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Crop Phenology, Pink Bollworm (*Pectinophora gossypiella,* Saunders) Damage and Yield of Cotton Hybrids in Relation to Sowing Dates

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ABSTRACT : The crop phenological estimates did not differ between hybrides, sowing dates and protected treatments with the exceptions of PKV HY 2 having higher number of vegetative branches than NHH 44, and higher physiological and entomological shedding under protected and unprotected situations, respectively besides higher number of harvestable bolls in unprotected than procted situation. The occurrence of other bollworms being minimal, the number of bad bolls, open boll damage and loculi damage by *P. gossypiella* was 55.5, 54.1 and 61 per cent lower in early than normal date of sowing, respectively. PKV HY 2 had 27 per cent higher *P. gossypiella* damage and 12 per cent reduced yield than NHH 44. However the interaction effects of the hybrids with planting dates for *P. gossypiella* damage revealed 39 per cent increased damage to PKV HY 2 than NHH 44 only during the normal sowing date. The hybrid x sowing date x protection treatment interactions indicated yield gain to the extent of 30 per cent by early sowing due to the escape from *P. gossypiella*. The phenology of open bolls revealed that the delay in crop maturity associated with PKV HY 2, normal sowing date and unprotected situation had led to greater damage by the late season *P. gossypiella*. The paper also discusses the mechanism of plant compensation as understood based on the growth and development of hybrids under sowing dates and protection treatments.

Key words : Crop phenology, *Pectinophora gossypiella*, sowing dates

Major loss to the Indian cotton due to bollworm complex *viz., Earias insulana* (Boisd.) and *E. vittella* (F.), *Helicoverpa armigera* (Hubner) and *Pectinophora gossypiella* (Saunders) has been estimated up to 60 per cent and more (Banerjee, 1998; Panchbhavi *et al.,* 1990). *P. gossypiella* is clearly a threat during late season of the cotton growth as its attack lowers quantity of both lint and seeds, and also the quality of lint affecting fibre length, fibre bundle strength and micronarie. Its increased severity of attack has been reported from almost all cotton growing areas if the country (Aggrwal *et al.* 1976).

Among the management strategies of *P. gossypiella*, the most effective ones are cultural practices that suppress carry over population and secondly that offer escape of the pest by avoidance through an early fruit cessation. Escape from late season pest attack could be by early sowing or by selection of early maturing cotton cultivars. Use of early maturing cultivars in reducing *P. gossypiella* damage and increasing yields have been studied extensively (Chapman 1937; 1938 and 1941). But for the general recommendation of early sowing, quantification of the extent of *P. gossypiella* damage and its effect on the yield are lacking. However, adopting a planting strategy by adjusting the sowing dates as cultural pest management tool should be a viable option. Hence, the present study examined the timing of sowing on the growth and development of cotton hybrids and its impact on the escape oe the susceptibility of hybrids to *P. gossypiella* and on yield, when attack by other two genera of early season bollworms was minimal.

MATERIALS AND METHODS

Investigation was conducted in the rainfed research farm of Central Institute for Cotton Research, Nagpur using the commonly grown *intra-hirsutum* hybrids of the central zone *viz.,* NHH 44 and PKV HY 2. A field experiment was laid with the two hybrids alloted in a split-plot design having five replications on two sowing dates *viz.,* June 16th (early) and July 7th (normal) during 1998-99 cotton production season, under protected and unproctected situations. Protected plots under both sowing dates had one systemic spray (Methyl-O-dematon @ 750 ml/ha) for the control of jassids *Amrasca devastans* (Distant) and a single spray of endosulfan @ 21/ha) against *H. armigera* at an economic threshold level (ETL) of two nymphs/leaf during mid August and one larvae/plant during September end, respectively. There was no spray against *P. gossypiella* in the early planted crop while normal sown crop had a single pyrethroid (Cypermethrin @ 750 ml/ha) spray based on the ETL of 10 per cent fruiting structure damage.

