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WHITE GRUB (*LEUCOPHOLIS CONEOPHORA* BURMEISTER) MANAGEMENT IN MID-HILL REGION OF MEGHALAYA

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ABSTRACT

White grubs are one of the most damaging soil insect pests inflicting economic losses in groundnut cultivation in India. The white grub *Leucopholis coneophora* (Burmeister) is a polyphagous pest of coconut and intercrops. However, in the mid-hill region of Meghalaya, the occurrence of this species was recorded, which calls for an investigation. Also, there is a need to develop location-specific and easily adoptable climate-ready technologies before it attains pest status. In this context, a field experiment was conducted to evaluate the efficacy of few insecticides and bioformulations with different methods of application. Results showed that seed treatment with imidacloprid 17.8SL @ 3ml/ kg seeds proved to be the most effective by exhibiting the lowest grub incidence (0.17 grubs/ 12 sq m plot) and minimum plant infestation (1.82%). For bioformulations, field spraying with *Metarrhizium anisopliae* (1x10^8 spores/ml @5ml/ l) was found to be superior over *Beauveria bassiana* at the same dose. These results will aid in formulating an ecofriendly IPM strategy for white grubs in this climate-resilient region of India.

Key words: Entomopathogenic fungi, biopesticides, efficacy, hill agriculture, *Arachis hypogeae*, *Leucopholis coneophora*, ecofriendly management, imidacloprid, seed treatment, *Metarrhizium anisapliae, Beauveria bassiana*

Groundnut (*Arachis hypogaea* L.), belonging to the family Fabaceae, is an important oilseed crop. After China, India is the world's second-largest producer and consumer of groundnut. In India, groundnuts are grown to produce 6.69 mt across 4.81 million ha (Anonymous, 2019; Yadav and Baloda, 2022). In the northeastern region (NER) of India, it is a non-traditional crop, but the average production suggests that the region has a tremendous potential. It has been reported that roughly 4000 ha was used for groundnut cultivation in the northeast region (Munda et al., 2006; Patel et al., 2020). Among the various biotic and abiotic constraints, infestation by insect pests is the most important (Umeh et al., 2001). A dozen insects feed on various groundnut parts; where half of these species are associated with soil and occur sporadically (Majumdar, 1997). Of these soil pests, white grubs present a major problem (Anitha et al., 2005; Anitha et al., 2006; Chandel et al., 2021). White grubs, also called as root grubs, (Scarabaeidae: Coleoptera) are considered as "national pests", which are prevalent in most of the Indian agroecological regions. Out of 1500 species recorded in India, 45 species are reported to be serious pests (Sreedevi et al., 2017; Chandel et al., 2021). White grubs are economically significant mostly due to the feeding activities of third instar grub (Chandel et al., 2015). Many of its species are associated with groundnut damage; *Holotrichia serrata* (F.), *H.consanguinea* (Blanchard), and *Leucopholis lepidophora* (Blanchard) are the predominant in North-Eastern Hill regions (Thakur et al., 2001; Shylesha et al., 2006).

Studies on the ecology and behaviour of melolonthid root grubs in India have mostly focused on *Holotrichia* sp. and other white grub species. Literature pertaining to this particular *L.coneophora* species is meager and information on their seasonal incidence, activity, and management tactics is limited from India (Seram and Saikia, 2015). Hence, an experiment was conducted on the ecofriendly management of white grubs on groundnut under field conditions. The indiscriminate use of pesticides to control this pest has upset the natural ecological balance (Pandey and Kanujia, 2005). The use of ecofriendly insecticides as an important and alternate control practice. Among microbials, entomopathogenic fungi like *Beauveria bassiana* (Balsamo) Vuillemin

(Sandhu et al., 2001; Monika et al., 2011; Patel et al., 2022), *Metarhizium anisopliae* (Metschinikoff) Sorokin (Patel et al., 2022) and *Nomuraea rileyi* (Farlow) (Tang et al., 1999) have shown excellent potential. These mycoinsecticides based deuteromycetous fungi have been considered as the most suitable bioagents (Patel et al., 2020). Although several workers have tested various insecticides applied before sowing and as a seed treatment against white grubs (Anitha et al., 2005), very little information is available on the management of white grubs on standing crops (Rajkumar et al., 2022) Considering the potential of this species becoming a pest in this region, the present field experiment was conducted to evaluate the efficacy of some commonly used insecticides and ecofriendly bioformulations against *L. coneophora* in groundnut.

