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I. C. A. R.

ALL INDIA NETWORK PROJECT ON SOIL ARTHROPOD PESTS

ANNUAL REPORT 2021-22

PRESENTED AT

XXIII ANNUAL GROUP MEETING

CSK HPKV PALAMPUR, HIMACHAL PRADESH

NETWORK UNIT

SKN AGRICULTURE UNVIERSITY

RAJASTHAN AGRICULTURAL RESEARCH INSTITUTE

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CONTENTS

SECTION 1
DETAILS OF TECHNICAL PROGRAMME ALLOWTED TO VARIOUS CENTERS FOR YEAR 2021-22

WHITE GRUBS

TRAP TECHNOLOGY

Species profiling of soil arthropods through light trap

The light trap designed by NCIPM (with timer), traps with LED bulb and mercury bulb as light source will be installed during the white grub emergence season (March–September) for collection of the adult beetles and also for monitoring of the "scarabaeidbeetles" activity (according to Agro-ecological region of each centre). Light traps will be operated in the crop vicinity in the evening hours just before dusk and till late in the night at convenient location. The adult beetles that are attracted to the light will be collected trap wise and brought to the laboratory for further processing. Daily collection of beetles (nos.) will be sorted, cleaned, pinned, labeled and identified up to species level, which will be further correlated with corresponding weather parameters *viz*., temperature, relative humidity, rainfall, etc. The GPS will be used to record the geographical coordinates of the collection sites, which will be used in documenting and drawing the distribution pattern of species restricted by altitude/ latitude/ longitude. The species diversity in terms of richness and evenness will be calculated out for each location/ region. Besides these, the light trap efficiency in adult beetle catch will also be evaluated with respect to different light sources. Studies on correlation between the luminance values (Lux) of the light sources in light traps and beetle catches will be carried out and documented.

*Each centre will send monthly report (MPR) of beetle catches during the season to coordinating cell.

(Allotted for all centers)

Population Monitoring of phytophagous scarab beetles on host trees

Survey will be carried out during peak emergence of the adult beetles, once in a month for monitoring the preferred and non-preferred host trees by them.

(Allotted for all centers)

Kairomonal study

After confirmation of the preferred host by the adult beetle kairomonal studies on scarab beetles as well as cutworm moths will be undertaken by all the centers. For these studies collect the sample of preferred host of beetles and send to Dr. Deepa Bhagat, Principal Scientist, NBAIR, and Bengaluru as her suggestion/protocol.

(Allotted for all centers)

Population monitoring of damaging stages of soil arthropod pests and their extent of damage in different crops

Surveys will be carried out at least once in a week during peak emergence to determine the extent of damage in specific crop inflicted by various soil insect and molluscan pests on different economically important crops by counting the number of the affected plants and grubs per square meter area in soil. The information with quality photographs should be sent to the Coordinating cell for further compilation (month wise). Use of GPS has been made mandatory for this survey works.

Observations table:

Date	Location (GPS)	Crops	Number of Grub/M^2 area in soil	Extent of damage

(Allotted for all centers)

Pheromone studies on predominant white grub species

The concerned centre will isolate pheromone gland of the relevant species by solvent extract of glands as well as whole body or isolation of pheromone by confinement and rinse method and trapping of volatiles/ pheromones by using suitable adsorbents. The extracts containing the pheromone will be analyzed in GC-MS to identify the compounds. Bioassay will be carried out with relevant species to establish the efficacy of identified compound.

L. mansueta (Efforts will be made to revisit the already identified pheromonal compounds through GCMS-EAG analysis and their further synthesis/field testing will be carried out in collaborative mode with other institutes)	**Jorhat Centre**
Extraction, identification, synthesis and field testing of pheromonal compounds of *Leucopholisburmeisteri*	**Bengaluru Centre**
Extraction, identification, synthesis and field testing of pheromonal compoundsof*Brahmina coriacea*	**Palampur Centre**
Extraction and identification of pheromones of *Anomala bengalensis* and their testing in both laboratory and field conditions.	**Almora Centre**
Being a newly introduced centre, concerted attempts should be madetostudy the diversity phytophagous scarab fauna of Gujarat. Subsequently based on severity of damage, pheromonal works on the most predominant white grub species has to be initiated in consultation with the Networking cell.	**Gujarat Centre**

Monitoring of natural enemies of soil arthropods

To monitor the occurrence of natural enemies (parasitoids, predators& pathogens) of major soil arthropod pests, seasonal soil sampling be done in the endemic pockets. Each centre will

undertake the sampling method of each organism according to the cropping system. Natural enemies should be sent to Dr. M. Nagesh, Pr. Scientist (Nematology) and Dr. R. Rangeshwaran, Pr. Scientist (Microbiology), NBAIR, Bangalore and Dr. Uma Rao, Head, Principal Scientist (Nematology), IARI, New Delhi who will act as consultant scientists of this group and will facilitate its identification, culturing and providing necessary details regarding receipt No. and code numbers etc.

(Allotted for all centers)

Surveillance of white grub through drone technology

Use of drone technology for monitoring the incidence of soil insect pests

Drone camera will be operated in crop fields during survey programme. The auto captured images and video clips can be downloaded and assessed for the incidence of soil insect pests.

Methodology: Drone camera (Model: DJI Phantom 4 with a flying capacity up to 2 KM and up to 120 m height or any other available models) can be operated after first shower of monsoon to capture the images to check the emergence of beetle and feeding on host trees as defoliation as well as in crop field (sugarcane, ground nut, areca nut, potato field etc.) during survey programme. The auto captured images and video clips can be downloaded and assessed for the incidence of soil insect pests. The technology can also be used for monitoring of scarab beetle incidence in fruit orchards of hilly regions as well as plain areas/ river line areas. Attempts should be made to use drone technology to survey the termite mounds and their architecture.

(Allotted for all centers)

MANAGEMENT OF WHITEGRUBS THROUGH CHEMICALS

Insecticides will be applied through seed treatment if the sowing time coincides with the emergence of beetles. Insecticides will be applied by soil drenching method in standing crops at the time of occurrence of eggs and neonate first instar grubs, if the crops sown much earlier than beetle emergence. In areas where both the situations occur (crops sown earlier than monsoon and crops sown with the onset of monsoon coinciding with beetle emergence) trials should be laid out separately for both the situations. In all the cases the critical timing of pesticide application should be according to the presence of eggs, neonates and first instar grubs for targeting the key species of each region. Pesticides residues analysis and B:C ration in terms of net income of the crop should also be given. Correlation of grub population with damage needs to be established following appropriate statistical methods. Considering the differential response of white grub species to various insecticides to be tested, the identity of targeted species should be properly mentioned.

Evaluation of granular insecticides against white grub

Experiment Details

Location/sowing time	Jorhat (pre-sowing), Palampur (post-sowing), Durgapura (Post sowing), Kolhapur (Post sowing), Ghaziabad (Post sowing) and Gujarat (Post sowing)

	As per Recommended Package of Practices
Design	RBD
Replication	3
Crop	Jorhat (Potato), Palampur (Potato), Durgapura (Groundnut), Kolhapur (Sugarcane), Ghaziabad (Sugarcane), Gujarat(Groundnut)
Fertilizer	at recommended doses
Treatments	7
Observation	Plant mortality (%), Larval population/ m^2, Yield (q/h), Pesticides residues analysis and B: C ratio.

Treatment details:

S.N.	Treatments	Hills	Plains
1.	Clothianidin 50 WDG	120 g a.i./ha	120 g a.i./ha
2.	Fipronil 0.3G	-	50 g a.i./ha
3.	Thiamethoxam 25WG	80 g a.i./ha	80g a.i./ha
4.	Imidacloprid 70 WG	300g a.i./ha	300g a.i./ha
5.	chlorantraniliprole 0.4% GR*	-	100 g a.i./ha
6.	Fifronil40%+Imidacloprid 40%WG*	300 g/ha	300 g/ha
7.	Control		

*For pesticides residues analysis centers try to send nearby residue analysis laboratory at your location otherwise may send their samples to AINP on Pesticide Residues' Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.

Evaluation of some insecticides against white grub as seed dresser application and drenching in standing crop

Experiment Details:

Location/ Sowing time	Jorhat (pre-sowing), Palampur (post-sowing), Durgapura, Kolhapur, Ghaziabad, Gujarat, Bangalore
	As per Recommended Package of Practices
Design	RBD
Replication	3
Crop	Jorhat (Colocasia), Palampur (Potato & Rajma), Durgapura (Groundnut), Kolhapur (Sugarcane, Groundnut & Soybean), Ghaziabad (Sugarcane), Gujarat (Groundnut), Bangalore (Areca nut)
Fertilizer	Recommended doses
Treatments	8
Observation	Plant mortality (%), Larval population /m^2, Yield (q/h) Pesticides residues analysis and B:C ratio

Treatment details:

S.N.	Treatment	Hill		Plain	
		Seed treatment	Drenching in standing crop (Post sowing)	Seed treatment	Drenching in standing crop (Post sowing)

1.	Imidacloprid 17.8 SL	48g a.i./ha	60g a.i./ha	-	-
2.	Thiamethoxam 30 FS	80g a.i./ha	150g a.i./ha	80g a.i./ha	150g a.i./ha
3.	Fipronil 5SC	-	-	100g a.i./ha	150g a.i./ha
4.	Clothianidin 50 WDG	80 g a.i./ha	125 g a.i./ha	80g a.i./ha	125g a.i./ha
5.	Imidacloprid 600 FS	500g a.i./ml/ha	1000 g a.i./ml/ha	500g a.iml./ha	1000g a.iml. /ha
6.	Chlorantraniliprole 18.5 SC*	-	-	500 ml/ha	500 ml/ha
7.	Fifronil 40%+Imidacloprid 40%WG*	3g per kg seed	300 g/ha	3 g per kg seed	300 g/ha
8	Control				

*For pesticides residues analysis centers try to send nearby residue analysis laboratory at your location otherwise may send their samples to AINP on Pesticide Residues Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.

MICROBIAL CONTROL OF WHITE GRUBS

Field evaluation of entomopathogenic fungi against white grub

Experiment Details:

Location	Jorhat, Palampur, Durgapura, Kolhapur, Ghaziabad, Gujarat, Bangalore
Sowing time	As per Recommended Package of Practices
Design	RBD
Replication	3
Crop	Jorhat (Green gram), Palampur (Potato & Rajma), Durgapura (Groundnut), Kolhapur (Sugarcane) Ghaziabad (Sugarcane), Gujarat (Groundnut), Bangalore (Arecanut & Sugarcane)
Fertilizer	as per Recommended doses
Treatments	8
Application	Apply entomopathogenic fungi's powered formulation mix with 100 kg FYM and without mix with FYM in row by 5 cm deep furrow extendingfront to back. The raised soil beside the furrow push back to coverformulation.
Observation	Observations will be recorded on plant damage due to white grubs; the number of white grubs per 10-meter row in the root zone will berecorded at 60 days after treatment (DAT). The per cent decrease in white grub damage and white grub population will be calculated. Data will be subjected to analysis of variance.

Treatments Details:

Sr. No.	Treatment	Dose
T_1	*Metarhizium anisopliae* (WP)	$1x10^9$ CFU per gm/m^2
T_2	*Metarhizium anisopliae* (WP) mixed with FYM	$1x10^9$ CFU per gm/m^2

T_3	*Beauveria bassiana* (WP)	$1x10^9$ CFU per gm/m^2
T_4	*Beauveria bassiana* (WP) mixed with FYM	$1x10^9$ CFU per gm/m^2
T_5	*Beauveria brongniartii* (Soil Formulation)	$1x10^9$ CFU per gm/m^2
T_6	*Beauveria brongniartii* (Soil Formulation) mixed with FYM	$1x10^9$ CFU per gm/m^2
T_7	Recommended insecticide	As per recommendation
T_8	Control	-

Field evaluation of entomopathogenic fungi against white grub

Treatment	Applied at the time of Planting/sowing				Yield (q/h)
	Whitegrubdamage		White grub population		
	Damage (%)	Per cent decrease over Control	No. of Grubs per m^2 area	Per cent decrease over Control	
T1					
T2					
T3					
T4					
T5					
T6					
T7					
T8					
CD (P=0.05)					
CV %					

Field evaluation of entomopathogenic bacterial strains against white grub

Experiment details:

Location	Jorhat, Palampur, Durgapura, Kolhapur, Ghaziabad, Gujrat, Bangalore, Almora
Plot size	1 x 5 cents for each treatment, 1 cent = 8x5 m^2
Replications	04
Design	RBD
Date of sowing	As per the package of practice
Variety	High yielding ruling variety
Treatments	1. NBAIR-BtAN4 strain of *Bacillus thuringiensis* 2. NBAIR-Bt25 strain of *Bacillus thuringiensis* 3. NBAIR-BATP strain of *Bacillus albus* 4. Recommended Insecticide application 5. Control (Untreated)
Observations	1. No healthy tillers and dead tillers / 1 m row length before application of entomo-pathogens 2. Per cent reduction of white grub population;

	3. Yield will be recorded at the time of harvesting (Comparison with insecticides and control), 4. CB Ratio

Method of Application:

1. *B. thuringiensis* NBAIR-BT25 @ 3 litre/acre as soil drenching for two times at 7 days intervals
2. *B. thuringiensis* NBAIR-BTAN4 @ 3 litre/acre as soil drenching for two times at f 7 days intervals
3. *Bacillus albus* NBAIR-BATP @ 2.5 Kg of talc mixed with 100 kg of FYM with intermittent water sprinkling and incubates for 15 days. After that soil apply to individual plant.

The material for biocontrol trials will be supplied by Dr. R. Rangeshwaran, Pr. Scientist (Microbiology), NBAIR, Bangalore (*Metarhizium anisopliae*) and Dr. J.P. Singh, FARMER, Ghaziabad (EPNs, *B. bassiana & M. anisopliae*) and Dr. Rajanna, PI, AINP on SAP-Bengaluru, (*Beauveria brongniartii*). Application of bio-pesticides should coincide with mass emergence of beetles after first shower of monsoon.

***All centres should communicate for above microbials for testing at least one month in advance.**

Evaluation of the bio-efficacy of promising EPN strains against white grubs

Experiment details

Location	Jorhat, Palampur, Durgapura, Kolhapur, Ghaziabad, Gujarat, Bangalore, SBI-Coimbatore
Sowing time	As per respected zones and centres
Crop	Jorhat (Green gram), Palampur (Potato & Rajma), Durgapura (Groundnut), Kolhapur (Sugarcane) Ghaziabad (Sugarcane), Gujarat (Groundnut), Bangalore (Arecanut & Sugarcane), SBI (Sugarcane)
Treatments	T_1*Heterorhabditis indica strain* SBITND78 @ 10^8 IJs/ac
	T_2*Heterorhabditis bacteriophora* strain SBIP5@ 10^8 IJs/ac
	T_3*Steinernemasurkhetense* strain SBIP3@ 10^8 IJs/ac
	T_4*Steinernemasiamkayai* strainSBITNT1@ 10^8IJs/ac
	T_5. Recommended insecticides
	T_6 Control
Design	RBD
Replication	3
Plot size	5 rows of 6 m length.

Method of application for EPNs:

- EPN should be applied at first beetle emergence during onset of summer shower (April – June)
- Irrigate the field prior and after EPN application and keeping the treated area wet for at least 5days post application
- The ideal time of application is at evening hours so EPN can become active at night without risk of sunlight damage
- Give more concentrated application in the border rows extending to five to seven meters inside (white grub infestation generally seen on the boundaries of the plots and extending to a few meters inside).
- Mix the EPN formulation with water (150g EPN formulation/ sprayer tank) and can be applied using knapsack sprayer (nozzle and inside filters of the spray equipment should be removed to prevent them from becoming clogged with nematodes) in each sugarcane clump /any crop by making a 15-20cm pit using a crowbar.

Observations to be recorded:

i) Initial grub population per sq. m
ii) Grub observation per sq. m at 15 days and 30 days after EPN application and observe for dead reddish coloured (*Heterorhabditis* infection) or brownish coloured (*Steinernema* infection) dead grubs

Evaluation of Bio-efficacy of EPN strains against white Grub in field

Treatment	Initial White grub population (Before EPNs Application)	White grub population (15 Days after EPNs Application)	White grub population (30 Days after EPNs Application)	Yield (q/h)
T1				
T2				
T3				
T4				
T5				
T6				
CD (P=0.05)				
CV %				

Study of local isolates of Entomopathogenic fungi and EPNs for their Infectivity against soil arthropod pests

The existing identified isolates would be screened against most damaging white grub species of the region and efforts should be given to determine LC_{50}/ LD_{50}value of potential strains.

Development of formulation and field testing of the same should be carried out against the targeted species.

(Allotted for all centres)

WHITE GRUB TAXONOMY (NBAIR, Bangalore and UAS, GKVK, Bangaluru)

A. Compilation of literature on Scarabs of India- Continued

B. Development of Taxonomic keys for Scarabs of India

C. Description of white grubs of Karnataka, Tamil Nadu, Telangana, Kerala, Himachal Pradesh, Eastern states, Uttarakhand, Utter Pradesh and Rajasthan in phased manner

D. All the centre will be sent new species recorded at your centre for identification.

Development of Distribution maps of white grub and other soil arthropod pests of India

Following centres will develop distribution maps of different predominant white grub species of respective states as mentioned below:

(A.) Durgapura : Rajasthan, MP and Haryana
(B.) Palampur : HP, JK, Punjab
(C.) Gujarat : Gujarat
(D.) Kolhapur : Maharashtra, Goa and Odessa
(E.) Bangalore : Karnataka, Andhra Pradesh, Telangana, Tamil Nadu and Kerala
(F.) Jorhat : Assam, Arunachal Pradesh and Manipur
(G) Almora : Uttarakhand

All the centres should complete the work under the supervision of Dr. K. Sreedevi, NBAIR, Bengaluru (Nodal Officer) and submit the map detail within six months to her.

SOCIAL ENGINEERING

Social Engineering/Large community mobilization/ Mass campaigning for both grub & adult management will be carried out at endemic pockets by following the work plan given below.

Details of work plan/activities of Social Engineering

Centres	Targeted white grub species	Districts' to be covered	Beneficiary farmers (Approx.)
Durgapura	*Holotrichia consanguinea*	Jaipur, Sikar, Dausa, Bikaner, Jodhpur, &Nagour	5000
Jorhat	*Lepidiotamansueta*	Majuli& Jorhat	5000
Palampur	*Brahmina coriacea*	Kinnaur, Lahual, Chamba	5000
Bangaluru	*Holotrichia serrata*,	Mandya, Mysore,	5000

	Leucopholislepidophora L. burmestri, Leucopholisconeophora	Chamarajanagar, Hassan, Belgaum, Dharwad, Bagalkot, Bijapur	
Kolhapur	*Leucopholislepidophora*and *Holotrichia serrata*	Sangli, Satara, Kolhapur	5000
Gujarat	*H. serrata, H. consenguniea*	Junagarh, Bhavnagar Amreli Rajkot and Surender Nagar	5000
Almora	*A. dimidiata*	Almora, Nainital	5000
Ghaziabad	*H. serrata, H. nagpurensis, A. dimidiata, Maladera insanabilis, H. consanguinea*	Ghaziabad, Hapur, Bulandshahar, Gautambudh Nagar, Amroha, Saharanpur, Muzaffarnagar	5000

Targets (in numbers) for implementing different social engineering tools throughout the year						
Centres	**Farmers training**	**Training for extension functionaries**	**Field day**	**Exhibition (organized/ participation**	**Method demonstration**	**Technology showcasing**
Durgapura	50	5	5	15	15	5
Jorhat	50	5	5	15	15	5
Palampur	50	5	5	15	15	5
Bangalore	50	5	5	15	15	5
Kolhapur	50	5	5	15	15	5
Gujrat	50	5	5	10	15	5
Almora	50	5	5	10	10	5
Ghaziabad	50	5	5	25	20	5

General guidelines:

- Only the proven technologies (use of pheromonal lures, light traps, scouting, use of microbials, seed treatment, mechanical exclusion methods etc.) should be demonstrated in the farmers field under Technology showcasing/Method demonstration

- Technology showcasing should be based on already eco-friendly IPM modules. It has to be demonstrated in the highly beetle endemic pockets covering an area (not less than 1-1.5 acres).
- All social engineering activities should be collaborated with KVKs, State Department of Agriculture, and NGOs etc. to establish better linkage.
- All social engineering activities should be planned/distributed throughout the year against both grubs and adults.
- All centres should report the "Coordinating cell" about their targeted activities so that the same is reflected in the Monthly progress report.
- The impact of activities should be assessed/studied in collaboration with Agricultural Economists/Extension Scientists and adopt follow-up actions.
- Success story of social engineering works should be shared/uploaded through social networking means (Facebook, WhatsApp) and YouTube.

TERMITE

MANAGEMENT OF TERMITE THROUGH CHEMICALS

A. Management of termite through seed treatment

Experiment Details

Location	Palampur, Durgapura, Bengaluru, Gujarat
Sowing time	As per POP
Design	RBD
Replication	3
Crop	Palampur (Wheat), Durgapura (Groundnut), Bengaluru (Groundnut), Jorhat (Moong bean) Gujarat (Groundnut)
Fertilizer	Recommended doses as per POP
Treatments	10
Observation	Per cent Plant damage, Protection over control, Yield (q/h) Pesticides residues analysis and B: C ratio.

Treatment details:

S.N.	Treatments	Dose (Per kg seed)
1.	Thiamethoxam 25 WG	3.2 g
2.	Imidacloprid 17.8 SL	3.0 ml
3.	Acephate 50% + imidacloprid 1.8%	4.0 g
4.	Fipronil 5 SC	10.00 ml
5.	Thiamethoxam 30 FS	3.0 ml
6.	Imidacloprid 600 FS	6.5 ml

7.	Clothianidin 50 WDG	1.5
8.	Fipronil 40%+Imidacloprid 40%WG*	3.0 g
9.	Chlorantraniliprole 18.5 SC*	2.0 ml
10.	Untreated check	-
*For pesticides residues analysis centers try to send nearby residue analysis laboratory at your location otherwise may send their samples to AINP on Pesticide Residues' Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.		

B. Management of termites through drenching:

Experiment details:

Location	Palampur, Durgapura, Bengaluru, Gujarat
Sowing time	As per POP
Design	RBD
Replication	3
Crop	Palampur (Wheat), Durgapura (Groundnut), Bengaluru (Groundnut),Jorhat (Moong bean) Gujarat (Groundnut)
Fertilizer	Recommended doses as POP
Treatments	10
Observation	Per cent Plant damage, Protection over control, Yield (q/h) Pesticides residues analysis and B:C ration should also be given.

Treatment details:

S.N.	**Treatments**	**Dose per ha**
1.	Thiamethoxam 25 WG	600 g
2.	Imidacloprid 17.8 SL	360 ml
3.	Acephate 50% + imidacloprid 1%	1250g
4.	Fifronil 5 SC	3.0 lit.
5.	Thiamethoxam 30 FS	600g
6.	Imidacloprid 600 FS	1042
7.	Clothianidin 50 WDG	300g
8.	Fifronil 40%+Imidacloprid 40%WG*	500 g
9.	Chlorantraniliprole 18.5 SC*	500 ml
10.	Control	-
*For pesticides residues analysis centers try to send nearby residue analysis laboratory at your location otherwise may send their samples to AINP on Pesticide Residues' Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.		

C. Management of termite through sett treatment in sugarcane crop

Experiment details:

Location	Kolhapur, Ghaziabad, Bengaluru, Jorhat (As OFT)
Sowing time	As per POP
Design	RBD
Replication	3
Fertilizer	Recommended doses as POP
Treatments	10
Observation	Per cent Plant damage, Protection over control, Yield (q/h)/ germination (%), Pesticides residues analysis and B:C ratio

Treatment details:

S.N.	Treatments	Dose (Per litre water)
1.	Thiamethoxam 25 WG	1 g
2.	Imidacloprid 17.8 SL	1ml
3.	Acephate 50% + imidacloprid 1%	1 g
4.	Fipronil 5 SC	1 ml
5.	Thiamethoxam 35 FS	1 ml
6.	Imidacloprid 600 FS	1 ml
7.	Clothianidin 50 WDG	1 g
8.	Fipronil 40%+Imidacloprid 40%WG	1 g
9.	Chlorantraniliprole 18.5 SC	0.5ml
10.	Untreated check	-
*For pesticides residues analysis centers try to send nearby residue analysis laboratory at your location otherwise may send their samples to AINP on Pesticide Residue's Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.		

