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Influence of dates of sowing on incidence of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) in cotton (*Gossypium hirsutum* L.)

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Abstract
A field experiment was conducted during *Kharif* 2021 at AICRP on Cotton, Chamarajanagara to investigate the influence of dates of sowing on the incidence of pink bollworm (PBW) in cotton. The experiment design was RCBD. *Bt* cotton (Puli) was sown on different dates of sowing starting from 2nd fortnight of March 2021 to 1st fortnight September 2021 at 15 days intervals. The crop sown during 1st fortnight of May recorded significantly lowest PBW incidence which is evidenced by lowest number of PBW larvae (4.25/20 green bolls), green boll damage (14.48%), open boll damage at harvest (13.25%) and higher seed cotton yield (1638 kg/ha). However, sowing of cotton at 2nd fortnight of May recorded on par with respect yield and PBW damage when sown on 1st fortnight of May. It was observed that as the sowing dates advances, the incidence of PBW was increased with lesser yields.

Keywords: *Pectinophora gossypiella*, Bt cotton, sowing dates, pink bollworm, boll damage, yield

Introduction
Cotton (*Gossypium hirsutum* L.) is a vital cash crop in India, contributing significantly to the agricultural economy. However, the pink bollworm (PBW), *Pectinophora gossypiella*, poses a severe threat to cotton production, causing substantial yield losses (Sharma and Summarwar, 2017) [11]. The widespread adoption of *Bt* cotton has reduced PBW damage, but recent reports indicate the pest's growing resistance to *Bt* toxins (Kiran Kumar *et al.*, 2022) [5]. Climate change and erratic weather patterns further exacerbate PBW infestations, necessitating adaptive management strategies (Reddy *et al.*, 2022) [10]. This study investigates the impact of different sowing dates on PBW incidence and cotton yield, aiming to identify optimal sowing periods for minimizing pest damage.

Materials and Methods
1. Experimental Design: The study was conducted during *kharif* 2021-22. A popular Bt cotton hybrid, *Puli*, was sown at fortnightly intervals from March to September. The experiment followed a randomized complete block design (RCBD) with twelve treatments and three replications.

2. Sowing Treatments: Twelve sowing dates were evaluated

3. Data Collection: PBW larval populations were assessed through destructive sampling of 25 green bolls at 15-day intervals (75, 90, 105, 120, 135, 150, 165, and 180 days after sowing). Green boll damage (%) and open boll damage (%) were recorded at 90 DAS and harvest, respectively.

4. Meteorological Data: Weather parameters (temperature, relative humidity, rainfall) were collected and correlated with PBW incidence.

5. Statistical Analysis: Data were analysed using ANOVA, Tukey's HSD test, and Pearson's correlation coefficient.

Table 1: Treatment details

Treatment No.	Treatment Particulars
T_1:	T_1: 2nd fortnight of March
T_2:	T_2: 1st fortnight of April
T_3:	T_3: 2nd fortnight of April
T_4:	T_4: 1st fortnight of May
T_5	T_5: 2nd fortnight of May
T_6:	T_6: 1st fortnight of June
T_7:	T_7: 2nd fortnight of June
T_8:	T_8: 1st fortnight of July
T_9:	T_9: 2nd fortnight of July
T_{10}:	T_{10}: 1st fortnight of August
T_{11}:	T_{11}: 2nd fortnight of August
T_{12}:	T_{12}: 1st fortnight of September