Five plants per plot were permanently selected for weekly observations throughout the crop season from the stage of square initiation. Tagging of all the squares formed during each of the standard weeks using labels and their development to flower and open boll stages was recorded. Also recorded were the numbers of squares and bolls shed due to entomological and physiological causes during each observation. Crop maturity was assessed based on the observed open bolls along the standard weeks. Post harvest plant mapping was done to evaluate final plant height, number of mainstem nodes, height-node ratio, and number of vegetative and fruiting branches. Incidence of bollworms as well as their damage was recorded simultaneously so as to decide on insecticidal applications based on ETLs. The *P. gossypiella* damage on loculi basis was recorded during the harvest of open bolls from the plants. Pooled damage of harvested bolls on loculi basis expressed as percentage, and yield obtained per plot projected per hectare were calculated. Data relating to all the crop phenological, damage and yield estimates were analysed through split plot ANOVA in MSTYAT, after appropriate transformations.

RESULTS AND DISCUSSION

The crop phenological estimates , *P. gossypiella* damage and yield levels for hybrids, sowing dates and protection treatments are furnished in Table 1. Hybrds, did not differ for all the phenological estimates except that PKV HY2 had higher number of vegetatve branches than NHH 44. PKV HY 2 had significantly higher (27%) *P. gossypiella* damage and 12 per cent reduced yield than NHH 44 although both the hybrids had almost equal number of harvestable bolls, open bolls and number of bad bolls.

Manipulation of sowing dates is an effective pest management strategy as it disrupts crop-pest association. *P. gossypiella* is a late season pest and early sowing is expected to favour cotton cultivars to escape from its attach (Leigh and Goodwell, 1996). In the present study all the phenological estimates were on par between sowing dates. However, significantly lower damage estmates *viz.,* number of bad bolls, per cent open boll damage and *P. gosspiella* damage on loculi basis to the extent of 55.5 percent, 54.1 per cent respectively, and 15 per cent increased yields in early than normal sown situation were recorded. Escape of hybrids from *P.gossypiella* was obvious with the early sowng.

Protected and unprotected situations had high degree of physiological and entomological square shedding, respectively but with no differences for the total square shed. This indicated that the loss of squares due to entomological causes have occurred under unprotected situation which otherwise would have shed physiologically as is the case in protectd situation and that the damage by early season bolloworms were very minimal. With no differnces for the boll set and shed and total fruiting structures shed, two of the hypotheses of cotton plant compensation described by Sadras (1995) fit to the present situation that either the reproductive structures are damagd that would have shed physiologically replace those damaged previously. Under such circumstances, there is also emerging evidence for revising the ETLs of early season bollworm damage for hybrids. Although the total number of harvestable bolls was significantly higher (10%) in unprotected situation, the reduced yield was a resultant effect of significantly higher number of bad bolls (54%) contributing to yield and higher damage (12%) by *P. gossypiella* in comparison with protected situation.

While difference of yields for hybrids and sowing dates were norrower (one to ne and half q/ha), near to three fold differnce was noticed between protected and unprotected situation. While hybrid x sowing date interaction was significant for *P. gossypiella* damage (Table 2), all the interaction effects *viz.,* hybrid x sowing date, hybrid x protection treatments (Table 3) and sowing date x protection treatments (Table 4) were significant for yields.

The only significant interaction effect of hybrids x sowing dates for *P. gossypiella* damage indicated both NHH 44 (17.3%) and PKVHY (14.7%) to be on par when plantd at an early date. The calculated extent of escape by early sowing to pink bollworm damage for NHH 44 and PKV HY 2 was 45 and 71 per cent, respectively as compared to normal date of sowing. PKV HY2 (52.2%) suffered an additional 20 percent. *P.gossypiella* damage than NH 44 (31.5%) wen its sowing was taken up within normal sowing date. This indicated the high sensitiveness of PKV HY2 to dates of sowing than NHH 44. Yield levels indicated superiority of NHH 44 under early as

Table 1. Crop phenological, damage and yield estimates for hybrids, sowing dates and protection treatments