A. Drenching in standing sugarcane/ tea crop through water

Experiment details:

Location	Jorhat (Tea), Kolhapur, Ghaziabad, Bengaluru
Sowing time	As per POP
Design	RBD
Replication	3
Fertilizer	Recommended doses as POP
Treatments	7
Observation	Per cent Plant damage, Protection over control, Yield (q/h) Pesticides residues analysis and B:C ratio

Treatment details:

S.N.	Treatments	Dose (per ha)
1.	Imidacloprid 600 FS	800 ml
2.	Imidacloprid 17.8 SL	350 ml

3.	Fipronil 5 SC	2 litre
4.	Imidacloprid 70 WS	160 ml
5.	Clothianidin 50 WDG	250 g
6.	Chlorantraniliprole 18.5 SC	500 ml
7.	Control	-
*For pesticides residues analysis centers try to send nearby residue analysis laboratory at your location otherwise may send their samples to AINP on Pesticide Residues' Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018		

E. Development of Distribution maps of termite

Following centres will develop distribution maps of termite species of respective states as mentioned below:

(A.) Durgapura : Rajasthan
(B.) Palampur : Himachal Pradesh
(C.) Gujarat : Gujarat
(D.) Kolhapur : Maharashtra
(E.) Bangalore : Karnataka
(F.) Jorhat : Assam
(G) Almora : Uttarakhand
(H) Ghaziabad : Uttar Pradesh

All the centres should complete the distribution map of termite under the supervision of Dr. Kalleshwara Swamy, Assistant Professor, Department of Entomology, COA, University of Agricultural & Horticultural Sciences, Navile, Shivamogga-577504. Karnataka and submit the map detail within six months to her.

F. Biodiversity studies termites

Biodiversity studies on termite species will be conducted in concerned state of the centre. Survey will be conducted in different habitats comprising agricultural crops, forestry and horticulture plantation, wooden structures (buildings) to collect different species of termites**.**

(Allotted for all centres)

CUTWORM

A. Monitoring of Cutworm

Palampur centres will monitor the population of the cutworm through light traps and pheromone traps.

Management of cutworms:

Field evaluation of pre-sown application of different granular insecticides against cutworm

Experiment details:

Location	Palampur
Sowing time	Normal
Crop	Cabbage
Design	RBD
Replication	4
Fertilizer	Recommended doses
Treatments	5
Observation	Per cent damage, Protection over control, Yield (q/h) Pesticides residues analysis and B:C ration should also be given

Treatment details:

S.N.	Treatments	Dose
1.	Imidacloprid 0.3GR	45 g a.i./ha
2.	Clothianidin 50 WDG	120 g a.i./ha
3.	Fipronil 0.3G	50 g a.i./ha
4.	Thiamethoxam 25WG	80 g a.i./ha
5.	Untreated check	-

Field evaluation of post-sown application of different granular insecticides against cutworm

Experiment details:

Location	Palampur
Sowing time	As Per POP
Crop	Cabbage
Design	RBD
Replication	4
Fertilizer	Recommended doses as POP
Treatments	5
Observation	Per cent damage, Protection over control, Yield (q/h) Pesticides residues analysis and B:C ration should also be given.

Treatment details:

S.N.	Treatments	Dose
1.	Imidacloprid 0.3GR	45 g a.i./ha
2.	Clothianidin 50 WDG	120 g a.i./ha
3.	Fipronil 0.3G	50 g a.i./ha
4.	Thiamethoxam 25WG	80 g a.i./ha
5.	Untreated check	-

Field evaluation of post planting application of different liquid insecticides against cutworm

Experiment details:

Location	Palampur
Sowing time	Normal
Crop	Cabbage
Design	RBD
Replication	4
Fertilizer	Recommended doses
Treatments	6
Observation	Per cent damage, Protection over control, Yield (q/h) Pesticides residues analysis and B:C ration should also be given.

Treatment details:

S.N.	Treatments	Dose
1.	Imidacloprid 17.8.SL	60 g a. i./ha
2.	Clothianidin 50 WDG	120 g a.i./ha
3.	Fipronil 0.3G	50 g a.i./ha
4.	Thiamethoxam 25WG	80 g a.i./ha
5.	Chlorpyriphos 20EC	500 g a.i./ha
6.	Untreated check	-

LOCATION SPECIFIC TRIALS

Each centre will conduct experiments of local importance based on the feedback received from different sources.

Durgapura Centre

- **Dissemination and Popularization of Nanogel Slow-ReleasePheromone Technology (SRPT)**

  The already isolated and characterized pheromone "Methoxy benzene" explored earlier for managing *H. consanguinea* in ground nut ecosystem was found highly volatile and required daily loading of new septa on host trees.

  This problem is overcome by using slow release "Nanogel formulation of Methoxy benzene" and the technology has been tested in white grub endemic areas of Rajasthan and perfected.

  This pheromonal lure is effective in aggregation of beetles up to one month and now daily loading of new septa wouldn't be required upto one month.

  Developed Nanogel slow-release pheromone technology will be disseminating through mass demonstration in white grub endemic areas of the Rajasthan.

- **Management of termite through some chemicals applied as seed dresser and standing crop of chick pea.**

Experimental Layout:

Design: Randomized Block Design

Number of treatments: 10

Replication: 3

Individual plot size: 6×4 sq. m.

Variety: "*Local variety*"

Treatments Details:

Sr. no.	Treatment	Dose Standing crop/ha	Dose Seed treatment (g or ml/kg seed)
T_1	Fipronil 40%+Imidacloprid 40%	400g	3.0g
T_2	Fipronil 40%+Imidacloprid 40%	500g	5.0g
T_3	Imidacloprid 17.8 SL	360ml	4.0ml
T_4	Fipronil 5SC	3.0 lit	10.0 ml
T_5	Clothianidin 50 WDG	300g	2.0g
T_6	Imidacloprid 600FS	700ml	4.0ml
T_7	Imidacloprid 600FS	900ml	5.0ml
T_8	Imidacloprid 600FS	1042ml	6.0ml
T_9	Chlorantraniliprole 18.5 SC	500ml	2.0ml
T_{10}	Untreated check	-	-

Observations to be recorded:

a. Initial plant population counting at 30 Days after sowing
b. Plant mortality at 40, 80 at harvesting
c. Total per cent plant mortality
d. Final plant stand
e. Yield

- **Management of soil arthropods through IPM**

Details of experiment

S.N.	**Treatments**	**Time of Application**
IPM-I	Soil application of Neem cake 250kg/ha	Before sowing in furrow
	ment with Imidacloprid 600 FS-@6.5 ml/kg seed	At the time of sowing
	Application of *Beauveria bassiana* –0.5g/m^2	15 days after sowing
	Application of Imidacloprid 17.8 SL@ 300 ml/ha	22 days after sowing
IPM-II	Soil application of Neem cake 250kg/ha	Before sowing in furrow
	Seed treatment with Imidacloprid 600 FS-@	At the time of sowing

	6.5ml/kg seed	
	Application of *Metarhizium anisopliae-0.5*g/m^2	15 days after sowing
	Application of Fipronil 5 SC-3.0 lit./ha	22 days after sowing
IPM-III	Soil application of Neem cake 250kg/ha	Before sowing in furrow
	Seed treatment with Imidacloprid 600 FS-@6.5ml/kg seed	At the time of sowing
	Application of *H. indica-0.5*g/m^2	15 days after sowing
	Application ofFipronil40%+Imidacloprid 40%WG@ 300g/ha	22 days after sowing
IPM-IV	Farmer practices	-

Jorhat Centre

- **Designing and field testing of few promising attractants against red ant, *Dorylusorientalis* in potato**

  Experimental Layout:

  Design: Randomized Block Design

  Number of treatments: 4

  Replication: 5

  Individual plot size: 4×3 sqm

  Variety: "*Kufri Jyoti*"

  Details of the treatments:

  T_1: Rice bran oil + Boric Acid based attractants

  T_2: Malathion 5% dust @ 40 kg/ ha

  T_3: Chlorpyriphos 20 EC @ 3ml/ lit as soil drenching

  T_4: Control

  Methodology:

  Potato crop (variety: *Kufri Jyoti*) will be grown by following all the recommended agronomic package of practices of Assam. The bait material (T_1) @ 25 ml/ bait or 25 g/ bait will be loaded by using locally available cheap bait stations. The bait stations will be randomly placed at 15 cm depth and diagonally at a distance of 2 meter before the 1st and 2nd earthing up operation in the plots. Malathion 5% dust @ 40 kg/ ha will be applied during the time of 1st earthing up. Chlorpyriphos 20 EC @ 3 ml/lit will be treated in furrows as soil drenching before sowing of potato tubers and one control plot will also be kept.

  Observations to be recorded

  Red ant populations will be monitored by counting the number of ants attracted to each bait stations and the data will be statistically analyzed.

  Advanced nutritional analysis of edible soil dwelling insects of Assam

  Species selected:

White grub (*Lepidiotamansueta*) and Field Cricket (*Brachytrupesportentosus*) aforementioned two species of edible insects will be collected through light trap and scouting from the diverse habitats of Jorhat and Majuli. Collected specimens will be sorted out and cleaned. Powdered samples will be prepared to study the toxicological aspects of the insects by following standard Acute Oral Toxic Class Method Test in Rats.

Impact of different cooking methods on nutritional profile of the above-mentioned insects will also be undertaken. For these, fresh insects will be cooked in different methods like frying, roasting, baking and boiling and then analysis will be done for different parameters by following standard protocols as mentioned below:

S. No.	**Parameters**	**Methodologies to be followed**
1.	Proximate composition	Carbohydrate (A.O.A.C, 1984), Fat, Protein (A.O.A.C, 2000) Fibre and Ash (A.O.A.C. 2000)
2.	Elemental composition	Na, K, Ca, Mg, P, Fe, Zn, Cu and Mn (John C. and Van, L., 1980**).**

- **Field evaluation of insecticidal mixture against some major soil insect pests of potato**

Experimental Layout:

Design: Randomized Block Design

Number of treatments: 4

Replication: 5

Individual plot size: 4×3 sqm

Variety: "*Kufri Jyoti*"

Details of the treatments:

T_1: Insecticidal mixture developed at AAU, Jorhat

T_2: Malathion 5% dust @ 40 kg/ha

T_3: Chlorpyriphos 20EC @ 300 g *a.i*/ha

T_4: Untreated control

Methodology:

Insecticidal mixture (developed at AAU Jorhat centre) will be tested against some major soil insect pests of potato under field conditions. The potato crop will be grown by following all the recommended package of practices. The T_1 and T_3 will be applied before sowing of the potato tubers whereas the T_2 will be applied during the time of 1stearthing up operation in the plots.

Observations to be recorded:

Data will be recorded in terms of per cent tuber damage (both in number and weight basis) along with the yield and data will be analyzed through 5 RBD ANOVA.

Palampur Centre

Management of adults of white grubs

A. Evaluation of insecticides against beetles of *Brahmina coriacea*

S.No	Name of chemical	Dose
1.	Chlorantraniliprole 18.5 SC	The beetles will be collected during beetle emergence period i.e., May-July and the culture will be maintained in the laboratory for evaluation of chemicals to work out LC50 values.
2.	Bifenthrin10EC	
3.	Clothianidin 50 WDG	
4.	Thiamethoxam 25 WG	
5.	Imidacloprid 17.8 SL	
6.	Chloropyriphos 20 EC	

B. Interaction effects of entomopathogenic fungi with insecticides

For evaluating interaction effects among different tested biocontrol agents and with insecticides, each bioagents will be tested in combination with insecticide. Entomopathogenic fungi i.e., *B. bassiana* and *M. anisopliae*, @ $5x10^7$ and $6x10^7$ conidia/ml, respectively, whereas the EPN (*H. indica*) will be applied @ 400 IJs/ml. the insecticides will be applied at lower concentrations viz., 150, 100, 75, 25, 50 and 50 ppm for Chlorpyriphos 20 EC, Imidacloprid 17.8 SL, Clothianidin 50 WDG, Chlorantraniliprole 18.5 SC, Flubendiamide 39.35 SC and Spinosad 45 SC, respectively.

Biocontrol agents	Dose	Insecticides	Dose (ppm)
Beauveria bassiana	$5x10^7$ conidia/ml	Imidacloprid 17.8 SL	150
Metarhizium anisopliae	$6x10^7$ conidia/ml	Chlorpyriphos 20 EC	100
H. indica	400 IJs/ml	Clothianidin 50 WDG	75
		Chlorantraniliprole 18.5 SC	25
		Flubendiamide 39.35 SC	50
		Spinosad 45 SC	50

Molecular characterization of *Melolontha* sp.

For phylogenetic analysis mitochondrial and nuclear gene will be amplified and sequenced using different primers. Amplified PCR products will be cloned and sequenced using standard molecular biology tools. Sequences thus obtained will be examined for sequence homology with the sequences at NCBI database employing BLAST N (https://blast.ncbi.nih.gov/Blast.cgi?PAGE-TYPE=BlastSearch).

Bangalore Centre

- **Studies on biogeography of major white grubs in Karnataka**

- **Evaluation of bio-agents against white grubs**
- **Evaluation of *Beauveria brongniartii* Isolate maintained at Bengaluru centre against sugarcane and arecanut white grubs**
- **Evaluation of NBAIR, Bengaluru isolates of *Beauveria bassiana* and *Metarhizium anisopliae* against sugarcane and arecanut white grubs and termites in sugarcane**
- **Evaluation of EPNs developed by the FARMER, Ghaziabad**
- **Demonstration and popularization of insecticide free managementpractices for arecanut white grubs such as digging and removal of grown-up larvae**

  The adults of *L. lepidophora*, *L. burmesterei* and *L. coneophora*are not known to aggregate on tree canopies as *H. serrata*. Usually, the beetles emerge around 6:40 pm and each beetle has to be virtually chased and collected using flash lights. Two farmers from Bhavane, Thirthahalli and Begane, Sringeri taluks are collecting beetles once in two years. Both *L. lepidophora* and *L. burmesterei* are very strong fliers. Therefore, managing their problems solely by adult collection is very much limited. However, their long larval duration offers larval removal as an additional efficient pest management strategy.

  During July-August third instar grubs of the preceding generation occur at less than 15 cm depth from the surface, which makes it possible to collect them by digging the entire garden and not just around the base of the affected palms. Additionally, it facilitates removal of yet-to-emerge adults in case of *L. lepidophora*. Timing is once again critical. As the season progresses, the grubs move further down the soil column owing to moisture loss in the upper layers and also in search of roots of the palms that are generally present at lower layers. Therefore, water stagnation for 2 to 3 days prior to grub hunting is recommended to force the grubs closer to the surface later in the season. Such grubs can be physically removed by digging the entire garden.

  Removal of grown-up grubs from the soil has an edge over sole adult collection. If the digging operation is done 10-15 days earlier to the adult emergence both grown up grubs as well as fully developed but yet-to emerge adults may also be removed. Depending upon the field saturation level at their respective farms, farmers resorted to digging operation at different months.

- **Creating digital repository of Indian Scarabaeidae using specimens available at Bengaluru centre**

  Beetles are extremely diverse. However, the stupendous diversity means that the character states separating two sister species are by themselves not very different. Therefore, the probability of committing errors while delineating species is perhaps the highest for this group.

In this situation, the importance of individuals becomes very high. Because, individual beetles that are presently considered under a particular species have a relatively higher probability of being brought under a different species.

In this regard, the Bangalore centre is utilizing a digital system that helps in documenting every individual specimen. The system helps in building a complete national (and international) database of insects housed in different institutional museums.

- **Capacity building**

  Organizing short/long duration *hands-on-training* programmes on taxonomy of Scarabs

Gujarat Centre

- Being a newly introduced centre, concerted attempts will be made to study the diversity of phytophagous scarab fauna of Gujarat
- Subsequently based on severity of damage management study will be carried out

Kolhapur Centre

- Distribution of the white grub species in Western Maharashtra.
- Biology of *Leucopholis lepidophora* and *Holotrichia serrata* under the changing climatic Conditions.
- Bio efficacy of Entomopathogenic fungi against *L. lepidophora* infesting Sugarcane
- Efficacy of new molecules of insecticides against the *H. serrata* infesting sugarcane/Groundnut.
- Bio-efficacy of EPN against the *H. serrata* in sugarcane and groundnut

Ghaziabad Centre

- Scaling up of effective doze of Entomopathogenic Nematodes (EPN) other than *H. indica* in the form of EPN infected *Galleria* Cadaver (GC) and WP formulation of EPN for the management of White Grub.
- Scaling up of effective dose of Entomopathogenic Fungus (EPF); *Metarhizium anisopliae* and *Beauveria bassiana* for the management of white grub.
- Biological studies of predominant species of white grub; *Holotrichia nagpurensis, Holotrichia serrata, Holotrichia consanguinea, Anomala dimidiate and Maladera insanabilis.*
- Isolation of entomopathogenic nematodes (EPN) and entomopathogenic fungi (EPF) strains from local soil
- Capacity building of state & sugar mills functionaries, rural youths, women and farmers by organizing training on mass multiplication of bio-agents; EPN and EPF

Almora centre

- **Molecular phylogeny of major Melolonthinae and Rutelinae white grubs using mitochondrial genes**

Target genes: Mitochondrial gens of evolutionary importance viz., Cytochrome oxidase I (COI) and Cytochrome b (Cytb). Sequence variation, molecular phylogeny and evolutionary divergence of major species of Rutelinae and Melolonthinae white grub's native to Uttarakhand will be studied.

- **Studies of gut micro flora of major white grub species of Uttarakhand**
  Identification of midgut micro flora diversity of major whitegrub species of Uttarakhand *viz.*, *Anomala dimidiata*, *A. bengalensis* and *Holotrichia seticollis*
  Characterization of chitinolytic and cellulolytic bacteria from isolated micro flora and identification of bioactivity
- **Isolation of native entomopathogens and their use in white grub management.**
  Different isolation technique and bio-efficacy studies are adopted for identification of potent isolates. Compatibility of different isolates will be studied, based on which consortia will be prepared for effective pest management.

SECTION 2

MANAGEMENT OF WHITE GRUB BY MULTI-LOCATION TRIALS

- **Species profiling of soil arthropod pests through light trap**
- **Population monitoring of soil arthropod pests on host trees.**
- **Kairomonal study**
- **Population monitoring of damaging stages of soil arthropod pests and their extent of damage in different crops**
- **Pheromone studies on predominant white grub species**
- **Monitoring of natural enemies of soil arthropods**
- **Surveillance of white grub through drone technology**

RARI, Durgapura

Species profiling of soil arthropods through light trap

Methodology: The light trap of known light range was operated for fixed few months of scarabaeid activity (from March to September) and during the active adult period. Daily collection of beetles was sorted out species wise and correlated with corresponding weather data pertaining to temperature, relative humidity & rainfall etc. The GPS will be used to record the date pertaining to geographical details to find the distribution pattern of species restricted by altitude/latitude/longitude.

For the monitoring of soil arthropods, the light traps were installed at different locations in Research farm of Rajasthan Agricultural Research Institute, Durgapura, Jaipur. During the season from March to September the light trap catches of soil arthropods were recorded separately for each light trap installed. On perusal of the data, it was observed that this year again species composition of the soil arthropods trapped in light trap was similar as compared to previous seasons. No new species was observed in the light trap catches. Among the coleopteran the species belonged to families, six from melolonthnae, three from rutelinae and one from eateridae. Among the lepidopterians one species belonged to family noctuidae was trapped during the season. Maximum numbers (2310) of beetles of ***Maladera insanabillis*** were caught during this period. However, the peak emergence was in the month of July where maximum (623) ***Maladera insanabillis*** beetles were trapped. Then after July the emergence decline and only 111 beetles were caught in trap. Next in sequence of higher emergence of beetles was whitegrub species ***H. consanguinea***. The total number of beetles collected during entire period was 2154. The emergence of ***H. consanguinea*** started in the month of July and continued till September. The peak emergence was noticed in the month of July where 1832 beetles were trapped.

The relative abundance of predominant species, *H. consanguinea* was (38.90%) and that of *M. insanabilis* was (41.71%). In the light traps the catches were low in number for the other species like *Maladera carinata* (13.34%) followed by *H. serrata* 3.28%.

The species *Anomala bengalensis, Pachyrrhinadoratus frontatus* and *Anomala dimidiata* belonging to family Rutelinae were caught in small numbers in the light traps. The population of *A. bengalensis* was 110 with relative abundance 1.98% in light traps. The peak emergence was in the month of July. The population of *A. dimidiata* was 25 (r.a. 0.45%) beetles with peak emergence in the month of July.

In the light trap specimens of wireworm belonging to family elateridae and *Agrotis* sp., of cutworm belonging to family noctuidae of Lepidoptera were also observed to be attracting in low numbers. The maximum emergence of predominant species *H. consangunea* of the area was in the month of July due to monsoon rains begun in this month only.

Conclusion: It was noted that cumulative count of the traps during the entire period from March to September was maximum in case of ***Maladera insanabillis*** (2310 beetles) and it was predominant species during the season. It was followed by ***H. consanguinea*** with 2154 catches. Rest of the species was low in number such as *Holotrichia serrata, Maladera carinata, Anamola bengalensis, Anolala dimidiata,* and *Schizonica*. This year maximum catches of ***H. consanguinea*** were recorded in the month of July and then the population decline. This was because the good monsoon rains begun in the first week of July. The same trend was also recorded in rest of the species.

Table 1. Beetles of different species of white grub trapped in the light trap during March to September 2021-22 at RARI, Durgapura.

Sr. No.	Name of species	Number of beetles collected								Relative abundance (%)
		March	April	May	June	July	Aug.	Sept.	Total	
A. Melolonthinae (6)										
1	*H. consanguinea*	-	-	-	-	1832	271	51	2154	38.90
2	*H. serrata*	-	-	-	-	167	15	-	182	3.28
3	*Maladera carninata*	-	51	168	216	243	46	15	739	13.34
4	*Maladera insanabillis*	17	203	422	433	623	501	111	2310	41.71
5	*Schizonicha sp*	-	-	-	-	7	02	-	09	0.16
B. Rutelinae (3)										
1	*Anomala bengalensis*	-	-	-	-	94	15	01	110	1.98
2	*A. dimidiata*	-	-	-	-	22	03	-	25	0.45
3	*Pachyrrhinadoretus frontatus*	-	-	-	-	05	03	-	08	0.14
C. **Elateridae (1)** 17			254	590	1044	2664	841	127	5537	-
1	Wireworm	-	-	-	-	13	01	03	26	-
D Noctuidae (Lepidoptera (1)										
1	*Agrotis* sp.	-	06	09	17	11	04	02	46	-
Rainfall (mm)		-	-	-	-	-	-	-	-	-

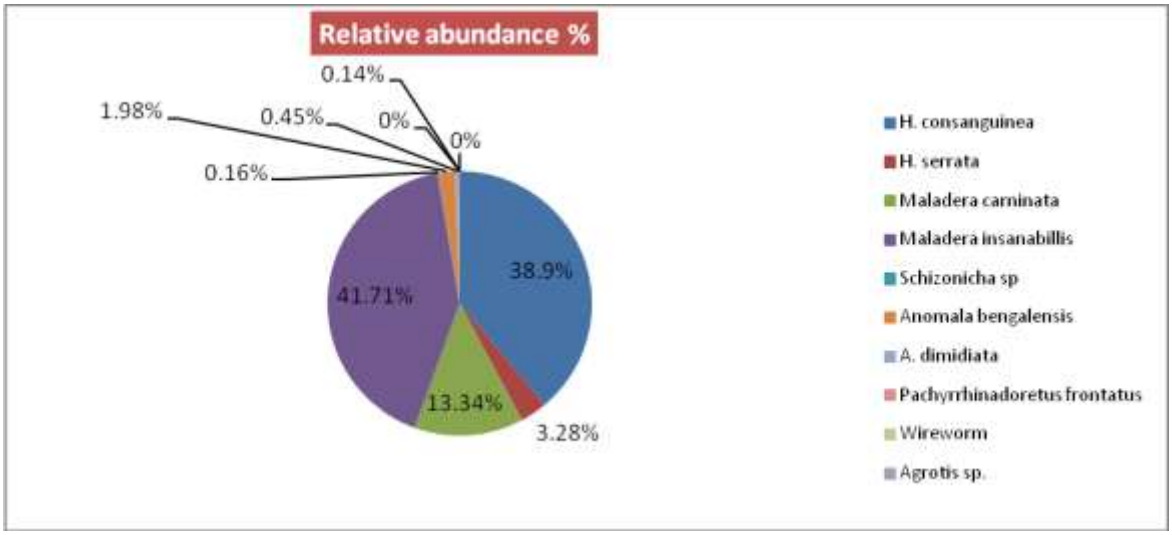


Fig. 1. Relative abundance of beetles throughout season (kharif, 2021-22)

POPULATION MONITORING OF SOIL ARTHROPOD ON HOST TREES

To identify the host rang of different whitegrub species population monitoring was done on host trees at six locations i.e., Bobas, Ramkui, Dhankiya, Dodsar, Sargot and Ringus villages near Jaipur and Sikar district during July to August. At all the locations maximum number of beetles was collected during July followed by August. The most preferred host was Apple Ber, but it was at par with Neem. Next in sequence were Khejari, Ber and Sanjana. The catches were high in the month of July because of the emergence started with the onset of rains in the second week of July. The catches were reduced at all these locations after August. In the month of July highest number of beetles was found on appleber at Ringus village. Search was also done to identify new host preferred by the beetles.