Results and Discussion

Larval Incidence

The population dynamics of pink bollworm were observed on *Bt* Cotton from flowering till harvest of the crop. The larval Incidence of PBW occurred throughout the crop among the sowing dates. A peak incidence was observed i.e., during 1st fortnight of September with a mean of 9.67 larvae/25 bolls followed by 2nd fortnight of August with a mean of 9.17 larvae/25 bolls. A lower incidence of PBW was observed during 1st fortnight of May (4.25 larvae/25 bolls) followed by 2nd fortnight of May (4.58 larvae/25 bolls). Similar results were reported by Feng *et al.* (2003) [3] that late cotton sowing attracts more bollworms than early sowing. The correlation matrix between PBW population on the *Bt* Cotton cultivar and meteorological variables revealed that the PBW population at 90 DAS showed a significant positive correlation with morning relative humidity (r=0.69*) and minimum temperature (r=-0.58) showed significant negative correlation. Other parameters like maximum temperature (r=-0.23) and evening relative humidity (r=-0.16) showed a non-significant negative relation. Whereas rainfall (r= 0.23) showed non-significant relation. Similarly, correlation matrix between Pink bollworm population and weather parameters at 120 DAS revealed that significant negative correlation with minimum temperature (r=-0.80**) and non-significant positive association with maximum temperature (r= 0.86), other parameters like rainfall (r =-0.52), morning relative humidity (r =-0.38) and evening relative humidity (r =-0.49) were found to exhibit a non-significant negative association. Likewise, weather parameters correlated at 150 DAS showed a significant negative association with evening relative humidity (r=-0.60*) and minimum temperature (r=-0.58*). Morning relative humidity (r=-0.41) exhibited a non-significant negative association. Whereas, rainfall (r=-0.51) exhibited a non-significant negative association and maximum temperature (r=0.33) showed a non-significant positive association. Similarly, the influence of weather parameters on PBW population at 180 DAS showed that maximum temperature (r= 0.31) showed a non-significant positive association, and other parameters like rainfall (r=-0.09), morning relative humidity (r=-0.10), evening relative humidity (r=-0.28) and minimum temperature (r=-0.26) were found to be non-significant negative relation on PBW larval incidence. These results corroborate with the findings of Divya *et al.*, (2020) [2] which showed a non-significant positive correlation with maximum temperature and rainfall. Similar results were found to be in close relation with the findings of Rawal *et al.*, 2020 [9] who reported that morning relative humidity showed positive correlation and minimum and maximum temperature, rainfall and evening relative humidity showed negative correlation. The present findings are similar to the findings of Verma *et al.* (2017) [13] who reported that PBW larval population exhibited negative correlations with maximum and minimum temperatures as well as rainfall, while showing positive correlations with morning and evening RH. A significant negative correlation between PBW population and maximum temperature, minimum temperature, wind velocity and rainfall were reported by Patel *et al.* (2015) [7]. Likewise, PBW incidence was favourably associated with maximum temperature and other weather parameter were negatively associated with the findings of Nadaf and Basavanna Goud (2005) [6].

Green boll damage and Open damage at Harvest

The green boll damage at 90 DAS indicated that lower green boll damage was observed during 1st fortnight of May (14.48%) followed by 2nd fortnight of May (14.81%). Higher green boll damage was noticed during 1st fortnight of September (21.69%). The lower open boll damage was noticed during 1st fortnight of may (13.25%) followed by 2nd fortnight of May (13.58%). Higher open boll damage was observed during 1st fortnight of September (19.50%)

Seed Cotton yield

Higher seed cotton yield was recorded on 1st fortnight of May (1638 kg/ha) followed by 2nd fortnight of May (1586 kg/ha). As the sowing advances the incidence of pink bollworm is increasing because the migration of pest from early sown crop to late sown crop. Early sowing of Cotton is important as the probability of Fruit set will be more before the key pest reaches the damage level. The maturity of the crop will be enough to dispose the residue much earlier reducing the host plant support in over wintering population of the pest (Frisbie *et al.*, 1994) [4].

This study features the critical role of different sowing dates in managing PBW infestations. Early sown crop (March-May) reduced the pink bollworm populations and boll damage, due to the avoidance of peak pest activity during crop maturity stages (Attia *et al.*, 2021) [1]. Conversely, late sown crop (August-September) coincided with higher pink bollworm activity, resulted in increased damage and yield losses. These findings corroborate with previous studies emphasizing the benefits of early sowing for pest management and yield optimization (Kiran Kumar *et al.*, 2022) [5]. The correlation between weather parameters and PBW incidence underscores the need for climate-resilient practices. Morning relative humidity was positively correlated with pink bollworm incidence, suggesting that higher humidity levels can favour the pest proliferation (Reddy *et al.*, 2022) [10]. In contrast, lower minimum temperatures were associated with reduced PBW activity, indicates the cooler conditions may suppress pest populations (Sharma, 2017) [11]. These findings are consistent with the studies on the impact of weather parameters on insect pest dynamics. Early sown crops escaped peak PBW infestations but also benefited from favourable growing conditions, resulting in higher yields. These findings also align with Attia *et al.*, (2021) [1], who reported similar trends in cotton growing regions with comparable climatic conditions.