MATERIALS AND METHODS

A field experiment was undertaken at the Entomology field, Division of Crop Improvement, ICAR-RC NEH Region, Umiam, Meghalaya during kharif (2018) on groundnut (variety JL-24). The white grub species was identified by Dr. V.V. Ramamurthy from the Division of Entomology, IARI, New Delhi. The experiment was laid out in RBD with eight treatments including control, replicated four times. The crop was sown in 12 sq m plots with 40 x 20 cm (row-plant) spacing following proper agronomic practices. The treatments included imidacloprid 17.8SL (3 ml/ kg), chlorpyrifos 20EC (25 ml/ kg) as seed-treatment; imidacloprid 17.8 SL (300 ml/ ha), chlorpyrifos 20EC (4l/ ha) as soil drenching; carbofuran 3G (33kg/ ha) as soil application; and *Beauveria bassiana* ($1x10^8$ spores/ml), *Metarhizium anisopliae* ($1x10^8$ spores/ ml) as spray application. Insecticides and bioformulations were obtained from Division of Entomology and Division of Plant Pathology, ICAR-RC for NEH Region, Barapani, Meghalaya. Treatments were applied at the time of sowing and on standing crop. Imidacloprid (3 ml/ kg) and chlorpyriphos (25 ml/ kg) were applied as seed-treatment (ST) following Mathur and Bhatnagar (2001), while other treatments were applied on standing crop at 45 days after sowing (DAS). Carbofuran (33 kg/ ha) was applied directly in soil. Liquid formulation of entomopathogenic fungi as foliar spray, soil drenching (SD) with imidacloprid (300 ml/ ha) and chlorpyriphos (4l/ ha) were done along the rows by mixing in pulverized soil following Singh et al. (1999), keeping spray volume @1 l/ plot. Observations were made on initial plant population at 15 days after sowing (DAS); pre-treatment observations on plant population at 45 days after sowing (DAS) and post-treatment observations on plant infestation at 15 days interval till harvesting. Plant infestation and plant mortality by grubs were converted into % infestation following Mathur and Bhatnagar (2001) and Patel et al. (2022).

At harvesting, three pits (100x100x30 cm) were dug in randomly selected 1 sq m area in each plot and observations on grub population per pit; yield of crop/ 1 sq m and weight of infested pods/ 1 sq m were recorded. Plants showing wilting, stunted growth and failure of crop emergence were recorded and considered as damage caused due to grub given by Metcalf and Flint (1975), Chandel et al. (2021), and Patel et al. (2022). Data were computed to derive mean values and statistically analyzed with ANOVA using SPSS. Plant infestation and mortality data in % were statistically analyzed with angular transformed values. Significant and non-significant results of the variance due to treatment effects were determined by calculating F values. Wherever the variance ratio (F) was significant, the CD was reported at p=0.05.

RESULTS AND DISCUSSION

Efficacy of eight treatments (including control) against *L. coneophora* grubs was evaluated following the methods given by Singh et al. (1999) and Patel et al. (2020) based on % plant infestation and mortality (Patel et al., 2022), grub population/ plot (12 sq m) and pod yield at the time of harvest. Field effectiveness of insecticides as seed treatment and soil drenching (imidacloprid 17.8SL and chlorpyriphos 20EC) and field spraying with *M. anisopliae, B. bassiana* formulations at 45 days after sowing (DAS) were evaluated. Observations were recorded on plant infestation and mortality before treatment and at 45, 60, 75, 90, 105 and 120 DAS. Pre-treatment data were found to vary from 8.54 to 11.15/ sq. m. at 15 DAS but did not differ significantly (Table 1). Imidacloprid seed treatment recorded lowest grub infestation (0.63%) at 45 DAS and was on par with chlorpyriphos seed-treatment (0.99%), however, were significantly different. Imidacloprid (seed treatment) recorded the lowest intertaken (1.03%); *M. anisopliae* treatment recorded 3.65 which did not differ significantly from *B. bassiana* (3.80%). Observations at 90 DAS showed that all treatments differed and lowest plant infestation was in imidacloprid ST (1.51%). The higher efficacy of imidacloprid (seed treatment) than chlorpyriphos seed treatment may be attributed to its systemic nature and excellent translaminar movement (Anitha et al., 2005).

