994). Scouting the whole plant is a tedious, laborious and time- consuming process. With the introduction of *Bt* Cotton hybrids for commercial cultivation in India it becomes imperative to develop a farmers' friendly rapid scouting technique as an alternative to know the appropriate time for simplest way.

Huxley first explained the general applicability of allometric relationship for biological situations during 1932 (Huxley, 1932). Pearsall observed the allometric relationship between root storage and shoot growth in carrot and turnip during 1927 (Pearsall, 1927). Similarly, Stanhill was able to predict the taproots' weight by 95% using the leaves' weight using this relationship in carrot (Stanhill, 1977). This allometric modal helps to obtain the estimated of other parameters, which are difficult to be assessed under filed conditions. Here in this paper an attempt has been made to know the allometric relationship between the square / boll damage in the whole plant, with the square/ boll damage in two third and one-third of the plant.

Materials and Methods

Studies on the development of farmers' friendly, rapid scouting technique for the released Bt cotton hybrids namely MECH 162 Bt and MECH 184 Bt were carried out in the farmers' holding under irrigated conditions during *Kharif* 2003 by the Department Agricultural Entomology, Tamil Nadu Agricultural University, Coimbatore. Two transgenic lines of cotton produced by MAHYCO *viz.,* MECH 162 Bt, MECH 184 Bt, their corresponding non-*Bt* lines *viz.,* MECH 162 non-Bt and the national check, Bunny were taken up for the study. Standard agronomic practices were followed in raising the crop. Observations on bollworm damage were recorded from 40 days after sowing (DAS) at weekly intervals till 120 DAS. Data on the bollworm damage were taken on randomly selected, tagged twenty-five plants in the *Bt* cotton hybrids with respect to the total number of bolls, number of affected bolls in the top one-third (t_1), top two-third (t_2) and the whole plant (t_3) and the per cent damage was worked out using the formula:

$$\text{Per cent square / boll damage} = \frac{\text{Total number of affected boll}}{\text{Total number of bolls}} \times 100$$

The data on percent damage were subject to statistical analysis using the mathematical model called allometric model. Allometric relationship was estimated as per Huxley (1924) using the form $t_3\ \alpha(t_1)^{\beta}$ and $t_3\ \alpha(t_2)^{\beta}$ where t_3 and t_1 represent the variables at a given time of the plant system, α and β represent the ratio of relative square / boll damage of two variables. The efficacy of empirical relationship observed from allometric model was tested by comparing co-efficient of determination (r^2) values.

Results and Discussion

The data on the allometric relationship between t_3 Vs t_2 during different crop stages are present in Table1. The square /boll damage in the whole plant (t_3) during 45-60 DAS can be predicted by taking the square/boll damage only at top one-third of the plant using the equation $t_3 = 1.2761\ t_2^{07492.}$ The logarithmic form of this allometric relationship was

$\log_e t_3 = \log_e 1.2761 + 0.7492 \log_e t_1$
$r^2 = 0.8378^{**}$.

If the square/boll damage was recorded in two third of the plant during 45-60 DAS, the whole plant damage can be predicted using

the form $t_3 = 1.1413\ t_2^{0.8731}$. The logarithmic form of this allometric relationship was

$\log_e t_3 = \log_e 1.1413 = 0.8731 \log_e t_2$.
$r^2 = 0.9137$**.

Between the two variables tested (t_1 and t_2) for the prediction of square/boll damage of the whole plant (t_3) after sixty days of sowing, t_2 was found to be the best fit. As there was no damage during the early stage of Bt cotton crop, the level of damage was less in the bottom one third of the plant even at the later stage of crop growth. Hence, after 60 DAS, scouting could be done only at top two-third portion of the plant. When the square/ boll damage was taken for top two-third of the plant during 60 to 75 DAS, the equation $t_3\ 1.2100\ t_2^{0.8999}$ will fit to the best to find out the relative square/ boll damage of the whole plant. The logarithmic form of this equation was

$\log_e t_3 = \log_e 1.2100 + 0.8990 \log_e t_2$.
$r^2 = 0.9403$.

The allometric relationship of the relative square/boll damage between top two-third and the whole plant, during 75 to 90 DAS will fit very well in the equation, $t_3 = 1.3160\ t_2^{0.8964}$. The logarithmic form of this relationship could be derived as

$\log_e t_3 = \log_e 1.3160 + 0.8964 \log_e t_2$.
$r^2 = 0.8681$.

So, it can be concluded that scouting at early stage of Bt cotton up to 60 DAS, could be done only on the top one-third of the plant and after sixty days, scouting at top two-third of the plant will give the best results. Hence, there is no need to scout the whole plant for bollworms especially in *Bt* cotton.

This model was developed based on the single season data recorded systematically. We intend to on-farm test this model at different locations in different Bt cotton hybrids in the ensuing season.

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