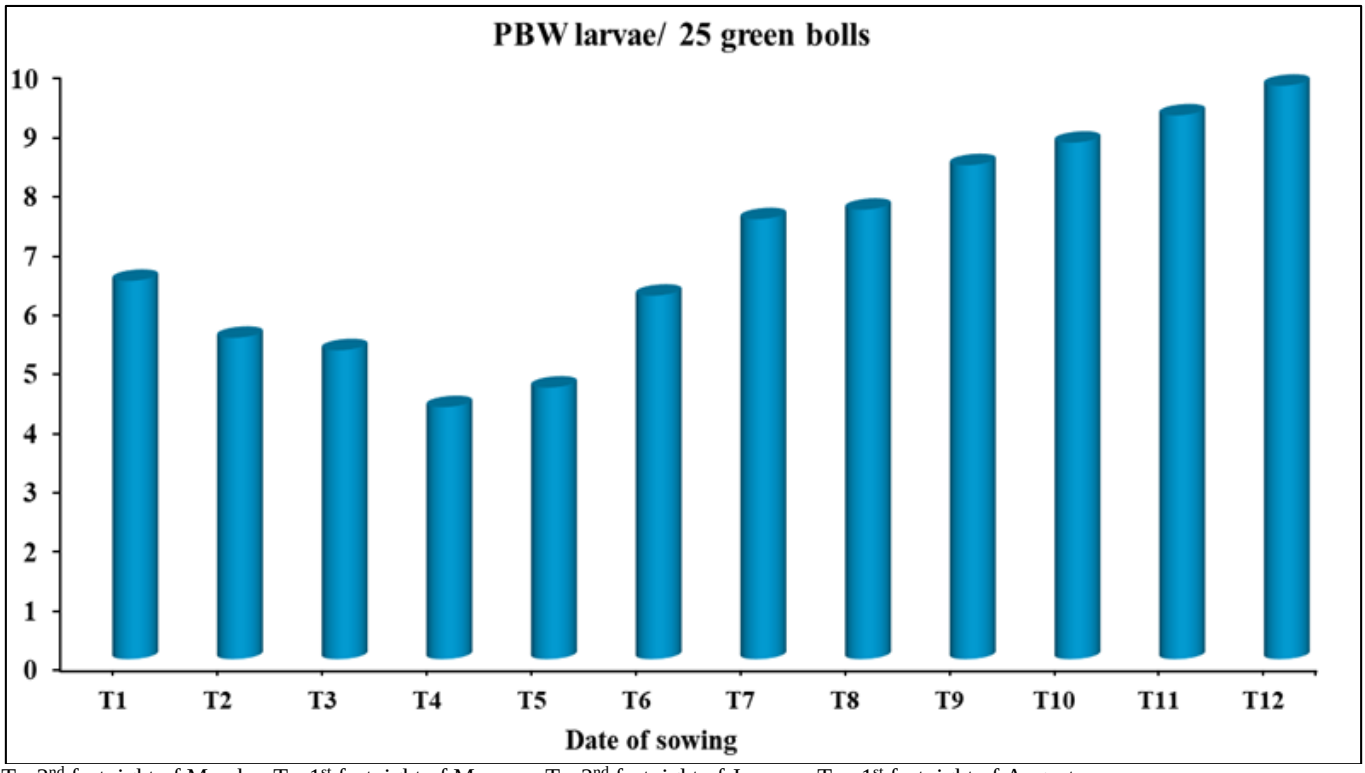
Table 2: Incidence of pink bollworm, *Pectinophora gossypiella* in cotton at different dates of sowing