Table 1. Efficacy of insecticides and bioformulations against *L. coneophora* in groundnut

Treatments	Dosage	Pre-treatment plant population (1 sq. m)	White grub infested plant (%) 45 DAS	60 DAS	75 DAS	90 DAS	105 DAS	120 DAS	No. of white grub larvae/ plot (12 sq m area)	Pod yield (q/ ha)
Imidacloprid ST	3ml/ kg	9.54	0.63 (2.27)^{b}	1.03 (4.13)^{d}	1.39 (5.87)^{e}	1.51 (6.12)^{d}	1.75 (6.59)^{d}	1.82 (6.71)^{c}	0.17^{d}	3.472^{a}
Chlorpyrifos ST	25 ml/ kg	9.40	0.99 (4.04)^{b}	1.19 (4.44)^{d}	1.55 (6.19)^{e}	1.74 (6.58)^{d}	2.07 (8.27)^{cd}	2.32 (8.74)^{bc}	0.33^{d}	3.392^{a}
Imidacloprid SD	300 ml/ ha	10.50	6.30 (14.40)^{a}	1.07 (4.20)^{d}	1.60 (6.30)^{e}	2.22 (8.56)^{c}	3.09 (10.01)^{c}	3.13 (10.09)^{b}	0.92^{c}	3.104^{ab}
Chlorpyrifos SD	4l/ ha	11.04	6.38 (14.49)^{a}	1.26 (4.56)^{d}	1.61 (6.32)^{de}	2.11 (8.34)^{c}	2.40 (7.60)^{cd}	2.55 (9.19)^{b}	0.58^{cd}	3.181^{a}
Beauveria bassiana FS	5 ml/ l	11.15	6.14 (14.27)^{a}	3.80 (11.08)^{b}	4.04 (11.59)^{b}	4.31 (11.87)^{b}	5.71 (13.55)^{b}	7.60 (15.83)^{a}	1.75^{b}	1.948^{d}
Carbofuran SA	33 kg/ ha	10.79	5.98 (11.67)^{a}	1.68 (6.46)^{cd}	2.44 (8.98)^{c}	2.97 (9.81)^{c}	3.14 (8.76)^{cd}	3.61 (9.32)^{b}	1.08^{c}	2.490^{c}
Metarhizium anisopliae FS	5 ml/ l	8.54	6.01 (13.93)^{a}	3.65 (9.47)^{b}	2.31 (8.74)^{cd}	2.77 (9.50)^{c}	3.03 (9.97)^{c}	3.18 (10.18)^{b}	1.00^{c}	2.684^{bc}
Control (water)	-	9.13	5.74 (13.84)^{a}	6.58 (14.53)^{a}	7.22 (15.51)^{a}	7.87 (16.28)^{a}	8.06 (16.47)^{a}	8.55 (16.99)^{a}	2.58^{a}	1.684^{d}
SEd±		6.40	1.80	1.67	1.23	0.90	1.46	1.23	0.26	0.22
CD (p=0.05)		NS	3.58	3.33	2.44	1.78	2.91	2.44	0.54	0.43

Means followed by same alphabet(s) in a column not significantly different from each other (p=0.05); Figures in parentheses angular transformed; values; ST- Seed treatment; SD- Soil drenching; SA- Soil application; FS – Foliar spray; NS – Non-significant; DAS – Days after sowing

Chaudhary and Dashad (2002a and 2002b) also reported that seed treatment with chlorpyriphos 20EC (@ 5, 10, 15, 20 and 25 ml/ kg seed) and imidacloprid (@1, 2, and 3 g/ kg seed) were effective in controlling *Holotrichia consanguinea* (Blanch.) in groundnut and pearl millet. Anitha et al. (2005) demonstrated that chlorpyriphos and imidacloprid seed-dressings were effective against *Holotrichia reynaudi* and *H. serrata* at rates as low as 0.6 and 3 g a.i/kg, respectively. Rakesha (2007) reported that chlorpyriphos 20 EC @ 1.2% as the best when evaluated against *L. lepidophora*.

