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Seasonal incidence of sugarcane white grub at Tamil Nadu, India

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Abstract

Sugarcane, a vital commercial crop, faces significant pest pressure from white grubs (Coleoptera: Scarabaeidae). It is an emerging problem especially in Tamil Nadu, where it causes severe damage to sugarcane production. This study aimed to assess the distribution, seasonal incidence and damage caused by white grubs in six districts of Tamil Nadu (Tiruvannamalai, Kallakurichi, Dharmapuri, Namakkal, Trichy and Thanjavur) during 2023-2024. The survey focused on larval population dynamics and correlated them with weather parameters. Roving surveys in four districts, where significant infestations were noted, showed that larval population peaks occurred in the 37th and 35th Standard Meteorological Weeks (SMWs) of 2023 and 2024 respectively. Larval damage per clump peaked at 79.67 % (37th SMW) in 2023 and 73.66 % (33rd SMW) in 2024, with the highest damage observed in Tiruvannamalai (79.88 %) in 2023 and Kallakurichi (76.13 %) in 2024. A significant positive correlation found between larval population and maximum temperature (r = 0.193 to 0.973 across districts) and a negative correlation with rainfall. For adult beetles, the maximum mean population of 105.49 adults/trap/week was recorded in the 24th SMW at Tiruvannamalai, with a general emergence starting from the 15th SMW (April). A significant positive correlation was observed between adult emergence and rainfall (r = 0.647 to 0.898) and minimum temperature (r= 0.456 to 0.743). Conversely, maximum temperature showed a negative correlation with adult emergence. These findings provide valuable insights for the development of Integrated Pest Management (IPM) strategies and enabling timely interventions to mitigate crop damage.

Keywords

correlation; damage; regression; seasonal incidence; Tamil Nadu; white grub

Introduction

Sugarcane is a commercial crop cultivated globally. It originated in the warm temperate and tropical regions of India, Southeast Asia and New Guinea. It is primarily grown for sugar production and provides 75–80 % of the world's sugar supply (1). Around 20-25 % of the world's sugar is derived from sugar beet grown at European countries. Sugarcane typically contains 63-73 % water, 11-16 % fiber, 12-16 % soluble sugars and 2-3 % non-sugar carbohydrates (2). The crop generally takes 12 to 18 months to reach maturity, depending on the plant type and season. Sugarcane pests such as borers, root grubs, white grubs, whiteflies, scale insects and woolly aphids are persistent throughout the year, but white grubs cause the most severe damage in sugarcane-growing regions.

Since 1960, white grubs have emerged as a major polyphagous pest, posing a significant threat to the sugarcane crop (3). White grubs (Coleoptera: Scarabaeidae) are the soil-dwelling, root-feeding larval stages of scarab beetles. White grubs have become serious pests for most of the agricultural crops, fruits, vegetables, ornamental plants, plantation crops, pastures, turf and meadow grasses, lawns and forest trees in different parts of the world (4).

First instar of white grub feeds on the organic matter. Second and third instar feeds roots of cultivated crops. They almost feed all the crops such as sugarcane, sorghum, rice, maize, cumbu napier, jasmine, rose, groundnut, potato, soybean, wheat, oats, pineapple, strawberry and coconut etc. Meanwhile adults are defoliating neem, acacia, oak, bhimal, toon, khirak, Rhododendron etc. (5). Severe infestations by white grub larvae can cause sugarcane clumps and stalks to dry out and die, potentially resulting in complete yield loss (6). The first instar larvae feed on organic matter in the soil, while the later instars feed on the roots of cultivated crops (7).

Stebbings was the first to report crop damage caused by white grubs in Punjab, India, in 1902 (8), where between 1400 and 2000 species were recorded (9, 10). Among them, *Holotrichia* and *Anomala* species are especially damaging to a variety of crops (11). White grubs were subterranean nature and difficult to control in sugarcane ecosystem because both having almost one year duration. Research on white grubs is still in its early stages, with limited publications available on their emergence and peak activity periods. This article aims to develop better IPM strategies.