Tr. No.	Dates of sowing	No. of PBW larvae at different days after sowing (DAS)								Overall mean
		75	90	105	120	135	150	165	180	
T_1	2 nd fortnight of March	0.67 (1.29) ^{e}	4.00 (2.2) ^{b}	2.00 (1.73) ^{d}	5.67 (2.58) ^{b}	7.33 (2.89) ^{bcd}	9.00 (3.16) ^{a}	10.33 (3.37) ^{a}	12.00 (3.61) ^{a}	6.38
T_2	1 st fortnight of April	3.00 (2.00) ^{cde}	3.00 (2.00) ^{b}	4.33 (2.31) ^{bcd}	4.00 (2.24) ^{b}	3.67 (2.16) ^{cd}	5.67 (2.58) ^{b}	10.00 (3.32) ^{a}	9.67 (3.27) ^{b}	5.42
T_3	2 nd fortnight of April	3.67 (2.16) ^{bcde}	3.33 (2.08) ^{b}	3.67 (2.16) ^{bcd}	4.67 (2.38) ^{b}	3.00 (2.00) ^{d}	6.67 (2.77) ^{b}	7.67 (2.94) ^{b}	9.00 (3.16) ^{b}	5.21
T_4	1 st fortnight of May	1.67 (1.63) ^{de}	1.33 (1.53) ^{b}	2.67 (1.92) ^{d}	4.00 (2.24) ^{b}	6.00 (2.65) ^{bcd}	6.00 (2.65) ^{b}	5.33 (2.52) ^{b}	7.00 (2.83) ^{b}	4.25
T_5	2 nd fortnight of May	1.33 (1.53) ^{de}	2.00 (1.73) ^{b}	3.33 (2.08) ^{cd}	3.67 (2.16) ^{b}	4.67 (2.38) ^{bcd}	7.67 (2.94) ^{a}	6.67 (2.77) ^{b}	7.33 (2.89) ^{a}	4.58
T_6	1 st fortnight of June	3.67 (2.16) ^{bcde}	4.33 (2.31) ^{b}	4.67 (2.83) ^{bcd}	6.00 (2.65) ^{b}	6.33 (2.71) ^{bcd}	6.33 (2.71) ^{b}	9.00 (3.16) ^{a}	8.67 (3.11) ^{b}	6.13
T_7	2 nd fortnight of June	6.67 (2.77) ^{abc}	7.00 (2.83) ^{a}	5.67 (2.58) ^{bcd}	6.33 (2.71) ^{a}	7.33 (2.89) ^{bcd}	7.67 (2.94) ^{a}	9.67 (3.27) ^{a}	9.00 (3.16) ^{a}	7.42
T_8	1 st fortnight of July	5.67 (2.58) ^{abcd}	6.67 (2.77) ^{a}	7.00 (2.83) ^{abcd}	6.67 (2.77) ^{a}	8.00 (3.00) ^{bc}	8.00 (3.00) ^{a}	10.00 (3.32) ^{a}	8.67 (3.11) ^{a}	7.58
T_9	2 nd fortnight of July	8.00 (3.00) ^{ab}	7.00 (2.83) ^{a}	8.67 (3.11) ^{ab}	7.00 (2.83) ^{a}	9.00 (3.16) ^{ab}	8.33 (3.05) ^{a}	10.33 (3.37) ^{a}	8.33 (3.05) ^{a}	8.33
T_{10}	1 st fortnight of August	9.00 (3.16) ^{a}	7.33 (2.89) ^{a}	6.33 (2.71) ^{abcd}	10.00 (3.32) ^{a}	7.67 (2.94) ^{bc}	8.67 (3.11) ^{a}	9.33 (3.21) ^{a}	11.33 (3.51) ^{a}	8.71
T_{11}	2 nd fortnight of August	9.33 (3.21) ^{a}	8.00 (3.00) ^{a}	8.33 (3.05) ^{abc}	9.00 (3.16) ^{a}	12.67 (3.70) ^{a}	7.67 (2.94) ^{a}	9.33 (3.21) ^{a}	9.00 (3.16) ^{a}	9.17
T_{12}	1 st fortnight of September	9.33 (3.21) ^{a}	10.00 (3.32) ^{a}	11.00 (3.46) ^{a}	8.00 (3.00) ^{a}	9.00 (3.16) ^{ab}	10.33 (3.37) ^{a}	9.67 (3.27) ^{a}	10.00 (3.32) ^{a}	9.67
CD @ 5%		1.58	1.75	1.64	1.90	1.44	1.31	1.48	1.67	-
SEm±		4.61	2.56	4.80	2.78	4.19	3.82	4.31	4.86	-