The soil drenching approach involves applying diluted insecticides directly to the base of the plant base or near the root region (Youssef et al., 2023). Since systemic insecticides can be translocated throughout plants via the root systems, they can also be applied through soil drenching (Mao et al., 2022). Therefore, soil drenching with systemic insecticides before sowing is suggested to be a potential strategy (Resende-Silva et al., 2020). In the present study, soil drenching with imidacloprid and chlorpyriphos each recorded 2.22 and 2.11% infested plants, putting them on par with *M.anisopliae* (2.77%) and carbofuran (2.97%). These findings are consistent with those of Baruah (2005) on imidacloprid and chlorpyriphos. Singh et al. (1999) and Bhagat et al. (2001) also validated the effectiveness of soil drenching with chlorpyriphos 20EC against *H. longipennis* on rice. Patil et al. (1991), Veeresh et al. (1977) and Kumar (2016) in chillies in Maharashtra, sugarcane in southern India and soybean in rain-fed conditions of Uttarakhand hills, respectively observed similar efficacy. The incidence of white grubs in the transplanted rice field was reduced up to 1.55% through soil application of chlorpyriphos 20 EC (80 ml/ 200 m^2 area) (NCIPM, 2008-09) Bhattacharya et al. (2015) observed that chlorpyriphos and imidacloprid before sowing was effective for controlling *Lepidiota mansueta* (Burmeister) in Majuli Island, Assam, India.

Entomopathogenic fungi (EPF) are being considered as promising bio-agents for the control of white grubs. This is because good moisture is present in the soil during the rainy season, which promotes fungal multiplication under natural field conditions (Monika et al., 2011). *M. anisopliae* and *B. bassiana* have both shown good results for a wide range of soil-inhibiting insect pests (Bhagat et al., 2003; Patial and Bhagat, 2005). Moreover, EPF can attract greater attention than other microbial agents for white grub management. In the present study, *M. anisopliae* field spraying (1.00 grubs/plot) was superior to *B. bassiana* (1.75 grubs/ plot), which was at par with other insecticide treatments (soil drenching of imidacloprid and soil application of carbofuran). This result corroborates with that of Rakesha (2007) and Monika et al. (2011) on *B. bassiana, M. anisopliae* and *B. brongniartii* Logan et al. (1999) found that an isolate of *M. anisopliae* (@ 1x1010 conidia/ ml) significantly increased sugarcane yield while reducing the number of greyback cane grubs (*Demolepida albohirtum*) after six months in Australia. Similar observations were recorded by Bhattacharya et al. (2008) in Assam. The current findings were also in agreement with Channakeshava (2006) on *L. lepidophora* using *M. anisopliae* in arecanut. Use of insecticides increases the risk of pest resistance (Chandel et al., 2018). Literatures pertaining to the bio-efficacy studies comparing different entomopathogenic (EPF) formulations against white grub species are meagre (Patel et al., 2022). At harvesting, the lowest *L. coneophora* larval counts plot was observed in imidacloprid ST (0.17 grubs/ plot), followed by chlorpyriphos ST (0.33 grubs/ plot) and chlorpyriphos SD (0.58 grubs/ plot) (Table 1). These observations are similar to the findings of Rakesha (2007) on reduction in number of grubs (*L. lepidophora*). Data on pod yield given in Table 1 reveal that pod yield for all treatments differed significantly from control (1.684 q/ ha) except *B. bassiana* (1.948 q/ ha). Maximum yield (3.472 q/ ha) and lowest weight of infested pods (0.126 q/ ha) were recorded in imidacloprid ST plots. These findings are in conformity with that of Anitha et al. (2005) with imidacloprid ST (3.5 g a.i./ kg seed) followed by chlorpyriphos seed-treatment. Among the bioformulations, the application of *M.anisopliae* ($1x10^8$ spores/ml) and *B. bassiana* ($1x10^8$ spores/ml) recorded groundnut yield of 2.684 q/ha and 1.948 q/ ha, respectively.

In conclusion, suitable management approaches such as seed treatment with imidacloprid and soil drenching with chlorpyriphos evolved from the present study were useful in the management of the white grub, *Leucopholis coneophora* in the groundnut field. In addition, the effectiveness of the bio-formulations (entomopathogenic fungi) can be enhanced through enrichment with various organic amendments, such as vermicompost, castor cake, and neem cake (Patel et al., 2022).

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AUTHOR CONTRIBUTION STATEMENT

DS arranged the materials and conducted the entire experiments. KS formulated the objectives. DS and HJW took observations, recorded the relevant information and analyzed the data. DS and ABTM wrote the manuscript, with the guidance from KS.

CONFLICT OF INTEREST

No conflict of interest.

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