Table 2. Population monitoring of major scarab beetles on host trees from July to August 2021 in different villages near Jaipur/Sikar

	Bobas	Neem	1301	*H. consanguinea* *M. insanabilis*
		Khejari	1071	
		Ber	977	
		Sanjana	577	
	Ramkui	Malbery	1072	*H. consanguinea* *M. insanabilis*
		Neem	1159	
		Khejari	943	
		Ber	681	
	Dhankiya	Sanjana	549	*H. consanguinea* *M. insanabilis*
		Neem	1255	
		Khejari	967	
		Ber	792	
	Dodsar	Sanjana	672	*H. consanguinea*
		Neem	1355	

July		Khejari	1019	
		Ber	609	
	Sargot	Sanjana	617	*H. consanguinea*
		Neem	1039	
		Khejari	859	
		Ber	701	
	Ringus	Sanjana	577	*H. consanguinea* *M. insanabilis*
		Apple ber	1344	
		Neem	1021	
		Khejari	734	
August	Bobas	Neem	294	*H. consanguinea* *M. insanabilis* *H. serrata*
		Khejari	153	
		Ber	155	
		Sanjana	200	
	Ramkui	Neem	211	*H. consanguinea* *M. insanabilis* *H. serrata*
		Khejari	167	
		Ber	90	
		Sanjana	71	
	Dhankiya	Neem	257	*H. consanguinea* *M. insanabilis* *H. serrata*
		Khejari	191	
		Ber	118	
		Sanjana	149	
	Dodsar	Neem	301	*H. consanguinea*
		Khejari	192	
		Ber	135	
		Sanjana	159	
	Sargot	Neem	217	*M. insanabilis* *H. serrata*
		Khejari	179	
		Ber	121	
		Sanjana	96	
	Ringus	Apple ber	504	*H. Consanguinea*
		Neem	313	
		Khejari	203	
		Sanjana	169	

Khejri

Neem

Ber

Mehndi

Defoliated Sahnjana

Fig. 2. Different host trees of white grub in Rajasthan

Population monitoring of damaging stage of white grub

The population monitoring of grub stage of whitegrub was done at eight locations near Jaipur and Sikar *i.e*., Bobas, Ramkui, Dhankiya, Kalak, Dodsar, Sargot, Ringus and RARI Research Farm. At these villages mainly groundnut and pearl millet field were observed. Pits sampling was done as per the standard procedure. The pit sampling was also done at Research farm RARI, Durgapura. The maximum number of grubs was recorded at Sargot (11 grubs/m^2), followed by Dhankiya (10 grubs/m^2), Bobas (9 grubs/m^2) & Ramkui and Dodsar (8 grubs/m^2), at RARI Research Farm 5 grubs per m^2 pit was recorded. The extent of damage at this location was high where the population was above 5 whereas low level of damage was observed at population of grubs were below 5 grubs/pit.

Table 3. Population monitoring of grubs in soil at different villages near Jaipur

S N	Location	Average grubs collected/pit	Host plant	Extent of damage
1	Bobas	09	Groundnut, Pearl millet	High
2	Ramkui	08	Groundnut	High
3	Dhankiya	10	Pearl millet, Groundnut	High
4	Kalak	04	Groundnut	Low
5	Dodsar	08	Groundnut, Pearl millet	High
6	Sargot	11	Groundnut, Pearl millet	High
7	Ringus	06	Pearl millet	High
8	RARI Research Farm	05	Groundnut	High

Fig. 3. Larval population of white grub in groundnut

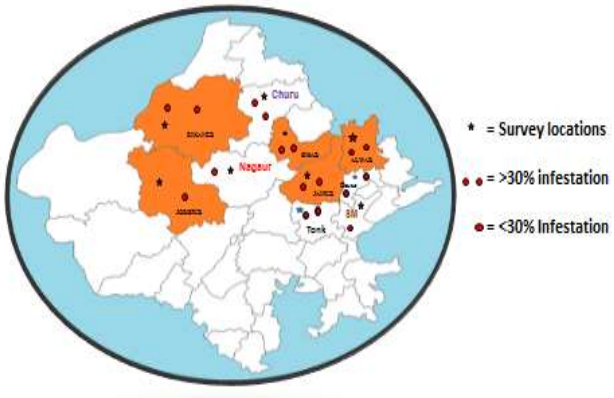


Fig. 4. Map Showing prevelance of whitegrub infestation in Rajasthan (Kharif, 2021-22)

AAU, Jorhat

Species profiling of soil arthropods through light trap

Methodology:

A light trap was set up at the Instructional Livestock Farm, Assam Agricultural University, Jorhat (26.7227° N, 94.1957° E) for the collection of scarab beetles from March to September, 2021. The numbers of beetles trapped were recorded and subsequently species wise sorting was carried out.

Result and Discussion:

The emergence of beetles was observed from the month of March and maximum numbers of beetles (881 nos.) were recorded during the month of April, 2021 (Table). However, from the month of May (643 nos.) onwards, the total light trap catches of the beetles showed a decreasing trend and reached the lowest population during July (148 nos.). Again, from the month of August onwards, the population showed an increasing trend up to September, 2021.

Correlation of scarab beetle population with different meteorological parameters:

Different meteorological parameters *viz.,* temperature (maximum and minimum), relative humidity (morning and evening), total rainfall, number of rainy days, bright sunshine hours and wind speed were correlated with the monthly population of scarab beetles. Among all the parameters, total rainfall (r =-0.633*) showed negative significant correlation and total bright sunshine hours (r =0.633*) exhibited significant positive correlation with the monthly population of the beetles, whereas remaining parameters were found non-significant correlation during the study period.

Conclusion:

The study on relative abundance of light trapped catches of scarab beetles indicated that *Apogoniaferruginea* was the most predominant species and contributed 61.21 per cent out of the total number of beetles trapped during the period of investigation. The second most abundant species was *Heteronychus sp.* (16.78%) followed by *Anomalachlorosoma* (6.74%). The other phytophagous scarab beetles which were found in lower numbers were *Sophropsirridipennis*, *Adoretus aerial*, *Holotrichia serrata*, *Oryctus*sp. etc.

Table 4. Light trap catches of scarab beetles along with the meteorological parameters during active season from March to September, 2021

Months	Beetles	Temperature	Relative	Total	Rainy	Total	Wind

	collected	(°C)		Humidity (%)		Rainfall (mm)	days	BSSH (hr.)	Speed (Km/h)
		Max.^{m}	Min.^{m}	Morn.	Even.				
March	383	29.3	16.2	95	55	52.4	4	141.7	2.2
April	881	31.7	18.6	87	51	42.9	2	187.6	2.8
May	643	31.0	21.9	93	73	171.0	16	95.3	2.4
June	166	32.0	24.3	94	75	270.1	18	111.2	3.0
July	148	31.1	25.2	94	74	170.4	13	137.5	2.6
August	296	32.9	25.0	93	76	225.5	11	112.6	3.3
Sept.	798	33.7	24.4	94	69	125.8	8	191.8	1.7

Table 5. Correlation of scarab beetle population with different meteorological parameters during 2021

Meteorological parameters	Correlation coefficient (r)
Maximum temperature (°C)	-0.249NS
Minimum temperature (°C)	-0.373NS
Morning relative humidity (%)	-0.609NS
Evening relative humidity (%)	-0.546NS
Total rainfall (mm)	-0.633*
Rainy days	-0.555NS
Total bright sunshine hour (hr.)	0.633*
Wind speed (km/hr)	-0.476NS

NS: Non-Significant

*Significant at 5 per cent probability level

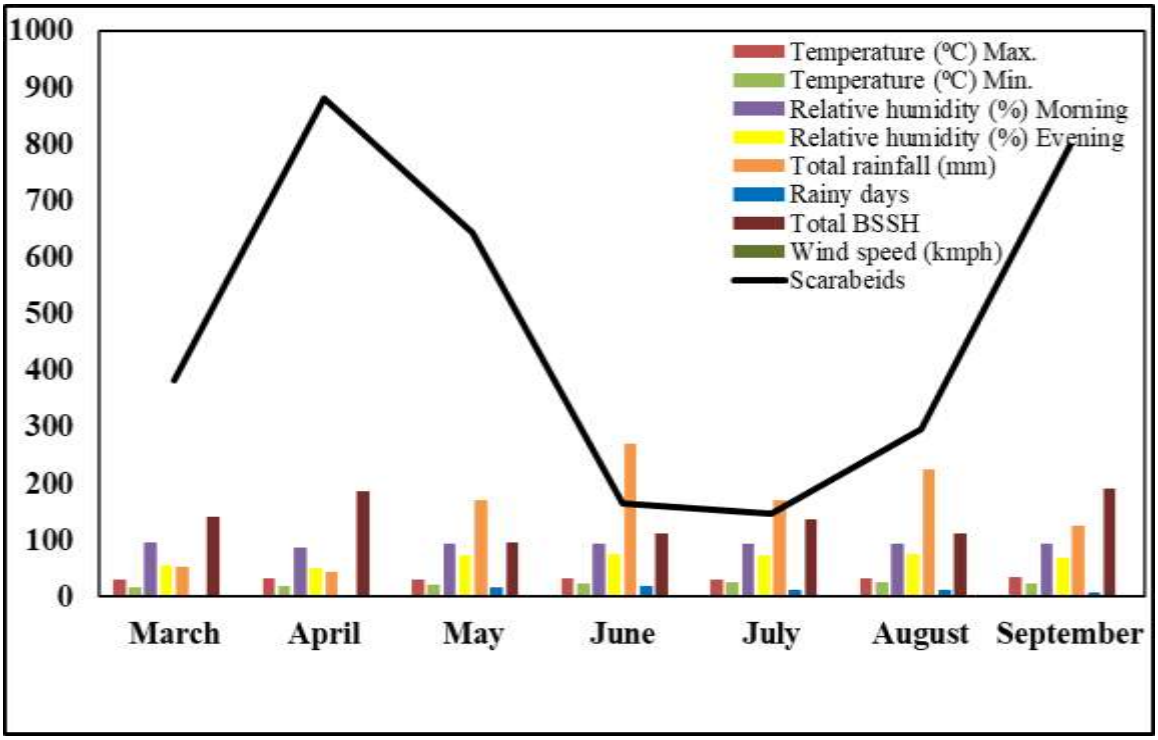


Fig. 5. Light trap catches of scarab beetles along with the meteorological parameters during March to September, 2021

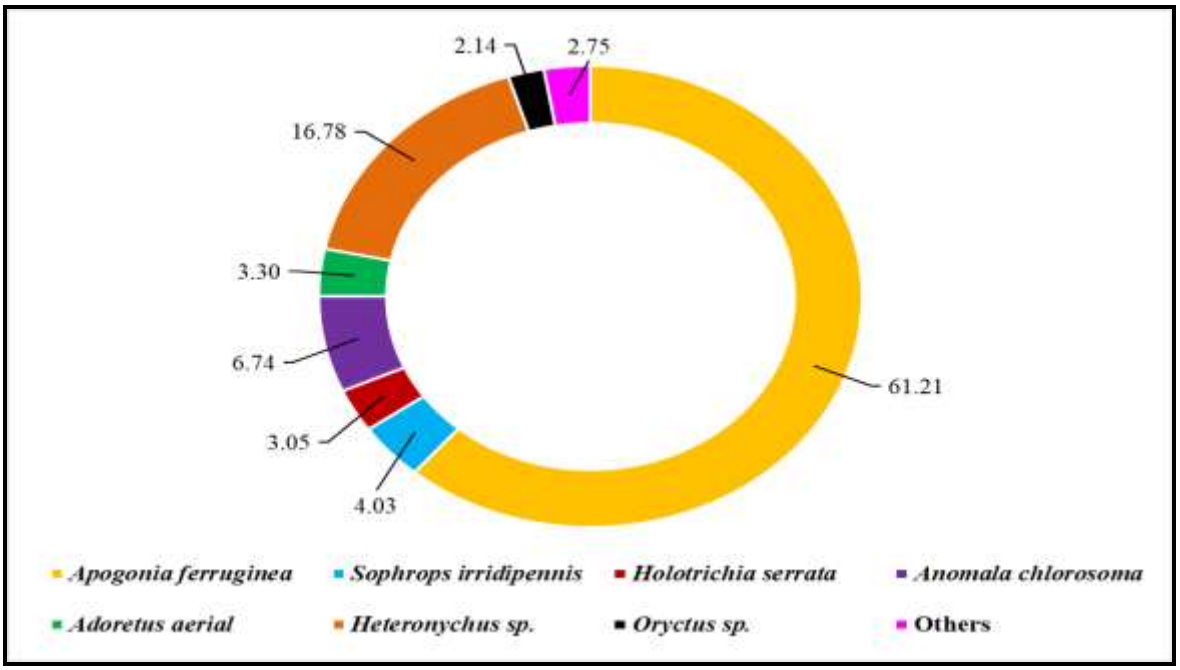


Fig. 6. Species profiling of scarab beetles during 2021

Population monitoring of scarab beetles on different host trees

Extensive survey programmes were also carried out to monitor the population of scarab beetles on some selected host trees *viz*., Rose (*Rosa* sp.), Ber (*Ziziphus* sp.), Guava (*Psidium guajava*), *Silikha* (*Terminalia chebula*), *Satadalpadma* (*Hibiscus mutabilis*), *Soalu* (*Litsaea monopetala*) and Agar (*Aquilaria malaccensis*) at Assam Agricultural

University, Jorhat campus (26.7509° N, 94.2037° E) by scouting method during March-September, 2021 (Plate 1). Scarab beetle population was noticed on their host trees from the month of Marchand attained maximum in numbers during the month of April followed by September and May.

Fig. 7. Population monitoring of scarab beetles on different host trees

Pheromonal and Kairomonal studies of *Lepidiota mansueta* at Majuli during 2021-22

Five pheromonal compounds (Cis-9 Hexadecenoic acid, Octadec- 9 enoic acid, 1-Tetradecene, 1-Hexadecene and 1-Octadecenol) in pure form and their five different blends were tested along with male and female body wash in a heavy*L. mansueta* endemic field at Maharichuk village, Majuli duringApril, 2021. Two pheromonal compounds *viz*., Cis-9 Hexadecenoic acid and Octadec-9 enoic acid were synthesized at ATGC Biotech Pvt. Ltd., Hyderabad through outsourcing and the rest of the compounds *i.e.*,1-

Tetradecene, 1-Hexadecene and 1-Octadecenol were procured from Sigma Aldrich and Avra synthesis Pvt. Ltd. Water traps were selected for conducting the experiments where the pure pheromonal compounds along with its blends were loaded (Plate 2. A-B) and the treatments were evaluated on the basis of the average number of beetles trapped to each treatment.

A. Preparation of blends | B. Loading of pheromonal and kairomonal lures | C. Water traps with loaded lures

Fig. 8. Setting up of water traps and loading of pheromonal and kairomonal lures

Fig. 9. Preparation of male and female body wash for kairomonal studies

Among the 13 different pheromonal and kairomonal blends tested, the mean maximum numbers of beetles (6.64) were recorded in the treatment T_4 (Octadec-9-enoic acid @100%) followed by T_{12}: Female body wash @100 per cent (6.08) and T_{11}: Male body wash @100 per cent (5.89) (Table). However, the nos. of beetles trapped in the aforementioned compounds were found to be statistically *at par* with the untreated control (7.50 nos.).

Fig. 10. *Lepidiota* beetles trapped in different treatments

Table 6. Efficacy of five pure pheromonal compounds, their different blends and male & female body wash used in trapping *L. mansueta* adults during 2021

Treatments	Total beetles trapped (Nos.) Mean±SD
T_1 (Hexadecene@100%)	1.91±0.51 (7.90)
T_2 (Tetradecene@100%)	3.46±2.75 (10.08)
T_3 (Hexadecenoic acid@100%)	3.96±1.71 (11.29)
T_4 (Octadec-9-enoic acid @100%)	**6.64±4.04 (14.42)**
T_5 (1-Octadecenol @100%)	5.14±1.66 (12.97)
T_6 (Hexadecene@20% + Tetradecene @20% + Hexadecenoic acid @20% + Octadec-9-enoic acid @20% +1-Octadecenol @20%)	3.79±2.43 (10.84)
T_7 (Hexadecene @30% + Tetradecene @20% + Hexadecenoic acid @20% +Octadec-9-enoic acid @20% + 1-Octadecenol@10%)	3.23±2.54 (9.87)
T_8 (Hexadecene@20% + Tetradecene@ 30% + Hexadecenoic acid @20% + Octadec-9-enoic acid @20% + 1-Octadecenol@ 10%)	3.16±0.83 (10.19)
T_9 (Hexadecene@20% + Tetradecene @20% + Hexadecenoic acid @30% + Octadec-9-enoic acid @20% + 1-Octadecenol @10%)	2.75±1.39 (9.29)
T_{10} (Hexadecene@20% + Tetradecene @20% + Hexadecenoic acid @20%+ Octadec-9-enoic acid @30%+ 1-Octadecenol@10%)	4.52±1.20 (12.19)
T_{11} (Male body wash@100%)	**5.89±5.72 (13.03)**
T_{12} (Female body wash@100%)	**6.08±2.96 (13.99)**
T_{13} (Male body wash @50% + Female body wash @50%)	5.08±2.45 (12.72)
Control (Water)	**7.50±2.52 (15.72)**
S. Ed (±)	0.93
CD (P=0.05)	1.88

***Data are mean of 12 days & data in parenthesis are angular transformed value*

By observing the results obtained from the previous experiment, an additional experiment was also conducted by selecting the 3 probables superior pheromonal compounds in trapping *L. mansueta* adults along with an untreated control. Experimental results revealed a relatively lower attraction of beetles in all the treatments as compared to the previous experiments. The mean beetles trapped during the experiment were ranged between 0.66-1.40 nos. in all the treatments where maximum was recorded from Octadec-9-enoic acid @100 per cent.

Table 7. Efficacy of probable superior pheromonal compounds in trapping *L. mansueta* adults during 2021

Treatments	**Total beetles trapped (Nos.)**
	Mean±SD
T_1 (Octadec-9-enoic acid@100%)	**1.40±0.64(6.64)**
T_2 (Male body wash@100%)	0.66±0.41(4.51)
T_3 (Female body wash@100%)	0.86±0.96(4.40)
Control (Water)	**1.00±0.85(4.99)**
S. Ed (±)	0.69
CD (P=0.05)	1.50

Data in parenthesis are angular transformed values

The efficacy of Octadec-9 enoic acid @100 per cent was also statistically compared with the untreated control in an additional experiment laid out and designed with "paired t" test. Data presented in Table revealed that the T (cal) value is 0.473 which is less than the T (p=0.05) *i.e.,* 2.776 and hence, there was no statistical difference observed between the aforementioned 2 treatments.

Table 8. Efficacy of Octadec-9-enoic acid@100 per cent in comparison with Control (Water)

Replications	**Octadec-9-enoic acid @100%**	**Control**
	Nos. of beetles trapped	
R_1	3.00	1.28
R_2	5.42	1.28
R_3	2.14	2.28
R_4	2.57	4.28
R_5	3.42	4.85
Mean	**3.31**	**2.79**
T (cal)	**0.473**	
T (p=0.05)	**2.776**	

A separate experiment was also conducted with 9 numbers of pheromonal lures received from NBAIR, Bengaluru for field evaluation. However, all the lures were found to be ineffective as the mean numbers of beetles trapped in the treatments were ranged between 0.60 to 2.38 and all the treatments showed statistical parity with each other except for the T_9 (Table).

Fig. 11. Field testing of pheromonal lures received from NBAIR, Bengaluru

Table 9. Efficacy of nine different pheromonal lures received from NBAIR, Bengaluru in trapping*L. mansueta* adults during 2021

Treatments	Total beetles trapped (Nos.)
	Mean±SD
T_1	1.42±1.02 (6.57)
T_2	2.38±0.70 (8.78)
T_3	1.70±1.21 (7.19)
T_4	1.25±0.58 (6.29)
T_5	1.46±1.09 (6.56)
T_6	2.00±1.16 (7.89)
T_7	1.32±0.82 (6.35)
T_8	1.64±0.52 (7.28)
T_9	0.60±0.54 (4.14)
Control (Water)	1.70±1.01 (7.22)
S. Ed (±)	0.58
CD (P=0.05)	1.18

**Figures in parenthesis are angular transformed values*

A large number of 3rd instar grubs as well as pupae were also collected during the month of February and March, 2022 from different locations of Majuli and were reared in Soil Arthropod Pests Laboratory. Sex based separation was also done so as to get sufficient numbers of virgin male and female beetles. The collected samples were sent to NBAIR, Bengaluru for conducting various electrophysiological studies in collaboration with Dr. Deepa Bhagat, Principal Scientist (Organic Chemistry), NBAIR, Bengaluru.

A. Collection of grubs and pupae of *Lepidiota mansueta* at Majuli

B. Sex based separation in AINP on SAP Laboratory

Population monitoring of soil arthropod pests and their extent of damage in different crops

Extensive surveys were conducted to monitor the different soil insects and their extent of damage to different crops.

Table 10. Extent of damage caused by major soil insect and molluscanpests in Assam

Species	Peak activity	Cropinfested	Stage of the crop	Infestation (%)
I. White grubs				
Lepidiotamansueta Study area: Majuli river island	Whole year (grubs)	Potato	Seedling & tuber	25-30
		Sugarcane	Standing crop	15-20
		Colocasia	Corm formation	25-35
		Green gram	Seedling	25-30
Lepidiotaalbistigma Study area: Sorbhog, Barpeta	Whole year (grubs) April-May (Adults)	Mango	Standing crop	10-20
		Ramie		15-20
		Arecanut		10-15
		Black pepper		5-7
***Pentodon* sp.** Study area: Majuli river island&Dhemaji	May-July (Grubs and Adults)	Kharif Rice	Standing crop	10-15
		Sugarcane		30-40
Heteronychusindicus Study area: Lakhimpur, Dhemaji, Jorhat, Golaghat, Nagaon, Baksa, Karbi Anglong& Dima Hasao districts of Assam Lohit&Namsai districts of Arunachal Pradesh	Sept-Oct. (Grubs)	Transplanted summer rice (Early *ahu*)	Panicle initiation stage	15-20
II.Cutworm				
Agrotisipsilon Study area: Jorhat &Majuli river island	Nov.- Feb.	Potato	Seedling	20-25
			Tuber	5-10
		Toria	Seedling	10-15
		King chilli	Seedling	10-15
III. Termite				
Odontotermesobesus Study area: Jorhat	Feb-March	Sugarcane	Setts (preserved)	35-50
	Aug- Dec.		Standing crop	12-15
	Round the year	Tea	Shed and standing crop	15-20
IV. Red Ants				
Dorylusorientalis Study area: Jorhat	Nov- Jan.	Potato	Tuber	20-25
	Oct-Dec.	French bean	Root	15-20
	Dec-Jan.	Cabbage	Standing crop	10-15

CSK-HPKV, Palampur

Species profiling of soil arthropods through light trap

Methodology:

During 2021, beetle collection on light trap was done at Palampur, Kullu, Badagaon, Sajar, shillaroo and Chamba**.** The data pertaining to these locations are presented here under.

At Palampur, 14 species were identified on light trap during May-September, 2021. During May, the population of scarab beetles was comparatively very low. In June, *Anomala varicolo r*showed peak activity on light trap (244 beetles) followed by *Maladera thomsoni* (210 beetles) and and *A. Lineatopennis* (147 beetles). The population of *M. insanabilis, A. dimidiata, B. coriacea, B. flavosericea, H. longipennis, H. sikkimensis, M. furcicauda, M. indica, M. insanabilis, M. cotesi, Onthophagous*spp, and *Schizonycha* sp. ranged from 0-131 beetles during June. The total beetles catch was highest in case of *A. varicolor* (397 beetles) followed by *M. thomsoni* (263 beetles). There was gradual decline in beetle catch during July for most of the species, whereas in case of *M. furcicauda* and *M. indica*, the catch was maximum in July (96 beetles) and Aug (83 beetles), respectively. Overall beetles catch was maximum in June (58.78%) followed by July (28.80%). *A. varicolor* showed maximum dominance (23.38 %), followed by *M. thomsoni* (15.49 %). The frequency of occurrence was highest in case of *H. longipennis* (100 %).