Table 3: Influence of different dates of sowing on green boll damage, open boll damage and seed cotton yield (kg/ha) by pink bollworm in Cotton

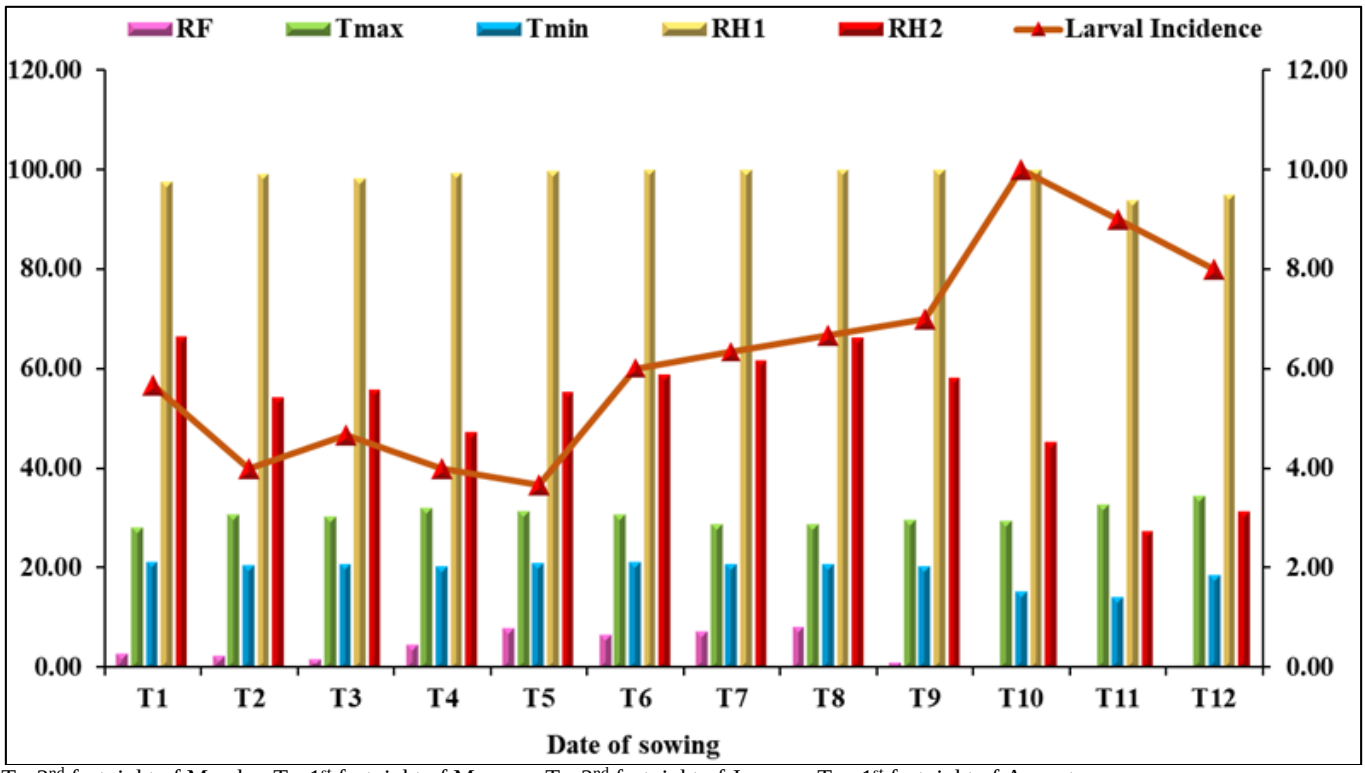
Sl. No.	Treatments	Percent green boll damage at 90 DAS	Percent open boll damage at harvest	Yield (kg/ha)
T_1	2nd fortnight of March	15.56 (23.22) ^{cd}	14.33 (22.20) ^{cd}	1353^{d}
T_2	1st fortnight of April	15.64 (23.24) ^{cd}	14.41 (22.30) ^{cd}	1467^{c}
T_3	2nd fortnight of April	15.39 (23.09) ^{d}	14.16 (22.04) ^{cd}	1545^{bc}
T_4	1st fortnight of May	14.48 (22.34) ^{cd}	13.25 (21.31) ^{d}	1638^{a}
T_5	2nd fortnight of May	14.81 (22.60) ^{cd}	13.58 (21.61) ^{d}	1586^{ab}
T_6	1st fortnight of June	16.34 (23.82) ^{cd}	15.11 (22.85) ^{bcd}	1380^{d}
T_7	2nd fortnight of June	17.61 (24.81) ^{cd}	16.38 (23.87) ^{bcd}	1326^{d}
T_8	1st fortnight of July	17.79 (24.94) ^{bc}	16.56 (24.01) ^{bcd}	1220^{e}
T_9	2nd fortnight of July	18.54 (25.48) ^{ab}	17.31 (24.52) ^{abc}	1184^{e}
T_{10}	1st fortnight of August	18.93 (25.78) ^{bc}	17.70 (24.86) ^{abc}	993^{f}
T_{11}	2nd fortnight of August	19.75 (26.36) ^{a}	18.20 (25.23) ^{ab}	951^{f}
T_{12}	1st fortnight of September	21.69 (27.70) ^{ab}	19.50 (26.14) ^{a}	829^{g}
CD @ 5%		0.94	0.98	28.41
SEm±		2.76	2.90	83.31