Particulars	Hybrids			Sowing dates			Protection treatments		
	NHH 44	PKV HY 2	C. D.	Early	Normal	C. D.	Protected	Unprotected	C. D.
Phenological estimates (Mean no./plant)									
Square production	183.25	175.30	33.60	191.10	167.45	29.15	182.8	175.75	15.30
Bolls set	118.75	112.05	19.63	133	97.8	15.72	113.5	117.65	10.85
Physiological square shedding	27.75	24.25	4.64	46.20	23.1	5.37	**29.55**[a]	**22.45**[b]	**3.73**
Entomological square shedding	20.90	18.40	7.07	21.1	18.25	4.87	**17.30**[b]	**22.00**[a]	**4.00**
Total square shedding	48.65	43.15	10.09	36.9	41.3	9.44	47.35	44.4	6.58
Physiological boll shedding	66.45	59.00	12.85	66.8	58.6	12.25	62.90	62.50	8.27
Entomological boll shedding	12.80	14.80	4.80	15.3	11.95	3.40	13.70	13.90	2.06
Total boll shedding	79.29	73.90	16.33	82.55	70.6	13.50	76.70	76.50	9.37
Total Physiological fruit shedding	92.20	83.75	15.56	96.2	79.7	16.39	91.00	84.90	8.77
Total Entomological fruit shedding	33.60	33.25	10.88	36.75	32.8	7.05	30.90	35.90	5.00
Total fruiting structures shed	127.90	117.05	24.07	133	11.9	21.30	124.10	120.90	12.3
Total number of harvestable bolls	32.4	34.5	6.19	33.9	33	5.04	**31.7**	**35.2**	**2.8**
Vegetative branches	**2.95**[b]	**5.85**[a]	**0.49**	4.4	4.4	0.47	4.50	4.30	5.80
Fruiting branches	17.55	17.05	3.53	17.3	17.3	3.90	18.05	17.30	1.97
Height/Node ratio	3.320	3.130	0.285	3.09	2.89	0.27	3.19	3.30	0.17
Damage estimates									
Bad bolls (Mean no./plant)	13.3	15.2	4.36	**8.8**	**19.8**	**3.49**	**13.6**	**30**	**2.06**
Open boll damage (%)	40.27	45.40	8.32	**26.95**[a]	**58.67**[b]	**8.15**	43.10	42.50	5.76
Pink bollworm (%) damage (loculi basis)	**24.37**[b]	**33.52**[a]	**6.56**	**16.03**[b]	**41.87**[a]	**6.43**	**27.00**	**30.87**	**3.09**
Yield (q/ha)	**9.48**[a]	**8.42**[b]	**0.38**	**9.68**[a]	**8.22**[b]	**0.29**	**10.94**[a]	**6.97**[b]	**0.27**

*In a row means underlined are significantly different with the C. D. values specified against them

Table 2. Interaction effects of hybrids x sowing dates on P. gossypiella damage (Per cent loculi basis)

Hybrid	Sowing date*		Mean
	Early	Normal	
NHH 44	$_{a}174.3^{a}$	$_{b}31.5^{a}$	24.4
PKV HY 2	$_{a}14.7^{a}$	$_{b}52.2^{b}$	33.5
Mean	16.0	41.9	

CD for comparison of mean *P. gossypiella* damage of hybrids for sowing dates and of planting dates for hybrids are 5.243 and 6.067, respectively.

*In a column means followed by same superscript and in a row means followed by same subscript are not significantly different at P≤0.01.

Table 3. Effect of sowing dates and protection treatments on yield of hybrids (q/ha)

Hybrid	Sowing date*		Protection treatments*		Mean
	Early	Normal	Protected	Unprotected	
NHH 44	$_{b}10.38^{a}$	$_{a}8.59^{b}$	$_{b}11.72^{b}$	$_{a}7.23^{a}$	9.48
PKV HY 2	$_{b}8.99^{a}$	$_{a}7.87^{a}$	$_{b}10.15^{a}$	$_{a}6.69^{a}$	8.43
Mean	9.68	8.22	10.93	6.97	

CD for comparison of mean yields of hybrids for planting dates and for spray situations are 0.560 and 0.550, respectively.

CD for comparison of mean yields of planting dates and spray situations for hybrids are 0.576 and 0.556, respectively.