Table 11. Abundance and frequency of beetles on light trap at Palampur during 2021

Species	Number of beetles collected in 2021					Total catch	Dominance (%)	Frequency (%)
	May	Jun	Jul	Aug	Sept			
A. lineatopennis	3	147	35	6	0	191	11.25	80
A. varicolor	2	244	125	26	0	397	23.38	80
A. dimidiate	0	8	3	2	0	13	0.77	60
B. coriacea	0	6	5	2	0	13	0.77	60
B. flavosericea	0	3	2	2	0	7	0.41	60
H. longipennis	3	93	23	3	2	124	7.3	100
H. sikkimensis	0	50	39	2	0	91	5.36	60
M. furcicauda	0	32	96	6	3	137	8.07	60
M. indica	0	0	12	83	32	127	7.48	60
M. insanabilis	3	131	81	14	0	229	13.49	80
M. thomsoni	3	210	48	2	0	263	15.49	80
M. cotesi	2	54	17	2	0	75	4.42	80
*Onthophagous*spp.	0	12	3	2	0	17	1	60
*Schizonycha*sp.	6	8	0	0	0	14	0.82	40
Total	22	998	489	152	37	1698	100	

The value of Simpson's index of diversity (D= 0.87) was high, whereas the value of Simpson's reciprocal index was low (1/D= 1.15). These values indicate high species diversity. The Shannon index (H') was calculated to be 2.21. At Palampur, only 14 species were collected, but there was no dominance of a single species. The Pielou's evenness index (J') was calculated to be 0.84 which showed reasonable evenness and moderate variation in community between different species of scarab beetles in Palampur area.

Table 12. Diversity of scarab beetles on light trap at Palampur

Diversity indices	Values of diversity indices
Shannon index (H')	2.21
Simpson's index of diversity (D)	0.87
Simpson's reciprocal index (1/D)	1.15
Pielou's evenness index (J')	0.84

At Kullu, total 10 species were collected on light trap. *A. linneatipennis* (14), *B. coriacea* (22), *B. flavosericea* (13), *H. longipennis* (15), *M. insanabilis* (37) and *M. thomsoni* (75) showed peak activity during June, whereas *M. cuprescens* (39), *M. furcicauda* (10) and *A. rufiventris* (13) showed their peak activity in July. During August, only *M. cuprescens* (21 beetles) registered higher catch. The leading species at Kullu was *M. thomsoni* constituting 27.92 per cent of total beetle catch. The frequency of occurrence was 100 per cent for *A. linneatipennis*. The overall beetle catch was maximum in June (50.76 %), followed by July (34.52 %), and August (8.12 %).

Table 13. Abundance and frequency of Scarabaeid beetles on light trap at Kullu during 2021

Species	Number of beetles collected during 2021					Total catch	Dominance (%)	Frequency (%)
	May	Jun	Jul	Aug	Sept			
A. lineatopennis	1	14	8	1	1	25	6.35	100
A. rufiventris	0	6	13	1	0	20	5.08	60
B. coriacea	1	22	13	1	0	37	9.39	80
B. flavosericea	0	13	9	2	0	24	6.09	60
H. longipennis	0	15	3	1	0	19	4.82	60
M. insanabilis	2	37	12	1	0	52	13.20	80
M. thomsoni	5	75	29	1	0	110	27.92	80
M. cuprescens	0	9	39	21	1	70	17.77	80
M. furcicauda	0	0	10	3	0	13	3.30	40
*Schizonycha*sp.	15	9	0	0	0	24	6.09	40
Total	24	200	136	32	2	394	100.00	

The Shannon index (H') was computed to be 2.08. The Simpson's index of diversity (D) and Simpson's reciprocal index (1/D) were calculated as 0.85 and 1.18, respectively, indicating low dominance of single of scarab beetles in Kullu area. The Pielou's evenness

index (J') was calculated to be J' = 0.90 indicating higher evenness with less variation in community between collected species of scarab beetles in Kullu.

Table 14. Diversity of scarab beetles on light trap at Kullu

Diversity indices	Values of diversity indices
Shannon index (H')	2.08
Simpson's index of diversity (D)	0.85
Simpson's reciprocal index (1/D)	1.18
Pielou's evenness index (J')	0.90

Total seven species were recorded on light trap at Badagaon and *Polyphyllafullo* was the most predominant species comprising 30.36 per cent of total beetle catch. Maximum numbers of 16 were collected in August and the frequency of its occurrence was recorded to be 100 per cent. The frequency of occurrence of *H. sikkimensis, M. insanabilis* and *M. passerinii*was observed to be 100 per cent. Overall catch of beetles was maximum in July (44.64 %) and June (34.82 %) as shown in.

Table 15. Abundance and frequency of beetles on light trap at Badagaon during 2021

Species	**Number of beetles collected in 2019**			**Total catch**	**Dominance (%)**	**Frequency (%)**
	Jun	**Jul**	**Aug**			
A. rufiventris	2	9	0	11	9.82	66.66
A. dimidiata	1	2	0	3	2.68	66.66
B. coriacea	2	2	0	4	3.57	66.66
H. sikkimensis	8	9	2	19	16.96	100
M. insanabilis	16	10	2	28	25.00	100
M. passerinii	4	6	3	13	11.61	100
P. fullo	6	12	16	34	30.36	100
Total	39	50	23	112	100.00	

The Shannon index (H') was computed to be 1.70. The Simpson's index of diversity (D) and Simpson's reciprocal index (1/D) were calculated as 0.79 and 1.26, respectively, indicating very low dominance of single species of scarab beetles in Badagaon area. The Pielou's evenness index (J') was calculated to be J' = 0.88 indicating high evenness between collected species of scarab beetles in Badagaon.

Table 16. Diversity of scarab beetles on light trap at Badagaon

Diversity indices	Values of diversity indices
Shannon index (H')	1.70
Simpson's index of diversity (D)	0.79
Simpson's reciprocal index (1/D)	1.26
Pielou's evenness index (J')	0.88

A total of seven species were recorded and *B. coriacea* was found to be predominant species constituting 29.73 per cent of total catch and frequency of occurrence of *H. longipennis* was recorded to be 100 per cent. *A. dimidiata* was found to

be least dominant (4.05 %). Overall catch of beetles was maximum in June (52.03 %) followed by July (38.81 %).

Table 17. Abundance and frequency of beetles on light trap at Sajar during 2021

Species	Number of beetles collected in 2021				Total catch	Dominance (%)	Frequency (%)
	May	Jun	Jul	Aug			
A. lineatopennis	3	8	5	0	16	10.81	75
A. dimidiate	0	4	2	0	6	4.05	75
B. coriacea	1	25	14	4	44	29.73	100
B. flavosericea	0	8	9	0	17	11.49	50
H. longipennis	0	16	10	3	29	19.59	75
M. furcicauda	0	4	6	3	13	8.78	75
M. insanabilis	4	12	7	0	23	15.54	75
Total	8	77	53	10	148	100.00	

The Shannon index (H') was computed to be 1.80. The Simpson's index of diversity (D) and Simpson's reciprocal index (1/D) were calculated as 0.81 and 1.23, respectively, indicating very low dominance of single species of scarab beetles in Sajar area. The Pielou'sevenness index (J') was calculated to be J' = 0.93 indicating high evenness between collected species of scarab beetles in Sajar.

Table 18. Diversity of scarab beetles on light trap at Sajar

Diversity indices	Values of diversity indices
Shannon index (H')	1.80
Simpson's index of diversity (D)	0.81
Simpson's reciprocal index (1/D)	1.23
Pielou's evenness index (J')	0.93

At Shillaroo, total 7 species were collected on light trap and *B. coriacea* was found to be predominant species constituting 91.99 per cent of total catch and frequency of occurrence was recorded to be 100 per cent. The other species recorded in less numbers were *B. flavosericea*, *H. longipennis*, *Mimelapasserinii*, *M. pectoralis*, *Popilliacyanea*, and *Schizonycha* sp. with a total catch ranging from 2-13 beetles throughout the season.

Table 19. Abundance and frequency of beetles on light trap at Shillaroo during 2021

Species	Number of beetles collected in 2021				Total catch	Dominance (%)	Frequency (%)
	May	Jun	Jul	Aug			
Brahmina coriacea	15	209	174	50	448	91.99	100
B. flavosericea	0	5	3	0	8	1.64	50
H. longipennis	0	7	4	2	13	2.67	75
Mimelapasserinii	0	3	2	0	5	1.03	50
M. pectoralis	0	2	2	0	4	0.82	50
Popilliacyanea	0	1	1	0	2	0.41	50
*Schizonycha*sp	1	4	2	0	7	1.44	75

Total	16	231	188	52	487	100.00	

Table 20. Diversity of scarab beetles on light trap at Shillaroo

Diversity indices	Values of diversity indices
Shannon index (H')	0.41
Simpson's index of diversity (D)	0.15
Simpson's reciprocal index (1/D)	6.56
Pielou's evenness index (J')	0.21

The Shannon index (H') was computed to be 0.41. The Simpson's index of diversity (D) and Simpson's reciprocal index (1/D) were calculated as 0.15 and 6.56, respectively, indicating very high dominance of single species of scarab beetles in Shillaroo area. The Pielou's evenness index (J') was calculated to be J' = 0.21 indicating very low evenness between collected species of scarab beetles in Shillaroo.

At Chamba, 9 species were collected on light trap and *Anomala rufiventris*was found to be the dominant species constituting 22.93 per cent of total catch followed by *B. coriacea* (16.27%), *M. furcicauda* (12.53%) and *H. longipennis* (12.00%). Overall catch of beetles was maximum in June (53.07 %) followed by July (36.53 %).

Table 21. Abundance and frequency of beetles on light trap at Chamba during 2021

Species	Number of beetles collected during 2021				Total catch	Dominance (%)	Frequency (%)
	May	Jun	Jul	Aug			
A. dimidiate	0	12	15	3	30	8.00	75
A. rufiventris	0	46	32	8	86	22.93	75
B. coriacea	2	32	25	2	61	16.27	100
B. crinicollis	15	9	0	0	24	6.40	50
B. flavosericea	0	23	18	0	41	10.93	50
H. longipennis	0	25	18	2	45	12.00	75
M. cuprescens	0	12	8	3	23	6.13	75
M. furcicauda	0	29	14	4	47	12.53	75
M. passerinii	0	11	7	0	18	4.80	50
Total	17	199	137	22	375	100.00	

The other species recorded in were *A. dimidiata*, *B. crinicollis B. flavosericea M. cuprescens M. passerine i*with a total catch ranging from 18-41 beeltes throughout the season. The Shannon index (H') was computed to be 2.08. The Simpson's index of diversity (D) and Simpson's reciprocal index (1/D) were calculated as 0.86 and 1.16, respectively, indicating very low dominance of single species of scarab beetles in Chamba area. The Pielou's evenness index (J') was calculated to be J' = 0.95 indicating high evenness between collected species of scarab beetles in Chamba.

Table 22. Diversity of scarab beetles on light trap at Chamba

Diversity indices	Values of diversity indices
Shannon index (H')	2.08
Simpson's index of diversity (D)	0.86
Simpson's reciprocal index (1/D)	1.16

Pielou's evenness index (J')	0.95

Similarity indices in relation to scarab fauna in different areas of Himachal Pradesh

The species richness and abundance revealed that Kullu and Rohru exhibited maximum similarity as indicated by the values of Sorensen's similarity index (SI=0.52), Jaccard similarity index (JCI= 0.26) and Bray-Curtis index (0.23). Maximum dissimilarity was recorded between scarab assemblages from Badagaon and Shillaroo as indicated by highest value of Bray-Curtis distance index (BCDI= 0.99).

Fig. 13. Light trap used for monitoring of beetles

Table 23. Beta diversity showing similarity among scarab species in different locations of HP in 2021

Locations → / Locations ↓	Kullu			Badagaon			Rohru			Shillaroo			Chamba		
	SI	JI	BCI	SI	JI	BCI	SI	JI	BCI	SI	JI	BCI	SI	JI	BCI
Palampur	0.5000	0.2500	0.1209	0.3200	0.1600	0.0298	0.5000	0.2500	0.058	0.3200	0.1600	0.0183	0.3571	0.1786	0.0632
Kullu				0.3000	0.1500	0.085	0.5217	0.2609	0.2306	0.3810	0.1905	0.0738	0.4800	0.2400	0.0344
Badagaon							0.3529	0.1765	0.1154	0.1333	0.0667	0.0067	0.4000	0.2000	0.0138
Rohru										0.3529	0.1765	0.1024	0.4762	0.2381	0.0339
Shillaroo													0.4000	0.2000	0.013

SI=Sorenson's index; JI=Jaccard's index; BCI=Bray Curtis index

Table 24. Bray Curtis distance index of scarab fauna in locations of HP in 2021

Locations → / Locations ↓	Kullu	Badagaon	Rohru	Shillaroo	Chamba
	BCI	BCI	BCI	BCI	BCI
Palampur	0.8791	0.9702	0.942	0.9817	0.9368
Kullu		0.9150	0.7694	0.9262	0.9656
Badagaon			0.8846	0.9933	0.9862
Rohru				0.8976	0.9661
Shillaroo					0.9870

Population monitoring of scarab beetles on different host trees

During 2021-22, adult sampling of scarab beetles was done at six different locations of Himachal Pradesh**.** *Brahmina coriacea* was collected at all the locations on host plants viz. apple, stone fruits, walnut, wild rose. At Palampur, sampling was done on pear, rose, nectrine, apple, toon, mulberry and pecannut. *H. longipennis*was collected in great numbers on toon. At Barot, beetles of *Polyphyllafullo* were collected in low numbers on walnut, apple, passion fruits and *Bathua* plants. On *Bathua* plants, *P. fullo* was also recorded during day time. In Kullu, *M. cuprescens*, was collected in higher numbers on apple trees. In Mandi district, *H. longipennis* and *B. coricea* were found to be predominant species and were recorded on Rose, *Toon* and Apple.

Table 25. Beetles collected on different host trees in Himachal Pradesh during 2021

Species	Palampur	Kullu	Badagaon	Sajar	Shillaroo	Chamba
A.lineatopennis	+	+	-	+	-	-
A. varicolor	+	-	-	-	-	-
A. rufiventris	+	+	+	-	-	+
A. dimidiata	+	-	+	+	-	+
B. coriacea	+	+	+	+	+	+
B. flavosericea	+	-	-	-	-	+
H. longipennis	+	+	-	+	+	+
H. sikkimensis	+	-	+	-	-	-
M. insanabilis	+	+	+	+	-	-
M. thomsoni	+	+	-	-	-	-
M. cuprescens	-	+	-	-	-	+
M. furcicauda	+	+	-	+	-	+
M. indica	+	+	-	-	-	-
P. fullo	-	-	+	-	-	-
Schizonycha sp.	+	+	-	-	+	-

(+): Present; (-): Absent

Estimation of population of soil arthropod pests and their incidence in different crops

Abundance and incidence of white grubs in potato during 2021:

The problem of white grubs in potato was quite serious in high hills where the potatoes are grown during summer season as rain fed crop under long day conditions. For the estimation of white grub incidence in potato, 12 locations in five districts were surveyed. In Badagaon, Kothikohar and Nalhota area of Kangra district and Barot area of Mandi district, *P. fullo* was the predominant species in potato fields. The grubs of *P. fullo*

inflicted large circular holes in potato tubers and in certain cases entire tuber was eaten by the grub**.** Maximum tuber damage was recorded at Badagaon (32.20 %) followed by Kothi Kohar (31.226.75 %) due to attack of *P. fullo*. The grub population was also high at these locations which were ranged from 9.1 to 10.2 grub population /ft^3. Least number of grubs was recorded from Dalash (3.5 ± 0.80 grubs/ ft^3) with tuber damage of 11.50 per cent.

Table 26. Incidence of white grubs in potato during 2021

District	Location (GPS)	Sampling size (n)	Grub population / m^2	Tuber damage (%)
Kangra	Baragaon (31.9826° N; 77.1318° E)	10	10.2 ± 1.40	32.20
	Kothi Kohar (32.0812° N; 76.7962° E)	10	9.1 ± 1.36	26.75
	Nalhota (32.0862° N;76.7806° E)	10	9.0 ± 1.42	25.25
Mandi	Barot (32.0441° N; 76.8403° E)	10	6.5 ± 1.30	19.25
	Bagsaid (31.5619° N; 77.1233° E)	10	4.8 ± 1.35	15.10
	Janjehli 31.5144° N; 77.2218°E)	10	5.7 ± 1.20	20.30
	Karsog (31.4433° N; 77.0767° E)	10	4.5 ± 1.10	12.20
	Pangna (31.3885° N; 77.1226° E)	10	5.8 ± 1.05	15.20
Kullu	Dalash (31.3839° N; 77.4337° E)	10	3.5 ± 0.80	11.50
Chamba	Salooni (32.7216° N, 76.0515° E)	10	6.8 ± 1.50	22.40
Shimla	Bhamnoli (77.5557° N; 31.2674° E)	10	4.5 ± 1.00	14.60
	Khadrala (31.2042° N; 77.7501° E)	10	5.9 ± 1.20	21.20
	Sajar (31.1960° N, 77.6580° E)	10	5.4 ± 1.05	18.80

Fig. 14. Tuber damage by *P. fullo*

Estimation of losses caused by white grubs in potato:

Surveys were conducted in 14 potato growing areas in Chamba, Mandi, Shimla, Kullu and Una districts of Himachal Pradesh. About 146 farmers were contacted from

these locations and 10-50 per cent infestation of white grubs in potato was observed**.** The data on economic losses will be analysed with the help of economist.

Table 27. Details of locations surveyed and farmers contacted for the estimation of losses caused by white grubs in potato

District	Locations	Farmers contacted	Infestation (%)
Chamba	Salooni	19	30-35
	Chamba	10	20-25
Mandi	Janjheli	10	25-30
	Barot	10	30-40
	Kamrah	18	15-20
	Bagsiad	10	20-25
	Dharampur	5	0
Shimla	Rohru	17	30-40
	Khadrala	11	25-30
	Pujarli	10	25-30
Kullu	Kullu	10	10-20
	Banjar	10	10-15
	Dalash	11	40-50
Una	Una	5	0

Incidence of wireworms in potato during 2021-22: The incidence of wireworms was recorded at the time of harvesting of potato during 2021-22. The infestation varied from 1.8 to 6.4 per cent from six locations of Himachal Pradesh. Maximum tuber infestation was recorded at Shillaroo (6.4%) in Shimla district.

Table 28. Incidence of wireworms in potato during 2021-22

Location	Tuber infestation (%)
Rohru (Shimla)	5.0
Shillaroo (Shimla)	6.4
Khangsar (Lahaul&Spiti)	2.1
Gondhla (Lahaul&Spiti)	1.8
Barot (Mandi)	3.2
Baragoan (Kangra)	3.6

Incidence of cutworms in different crops during 2021-22:

Data on incidence of cutworm were recorded from 7 locations on 5 crops i.e. cabbage, tomato, pea, potato and maize during 2021-22. Maximum plant infestation was recorded in maize (14.2 %) at Salooni in Chamba district followed by cabbage (12.4 %) and potato (8.5 %) at Palampur.

Table 29. Incidence of cutworms in in different crops during 2021-22

Location	Crop	Per cent plant infestation
Palampur (Kangra)	Cabbage	12.4
	Potato	8.5
Baragaon (Kangra)	Potato	4.1
	Cabbage	3.6
Khangsar (Lahaul&Spiti)	Potato	4.8
Chail Chowk (Mandi)	Tomato	3.4
Thunag (Mandi)	Cabbage	4.3
Janjehli (Mandi)	Potato	5.2
Salooni (Chamba)	Pea	4.5

	Maize	14.2
Theog (Shimla)	Cabbage	3.2

Incidence of termites in wheat during 2021-22:

The incidence of termites was noticed in wheat during 2021-22. The moderate level of infestation was observed and varied from 3.1 to 9.3 per cent in four locations of Himachal Pradesh. Maximum plant infestation was recorded at Berthin (9.3%) in Shimla district.

Table 30. Incidence of termites in wheat during 2021-22

Location	Plant infestation (%)
Nurpur (Kangra)	6.8
Berthin (Bilaspur)	9.3
Rampur (Una)	7.5
Palampur (Kangra)	3.1

Incidence of red ants in potato at Palampur:

The infestation of red ants (*Dorylus*sp.) was recorded in potato in the month of April-May at Palampur and surrounding areas. The data were recorded on tuber infestation at the time of harvesting. The infestation varied from 1.8 to 6.4 per cent from six locations of Himachal Pradesh. Maximum tuber infestation was recorded at Shillaroo (6.4%) in Shimla district.

Fig. 15. Tuber damage by red ants

Table 31. Incidence of red ants in potato during 2021-22

Location	Tuber infestation (%)
Rajpur	9.8
Holta	7.4
Banuri	4.3
Patti	2.1
Aweri	1.8

Incidence of molluscs in different crops during 2021-22:

Data on incidence of molluscs were recorded from four locations in vegetable crops during 2021-22. Maximum attack was recorded at Pangna followed by Rohanda in beans (13.9%) and pea (12.4%), respectively.

Table 32. Incidence of molluscs in different crops during 2021-22

Location	Crop	Per cent plant infestation

Rohanda (Mandi)	Pea	12.4
	Beans	11.8
Pangna (Mandi)	Potato	8.2
	Beans	13.9
Shillaroo (Shimla)	Potato	6.4
Palampur (Kangra)	Okra	3.7

GKVK, Bengaluru

Species profiling of soil arthropods through light trap

Method of observation:

During 2021, modified Robinson's light traps with 165 W mercury vapour lamp were set up in eight locations. Light traps were operated at from 6 pm to 6.00 am during June-August, 2021. Collections were also opportunistically made from host plants. Apart from this the collection were also made near the lamp posts/street lights in the various locations. The beetles were sorted out and labeled as morpho species. Corresponding weather data pertaining to temperature, relative humidity, rainfall, etc. were also recorded and tabulated.

The abundance, species richness and diversity of Pleurostict Scarabaeidae (phytophagous scarabs) were studied and analyzed in three major agro-climatic zones (ACZs) of Karnataka *viz*., Dry Zone (included Central Dry Zone, Eastern Dry Zone and Southern Dry Zone), Hilly Zone and Coastal Zone for 2017-21.

Result:

Scarab sampling during the years 2017 and 2021 yielded a total of 4150 beetles belonging to 75 species distributed in 24 genera and four subfamilies *viz*., Cetoniinae, Dynastinae, Melolonthinae and Rutelinae. The subfamily Cetoniinae constituting 30 species under 12 genera and accounting 40% of the total number of species collected followed by the subfamily Rutelinae comprising 32% of species (n=24) belonging to three genera. The details of the species analysed were given in Annexure-1.

Conclusion:

Among the three ACZs, the hilly zone was more diverse followed by dry zone and coastal zone. Diversity indices were significantly different across the location and evenness index is more in hilly region followed by coastal region and dry region.

Table 33. Number of species of phytophagous scarabs trapped in the light trap during 2017-2021.

Subfamily	No. of genera	No. of species	No. of specimens	Relative abundance
Cetoniinae	12	30 (40%)	1454	35.03

Dynastinae	4	5 (6.66%)	338	8.14
Melolonthinae	5	16 (21.33%)	1586	38.21
Rutelinae	3	24 (32%)	772	18.60
Total	24	75	4150	-

Table 34. The mean catches by numbers, species and mean diversity indices of phytophagous scarabeoid beetles collected at three ACZs of Karnataka during the year 2017 to 2021.

Particulars	Dry Zone	Hilly Zone	Coastal Zone	Total Individuals
Taxa_S	55	44	12	75
Individuals	3284	711	155	4150
Dominance_D	0.08759	0.05907	0.3305	0.06197
Simpson_1-D	0.9124	0.9409	0.6695	0.938
Shannon_H	2.877	3.156	1.583	3.273
Evenness_e^H/S	0.323	0.5335	0.4057	0.3519
Margalef	6.669	6.548	2.181	8.883
Chao-1	62	51	13.5	82.2

Population Monitoring of phytophagous scarab beetles on host trees

The host plants were surveyed and searched for adult scarab beetles which have the behavior of emerging *én massé* and aggregating on tree canopies during night hours. Effort was made to collect all the beetles from the host plants using insect nets with long handles. Wherever this was not possible (as in *Leucopholis lepidophora*, *L. burmeisteri* and *L. coneophora*), their numbers were recorded using flashlights. Number of beetles per plant was calculated. Similarly, the abundance of anthophilous scarabs was also recorded in the same manner.