Values in the column followed by common letters are non-significant at p= 0.05. Figures in the parenthesis indicate arc sign transformation.



T_1: 2nd fortnight of March T_4: 1st fortnight of May T_7: 2nd fortnight of June T_{10}: 1st fortnight of August
T_2: 1st fortnight of April T_5: 2nd fortnight of May T_8: 1st fortnight of July T_{11}: 2nd fortnight of August
T_3: 2nd fortnight of April T_6: 1st fortnight of June T_9: 2nd fortnight of July T_{12}: 1st fortnight of September

Fig 1: Mean number of pink bollworm larvae at different dates of sowing



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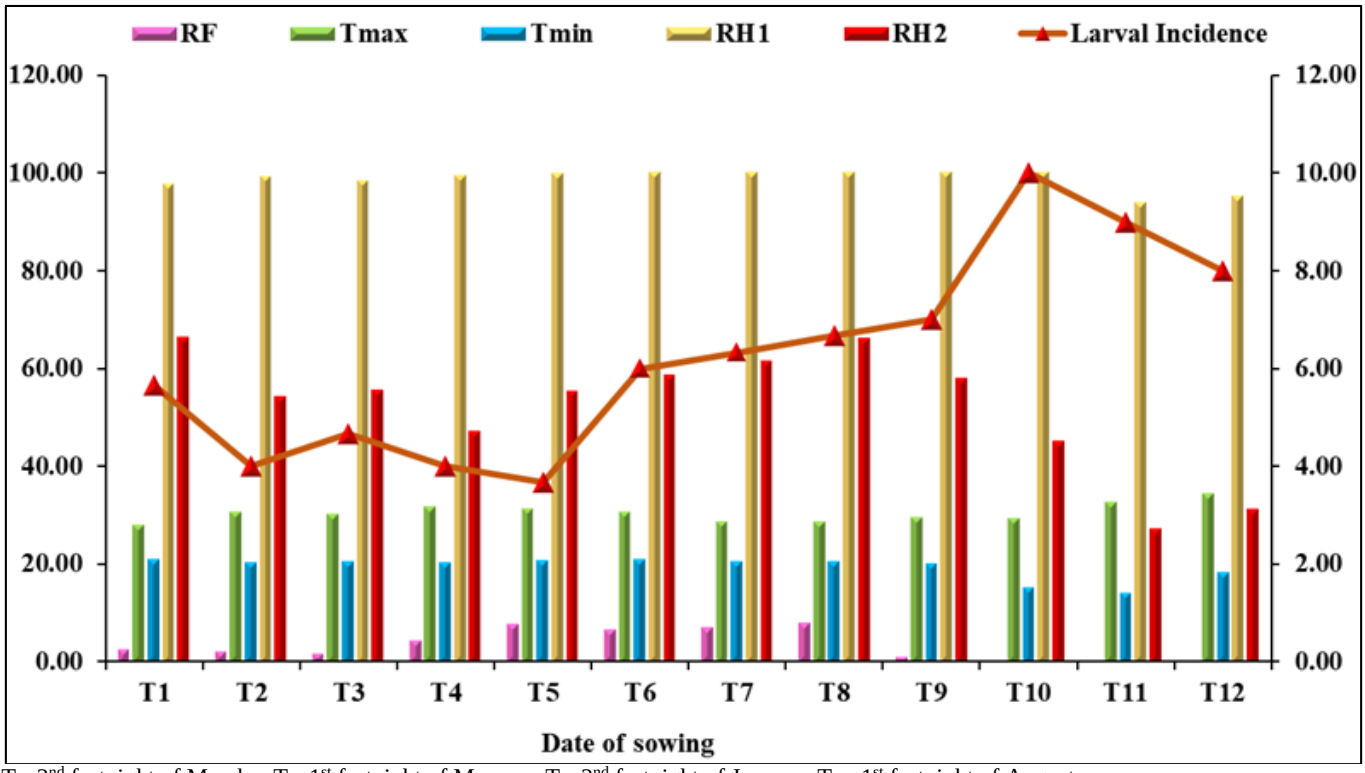
T_3: 2nd fortnight of April T_6: 1st fortnight of June T_9: 2nd fortnight of July T_{12}: 1st fortnight of September