*In a column means followed by same superscript and in a row means followed by same subscript are not significantly different at P≤0.01.

Table 4. Interaction effects of sowing dates and protection treatments on yield of hybrids (q/ha)

Sowing date*	Protection treatments*		Mean
	Protected	Unprotected	
Early	$_{a}10.86^{a}$	$_{b}8.51^{b}$	9.68
Normal	$_{a}11.01^{a}$	$_{b}5.44^{a}$	8.22
Mean	10.93	6.97	

CD for comparison of yeilds of planting dates for spray situations and *vice versa* are 0.400 and 0.393. respectively.

*In a column means followed by same superscript and in a row means followed by same subscript are not significantly different at P≤0.01.

well as normal sown dates and ner protected situation. The comparatively high vegetative growth of PKV HY2 inferred through high number of vegetative branches over NHH 44,with no differences in all other phenological estimates indicate the possibility of high attractiveness offered to *P.gossypiella* moths in the former hybrid. The supporting evidence comes from within the study that PKV HY2 had suffered higher damage due to pink bollworm. Yield levels of both the hybrids were on par under unprotected situation. The sowing date and protection treatment interaction results had shown yield increases of 21 and 51 per cent under protected over unprotected situation in respect of early and normal sowing dates with no yield difference between sowing dates under protected situation for both the hybrids. The non significant differences in yield between hybrids under protected situation and between sowing dates under protectd situation emphasis the need for protection against *P.gossypiella* damage on the both the hybrids during normal sowing date and that early sowing to be better in reducing *P. gossypiella* damage and increasing te ields of both the hybrids. The interaction of planting date and spray situation also revealed the fact that yields uner two planting dates could be equal only with the control of *P. gossypiella* and that early sowing could result in 3 per cent yield gain due to the escape from *P.gossypiella.* From the perspective of PBW management, either of the hybrids could be opted for early sowing and with the delayed sowings NHH 44 should be prefrred over PKV HY2.

Further analysis of the phenology of open bolls (Fig.1) contributing to yield between hybrids, sowing dates and protection treatments pointed out the delayed crop maturity associated with PKV HY 2, normal sowing date and unprotected treatment thus supplementing the greater damage due to *P.gossypiella.* Wilson *et.al.* (1971) had reported greater accumulation of insect damage with each delay in the crop set and with the plants older and larger, as evidenced through the present study. Relating to the hypotheses by Sadras (1995), the hybrids' response represents the tme dependent passive compensation with associated delayed maturity wherein the reproductive structures that would have shed physiologically replaced those damaged previously and no increase in number of fruiting sites had occurred. This mplies that the carrying