Methodology:

Two persons walked along the road looking for host trees on either side for a stretch of 3 km. Each of the potential host plants encountered was searched for scarab beetles and collections were made. The geographical details of the study areas have been recorded using GPS and furnished in Appendix-II.

Results:

In March & April, 2021 adult aggregation of different species of scarab beetles was estimated in endemic regions. During the sampling conducted, 14420 beetles of *H. serrata from* canopies of neem (*Azadirachta indica, Ricinus communis* and *Morus* sp.), 869 beetles of *H. rufoflava* from canopies of Neem and *Anomala* sp. (123 numbers from *Cassia fistula* tree) were collected.

Table 35. Abundance of major scarab beetles on tree canopies in March & April, 2021

Date	Location	Coordinates	Tree canopy	Scarab species collected	No. of beetles collected

30.03.2021	Medhani (Mysuru)	12.20523°N; 77.118344°E	*A. indica*	*H. serrata*	663
31.03.2021	Medhani (Mysuru)	12.20523°N; 77.118344°E	*A. indica*	*H. serrata*	1456
15.04.2021	Gunnanayakanahalli, (Mandya)	12.618973°N; 76.836894°E	*A. indica*, *Ricinus communis*, *Acacia auriculiformis*	*H. serrata*	2678
19.04.2021	Katrighatta, (Hassan)	12.9354°N; 76.32555°E	*A. indica*, *Morus* sp.	*H. serrata*	2354
22.04.2021	GKVK, Farm (Agronomy)	13.083204°N; 77.5691°E	*A. indica*	*H. serrata*	532
				H. rufoflava	23
26.04.2021	GKVK, Medicinal plots.	13.081203°N; 77.5676°E	*A. indica*	*H. serrata*	1632
				H. rufoflava	241
27.04.2021	GKVK, Medicinal plots.	13.081203°N; 77.5676°E	*A. indica*	*H. serrata*	1853
				H. rufoflava	152
			Cassia fistula	*Anomala* sp.	123
28.04.2021	GKVK, Farm (Crop Physiology)	13.081216°N; 77.5681°E	*A. indica*	*H. serrata*	638
			A. indica	*H. rufoflava*	453
28.04.2021	Sorekunte (Tumkur)	13.7465°N; 76.8363°E	*A. indica*	*H. serrata*	2614

A total of 12, 811 adult beetles of sugarcane white grub, *Holotrichia serrata* and 440 beetles of *H. rufoflava* were collected from different tree canopies *viz.,* Neem (*Azadirachta indica*), mahogany (*Swietenia macrophylla*), mango (*Mangifera indica*), tamarind (*Tamarindus indica*) and Hebbevu (*Melia dubia*) from Chikkaballapur, Chamarajnagar and Bengaluru rural. During the field visits several hands on *training-cum-demonstration on adult beetle collection* were conducted in white grub endemic areas. The detail of abundance of scarab beetles on tree canopies is given in table 4. In April, 2022 a total of 16214 sugarcane white grub, *Holotrichia serrata* beetles were collected from Neem (*Azadirachta indica*).

Table 36. Abundance of major scarab beetles on tree canopies in May, 2021

Date	Location	Coordinates	Tree canopy	Scarab species collected	No. of beetles collected
03.05.2021	Muddalapalli (Chikkaballapur)	13.80037°N; 77.87799°E	Neem	*H. serrata*	814
05.05.2021	Palya, Kollegal Tq, Chamarajanagar Dist	12.184816 °N;	Neem	*H. serrata*	3542

		77.184485°E			
07.05.2021	Agara, Yelandur Tq. Chamarajanagar Dist	12.116843 °N; 77.076167°E	Mahogany	*H. serrata*	5024
13.05.2021	Gunnahalli, Chintamani Taluk, Chikkaballapur dist	13.320788°N; 78.010241°E	Neem	*H. serrata*	856
			Tamarind	*H. serrata*	254
				H. rufoflava	65
			Hebbevu	*H. serrata*	648
			Mango	*H. serrata*	257
19.05.2021	Dodda Muddenahalli, Chikkabalapur Tq and Dist	13.329941°N; 77.763361°E	Neem	*H. serrata*	864
				H. rufoflava	251
25.05.2021	Muduguriki, Devanahalli Tq, Bengaluru Rural Dist.	13.343221°N; 77.722589°E	Neem	*H. serrata*	552
				H.rufoflava	124

Table 37. Abundance of major scarab beetles on tree canopies in April, 2022

Date	Location	Coordinates	Tree canopy	Scarab species collected	No. of beetles
04.04.2022	Dhanagere, Kollegal	12.1710°N; 77.1861°E	Neem	*H. serrata*	1409
06.04.2022	Palya, Kollegal	12.1805°E; 77.1769°E	Neem	*H. serrata*	1615
13.04.2022	Medhani, T.Narasipur	12.2383°N; 76.9612°E	Neem	*H. serrata*	2015
18.04.2022	Sira	13.4704°N; 76.9909°E	Neem	*H. serrata*	1852
19.04.2022	Mullahalli, Chintamani	13.2154°N; 77.8456°E	Neem	*H. serrata*	3214
26.04.2022	Muddalapalli, Bagepalli	13.7534°N; 77.8647°E	Neem	*H. serrata*	1856
29.04.2022	Sira	13.4931°N; 76.9456°E	Neem	*H. serrata*	4253

Conclusion:

H. serrata found to be the predominant species among scarab beetles collected during the operation followed by *H. rufoflava* and *Anomala* sp. Aggregation of *H. serrata* was noticed on tree canopies other than its usual host *ie*., neem such as castor, mulberry and acasia. The study also revealed that the sugarcane white grub, *H. serrata* aggregated on canopies of 23 trees belonging to 13 families. The aggregation behavior of adult beetles indicated that tree canopies are the mating platforms and the beetles opportunistically aggregates on tree canopies and did not show any preference to trees. This information

was shared with the farmers and line department official for efficient collection of adult beetles during night hours of the day.

Studies on the influence of weather parameters on emergence pattern of adult beetles of *Holotrichia serrata* revealed that rainfall has negatively correlated with soil temperature and in turn triggering the adult emergence. Further, the study also confirmed the event is greatly location specific.

Kairomonal studies

A kairomone is a chemical emitted by an organism, whose behavioural response is advantageous to the receiving individual. For many coniferophagous bark beetles, host monoterpenes can function independently as attractant kairomones or as co-attractants with pheromone components. Ethanol emanating from fermenting tree tissue due to damage from fire, flooding, or other causes also can act as a kairomonal cue for host location. Similarly, volatile host tree compounds, primarily monoterpene hydrocarbons and various alcohols known to attract Woodwasps in *Sirex* and related genera.

Methodology:

Thus, we systematically investigated *H. serrata*-tree canopy chemical interactions in the 'K' block, GKVK campus. We had developed an Ultrahigh Performance Liquid Chromatography/Mass spectrometry/Selected Reaction Monitoring (UHPLC-MS/SRM) assay and validated the same for five neem metabolites. Using the validated method, azadirachtin A (Aza A), nimbin, salanin, azadiradione (azadi) and epoxy or hydroxyl-azadiradione (E/H-azadi) were quantified from neem leaf extraxts. Neem leaf (both tender and mature) were collected at two time points (4 pm and 7.30 pm) from beetle infested and non-infested five-year-old trees. Simultaneously, leaves were collected from young neem tree (three years) for reference.

Results:

It was observed that in beetle infested neem tree, tender leaf collected at 7.30 pm reflected high values of E/H-azadi levels (31316.17pg) as compared to mature leaf (19272.9 pg). The level of secondary metabolites was higher in unaffected tree indicating role of beetle feeding (Table). As the levels of metabolite are reduced in infested plant, it would be interesting to analyse the enzyme activity level for beetles to have a better understanding of '*insect-tree*' relationship. Due to some technical problem this study was not extended further.

Table 38. Diversity of secondary metabolites in infested and non-infested neem leaf

Metabolite	Infested tree				Non-Infested tree			
	Tender leaf		Mature leaf		Tender leaf		Mature leaf	
	4.00 pm	7.30 pm	4.00 pm	7.30 pm	4.00 pm	7.30 pm	4.00 pm	7.30 pm
Azadirachtin	NF	NF	23.692	NF	NA	52.713	NA	NF
Nimbin	NF	NF	NF	NF	NA	NF	NA	66.202

Salanin	3.761	170.029	20.444	128.114	NA	1839.961	NA	173.255
Azadiradione	NF	NF	NF	13.811	NA	75.456	NA	34.976
E/H-azadiradione	955.459	31316.174	2698.855	19272.992	NA	280095.364	NA	51538.337

Population monitoring of damaging stages of soil arthropod pests and their extent of damage in different crops

Species and abundance of soil arthropod pests were monitored at monthly interval throughout the year for groundnut, sugarcane, arecanut and other crops. Sampling methodology varied with the crop. However, in each crop, specific soil samples were drawn to obtain data.

Incidence of *Holotrichia serrata* in groundnut

Fifteen groundnut fields were visited in Chintamani and pavagada taluks for incidence of white grubs. At every five-metre length distance in an affected row, plants were uprooted to record the extent of damage and to estimate the larval population per metre length. The larval population varied from 1 to 7 grubs per five metre length. About 20 to 30 per cent of the area was damaged by white grub infestation.

Incidence of white grubs in Sugarcane and estimation of larval population

Thirty-seven fields in four districts-Mandya, Mysuru, Chamarajnagar and Davanagere were visited at various times of the year to record sugarcane white grub, *H. serrata* incidence. Population density of larvae was estimated at monthly interval. The incidence ranged from 11 to 37 & 53 to 84 per cent in seed and ratoon crops respectively. In each of the locations infestation was not widespread in the seed crop and it was limited to a few patches within the field. However, ratoon crops suffered higher damage everywhere. Population density of third instar grubs was 0.76±1.25 and 2.76±1.88 per meter (along the row) in seed and ratoon crops respectively. In the southern parts of the State, some farmers practice 3 or 4 ratoon crops. This helps in buildup of white grub population in the affected fields. The yield decreases gradually in the ratoon fields due to pest as well as agronomic factors. The farmers are advised to discontinue repeated cultivation of sugarcane and adopt crop rotation with puddled paddy to break the resource supply which would reduce pest populations.

Table 39. Infestation of sugarcane white grub in ratoon sugarcane fields in Karnataka

Sl. No.	Location	Total area (ac)	Affected area (ac)	Population density of grubs (per metre length)
1	Medini	7	2.00	0.76±1.25
2	Narahalli	1	0.25	1.76±1.52
3	Palalli	3	0.75	2.76±1.88

Incidence of white grubs in arecanut and estimation of larval population

A total of 28 fields were visited in Shivamogga, Chikkamagalur, Uttara Kannada & Dakshina Kannada districts in Karnataka to record the arecanut white grub incidence.

Table 40. Arecanut white grub infestation, age structure & density of grubs

Location	White grub species	Population density of grubs (per sq.m)		
		First instar	Second instar	Third instar
Shivamogga District				
1. Kannangi	*L.lepidophora*	-	0.1±0.37	3.09±9.54
2. Hulagar	*L. burmeisteri*	-	-	2.41±2.59
3. Biluve	*L.lepidophora*	-	-	1.66±2.42
4. Mrigavade	*L.lepidophora*	-	-	2.0±1.76
5. Thirthahally	White grub incidence was not observed			
6. Soraba	White grub incidence was not observed			
Dakshina Kannada district				
1. Sulkery	*L. coneophora*	-	-	0.1±0.31
2. Gerukatte	*L. coneophora*	-	0.9±1.72	0.7±2.21
3. Maninalkur	*L. coneophora*	-	2.2±1.98	1.3±1.94
4. Kalladka	*L. coneophora*	-	1.16±1.52	2.16±5.21
5. Mantrady	*L. coneophora*	-	2.21±2.08	0.07±0.26
6. Iruvail	*L. coneophora*	-	4.17±5.32	1.31±2.72
7. Markanja	*L. burmeisteri*	0.53±1.12	-	0.13±0.35
8. Mulia	White grub incidence was not observed			

Incidence of Giant African Snail

The impact of Giant African Snail, *Lissachatina* (*Achatina*) *fulica* (Bowdich, 1822) damage on quantitative and qualitative loss of Vanilla (*Vanilla planifolia* Andrews) beans produced in different cropping systems was studied. Feeding damage to the floral parts resulted in production of inferior quality beans possessing lower marketable properties. The study has been translated in to a research paper and submitted for the publication.

Conclusion:

About 50 per cent of the arecanut and 80% of sugarcane fields visited were affected by white grubs. The extent of damage was 25 to 60% and 10 to 40% respectively in sugarcane and arecanut gardens. It was observed that a steady increase in the pest expansion was evident. However, white grub incidence in groundnut was negligible.

Pheromonal studies on predominant white grub species

Deciphering the sex pheromones in arecanut white grub, *Leucopholis burmeisteri* Brenske

The electrophysiological studies for *Leucopholis burmeisteri*, virgin males were conducted based on the procedure described by Kamala Jayanthi 2021. The extracted samples were analysed for their chemical composition using Gas Chromatography-Mass Spectroscopy. The mass spectral analysis was completed on Agilent 7890 B Gas Chromatography

apparatus coupled to an MSD (Agilent 5977 B). The compounds elicited response in the GC-EAD in the form of peaks corresponding to the GC peaks were further need to be identified through GC-MS.

FARMER - GHAZIABAD

Methodology:

Pilot survey for species profiling was conducted in western UP covering twelve locations at twelve villages in three districts: Muzaffarnagar (two villages: Datiyana, Meghakhadi), Bulandshahar (two villages: Mukhada, Poothri) and Ghaziabad (eight villages: Dabana, Jalalabad, Yusufpurmanota, Badkaarifpur, Firozpur, Kunhada, Kathawadi, Masuri). Locations were selected for conducting survey on the basis of cropping pattern and presence of host trees (Figure 3). The collections of beetles were carried out after onset of first pre-monsoon showers and monsoon rains in the months of April - September, 2021. However, it was observed that the emergence of beetles was mainly recorded in the months of May- June 2021. The survey was conducted by using Light traps fitted with fitted with 6-8 watts mercury tube Light; ACTINIC BL, PHILIPS and Pheromone traps fitted with vials and foam containing Anisole (Methoxy Benzene) (Figure 1). The Light traps and Pheromone traps were placed in the field at a height of three feet to ten feet above the ground and operated between 7:30 PM to 9:30 PM to attract the beetles in maximum numbers. The average temperature and relative humidity during the period of emergence (April-September) of adult beetles were ranging between 21-41^{0}C and 24-78 % RH, respectively. The collected beetles were processed in the laboratory for preliminary morphological identification and were preserved in 70% alcohol. After preliminary screening, the specimens of species were forwarded for confirming of identification up to the genus level to Dr. (Mrs.) Kolla Sreedevi, Principal Scientist (Agricultural Entomology), Division of Insect Systematic, ICAR- National Bureau of Agricultural Insect Resources, Bengaluru, Karnataka and Dr. K V Prakash, Scientist, Gandhi Krishi Vigyana Kendra (GKVK), campus and administrative headquarters of UAS (University of Agricultural Sciences, Bangalore), Suburb Yelahanka, Karnataka, for confirmation of identification.

Result:

A total of number of 3930 white grub beetles belonging to 10 species of Scarabaeidae family were collected during 2021-22. The 10 species of white grubs collected during the period are; *Holotrichia serrata*, *H. nagpurensis, H consanguinea*, *Maladera insanabilis, Schizonycha ruficollis* from the sub family Melolonthinae, *Anomala polita, A. dimidiate*, *A.varicolar* belong to sub family Rutelinae, *Pentodon sp*., of sub family Dynastinae; and one non phytophagous species Onitis sp. of sub family Scarabaeinae.

Summary/Conclusion:

The total number of white grub beetles collected during the season belongs to four sub family viz., Melolonthinae (96.69%), Rutelinae (2.24%), Scarabaeinae (0.61%) and

Dynastinae (0.46%). Out of 10 white grub species collected, the species namely *Holotrichia serrata* (Melolonthinae) was found in abundance during the period (73.01%).

Fig. 16. Beetle collection in pilot survey by using Light Trapand Pheromone Trap

Fig. 17. Grouping of collected beetles for identification

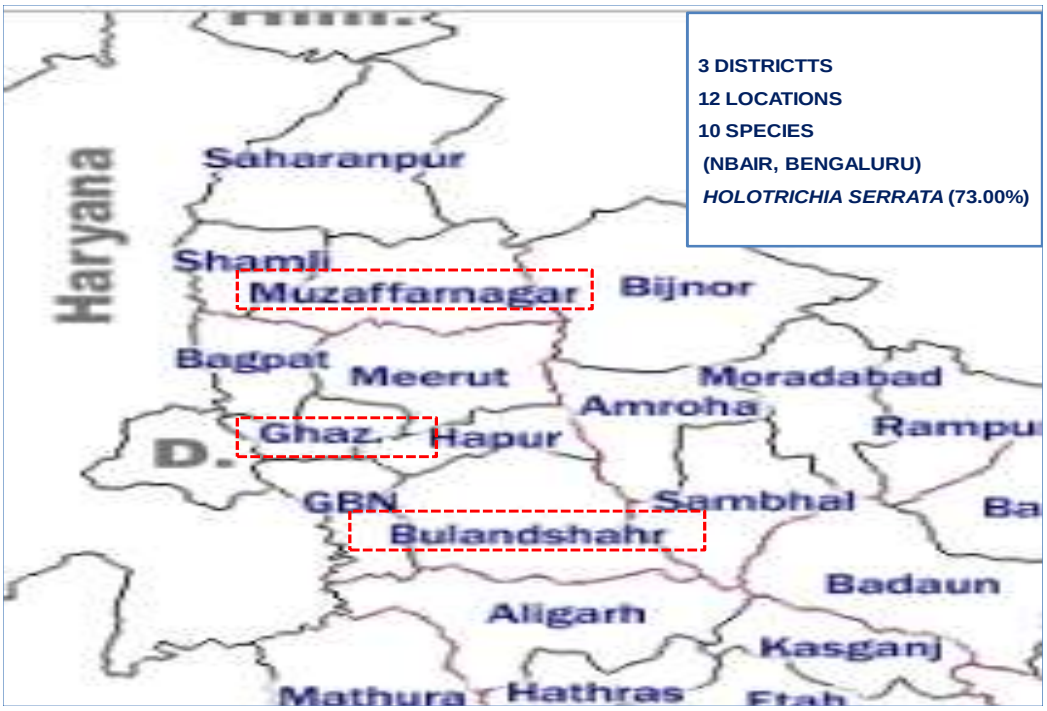


Fig. 18. Pilot survey for species profiling was conducted in western UP

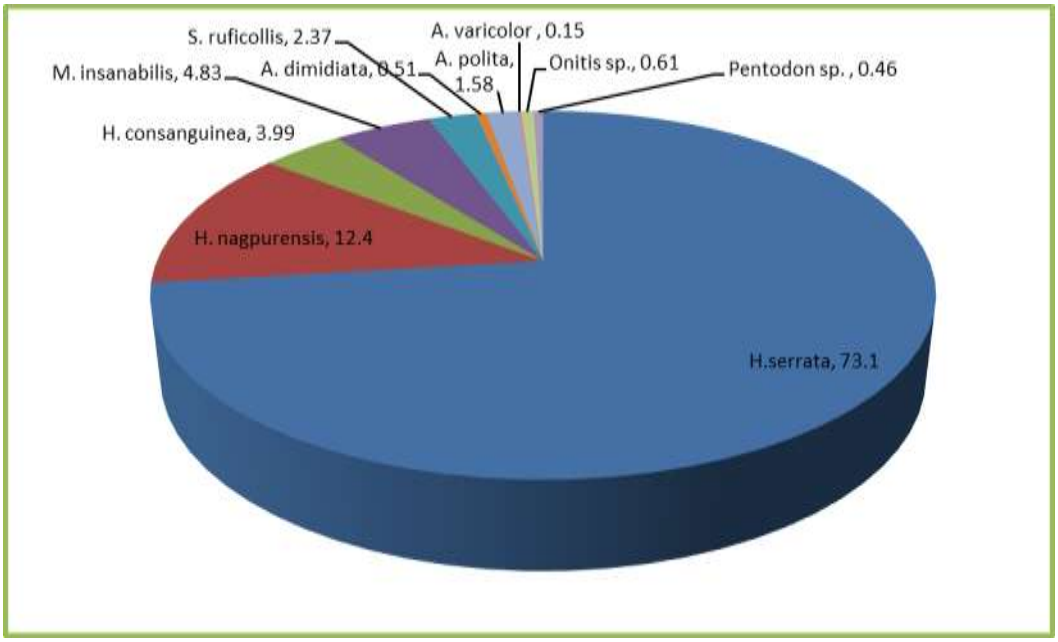


Fig. 19. White grubs beetles prevailing in western Uttar Pradesh during 2021-22

Table 41. Beetles collections and weather conditions during 2021-22 in western Uttar Pradesh

S. No.	Months	Temperature (^{0}C)	Humidity (%)	Rainfall (mm)	Rain days (No.)	Beetle collection (No.)
District: Muzaffarnagar (2 villages: Datiyana, Meghakhadi)						
1.	April	22.1-37.3	24	0.1	05	00
2.	May	26.8-41.4	37	0.2	01	00
3.	June	28.6-41.7	51	0.8	04	00
4.	July	27.1-36.3	75	2.0	09	07
5.	August	25.6-33.9	78	2.0	10	00
6.	September	23.4-32.7	69	1.5	04	00
District: Bulandshahar (2 villages: Mukhada, Poothri)						
1.	April	20.9-36.7	30	0.6	02	00
2.	May	25.1-39.2	34	0.7	04	00
3.	June	27.2-37.7	49	3.0	07	536
4.	July	26.4-33.2	74	9.4	16	00
5.	August	25.6-31.9	74	8.5	16	00
6.	September	23.7-31.8	76	4.9	09	00
District: Ghaziabad (8 villages: Dabana, Jalalabad, Yusufpurmanota, Badkaarifpur, Firozpur, Kunhada, Kathawadi, Masuri)						
1.	April	20.9-36.6	30	0.7	03	00
2.	May	25.1-39.4	33	0.8	04	78
3.	June	26.6-33.6	48	8.6	16	3309
4.	July	26.8-33.8	73	8.6	16	00
5.	August	25.8-32.3	78	7.8	16	00
6.	September	23.8-32.1	74	4.9	08	00

Table 42. Relative abundance of white grub beetles during 2021-22 in western Uttar Pradesh

S.N.	Family	Sub family	Species	Number	RA (%)	Location (districts)
1.	Scarabaeidae	Melolonthinae	*H. serrata*	2873	73.10	Muzaffarnagar, Ghaziabad
2.	Scarabaeidae	Melolonthinae	*H. nagpurensis*	487	12.40	Bulandshahar Ghaziabad
3.	Scarabaeidae	Melolonthinae	*H. consanguneia*	157	3.99	Muzaffarnagar, Ghaziabad
4.	Scarabaeidae	Melolonthinae	*M. insanabilis*	190	4.83	Muzaffarnagar, Ghaziabad
5.	Scarabaeidae	Melolonthinae	*S. ruficollis*	93	2.37	Muzaffarnagar, Ghaziabad
6.	Scarabaeidae	Rutelinae	*A. dimidiata*	20	0.51	Ghaziabad
7.	Scarabaeidae	Rutelinae	*A. polita*	62	1.58	Bulandshahar Ghaziabad
8.	Scarabaeidae	Rutelinae	*A. varicolar*	6	0.15	Ghaziabad
9.	Scarabaeidae	Scarabaeinae	*Onitis sp.*	24	0.61	Ghaziabad
10.	Scarabaeidae	Dynastinae	*Pentodon sp.*	18	0.46	Ghaziabad
Total	1	4	10	3930	100	3

Table 43. Beetles collection during 2021-22 by using Light Traps in western Uttar Pradesh

Location (Districts)	Species	Monthly beetles' collection (2021-22)							RA (%)
		April	May	June	July	August	September	Total	
Melolonthinae									
Muzaffarnagar, Ghaziabad	*H. serrata*	00	45	2828	00	00	00	2873	73.10
Bulandshahar, Ghaziabad	*H. nagpurensis*	00	00	487	00	00	00	487	12.40
Muzaffarnagar, Ghaziabad	*H. consanguneia*	00	00	150	07	00	00	157	3.99
Muzaffarnagar, Ghaziabad	*M. insanabilis*	00	00	190	00	00	00	190	4.83
Muzaffarnagar, Ghaziabad	*S. ruficollis*	00	00	93	00	00	00	93	2.37
Rutelinae									
Ghaziabad	*A. dimidiata*	00	02	18	00	00	00	20	0.51
Bulandshahar, Ghaziabad	*A. polita*	00	00	62	00	00	00	62	1.58
Ghaziabad	*A. varicolar*	00	06	00	00	00	00	6	0.15
Scarabaeinae									
Ghaziabad	*Onitis sp.*	00	19	05	00	00	00	24	0.61
Dynastinae									
Ghaziabad	*Pentodon sp.*	00	06	12	00	00	00	18	0.46
12	10	00	78	3845	07	00	00	3930	100

H. serrata 	***A. dimidiata*** 
H. nagpurensis 	***A. polita*** 
H. consanguinea 	***A. varicolar*** 
M. insanabilis 	***Onitis sp*. (non-phytophagous)** 
S. ruficollis 	***Pentodon sp.*** 

Fig. 20. White grub beetles prevailing in western Uttar Pradesh during 2021-22

Population monitoring of soil arthropod pests on host trees

Methodology:

The periodical visual survey of different host trees of white grub beetles was conducted at different locations during day time and night in the month of April to September 2021. The white grub beetles were found feeding on host trees during night time and foliage damage was also recorded on host trees in day time.