Fig 2: Relationship between incidence of pink bollworm and Meteorological variables at 90 DAS

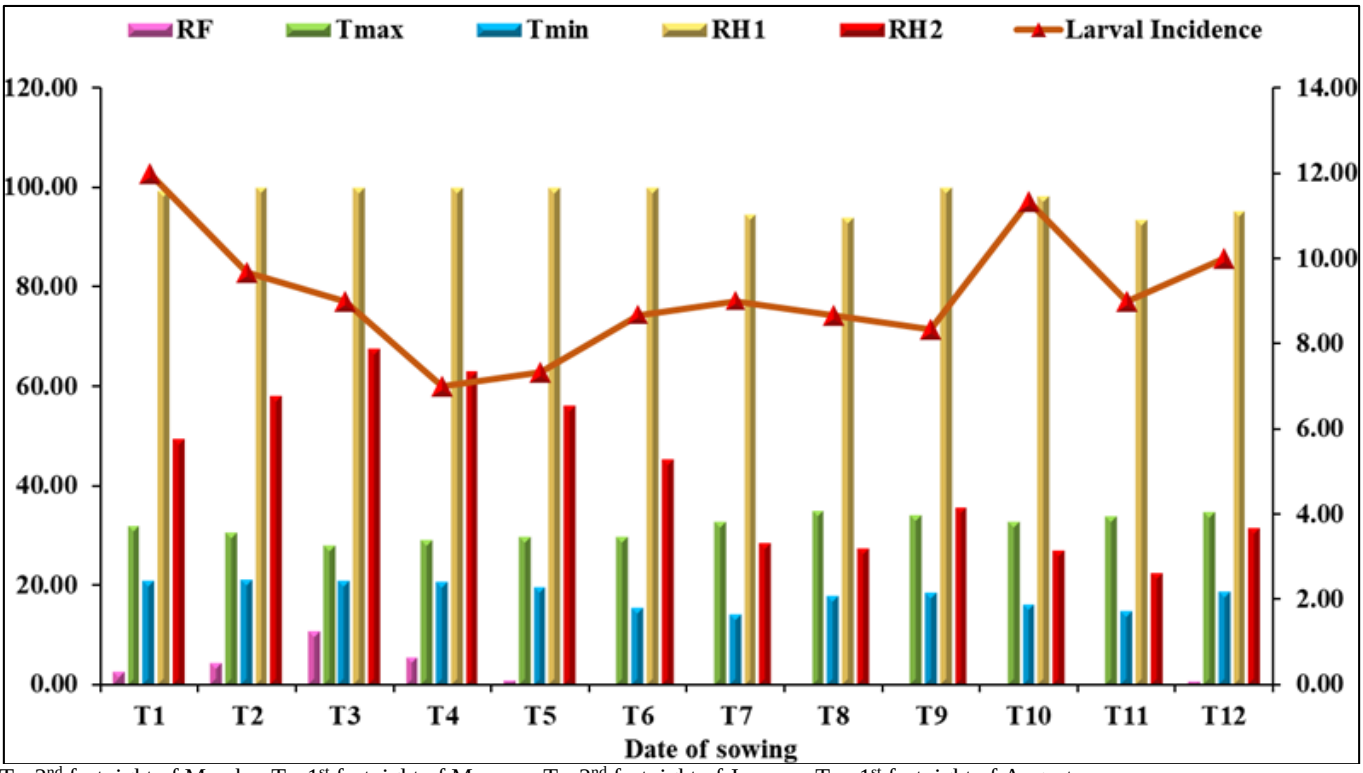


T_1: 2nd fortnight of March T_4: 1st fortnight of May T_7: 2nd fortnight of June T_{10}: 1st fortnight of August
T_2: 1st fortnight of April T_5: 2nd fortnight of May T_8: 1st fortnight of July T_{11}: 2nd fortnight of August
T_3: 2nd fortnight of April T_6: 1st fortnight of June T_9: 2nd fortnight of July T_{12}: 1st fortnight of September

Fig 3: Relationship between incidence of pink bollworm and Meteorological variables at 120 DAS

T_1: 2nd fortnight of March T_4: 1st fortnight of May T_7: 2nd fortnight of June T_{10}: 1st fortnight of August
T_2: 1st fortnight of April T_5: 2nd fortnight of May T_8: 1st fortnight of July T_{11}: 2nd fortnight of August
T_3: 2nd fortnight of April T_6: 1st fortnight of June T_9: 2nd fortnight of July T_{12}: 1st fortnight of September

Fig 4: Relationship between incidence of pink bollworm and Meteorological variables at 150 DAS



T_1: 2nd fortnight of March
T_2: 1st fortnight of April
T_3: 2nd fortnight of April
T_4: 1st fortnight of May
T_5: 2nd fortnight of May
T_6: 1st fortnight of June
T_7: 2nd fortnight of June
T_8: 1st fortnight of July
T_9: 2nd fortnight of July
T_{10}: 1st fortnight of August
T_{11}: 2nd fortnight of August
T_{12}: 1st fortnight of September

Fig 5: Relationship between incidence of pink bollworm and Meteorological variables at 180 DAS

Conclusion

The present study demonstrates that sowing date critically influences pink bollworm (PBW) larval incidence, boll damage, and cotton yield in *Bt* cotton. Early sowing (March-May) consistently resulted in lower PBW larval populations and reduced green and open boll damage, with the lowest larval incidence recorded in the first fortnight of May (4.25 larvae/25 bolls) and the highest damage during the first fortnight of September (21.69% green boll damage). Conversely, late sowing (August-September) coincided with peak PBW larval