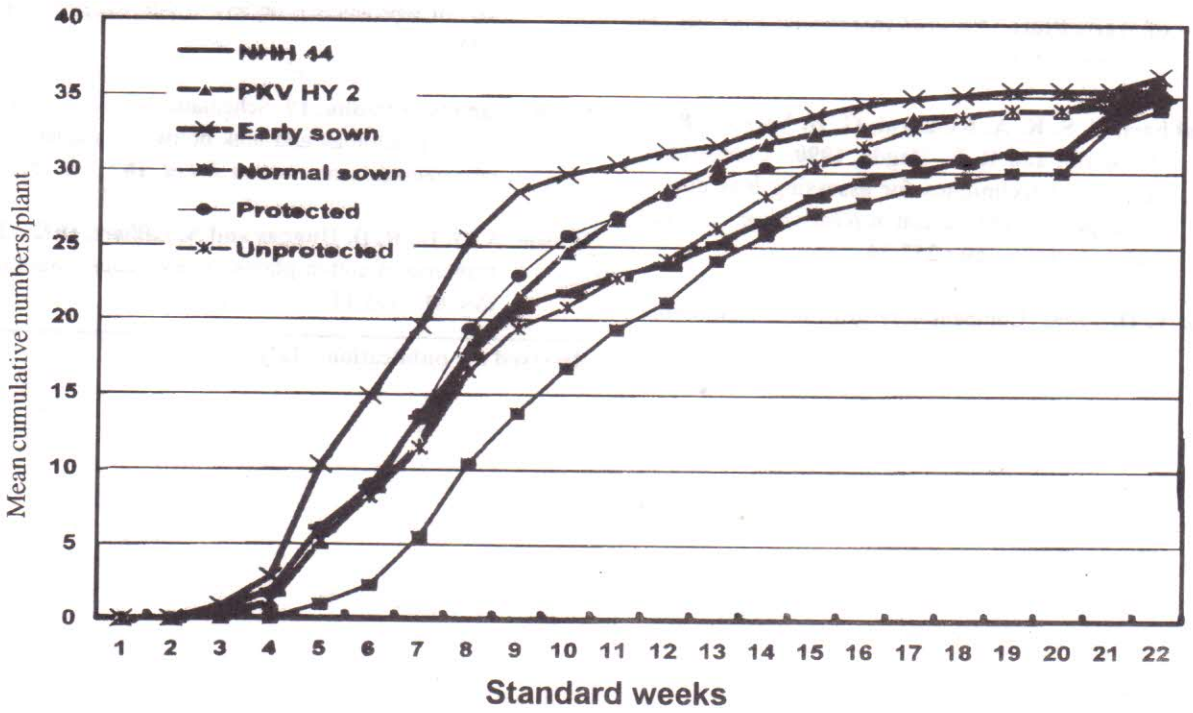

Fig. 1. Phenology of open bolls for hybrids, sowing dates and protection treatments

capacity of the cotton remains the same but for variations in maturation rates of the plants. Measurement of maturation rates in physiological time units may be quite striking so as to develop rule based management recommendations. In the construction of crop or crop - pest models, dealing with distributed maturation rates is a standard practice (Bagwell and Tugwell, 1992). Present study is a pointer towards the need to translate impact of cotton production practices such as sowing dates and insecticidal applications on the crop growth and development under Indian conditions for optimsing management decisions to realise the cultivars' yield potential.

REFERENCES

Aggarwal, R. A., S. K. Banerjee, Munishi Singh and K. N. Katiyar, 1976. Resistance to insects in cotton to pink bolloworm *Pectinophora gossypiella* (Saunders). *Cot. Fib. Trop.*, **31** : 217-21.

Bagwell, R. D. and N. P. Tugwell, 1992. Defining the period of boll susceptibility to insect damage in heat units from flower. *Proceedings of the Cotton Beltwide Conferences*, 767-68.

Banerjee, S. K. 1998. Assessment of losses due to major pests of cotton. CICR Annual Report, Nagpur.

Chapman, A. F. 1937. Varietal resistance to pink bollworm. *Tex.Expt. Sta. Ann. Rept.* **50,** 62-63.

Chapman, A. F. 1938. Pink bollworm. *Tex. Agr. Expt. Sta. Ann. Rept.* **51,** 44.

Chapman, A. F. 1941. Cotton varieties. *Tex. Agr. Expt. Sta. Ann. Rept.* **54,** 35.

Leigh, T. F. and P. B. Goodwell, 1996. Insect Management pp.260-293. In : Cotton Production Manual **(eds. Hake, S. J., T. A. Kerby and K. D. Hake),** Division

of Agriculture, *Natural Resources Pub.* 3352, *California.* P. 417.

Panchabhavi, K. S. K. A. Kulkarni, G. H. Veeresh, P. C. Hiremath, and R. K. Hegde, 1990. Comparative efficacy of techniques for assessing loss due to insect pests in upland cotton *(Gossypium hirsutm). Ind. J. Agrl. Sci.,* **60 :** 252-54.

Sadras, V. O. 1995. Compensatory growth in cotton after loss of reproductive organs. *Field Crops Res.* **40 :** 1-18

Singh, J. and A. S. Sidhu, 19. Schematic model of *hirsutum* cotton phenology and pink bollworm incidence for pest management. *Indian J. Ent.* **10 :** 310-15.

Wilson, A. G. L., R. D. Hughes and N. Gilbert, 1972. The response of cotton plants to pest attack. *Bull. ent. Res.* **61 :** 405-14.

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