Materials and Methods

Roving surveys were conducted in six districts of Tamil Nadu such as Tiruvannamalai, Kallakurichi, Dharmapuri, Namakkal, Trichy and Thanjavur which are the hotspots for sugarcane white grub (Table 1) occurrence during 2023-2024 to assess its distribution, seasonal incidence and damage of white grubs. From each block, three farmers' fields were selected to assess the population count and percent damage. In each field, three replications were maintained, with 10 plants per replication. Thirty plants were observed per field. Completely, for three fields, 90 plants were observed for assessing population count and per cent damage at fortnight interval during 2023 and 2024. Different instars of white grub, pupae and adults were collected from different locations to characterise the different species of white grub in Tamil Nadu. The larvae were collected at a depth of 5-10 cm from June to October and diapause staged adults were collected at a depth of 40-90 cm depth from December month onwards. For assessing the adult population and damage**,** light traps with 100 watts bulb were fixed in the neem trees nearby sugarcane field during 6:30 to 10:00 pm to attract adult of white grubs (12). Totally, 16 number of different white grub adult beetles collected from neem trees were segregated based on the colour and size and sent for identification. At Dharmapuri and Tiruchirappalli district, the white grub was recorded from different hosts other than sugarcane. All the collected insects were maintained at Anbil Dharmalingam Agricultural College and Research Institute, Trichy for the purpose of mass multiplication. The weather data for maximum temperature, minimum temperature, relative humidity and rainfall was obtained from NASA Power website and from automatic weather stations of different districts and correlated with the population of white grub. The data were analysed by using OPSTAT online tool for correlation studies and AGRESS software for regression studies.

Table 1. Seasonal incidence of sugarcane white grub larva in Tamil Nadu from September 2023 to September 2024

SMW	Mean				Mean
	Tiruvannamalai	Kallakurichi	Dharmapuri	Namakkal	
			2023		
37	3.94 (2.09)[a]	3.29 (1.94)	3.95 (1.99)[c]	3.15 (1.91)[c]	3.58
39	3.91 (2.08)[b]	3.28 (1.94)	3.90 (1.99)[c]	3.05 (1.88)[c]	3.54
42	3.89 (2.08)[b]	3.23 (1.93)	3.79 (1.98)[c]	3.03 (1.88)[c]	3.48
44	3.29 (1.94)[c]	2.72 (1.78)	3.28 (1.78)[c]	3.01 (1.87)[c]	3.08
46	2.67 (1.78)[c]	1.02 (1.20)	2.65 (1.77)[c]	2.77 (1.81)[c]	2.28
48	0.23 (0.84)[e]	0.13 (1.94)	0.25 (0.75)[e]	0.03 (0.73)[e]	0.16
Mean	2.99	2.28	2.97	2.51	2.68
			2024		
24	0.22 (0.84)[e]	0.29 (0.87)	0.25 (0.85)[h]	0.17 (0.81)	0.23
26	1.46 (1.38)[d]	1.30 (1.32)	1.11 (1.25)f	0.41 (0.93)	1.07
28	1.972 (1.56)[c]	1.69 (1.48)	1.45 (1.38)[e]	1.61 (1.44)	1.69
31	2.36 (1.68)[c]	2.24 (1.65)	1.89 (1.54)[b]	2.14 (1.62)	2.16
33	2.69 (1.78)[c]	2.66 (1.77)	2.14 (1.62)[a]	2.74 (1.79)	2.56
35	2.66 (1.77)[c]	2.73 (1.79)	2.29 (1.66)[a]	3.03 (1.87)	2.68
37	1.83 (1.52)[c]	2.33 (1.68)	2.08 (1.60)[a]	1.90 (1.53)	2.04
39	0.63 (1.12)[d]	1.86 (1.53)	1.66 (1.46)[c]	1.56 (1.42)	1.43
Mean	1.73	1.89	1.61	1.69	1.73

Results

Larval population assessment

A study on the seasonal incidence of white grub was carried out from September 2023 to September 2024 at 6 Districts of Tamil Nadu. In the localities surveyed, Thanjavur Dt. was free from white grub infestation while in Trichy August 2024 in our campus white grubs were seen on Guava trees and adults also collected nearby neem trees but none of the surveyed locations shown white grub infestation. So, the population analysis and correlation studies done only for four districts *viz.,* Tiruvannamalai, Kallakurichi, Dharmapuri, Namakkal because those districts only showed higher infestation and population during that survey period.