The periodical visual survey of different host trees of white grub beetles was conducted at different locations during day and night time in the months of April-September 2021. The survey was conducted at 14 locations in four districts; Muzaffarnagar, Ghaziabad, Gautambuddh Nagar and Bulandshahar on common host trees; Neem (*Azadirachta indica*), Sheesham (*Dalbergia sissoo*), Poplar (Populus sp.), Guvava (*Psidiumguajava*), Jamun (*Syzgiumcumcumini*), Bakayan (*Melia azedarach*) and Tun (*Meliaceae* family).

Result:

The white grub beetles were found feeding on host trees namely Neem (*Azadirachta indica*) and Sheesham (*Dalbergia sissoo*), Poplar (Populus sp.) Guvava (*Psidiumguajava*), Jamun (*Syzgiumcumcumini*), Bakayan (*Melia azedarach*) and Tun (Meliaceae family) at 14 different locations during night timeand the leaves of these host trees were also found damaged during day time.

Summary/Conclusion:

The emergence of beetles of two sub family viz., Melolonthinae and Rutelinae were noticed feeding on host trees in the months of June and July in western UP during 2021. The eight species recorded on Neem (*Azadirachta indica*), Sheesham (*Dalbergia sissoo*), Poplar (Populus sp.), Guvava (*Psidiumguajava*), Jamun (*Syzgiumcumcumini*), Bakayan (*Melia azedarach*) and Tun (Meliaceae family) during the season.

Fig. 21. Population monitoring of phytophagous scarab beetles on host trees

Table 44. Summary of population monitoring of phytophagous scarab beetles on host trees

SN	Location	Host trees	Sub family	Species
1	Muzaffarnagar • Datiyana • Meghakhadi	• Neem (*Azadirachta indica*) • Jamun (*Syzgiumcumcumini*) • Poplar (Populus sp.)	Melolonthinae	*H. serrata* *S. ruficollis*

2	Ghaziabad • Dabana • Jalalabad • Yusufpurmanota • Badkaarifpur • Firozpur • Kunhada • Kathawadi • Masuri	• Neem (*Azadirachta indica*) • Bakayan (*Melia azedarach*) • Tun (Meliaceae family) • Sheesham(*Dalbergia sissoo*) • Guava(*Psidium guajava*)	Melolonthinae Rutelinae	*M. insanabilis* *H. serrata* *H. consanguinea* *A. dimidiata* *A. varicolar*
3	Bulandshahar • Mukhada • Poothri • Sabitgarh	• Neem (*Azadirachta indica*)	Melolonthinae Rutelinae	*H. nagpurensis* *A. polita*
4	Gautambuddh Nagar • Saithali	• Neem(*Azadirachta indica*)	Melolonthinae	*H. serrata*
Total	14	7	2	8

Population monitoring of damaging stage of soil arthropod pests and their extent of damage in different crops

Methodology:

The visual survey of soil arthropod pests and their extent of damage in seven crops were conducted periodically from April to November 2021-22. Total 30 locations located in seven villages Kunheda, Yusufpur Manota, Barka Arifpur, Surena, Noorpur, Jalalabad and Dabana in Ghaziabad district; two villages Megha Khadi and Datiyana in Muzaffarnagar district; one village Sabitgarh in Bulandshahar district and one village Sainthali in Gautambuddhnagar district of western Uttar Pradesh. The survey of sugarcane, turmeric, banana, pigeon pea, citrus and sorghum growing fields were undertaken to monitor damaging stage of white grub.

Results:

In the months of April - May, no infestation was recorded in sugarcane and sorghum crop fields. In the months of June - July 5-7 grubs/m^2 in sugarcane and 0-2 grubs/ m^2 in turmeric was recorded. In the months of August - September, 2021, white grub beetles with eggs and cicadas sp. collected from sugarcane crop field and 1-4 grubs/m^2 in sorghum crop field. Infestation of white grub was recorded from each point. No white grub infestation recorded in paddy crop. In the months of October November 0-6 grub/m^2 in sorghum, 1-6 grub/m^2 in sugarcane and 0-1 grub/m^2 in banana were recorded. Beetles, eggs, and all three 1^{st}, 2^{nd} and 3^{rd} instar stage of white grub recorded in sugarcane crop fields in the month of August 2021.

Summary/Conclusion:

White grub in different crop were recorded as 5-7 grubs/ m^2 in sugarcane, 0-2 grub/ m^2 plant in turmeric, 1- 4 grubs/m^2 in sorghum crop, 0-1 grub/m^2 in banana during April to

November 2021 in western Uttar Pradesh. Beetles, eggs, and all three 1st, 2nd and 3rd instar stage of white grub recorded in sugarcane crop fields in the month of August 2021.

Table 45. Population monitoring of damaging stage of soil arthropod pests and their extent of damage in different crops during 2021-22 in western Uttar Pradesh

Date	Location (GPS)	Crops	Number of grubs/m2 area in soil	Extent of damage
April (Ghaziabad)				
05.04.2021	Dabana Ghaziabad (N $28^0$50'12.4512, E $77^0$3006.6564)	Sugarcane	00	00
05.04.2021	Dabana Ghaziabad (N $28^0$50'13.1892'' E $77^0$30'04.8276)	Sorghum	00	00
05.04.2021	Jalalabad Ghaziabad (N $28^0$46'08.3136" E $77^0$31'29.9604")	Sugarcane	00	00
05.04.2021	Jalalabad Ghaziabad (N 28^0 45'48.006" E 77^0 32'05.3952")	Sugarcane	00	00
May (Ghaziabad)				
27.05.2021	Dabana Ghaziabad (N $28^0$50'12.4512, E $77^0$3006.6564)	Sugarcane	00	00
27.05.2021	Dabana Ghaziabad (N $28^0$50'13.1892'' E $77^0$30'04.8276)	Sorghum	00	00
27.05.2021	Jalalabad Ghaziabad (N $28^0$46'08.3136" E $77^0$31'29.9604")	Sugarcane	00	00
27.05.2021	Jalalabad Ghaziabad (N 28^0 45'48.006" E 77^0 32'05.3952")	Sugarcane	00	00
June (Ghaziabad)				
30.06.2021	Dabana Ghaziabad (N $28^0$50'12.4512, E $77^0$3006.6564)	Sugarcane	5-7	Not significant
30.06.2021	Jalalabad Ghaziabad (N $28^0$46'08.3136" E $77^0$31'29.9604")	Sugarcane	3-5	Not significant
30.06.2021	Jalalabad Ghaziabad (N 28^0 45'48.006" E 77^0 32'05.3952")	Sugarcane	4-6	not significant
July (Ghaziabad, Muzaffarnagar)				
10.07.2021	Datiyana Muzaffarnagar N 29^0 53'78.26, E 77^0 78'61.172	Sugarcane	3-7	Not significant

10.07.2021	Megha Khadi Muzaffarnagar N 29^0 50'69.748, E 77^0 77'93.582	Turmeric	0-2	Not significant
23.07.2021	Kunhaida, Ghaziabad (N 28^0 35'07.3536" E 77^0 25'53.6808")	Sugarcane	0-1	not significant
23.07.2021	YusufpurManota, Ghaziabad N 28^0 46'11.838 E 77^0 31'22.2528	Sugarcane	0-3	Not significant
August (Ghaziabad)				
04.08.2021	Noorpur, Ghaziabad (N $28^0$44'26.664" E 77^0 32'55.1572")	Sugarcane	Beetles (7)	-
11.08.2021	Badkaarifpur, Ghaziabad (N $28^0$44'55.8276" E 77^0 32'25.9836")	Sorghum	1-4	Not significant
18.08.2021	Kumheda, Ghaziabad (N $28^0$52'51.9168" E 77^0 26'10.4892")	Sugarcane	00	-
25.08.2021	Surana, Ghaziabad (N $28^0$51'09.9432" E $77^0$25'29.0352")	Paddy	00	-
September (Ghaziabad, GautambudhNagar)				
03.09.2021	YusufpurManota, Ghaziabad N 28^0 46'07.7232 E 77^0 31'29.7336	Sorghum	00	-
10.09.2021	Kumheda, Ghaziabad (N $28^0$52'48.198" E 77^0 26'10.6764")	Sugarcane	03	-
18.09.2021	Saithali, Gautambudh Nagar (N $28^0$30'46.3248" E $77^0$39'18.5184)	Sorghum, banana, Pigeon pea, citrus	00	-
23.09.2021	Sabitgarh, Bulandshahar (N $28^0$17'07.6236" E $77^0$56'19.9248)	Sugarcane	8 grubs 6 cicadas	Not significant
October (Ghaziabad, Bulandshahar)				
01.10.2021	Baraka Arifpur, Ghaziabad-201206 (N $28^0$44'59.2116" E $77^0$32'20.436)	Sorghum	5-6	Significant
12.10.2021	Sabitgarh, Bulandshahar-203129 (N $28^0$17'07.296" E $77^0$56'18.9888)	Sugarcane	4-6	Significant

19.10.2021	Sabitgarh, Bulandshahar-203129 (N $28^0$17'12.9048" E $77^0$56'16.4616)	Sugarcane	2-3	Not significant
November (Ghaziabad, Gautambudh Nagar, Bulandshahar)				
11.11.2021	YusufpurManota, Ghaziabad (N 28^0 46'07.7232 E 77^0 31'29.7336)	Sorghum	0-1	Non-Significant
15.11.2021	Kumhera, Ghaziabad (N $28^0$52'48.198" E 77^0 26'10.6764")	Sugarcane	1-2	Non-Significant
26.11.2021	Saithali, Gautam Budh Nagar (N $28^0$30'46.3248" E $77^0$39'18.5184)	Banana	0-1	Non-significant
30.11.2021	Sabitgarh, Bulandshahar (N $28^0$17'07.6236" E $77^0$56'19.9248)	Sugarcane	1-2	Non-significant


Population monitoring of damaging stage of soil arthropod pests in sorghum and sugarcane field at Dabana village, Ghaziabad


Population monitoring of damaging stage of white grub in sugarcane crop


Population monitoring of damaging stage of white grub in sugarcane and turmeric crop at different locations


Population monitoring of damaging stage of white grub in sorghum, paddy and sugarcane crops at different locations in western Uttar Pradesh

Fig. 22. Beetle, eggs, 1st instar, 2nd instar and 3rd instar grub of white grub in sugarcane crop field in western UP

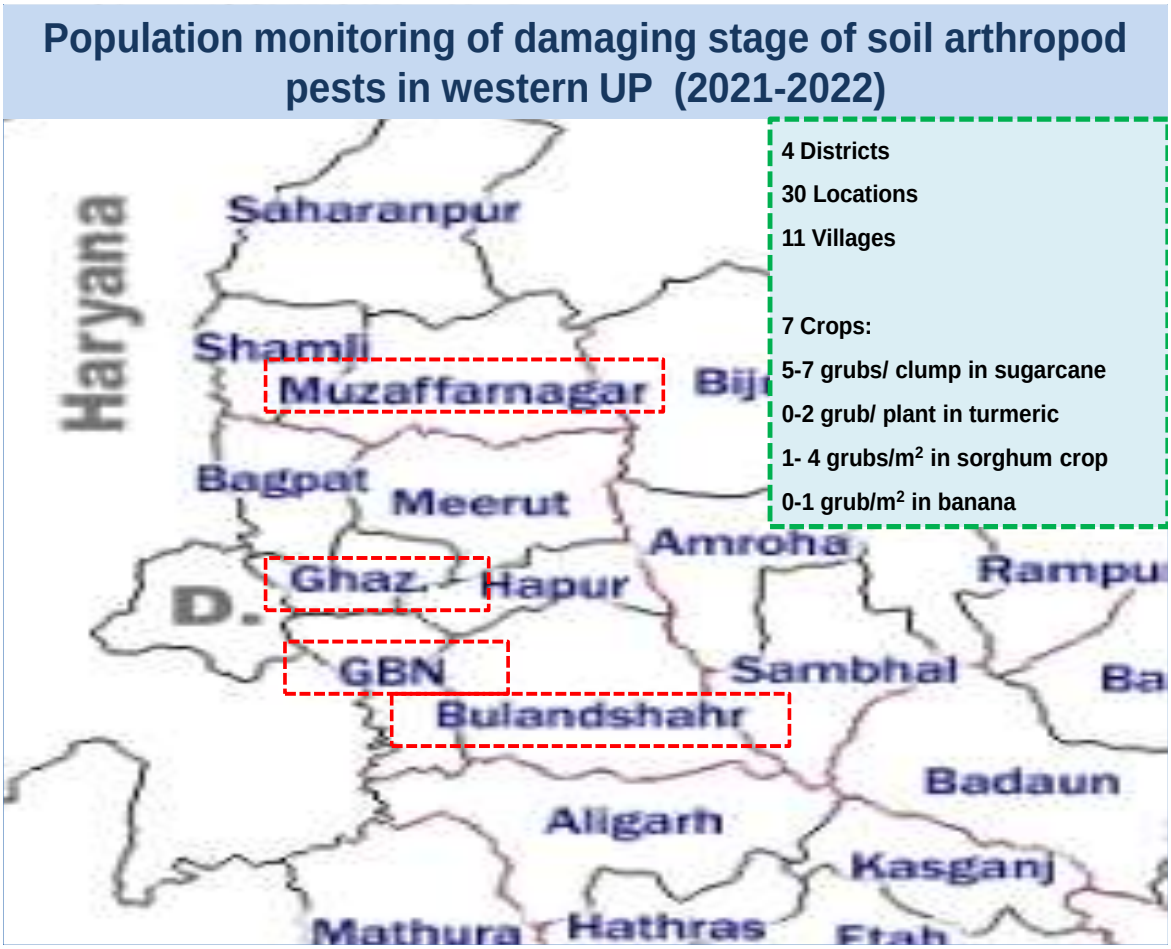


Fig. 23. Population monitoring of damaging stage of soil arthropod pests in western UP

Fig. 24. Population monitoring of damaging stage of soil arthropod pests in western UP

Monitoring of natural enemies of soil arthropods

Methodology:

To monitor the occurrence of natural enemies (parasitoids, predators & pathogens) of major soil arthropods, seasonal soil sampling was done in the endemic pockets of white grub infestation to isolate Entomopathogenic Nematodes (EPNs) and Entomopathogenic Fungi (EPFs). The EPNs isolation was done by baiting method and EPFs isolation was done by serial dilution method. Two hundred thirty-three soil samples were collected from village Datyana in Muzaffarnagar district; villages Surana, Rawali, Baraka Arifpur, YusufpurManota, Kumhera in Ghaziabad district, Sabitgarh in Bulandshahar district and village Saithaliin Gautambudh Nagar district covering eight locations in four districts in western UP.

Table 46. Monitoring of natural enemies of soil arthropods

Months	Soil samples (no)	Location	Crops	EPN	FUNGI
June 2021	30	Ghaziabad	Sugarcane	No	No
July 2021	10	Muzaffarnagar	Sugarcane	No	Yes 
September 2021	21	Ghaziabad	Paddy	No	Yes 
October 2021	90	GB Nagar	Banana, Pigeon pea, Citrus, Radish, Fenugreek	No	No
November 2021	42	Ghaziabad	Sugarcane	No	No
January 2022	40	Bulandshahar	Sugarcane	No	No
Total	233	4		No	No

Fig. 25. Soil samples collected from different locations for EPN & EPF isolation

Fig. 26. Collected soil samples from different locations

Fig. 27. Using of bating methodology for EPN & EPF isolation from soil samples collected from different locations

Result:

Two strains of fungus also isolated during current season; multiplication of these cultures isgoing on in FARMER laboratory to further identification.

	**Fungus isolated from soil from sugarcane (Muzaffarnagar) and soil from paddy (Ghaziabad)**

The identification report of two strains of entomopathogenic nematodes (EPNs) isolated by bating method from the soil samples in last season has been received from Division of Nematology, IARI, New Delhi and both strains have been identified by D2/D3 marker and deposited in GenBank as;

1. *H. indica* Muzaffarnagar strain D2/D3 (GenBank Accession Number OM149711)
2. *H. indica* Saharanpur strain D2/D3 (GenBank Accession number OM149712)

Confirmation of identification report is enclosed at **Annexure –I**.

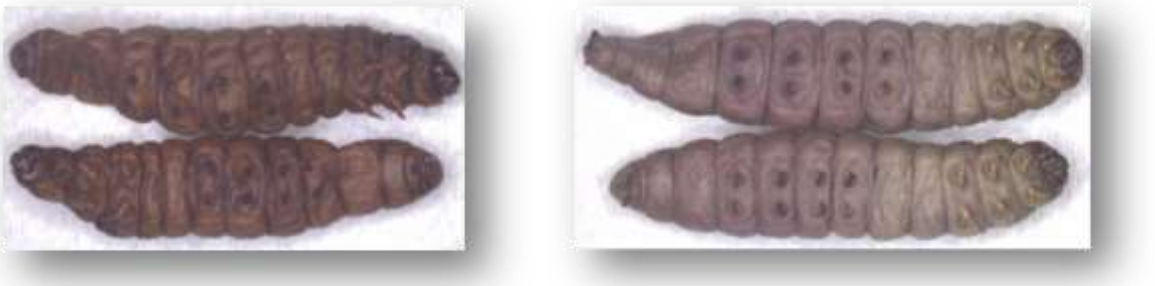


Fig. 29. *Galleria* cadavers infected by Entomopathogenic nematodes *H. indica* (OM149711) and *H. indica* (OM149712)

The culture of all 9 native strains isolated, identified and deposited in GenBank by FARMER so far and their culture is being maintained in FARMER laboratory by further multiplication of those strains of EPNs on host insect larvae (wax moth).

Summary/Conclusion:

Two types of fungus were isolated from 233 soil samples during the year. Nine strains of Entomopathogenic Nematodes are available in FARMER VC Ghaziabad. Culture of isolated strains is being maintained throughout the year.

Year	Infected *Galleria* cadaver	Molecular identification by ITS marker	Crop	Location	Gene Bank Accession No.
2014		*Heterorhabditis indica*	Mango	Noorpur Ghaziabad, UP	*MK078600*
2014		*Steinernema thermophilum/ abbasi*	Sugarcane	Chilla, Amroha, UP	*MK078603*
2016		*Heterorabditis indica*	Mango	Sabitgarh, Bulandshahr, UP	*MK078602*
2016		*Steinernema thermophilum/ abbasi*	Sugarcane	Jallopur, Amroha, UP	*MK078606*
2017		*Heterorhabditis indica*	Sugarcane	Noorpur Ghaziabad, UP	*MK078601*
2017		*Steinernema siamkayai*	Pigeon pea	Kushaliya, Ghaziabad, UP	*MK078604*
2017		*Steinernema siamkayai*	Star fruit	Moh. kidim, Ghaziabad, UP	*MK078605*
2020		*Heterorhabditis indica*	Sugarcane	Muzaffarnagar, UP	OM149711
2020		*Heterorhabditis indica*	Sugarcane	Saharanpur , UP	OM149712

Fig. 30. Nine strains of Entomopathogenic Nematodes are available in FARMER VC Ghaziabad

KOLHAPUR, MAHARASHTRA

Species profiling of soil arthropods through light trap

Experimental details:

No. of locations	:	05
No. of light traps/location	:	01
Power of light trap	:	100-watt bulb
Date of start of experiment	:	10.05.2021
Date of termination of experiment	:	30.09.2021

Method of recording observations:

Collection of beetles by light trap and scouting:

Surveys were randomly conducted at various locations in 05 districts of Maharashtra. The collection of scarab beetles started immediately after the onset of pre-monsoon rain in the month of May-June which is the peak season of beetle emergence in diverse habitats. Beetle activity was noticed between IST 18.15 to 19.20 hours; hence, collections were made by light trapping at four locations between 18.00-21.00 hours. The collected beetles were brought to the laboratory of All India Network Project (AINP) on Soil Arthropod Pests, College of Agriculture, Kolhapur for further identification.

Species profiling of beetles through light trapping:

To monitor the incidence of scarab beetles in a fixed location, a light trap of 100-watt bulb were installed from May onwards. The light trap was continuously operated from May to September from 18.00 to 21.00 hours during this period. The light trap catches of beetles were collected daily and counted. Further, the beetles were sorted species wise. The data on monthly collection of beetles and their average population per day were calculated out.

Correlation studies with weather parameters:

The data on different weather parameters *viz*., average aerial & soil temperature, relative humidity, rainfall, number of rainy days, bright sunshine hours and wind speed data were collected from the Division of Agronomy, College of Agriculture, Pune and Kolhapur. The monthly population of beetles was correlated with different weather parameters by following standard statistical procedure.

Results:

Collection of scarab beetles by light trap and scouting:

The duration of swarming of beetles was noticed for fourteen to seventeen weeks during the study. Emergence of white grub started from 18MW after the first pre-monsoon rainfall of the season and peak emergence of beetles was reported in the month of July. A total of 7 species of beetles were collected (**Table**, 3834 beetles). Species richness attributed to availability of preferred host, both in terms of quality and quantity and suitability of various abiotic factors like light intensity which can attract more number of beetles. Majority of the phytophagous beetles belonged to the subfamily Melolonthinae.

Under the subfamily Melolonthinae, 5 species were identified of which *Holotrichia serrata, Phyllognathusdionysius, Holotrichia consanguinea, Leucopholis lepidophora and Holotrichia fissa*.

Species profiling of scarab beetles through light trapping:

Based on the relative abundance of light trapped catches of three species of beetles, the mean emergence of beetles was observed from the month of May and showed a gradually increasing trend up to July, where maximum numbers of beetles (1917 numbers) were recorded. Thereafter, the population of beetles declined and lowest population was observed during September (191 numbers) (**Table)**. Further, light trap catches revealed that, among the phytophagous beetles, *H. serrata*was the dominant species followed by *L. lepidophora* and *P. dionysius.*

Correlation studies with weather parameters:

The different weather parameters were correlated with the monthly population of beetles trapped in the light trap at College of Agriculture, Kolhapur and Padegaon. Out of the weather parameters, total rainfall, rainy days, wind speed and evening relative humidity had significant correlation with the monthly collection of light trap catches of scarab beetles. White grub emergence was positively correlated with the temperature (r=0.80), relative humidity (r=0.78) and rainfall (r=0.76). Thus, temperature and relative humidity had positive correlation with *H. serrata*, beetle emergence.