incidence (9.67 larvae/25 bolls) and increased boll damage, reflecting the pest's migration and population buildup on late-sown crops. This pattern aligns with previous findings of late sowing can attract more bollworms due to synchronization with peak pest activity and favourable environmental conditions. Correlation analysis revealed that morning relative humidity positively influences PBW populations, while minimum temperature and evening relative humidity show significant negative correlations, indicating that cooler and less humid conditions suppress pest proliferation. Other weather parameters such as maximum temperature and rainfall exhibited non-significant associations, underscoring the complex interplay of climatic factors on PBW dynamics.

The yield data further supports the pest incidence findings, with early sowing yielding significantly higher seed cotton production (1638 kg/ha) compared to later sowing dates. Early sowing allows the crop to mature before peak PBW activity, reducing pest damage and facilitating residue management, which limits overwintering pest populations. Overall, these results emphasize that early sowing is an effective cultural strategy to manage PBW infestations in Bt cotton, minimizing damage and optimizing yield. Integration of sowing time with monitoring of key weather parameters can enhance pest management programs, promoting sustainable cotton production under varying climatic conditions.

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Author Contribution Statement

P. Ashish Kamal-Conceptualization, investigation, draft preparation and analysis;
Shivaray Navi-Conceptualization, framed research proposal and draft correction;
L. Vijaykumar, C. Shashi Kumar and G. Somu-Writing, reviewing and editing of research article. All authors read and approved the manuscript.

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Conflict Of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

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