Upon general observation, the larval population started in the 24th SMW. However, our study began in the 37th SMW of 2023. Therefore, the previous statement is based on data from the 2024 survey. In 2023, 37th SMW showed highest mean population 3.58 larva / week. In 2024, highest mean population (2.68 larva/ week) observed 35th SMW. While coming to

districts, Tiruvannmalai Dt. showed highest mean population during 2023 (2.99 larva/week). In 2024 Kallakurichi Dt. showed highest mean population (1.89 larva/week) among all the districts. In both the years common SMW is 37th and 39th. Comparing these two SMW, 2023 showed highest mean population because of highest downpour of rainfall during April month that stipulates the adult population (Table 1).

Damage assessment

Damage caused by larva was assessed simultaneously when population was assessed. In 2023 and 2024, 37th SMW (79.67 / clump) and 33rd SMW (73.66 / clump) respectively showed highest damage per cent. When comparing the districts Tiruvannamalai Dt. (79.88 % clump) in 2023, Kallakurichi dt (76.13 %/ clump) in 2024 showed highest damage. It was positively correlated with population of larval white grub (Table 2).

Table 2. Percent damage caused by white grub larva in Tamil Nadu during 2023 to 2024

SMW	Mean				Mean
	Tiruvannamalai	Kallakurichi	Dharmapuri	Namakkal	
			2023		
37	84.17 (66.55)^{a}	76.16 (60.77)^{a}	83.21 (1.99)^{c}	75.15 (1.91)^{c}	79.67
39	84.12 (66.51)^{a}	76.14 (60.76)^{b}	83.46 (1.99)^{c}	72.05 (1.88)^{c}	78.94
42	82.29 (65.11)^{a}	75.65 (60.43)^{c}	82.43 (1.98)^{c}	65.03 (1.88)^{c}	76.35
44	82.79 (65.49)^{a}	75.58 (60.39)^{d}	81.67 (1.78)^{c}	63.01 (1.87)^{c}	75.76
46	80.52 (63.81)^{b}	73.88 (59.26)	75.65 (1.77)^{c}	59.77 (1.81)^{c}	72.46
48	65.44 (53.99)^{e}	63.23	72.07 (0.75)^{e}	58.03 (0.73)^{e}	64.69
Mean	79.88	73.44	79.74	65.50	74.64
			2024		
24	52.64 (46.51)^{e}	74.69 (59.79)^{e}	60.23 (50.90)^{a}	73.02 (58.71)^{e}	65.15
26	71.91 (57.99)^{d}	75.69 (60.45)^{d}	60.80 (51.24)^{d}	73.27 (58.87)^{d}	70.42
28	76.23 (60.82)^{c}	74.83 (59.89)^{e}	61.02 (51.37)^{c}	73.90 (59.28)^{e}	71.50
31	78.90 (62.65)^{d}	76.65 (61.10)^{d}	61.34 (51.55)^{b}	75.00 (60.00)^{d}	72.97
33	80.51 (63.80)^{c}	77.07 (61.38)^{c}	61.49 (51.64)^{a}	75.58 (60.39)^{c}	73.66
35	79.60 (63.15)^{c}	77.13 (61.43)^{b}	61.33 (51.55)^{b}	75.89 (60.60)^{b}	73.49
37	74.35 (59.57)^{d}	76.73 (61.16)^{d}	61.45 (51.62)^{a}	74.40 (59.60)^{d}	71.73
39	69.05 (56.19)^{d}	76.27 (60.84)^{a}	61.18 (51.46)^{e}	74.42 (59.62)^{a}	70.23
Mean	72.89	76.13	61.11	74.43	71.14

Correlation between sugarcane white grub larval population and weather

***Parameters* :** When the incidence of grub population was correlated with weather parameters it was positively correlated with maximum temperature in all districts such as Tiruvannamalai (r=0.831**), Kallakurichi (r=0.876**), Dharmapuri (r=0.973**), Namakkal (r= 0.193**). Rainfall was negatively correlated with larval incidence at Tiruvannamalai (r= -0.061), Kallakurichi (r= -0.646*), Dharmapuri (r= -0.287), Namakkal (r= -0.081*). When minimum temperature increased the larval population decreased. Relative humidity had no significant effect on larval population (Table 3).