Table 47. District wise distribution and relative abundance of White Grub in Western Maharashtra

Species	District					
	Pune	Satara	Sangali	Kolhapur	Solapur	Total
Holotrichia serrata (Fabricius)	259	188	196	312	172	1127
Phyllognathusdionysius	--	--	172	286	67	525
Holotrichia consanguinea (Blanchard)	--	--	98	143	39	280
Leucopholislepidophora (Blanchard	--	213	184	262	--	659
Holotrichiafissa (Brenske)	--	43	79	96	--	218
Chafer beetles (yellowish medium)	136	154	87	191	118	686
Chafer beetles (Small black)	68	73	64	86	48	339
Total	463	671	880	1376	444	3834

Table 48. Monthly collection of phytophagous beetles

Month	Pune	Satara	Sangali	Kolhapur	Solapur	Total
May, 2021	42	61	79	119	38	339
June, 2021	91	123	169	272	89	744
July, 2021	229	338	442	687	221	1917
August, 2021	78	115	147	229	74	643
September, 2021	23	34	43	69	22	191

Total	463	671	880	1376	444	3834

Table 49. Monthly collection of *Holotrichia serrata* beetles

Month	Pune	Satara	Sangali	Kolhapur	Solapur	Total
May, 2021	24	13	16	29	12	94
June, 2021	59	47	48	72	44	270
July, 2021	123	94	98	156	86	557
August, 2021	40	26	25	42	23	156
September, 2021	13	8	9	13	7	50
Total	259	188	196	312	172	1127

Table 50. Correlation studies with weather parameters

Variables	Arial Temperature (°C)	Soil Temperature (°C)	Relative Humidity (%)	BSH	Rainfall (mm)
Beetles	0.49	0.80**	0.78**	0.54	0.76**

Population monitoring of white grub beetles on host trees

Experimental details:

No. of locations : 10

No. of host plants/location : 10

Date of start of experiment : 10.5.2021

Date of termination of experiment : 30.09.2021

Method of recording observations:

Surveys were carried out once in a month for monitoring of beetles species in different host trees at various locations in two districts of MPKV jurisdiction from April to August. The collection of scarab beetles started immediately after the onset of pre-monsoon rain in the month of April-May which is the peak season of beetle emergence in diverse habitats. Collections were made by scouting on host trees at several locations at 18.00-21.00 hours. The collected beetles were brought to the laboratory of All India Network Project (AINP) on Soil Arthropod Pests, RCSM College of Agriculture, Kolhapur, sorted as host-wise and preserved in glass vials containing 70% alcohol for further identification. The collected and preserved beetle specimens were identified with the help of Zoology Department, Shivaji University, Kolhapur.

Results:

The survey of major groundnut, soybean and sugarcane growing areas of Pune, Satara, Sangli, Kolhapur and Solapur districts during the first monsoon rainy season of May to August, 2021 revealed that823 beetles collected from various host tree, indicated that distinct host preferences occur among the species encountered. The adult survey resulted in two species *viz*., *Holotrachia serrata*and *Phyllognathus dionysius*was observed. Among two, *H.serrata* was dominant and collected from host plant Neem, Bhabul, Ber and Moringa; while *Phyllognathusdionysius* were collected from Neem, Bhabul, Ber and Ker during May 2021 to September 2021. .

Table 51. White grub species collected as adults on host trees during 2021-22.

Species	Location	Host trees	No of adult collected
Holotrachia serrata	Supe, Padegaon, Digraj, Sajani, Wadala	Neem, Bhabul, Ber, Moringa	559
Phyllognathusdionysius	Manjari, Phaltan, Shevgaon, Karnur, Mardi	Neem, Bhabul, Ber, Khair	264
		Total	823

Table 52. White grub species collected as adults on host trees-2021-22

Species	Location	Host trees	No of adult collected
Holotrachia serrata	Hatkanangle	Neem, Babul, Ber,	349
	Shirol	Neem, Moringa	217
	Karveer	Neem, Moringa, Almond	157
		A-total	623
Leucopholislepidophora	Shirol	Sugarcane	91
	Karveer	Sugarcane	182
		B-total	273
	Total	A + B	896

Population monitoring of damaging stage of white grub and their extent of damage in different crops

Experimental details :

Design : Half block

Crop : Sugarcane and ground nut

Date of sowing : 17.01.2021

Date of termination : 23.02.2022

Method of recording observations:

Visual monitoring of white grub pest species and their extent of damage in different crops were recorded. Survey was carried out once in a month and extent of damage to different crops by white grub species were reported periodically. All information was supported by GPS locations.

Infested plant often wilts quickly and turns yellow due to root damage. The soil under the plant may feel spongy and plant may have lost enough of the root system to easily be pulled from the soil. The cuts of 10- 12 inch deep at three sides of plant with a stout shovel were taken and carefully inspected the root zone and upper 1-3 inches of soil. Sample several areas and determine the average number of grubs per square meter.

Results:

The survey of major groundnut and sugarcane growing areas of Kolhapur district during *Kharif* season of 2021 revealed that 24 grubs were observed at only one survey in August. Among these, 49 and 63 grubs were collected from sugarcane and ground nut field, respectively. On an average 4.45 grubs were observed per 5 clumps of sugarcane; while it was 5.73/m^2 in groundnut field. Moreover, 20 and 27.45% damage was noticed in sugarcane and ground nut, respectively.

Table 53. Monitoring of damaging stage of white grub and their extent of damage in different crops

Species	Location	Crop	No of grubs/5 clump [5m^2]	Crop	No of grubs/m^2
Holotrachia serrata	Gadmudshingi, Karveer	Sugarcane	4	Ground nut	5
	Kanheri math, Karveer	Sugarcane	9	Ground nut	10
	Banage, Kagal	Sugarcane	1	Ground nut	2
	Saverde Bk, Kagal	Sugarcane	5	Ground nut	7
	Lingnur, Kagal	Sugarcane	7	Ground nut	9
	Vathar, Hatkanagale	Sugarcane	2	Ground nut	3
	Ghunaki, Hatkanagale	Sugarcane	3	Ground nut	4

	Mandukali, Gaganbawada	Sugarcane	3	Ground nut	4
	Ambewadi, Chandgad	Sugarcane	1	Ground nut	2
	Gadhingalaj	Sugarcane	8	Ground nut	9
	Yerdul, Ajara	Sugarcane	6	Ground nut	8
Total			49		63
Average	--		4.45		5.73

Table 54. Extent of damage by white grub, *Holotrachia serrata* in sugarcane

Location	No of grubs/5 clump [5m^2]	Yield t/ha		% Damage
		Treated	Untreated	
Gadmudshingi, Karveer	4	90	73	19
Kanheri math, Karveer	9	85	60	29
Banage, Kagal	1	96	84	13
Saverde Bk, Kagal	5	89	70	21
Lingnur, Kagal	7	87	65	25
Vathar, Hatkanagale	2	93	79	15
Ghunaki, Hatkanagale	3	92	75	18
Mandukali, Gaganbawada	3	91	76	16
Ambewadi, Chandgad	1	94	81	14
Gadhingalaj	8	85	62	27
Yerdul, Ajara	6	88	68	23
--	4.45	90.00	72.17	20.00

Table 55. Extent of damage by white grub, *Holotrachia serrata* in groundnut

Location	No of grubs/5 clump [5m^2]	Yield q/ha		% Damage
		Treated	Untreated	
Gadmudshingi, Karveer	5	15	11	28
Kanheri math, Karveer	10	11	7	38
Banage, Kagal	2	19	16	15
Saverde Bk, Kagal	7	14	10	31
Lingnur, Kagal	9	13	9	34
Vathar, Hatkanagale	3	17	13	21
Ghunaki, Hatkanagale	4	17	13	23
Mandukali, Gaganbawada	4	16	12	25
Ambewadi, Chandgad	2	18	15	18
Gadhingalaj	9	12	8	36
Yerdul, Ajara	8	14	9	33
--	5.73	15.09	11.12	27.45

Monitoring of natural enemies of white grub

Experimental details	**:**	Field condition
Design	:	RBD
No. of replications	:	03
No. of treatments	:	07 (The endemic pockets)
Crop	:	Cereals, Pulses, vegetables, etc.
Spacing	:	--
Date of sowing	:	20.6.2021
Date of termination	:	15.11.2021

Method of recording observations:

To monitor the prevalence of natural enemies (parasitoids, predators& pathogens) of white grub, seasonal soil sampling was done in the endemic pockets. The Centre undertook the sampling method of each organism per the cropping system. Natural enemies were sent to NBAIR, Bangalore, IARI, New Delhi, for its identification, culturing and providing necessary details regarding receipt number and code numbers.

Result

Based on information collected from the students and their host as well as contact farmers the bird crow is major predator followed by bandicoot, however, statistical data is not available.

Table 56. Natural enemies of white grub, *Holotrachia serrata* in sugarcane and groundnt

Location	Natural enemies	Observations
Gadmudshingi, Karveer	Crow, Crane	
Kanheri math, Karveer	Crow, Crane, Bandicoot	Sugarcane trash mulching
Banage, Kagal	Crow, Crane	
Saverde Bk, Kagal	Crow, Crane	
Lingnur, Kagal	Crow, Crane	
Vathar, Hatkanagale	Crow, Crane	
Ghunaki, Hatkanagale	Crow, Crane, Rats	Sugarcane trash mulching

VPKAS- Almora

The monitoring studies of scarab beetles were carried out at Experimental Farm, Hawalbagh, ICAR- VPKAS, Almora to generate the basic information on scarab beetle population dynamics. Scarab beetles were collected with the help of light trap (VL white grub beetle trap; IN 290170), and from host trees during field surveys (*In-situ* sampling).

Collection of scarab beetles using light trap

A total of 8,504 scarab beetles belonging to 54 species were trapped in light trap in 2021. The collected beetles belonged to 6 subfamilies *viz*., Rutelinae, Melolonthinae, Scarabaeinae, Dynastinae, Geotrupidae and Aphodiinae of family Scarabaeidae. Members of the subfamily Melolonthinae predominated with 44.04% of the species, followed by Rutelinae (23.08%), Scarabaeinae (11.83%), Aphodiinae (9.25%), Hybosoridae (5.96%), Dynastinae (5.41%) and Geotrupidae (0.42%). The pre-dominant species were *Maladerasimilana* (11.5%) and *Aphodiusnigrovirgatus* (9.25%). The maximum number of scarab beetles (4,412 beetles) was collected in June month.

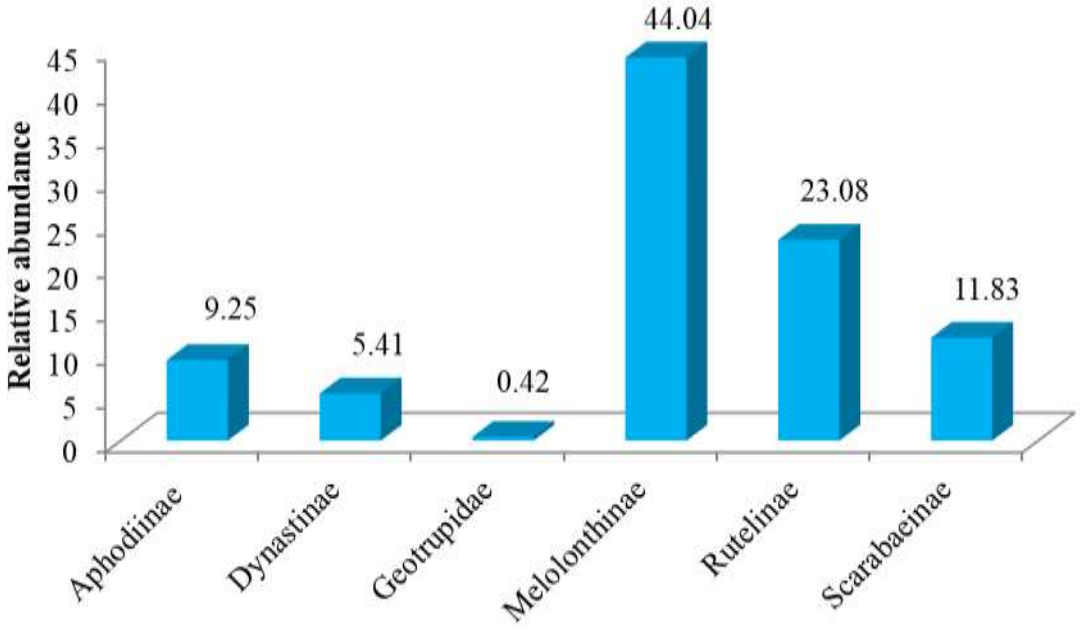


Fig. 31. Subfamily-wise trap of scarab beetles in Experimental Farm, ICAR-VPKAS, Hawalbagh in 2021

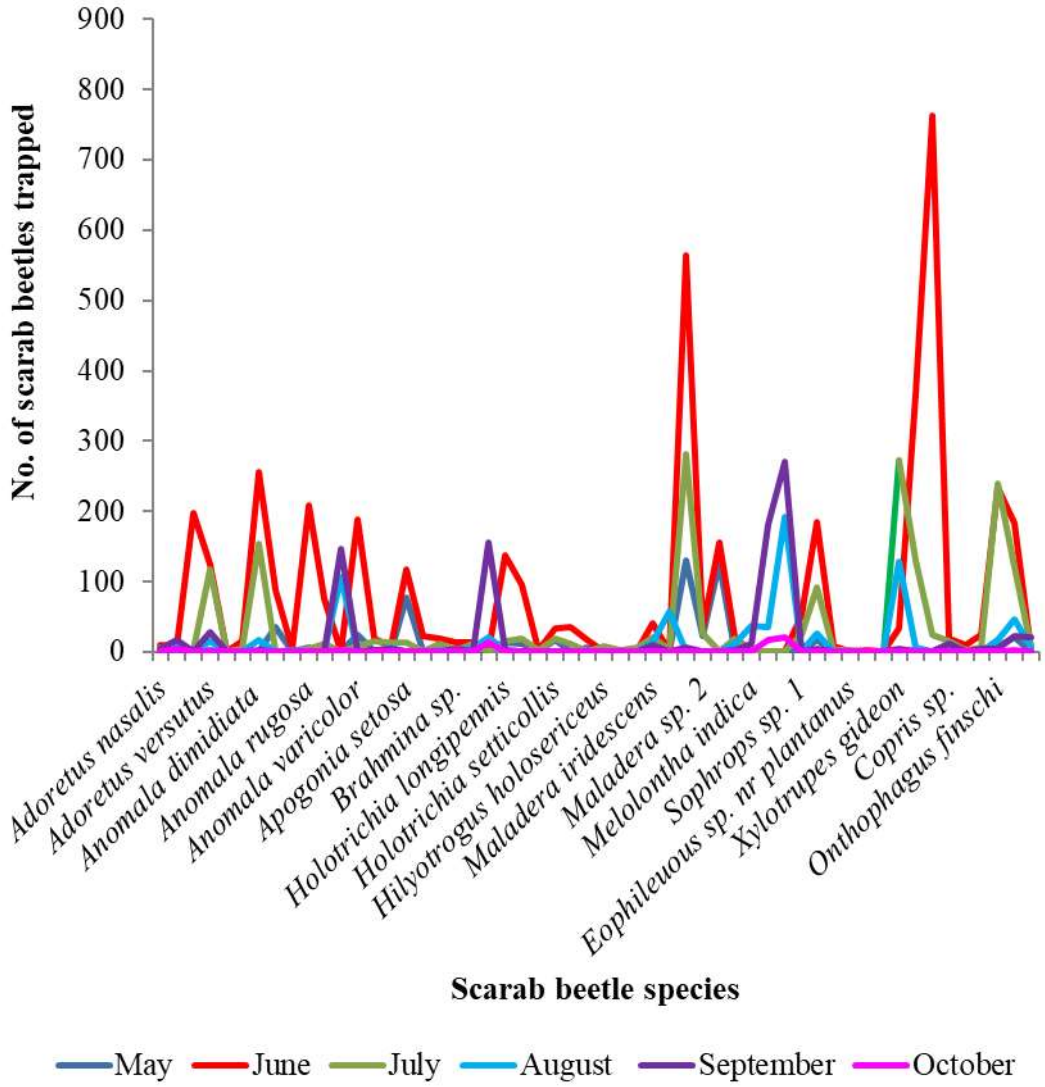


Fig. 32. Scarab beetles trapped in light traps at Experimental Farm, Hawalbagh in 2021

***In situ* sampling**

A total of 9,523 pleurostict scarab beetles belonging to 32 species and 18 genera were collected during *in situ* sampling in 2021. The collected beetles belonged to 03 subfamilies *viz.*, Cetoniinae (2.32%), Melolonthinae (53.92%) and Rutelinae (43.76%) of family Scarabaeidae (Figure 3). Out of 32 species, 16 species belonged to subfamily Melolonthinae, 11 species belonged to Rutelinae, and 5 species belonged to Cetoniinae. The maximum number of scarab beetles (82.92% of total catch) was collected in June. Of 32 pleurostict scarab beetles species, *H. setticollis*was the predominant species with 26% relative abundance followed by *Sophrops*sp. 2 (21%), *Adoretusversutus* (20.2%), *Anomala lineatopennis* (10.1%) and *Anomala bengalensis* (9.92%) during the study period. These 5

species occupied more than 85% of the scarab population i.e., 87.22% of total pleurostict scarab beetles collected whereas, rest 36 scarabs represented only 12.78% of the population in the study area.

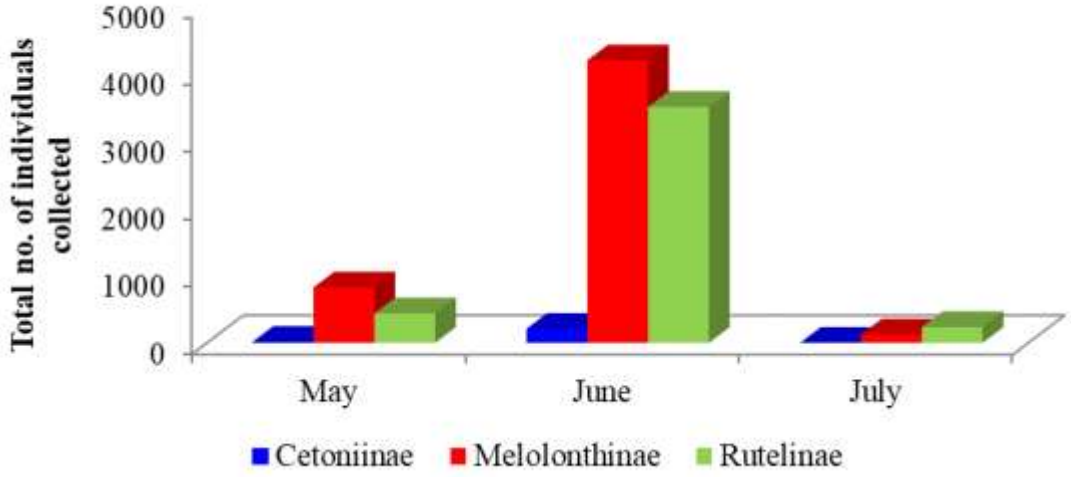


Fig. 33. Month-wise catch of scarab beetles belonging to different subfamilies during *in situ* sampling in Experimental Farm, Hawalbagh in 2021

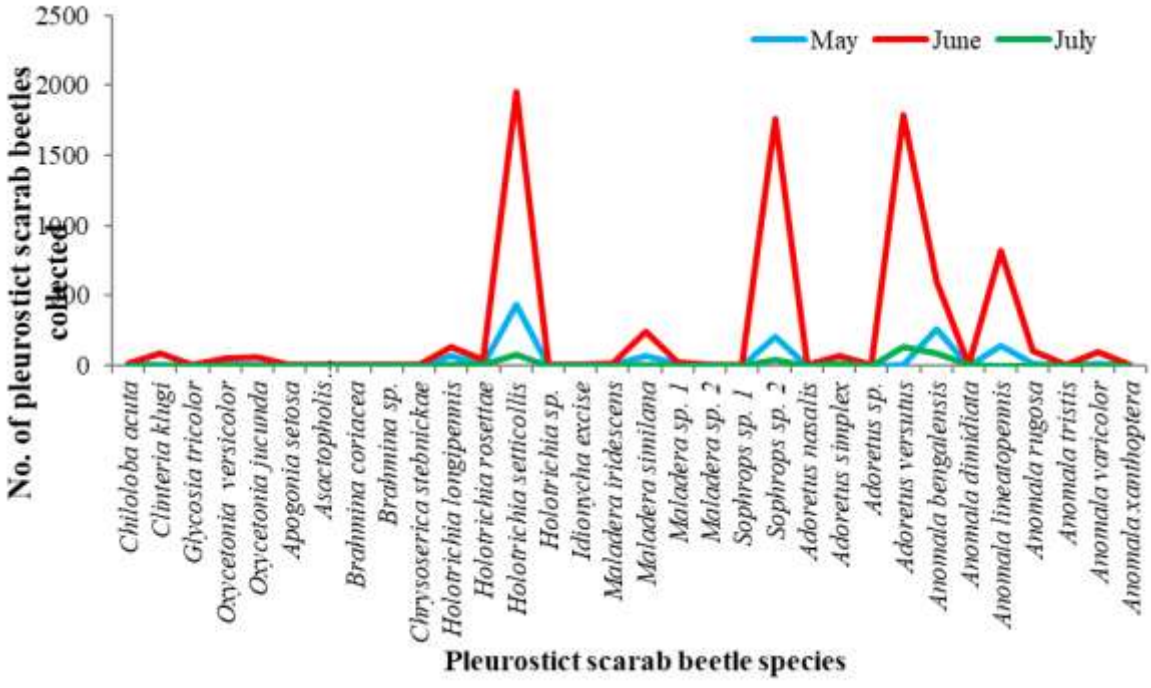


Fig. 34. Pleurostict scarab beetles collected at Experimental Farm, Hawalbagh, during *in situ* sampling

Bio-efficacy of entomopathogenic nematodes against native white grub species

The present study was carried out to determine the pathogenicity of various entomopathogens against first instars of two notorious and economically important white grub species, (*Anomala bengalensis* and *Sophrops* sp.) of Indian Himalayan region. The entomopathogenic bacteria and fungi tested against the white grubs recorded mortality of less than 25% while, two strains of entomopathogenic nematode (*Heterorhabditis indica*) recorded mortality of more than 70%. The median lethal dose and median lethal time estimation showed LD_{50} value of 1230.27 Infective Juveniles (IJs)/ml and 891.25 IJs/ml against the grubs of *A. bengalensis* for commercial and native strain of EPN respectively (**Table**). While, for the grubs of *Sophrops* sp. LD_{50} value of 1023.29 IJs/ml and 954.99 IJs/ml were obtained for commercial and native strains, respectively.The obtained LT_{50} values were 70.79 hrs and 91.20 hrs for *A. bengalensis* grubs and 74.13 hrs and 77.62 hrs for *Sophrops* sp. grubs with commercial and native strains of EPN, respectively (Table).Overall, among all the tested entomopathogens, the *H. indica* (both commercial and native strain) showed good potential for biological control of grubs of *A. bengalensis* and *Sophrops* sp. under NW Himalayan conditions.

Table 57. Lethal dose of entomopathogenic nematodes against first larval instars of white grubs at Experimental farm, ICAR-VPKAS, Hawalbagh, Almora, Uttarakhand

White grub species	Entomopathogenic nemtode	Linear equation (Y= ax+b)	Slope±SE	χ^2	LD_{50} (IJs)	LD_{90} (IJs)
Anomala bengalensis	*H. indica* (Commercial strain)	Y=1.95x-1.02	1.95±0.2	0.91	1230.27	5495.41
	H. indica (Native strain)	Y=2.69x-2.93	2.69±0.06	0.99	891.25	2630.27
Sophrops sp.	*H. indica* (Commercial strain)	Y=1.67x-0.02	1.67±0.11	0.96	1023.29	5888.44
	H. indica (Native strain)	Y=2.09x-1.23	2.09±0.12	0.97	954.99	3890.45

Table 58. Lethal time of entomopathogenic nematodes against first larval instars of white grubs at Experimental farm, ICAR-VPKAS, Hawalbagh, Almora, Uttarakhand

White grub species	Entomopathogenic nemtode	Linear equation (Y= ax+b)	Slope±SE	χ^2	LT_{50} (inhrs)	LT_{90} (inhrs)
Anomala bengalensis	*H. indica* (Commercial strain)	Y=2.71x-0.02	2.71±0.08	0.99	70.79	208.93
	H. indica (Native strain)	Y=2.54x+0.01	2.54±0.22	0.93	91.20	295.12
Sophrops sp.	*H. indica* (Commercial strain)	Y=2.64x+0.06	2.64±0.11	0.98	74.13	229.09
	H. indica (Native strain)	Y=3.26x-1.16	3.26±0.2	0.97	77.62	190.55

Host range of pleurostictscarabaeid fauna

To know the host preferences of the pleurostict scarab beetles, the host plant infested by the adults were surveyed during both day as well as night hours.

Table 59. Preferred host plant of pleurostrict scarab beetles.