One unit rise in maximum temperature led to 1.0134, 0.6547, 0.6109 and 0.6109 units increase in the larval population at Tiruvnnamalai, Kallakurichi, Dharmapuri, Namakkal districts respectively. Similarly, one degree rise in relative humidity led to an increase in the larval population by 1.4164, 0.0767, 0.0771 and 0.0611 units at Tiruvnnamalai, Kallakurichi, Dharmapuri, Namakkal districts respectively. One unit rise in minimum temperature decreased the grub population by -0.146, -0.1371 and -1.6767 units at Tiruvnnamalai Kallakurichi, Dharmapuri, Namakkal districts respectively. In the same way, rainfall decreased the grub population by -0.0064, -0.1159, -0.1650 and -0.0065 units at Tiruvnnamalai, Kallakurichi, Dharmapuri, Namakkal districts respectively. Together, all weather factors contributed to 80.08 % (R^2 = 0.8008) to 95 % (R^2= 0.95) variation in larval population (Table 4).

Adult population assessment

The adult population was assessed in 2024 because the survey period in 2023 did not coincide with the emergence period of adults, as analyzed in previous studies. Emergence of adults occurs during summer showers. So, survey started from 2024, April. The maximum mean population (105.49 / trap / week) of June beetle was seen during 24th SMW at

Table 4. Regression of sugarcane white grub larval population and weather parameters during 2023 - 2024

Location	Regression equation	R^2
Thiruvannamalai	Y= -18.6889+(1.0134)X_1+(-0.1962) X_2+(1.4164)X_3+(-0.0064)X_4	0.8008
Kallakurichi	Y= -23.006+(0.6547)X_1+(-0.146)X_2+(0.0767) X_3+(-0.1159)X_4	0.95
Dharmapuri	Y= -21.7362+(0.6109)X_1+(-0.1371) X_2+(0.0771)X_3+(-0.1650)X_4	0.9172
Namakkal	Y=-38.9957+(0.0701)X_1+(-1.6767) X_2+(0.0611)X_3+(-0.0065)X_4	0.9424

X1-Max. temperature, X2- Min. temperature, X3- Relative Humidity, X4-Rainfall

Table 3. Correlation between sugarcane white grub larval population and weather parameters during 2023 - 2024

Weather parameters	Correlation co-efficient (r)			
	Thiruvannamalai	Kallakurichi	Dharmapuri	Namakkal
Maximum temperature	0.831**	0.876**	0.973**	0.193*
Minimum temperature	-0.240	-0.481	-0.332	-0.715
Relative humidity	0.219	0.669*	0.760*	0.622
Rainfall	-0.067	-0.646*	-0.287	-0.081*

*=significant at 5 %, **= significant at 1 %

Tiruvannamali Dt. The minimum mean population (0.45 / trap) was seen during 31st, SMW at Dharmapuri Dt. 24th SMW showed highest mean population 99.67 adults/trap/week. The population of white grub adult ranged from 1.04 to 105.9 per clump at Tiruvannamalai, 0.65 to 97.01 per clump at Kallakurichi, 0.45 to 93.50 per clump at Dharmapuri and 1.03 to 102.99 per clump at Namakkal. Among all the districts Tiruvannamali Dt. showed highest adult population (58.90 adults/trap/week) followed by Namakkal (56.35 adults/trap/week), Kallakurichi (55.48 adults/trap/week) and Dharmapuri (50.21 adults/trap/week). From our observation adult population starts from 15th SMW (April), attains its peak during 24th SMW (June), after that adult population reduced (Fig. 1).

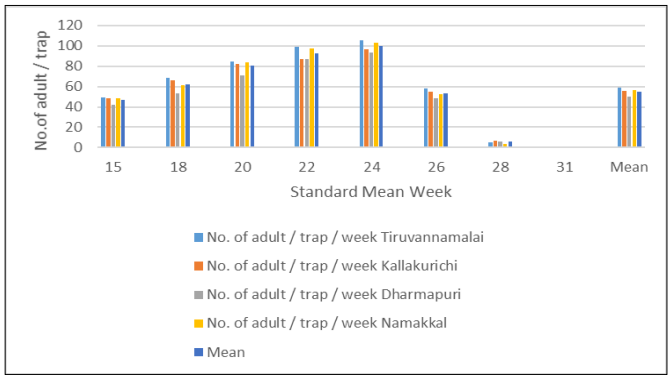

Fig. 1. Seasonal incidence of sugarcane white grub adult collected through light trap at Tamil Nadu from January 2024 to September 2024.

Correlation between sugarcane white grub adult population and weather parameters

When beetle emergence was correlated with weather parameters, it was positively correlated with rainfall at all districts *viz*., Tiruvannamalai (r=0.647**), Kallakurichi (r=0.800**), Dharmapuri (r=0.898**) and Namakkal (r= 0.795**). Minimum temperature was also found to show positive correlation with adult beetle emergence. Relative humidity showed positive correlation with adult emergence in all the districts. Maximum temperature had a significant negative correlation at Tiruvannamalai (r= -0.614**), Kallakurichi (r= -0.756), Dharmapuri (r= -0.0014) and Namakkal (r= -0.155) (Table 5).

One unit rise in minimum temperature, relative humidity and rainfall led to an increase the beetle population by 0.578, 7.688, 6.688, 7.788 units, 1.1059, 1.2079, 2.2079, 1.3089 units and 0.4488, 1.7498, 0.8598 units at Tiruvannamalai, Kallakurichi, Dharmapuri and Namakkal respectively. A one unit rise in maximum temperature led to decrease the grub population by -2.721, -2.791, -1.791, -2.891 units at in Tiruvannamalai, Kallakurichi, Dharmapuri and Namakkal respectively. Together, these weather factors contributed to an 59.63 % (R^2 = 0.5963) to 64.63 % (R^2 = 0.6463) increase in the adult population (Table 6).

Discussion

In this present study, white grub larvae initiated from June month and peak adult emergence occurred from July to August, but it was contrary to some previous works (13) who stated that larval population appeared from Nov to peak population during May-June in northern Kashmir. Considering weather parameter, this study supported the finding, where the maximum temperature had positive correlation (r = 0.89) with larval population (13). The low incidence of larval population may be attributed due to the soil's moisture saturation during the winter season, as the soil remained completely submerged that supported the negative correlation of rainfall to the larval population (14). This study was in consistent with larval population was non-significant with rainfall and relative humidity (13). Peak beetle population was observed in June and July month, it was contrary to the commencement of adult beetle occurred during June month, while peak emergence occurred during August (12). In this study, adult beetle emergence began in April, which contrasts with the findings, that rainfall in April impeded adult emergence (15). Beetle activity completely ceased by the second week of September, which closely matched the findings of previous works (16). However, this was contrary to reports stating that emergence continued until August (12, 17). *Leucopholis coneophora* emerged in the Alappuzha district as late as August and September during the years 1976 to 1978 (18, 19). Minimum temperature was positively correlated with adult population and it was supported by the statement of minimum temperature was positively correlated with adult population (20). The current findings differred from the statement that atmospheric humidity significantly influenced

Table 5. Correlation between sugarcane white grub adult population and weather parameters during 2024

Weather parameters	Correlation co-efficient (r)			
	Thiruvannamalai	Kallakurichi	Dharmapuri	Namakkal
Maximum temperature	-0.614**	-0.756	-0.0014	-0.155
Minimum temperature	0.736**	0.743**	0.711*	0.456
Relative humidity	0.548**	0.780**	0.094	0.166
Rainfall	0.647**	0.800**	0.898**	0.795**

*=significant at 5 %, **= significant at 1 %

Table 6. Regression of sugarcane white grub adult population and weather parameters of during 2024

Location	Regression Equation	R^2
Thiruvannamalai	$Y= -106.8844+(-2.721)X_1+(0.578)X_2+(1.1059)X_3+(0.4488)X_4$	0.6373
Kallakurichi	$Y= -108.8844+(-2.791)X_1+(7.688)X_2+(1.2079)X_3+(0.7498)X_4$	0.6463
Dharmapuri	$Y= -102.8844+(-1.791)X_1+(6.688)X_2+(2.2079)X_3+(1.7498)X_4$	0.5963
Namakkal	$Y= -109.8844+(-2.891)X_1+(7.788)X_2+(1.3089)X_3+(0.8598)X_4$	0.6463

X1-Max. temperature, X2- Min. temperature, X3- Relative Humidity, X4-Rainfall

the emergence, movement and distribution of dominant white grub species in the Garhwal region of Uttar Pradesh (21).

Conclusion

White grub larvae initiated from June month and maximum adult emergence occurred during July month. Larval population of white grub always coincide with maximum temperature and adult population always coincide with rainfall. The knowledge about the pest occurrence based on the weather parameters is essential to identify the best management practices. This study describes the emergence timing of both the larval and adult stages of white grubs. The information on the ecological prospective of white grubs was very less published. It helps to develop the better IPM strategies for management of both larva and adult.

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Authors' contributions

This study was designed and conducted by PY and SA. Manuscript was prepared by SA and PY. SA, SSJR, VKS, KR helped to change the article to PST format.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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