Name of species	Host plants
Chiloloba acuta	*Ligustrum nepelensis, Zinnia elegans*
Clinteriaklugi	*Ligustrum nepelensis, Zinnia elegans*
Glycosia tricolor	*Zinnia elegans*
Oxycetonia versicolor	*Ligustrum nepelensis, Zinnia elegans, Rosa indica*
Oxycetoniajucunda	*Ligustrum nepelensis, Zinnia elegans*
Apogoniasetosa	*Rosa indica, Ligustrum nepalensis, Largestroemia indica*
Asactopholismicrosquamosus	*Largestroemia indica*
Brahmina coriacea	*Carya illinoinesis, Rosa indica*
*Brahmina*sp.	*Carya illinoinesis, Largestroemia indica*
Chrysosericastebnickae	*Sapium*sp., *Rosa indica*
Holotrichia longipennis	*Sapium*sp., *Caryaillinoinesis, Rosa indica, Largestroemia indica, Helianthus annuus, Juglans regia*
Holotrichia rosettae	*Sapium* sp., *Juglans regia, Largestroemia indica, Carya*

	illinoinesis, Ligustrum nepalensis, Rosa indica, Helianthus annuus
Holotrichia setticollis	*Rosa indica, Helianthus annuus, Dalbergia sisso, Cedrus deodara, Thuja occidentalis, Sapium*sp., *Largestroemia indica*
Holotrichia sp.	*Rosa indica, Largestroemia indica, Carya illinoinesis*
Idionycha excise	*Rosa indica, Largestroemia indica*
Maladera iridescens	*Rosa indica, Zinnia elegans, Largestroemia indica, Ligustrum nepalensis*
Maladera marginella	*Rosa indica*
Maladera similana	*Rosa indica, Helianthus annuus, Tagetes erecta, Solanum tuberosum, Zinnia elegans, Hibiscus rosa-sinensis, Sapium*sp., *Largestroemia indica, Carya illinoinesis, Ligustrum nepalensis, Juglans regia*
Maladera sp. 1	*Rosa indica, Largestroemia indica¸ Zinnia elegans*
Maladera sp. 2	*Rosa indica¸ Zinnia elegans*
Sophrops sp. 1	*Carya illinoinesis, Rosa indica*
Sophrops sp. 2	*Carya illinoinesis, Rosa indica, Sapium*sp., *Largestroemia indica, Ligustrum nepalensis, Helianthus annuus, Hibiscus rosa-sinensis, Juglans regia*
Adoretus nasalis	*Rosa indica, Zinnia elegans, Largestroemia indica*
Adoretus simplex	*Rosa indica, Helianthus annuus, Zinnia elegans, Sapium*sp., *Largestroemia indica, Carya illinoinesis, Ligustrum nepalensis, Hibiscus rosa-sinensis, Juglans regia*
Adoretus sp.	*Rosa indica, Zinnia elegans*
Adoretusversutus	*Rosa indica, Helianthus annuus, Zinnia elegans, Sapium*sp., *Largestroemia indica, Carya illinoinesis, Ligustrum nepalensis, Hibiscus rosa-sinensis, Juglans regia*
Anomala bengalensis	*Ligustrum nepalensis, Largestroemia indica, Carya illinoinesis*
Anomala dimidiata	*Largestroemia indica, Rosa indica, Ligustrum nepalensis*
Anomala lineatopennis	*Ligustrum nepalensis, Largestroemia indica*
Anomala rufiventris	*Ligustrum nepalensis*
Anomala rugosa	*Ligustrum nepalensis, Largestroemia indica*
Anomala tristis	*Ligustrum nepalensis*
Anomala varicolor	*Ligustrum nepalensis, Largestroemia indica, Carya illinoinesis*
Anomala xanthoptera	*Ligustrum nepalensis, Largestroemia indica*

Analysis of the gut bacterial diversity of native white grub species

The gut microbial diversity of four notorious white grub species *i.e.*, *A. bengalensis, H. longipennis, H. seticollis* and *B. coriacea* were carried. A total of 45 bacteria isolated from the gut of white grubs were selected for identification through

molecular characterization. The sequences obtained from PCR products of gut bacterial isolates were submitted to GenBank, NCBI and assigned accession numbers.

Cellulolytic bacteria isolated from white grubs

A total twenty-five cellulolytic bacteria isolated from the different regions of the gut of white grub species, *A. bengalensis*, *H. longipennis*, *H. seticollis*, and *B. coriacea* were selected for identification through 16s rRNA sequencing and the phylogenetic tree was constructed using MEGA X software (Fig 5).

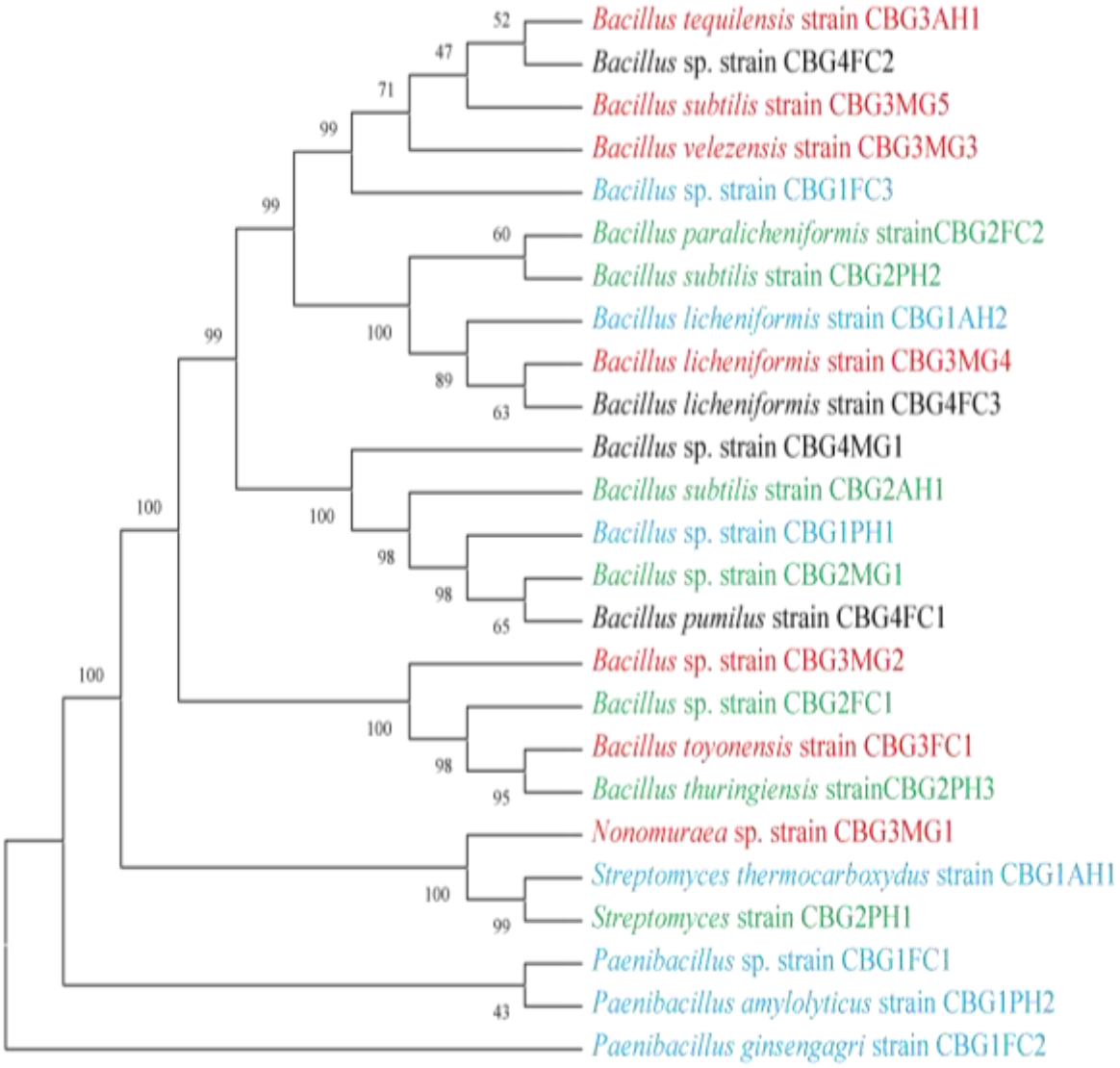


Fig. 35. Phylogenetic tree showing evolutionary relationship of cellulolytic bacteria isolated from gut of white grubs. Bacteria isolated from the gut of *A. bengalensis*, *H. longipennis*, *H. seticollis* and *B. coriacea* are highlighted with blue, green, red and black colour, respectively

Chitinolytic bacteria isolated from white grubs

Twenty bacterial isolates from different compartments of the gut of selected white grub species showed chitinolytic activity. The gut bacterial pure culture was selected for identification through 16s rRNA sequencing and the phylogenetic tree was constructed using MEGA X software.

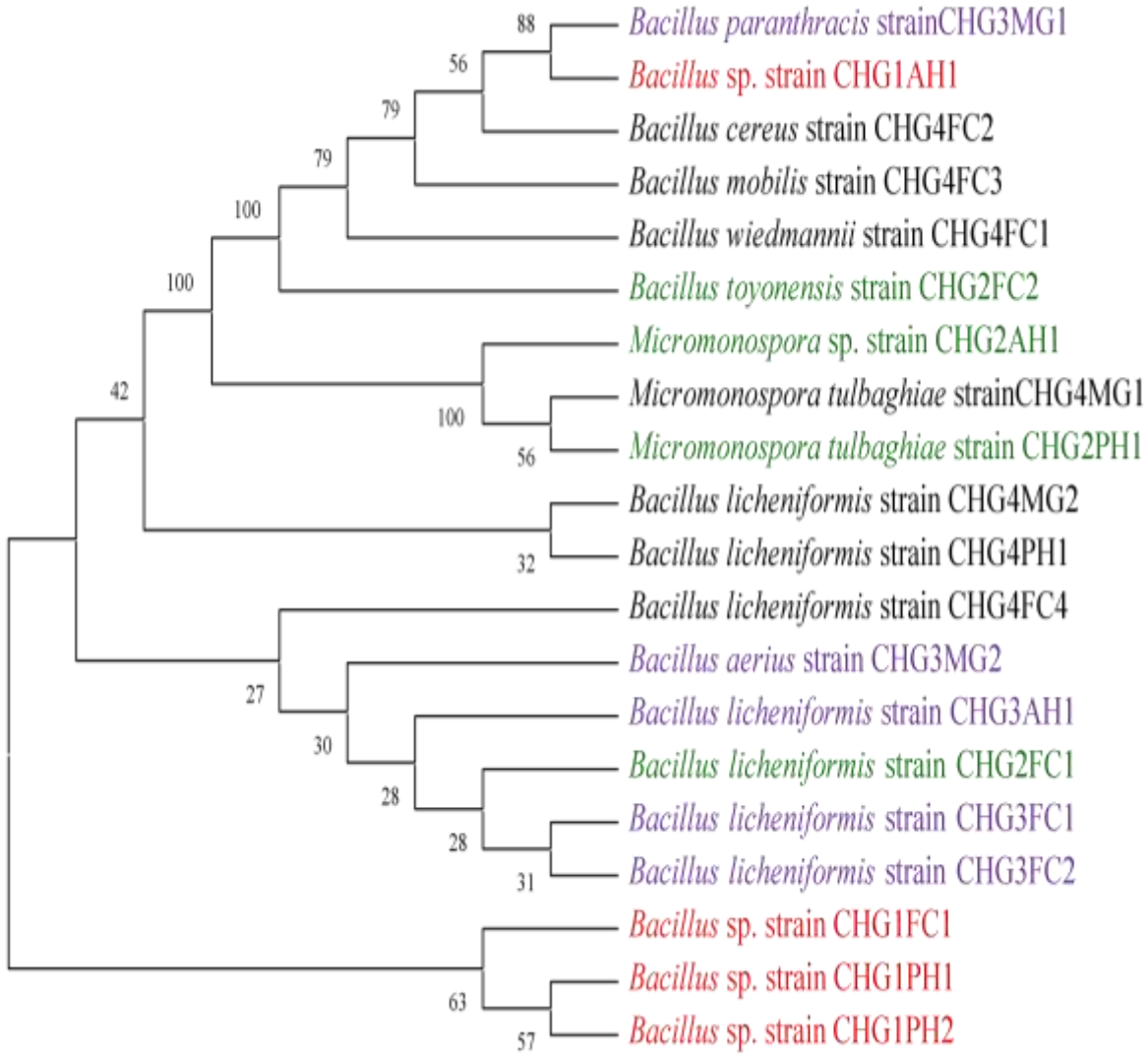


Fig. 36. Phylogenetic tree showing evolutionary relationship of cellulolytic bacteria isolated from gut of selected white grub species. Bacteria isolated from the gut of *A. bengalensis, H. longipennis, H. seticollis*and *B. coriacea* are highlighted with red, green, purple and black colour, respectively

SECTION 3

MANAGEMENT OF WHITE GRUBS THROUGH CHEMICALS

- **Evaluation of granular insecticides against white grub (drenching in standing crop)**

  i. Potato: Jorhat (pre-sowing), Palampur (post-sowing), Pantnagar

  ii. Soybean: Pantnagar (pre-sowing as well as post-sowing)

  iii. Groundnut: Durgapura

  iv. Sugarcane: Kolhapur, Ghaziabad, Pantnagar

- **Evaluation of insecticides against white grub (Seed treatment/Soil/Furrow aplication/ Drenching)**

  i. Potato & Rajma: Palampur

  ii. Areca nut: Bangalore (entire garden covering)

  iii. Soybean: Pantnagar, Kolhapur

  iv. Groundnut: Durgapura, Kolhapur

  v. Colocasia: Jorhat

  vi. Sugarcane: Kolhapur, Ghaziabad, Pantnagar (Sett treatment)

RARI, Durgapura

Management of whitegrub in groundnut crop through soil treatment with granular insecticide

For control of white grub through granular insecticides an experiment were conducted. The data present in **table** indicated that minimum plant mortality and maximum pod yield was recorded in chlorantraniliprole 0.4 % GR with 10.13 % plant mortality and 20.68 q/ha yield followed by imidacloprid 70WG. In untreated control 91.66 per cent plant mortality was recorded.

Design: RBD

Treatments: 7

Replication: 3

Date of sowing: 12 July

Table 60. Evaluation of granular insecticides against white grub, *Holotrichia consanguinea* in groundnut crop during *kharif* (2021-22)

Sr.No.	Treatments	Dose per kg seed	Plant mortality (%)	Larval population /m^2	Pod yield (q/ha)
1	Clothianidin 50 WDG	120 g a.i./ha	46.13 (42.75)	3.00	10.84
2	Fipronil 0.3G	50 g a.i./ha	56.87 (48.95)	3.66	8.73
3	Thiamethoxam 25WG	80 g a.i./ha	72.06 (58.20)	4.66	5.73
4	Imidacloprid 70 WG	300g a.i./ha	13.08 (20.81)	0.33	20.00
5	chlorantraniliprole 0.4% GR*	100 g a.i./ha	10.13 (18.50)	0.33	20.68
6	Fifronil40%+Imidacloprid 40%WG*	300 g/ha	72.84 (58.57)	4.00	4.49
7	Control	750 g a.i./ha	91.66 (73.37)	6.00	1.16
	SE(m)	-	1.986	0.506	0.682
	C.D. at 5%	-	6.08	1.54	2.08
	C.V. %	-	7.28	12.28	12.10

*Data in parentheses are angular transformed values

Evaluation of some insecticides used as seed dresser against whitegrub, *Holotrichia consanguinea* in groundnut crop during *kharif* (2021-22)

To protect the groundnut crop against whitegrub different insecticides were evaluated by using them as seed dresser. Perusal of the data in **table** indicated that imidacloprid 600 FS at 6.5 ml/kg seed and clothianidin 50 WDG at 2 g/kg seed were found superior to all the other tested insecticides, with minimum 8.50 and 9.66 per cent plant mortality and maximum 28.04 and 26.49 q/ha pod yield, respectively. Larval population was found 0.33 larvae/m^2 in both the treatment. In untreated control 92 per cent plant damage was recorded**.**

Design: RBD

Treatments: 8

Replication: 3

Date of sowing: 12 July

Table 61. Evaluation of some insecticides used as seed dresser against whitegrub, *Holotrichia consanguinea* in groundnut crop during *kharif* (2021-22)

Sr.No.	Treatments	Dose per kg seed	Plant mortality (%)	Larval population /m^2	Pod yield (q/ha)
1	Imidacloprid 17.8 SL	3.0 ml	22.99 (28.61)*	0.66	23.12
2	Thiamethoxam 30 FS	4.0 ml	74.89 (59.96)	2.66	7.27
3	Fipronil 5 SC	8.0 ml	80.80 (64.06)	3.33	5.40
4	Clothianidin 50 WDG	2.0 g	9.66 (18.09)	0.33	26.49
5	Imidacloprid 600 FS	6.5 ml	8.50 (16.94)	0.33	28.04
6	Chlorantraniliprole 18.5 SC	2.0 ml	56.96 (48.99)	2.66	10..28
7	Fipronil 40% + Imidacloprid 40%	3.0 g	49.05 (44.44)	2.33	10.06
8	Control	-	92.00 (73.62)	5.66	8.00
	SE(m)	-	1.304	0.292	1.187
	C.D. at 5%	-	3.99	0.89	3.63
	C.V. %	-	9.09	12.48	11.75

*Data in parentheses are angular transformed values

Evaluation of some insecticides used against whitegrub, *Holotrichia consanguinea* in standing crop of groundnut during *kharif* (2021-22)

For the management of white grubs, if farmer escapes the seed treatment at the time of sowing done after the monsoon rain or in early sowing of the groundnut crop than standing crop treatment is required within 21 days of mass emergence of beetles. For this purpose an experiment was conducted to evaluate different insecticides applied as standing crop of groundnut. It was found that application of imidacloprid 17.8 SL @ 360 ml/ha and chlorantraniliprole 18.5 SC @ 500 ml/ha was found significant to all the other tested insecticides in respect to protection as well as production. However, in these treatments 13.29 & 14.58 per cent plant mortality were observed. The maximum yield were recorded in similar manner with 25.68 and 23.95 q/ha, respectively. In untreated control 91.0 per cent plant mortality was observed.

Table 62. Evaluation of some insecticides used against whitegrub, *Holotrichia consanguinea* in standing crop of groundnut crop during *kharif* (2021-22)

Sr.No.	Treatments	Dose per ha	Plant mortality (%)	Larval population /m^2	Pod yield (q/ha)
1	Imidacloprid 17.8 SL	360 ml	13.29 (21.28)	0.33	25.68
2	Thiamethoxam 30 FS	600 ml	72.47 (58.34)	3.33	5.51
3	Fipronil 5 SC	3.0 lit.	44.16 (41.61)	2.33	13.02
4	Clothianidin 50 WDG	300 g	45.58 (42.43)	3.00	13.63
5	Imidacloprid 600 FS	1042 ml	51.49 (45.84)	2.33	12.13
6	Chlorantraniliprole 18.5 SC	500 ml	14.58 (22.41)	0.33	23.95
7	Fipronil 40% + Imidacloprid 40%	500 g	36.59 (37.16)	2.66	15.19
8	Control	_	91.00 (72.56)	6.00	0.81
	SE(m)	-	1.471	0.420	72.187
	C.D. at 5%	-	4.50	1.28	221.07
	C.V. %	-	5.96	14.63	9.09

*Data in parentheses are angular transformed values

AAU, Jorhat

Evaluation of granular insecticides against white grubs in potato

Out of six different insecticides tested against the 3rd instar grubs of white grub, *Lepidiotamansueta* during 2017-20, the soil application of clothianidin 50 WDG @120 g *a.i.*/ha (0.5g/lit. of water) recorded lowest per cent of tuber damage as well as maximum yield. Hence, this technology has already been approved and recommended for the inclusion in the package of practices for *Rabi* crops of Assam.

CSK-HPKV, Palampur

Evaluation of granular insecticides against white grub:

Experiment Details:

Location	Sazar, District Shimla
Crop	Potato cv Kufri Jyoti
Sowing time	10 April, 2021
Design	RBD
Date of treatment	24-06-2021
Treatments	6
Replications	4
Date of harvesting	24 October, 2021

The experiment was conducted in potato fields in Shimla hills. Potato cv Kufri Jyoti was sown in plots of 12 m^2 in the month of April. The crop was raised as per recommended package of practices. All the treatments were applied in the first week of July at the time of earthing up. Data on tuber damage on number and weight basis were recorded at the time of harvesting in October 2021 to calculate the per cent tuber damage. Grub population was also recorded and expressed as number of grubs/m^2. Among all the tested insecticides, clothianidin 50 WDG was found most effective with least tuber damage on weight basis (4.86%) and number basis (5.36%).

Table 63. Evaluation of granular insecticides against white grubs in potato during 2021

S. No.	Treatment	Dose	Per cent tuber infestation		No. of grubs/m^2
			Wt. basis	No. basis	
1	Imidacloprid 17.8 SL	60g a.i./ha	6.03	6.63	3.33
2	Thiamethoxam 30 FS	150g a.i./ha	8.00	8.66	5.33
3	Fipronil 5SC	-	8.56	9.23	4.00
4	Clothianidin 50 WDG	125 g a.i./ha	4.86	5.36	1.66
5	Imidacloprid 600 FS	1000 a.i./ml/ha	6.80	7.20	6.00
6	Chlorantraniliprole18.5 SC*	-	5.30	5.86	2.33
7	Fipronil 40%+Imidacloprid 40%WG*	300 g/ha	9.46	10.10	5.66
8	Control		19.26	20.40	9.33
	CD (0.05)		1.97	2.28	2.54

Fipronil 40%+ imidacloprid 40% was least effective among all the tested insecticides and per cent tuber infestation of 9.46% and 10.10% was recorded on weight and number basis, respectively.

On weight basis, thiamethoxam, imidacloprid and chlorantraniliprole yielded 8.0, 6.03 and 5.30 % tuber damage. In untreated check, 19.26 % tubers were found damaged. Maximum number of grubs (6.00 grubs/m^2) was recorded in imidacloprid 600FS treatment while least number of grubs (1.66 grubs/ m^2) was recorded in clothianidin treatment.

Management of white grub in rajmash in Barot valley through seed treatment

Different insecticides were evaluated through seed treatment against white grubs in rajamsh in Barot valley of district Mandi. Observations on per cent plant damage were recorded after three weeks of treatment.

The per cent plant damage was minimum (6.8%) in clothianidin 50 WDG with 2.33 grubs/m^2 followed by chlorantraniliprole18.5 SC with 7.2% plant damage and 3.0 grubs/m^2 whereas, in control 19.96 % plant damage was recorded with with 12.67 grubs/m^2.

Table 64. Management of white grub in rajmash in Barot valley through seed treatment after three weeks of treatment

Treatments	Dose (g/ml per kg seed)	Plant damage (%)	Mean no. of grubs/ m^2
Imidacloprid 17.8 SL	48 g a.i./ha	15.467	5.667
Thiamethoxam 30 FS	80 g a.i./ha	12.800	5.000
Fipronil 5SC	50 g a.i./ha	12.600	6.000
Clothianidin 50 WDG	80 g a.i./ha	6.800	2.333
Imidacloprid 600 FS	500 g a.i./ml/ha	12.067	6.333
Chlorantraniliprole18.5SC	100 g a.i./ha	7.200	3.000
Fipronil 40% + Imidacloprid 40% WG	3g per kg seed	14.767	8.667
Control		19.967	12.667
CD (0.05)		2.073	2.351

GKVK, Bengaluru

Evaluation of insecticides against white grub as seed/soil furrow application and drenching in standing crop:

Arecanut:

First instar grubs are the most vulnerable ones to insecticides. Majority of the new generation grubs will be in their first instar during the third week of September. Therefore, insecticide application was synchronized with that time and the treatments on whole farm basis covering the entire garden using Rose-Can sprayer were imposed.

Methodology:

The trial for testing insecticides under field conditions was laid out in seven locations belonging to Shivamogga, Chikkamagalur and Uttara and Dakshina Kannada districts against *L. lepidophora* and *L. burmeisteri*. In addition, treatments were also

imposed in a farm near Moodabidri, Dakshina Kannada. However, the observations were made only at four locations listed in the results tables.

The insecticides were applied during first fortnight of September, 2021 in Shivamogga and Chikkamagalur district against *L. lepidophora*, where as in Dakshina Kannada during Agust, 2021 against *L. burmeisteri*. All the insecticides were applied only once. Pre-counts of first instar grubs were recorded prior to application of insecticide from the field. Soon after the application of insecticides all the plots were irrigated to facilitate the percolation of the chemicals in the soil. The post–treatment observation (the number of third instar grubs/palm) was recorded during August/ September, 2021 for *L. burmeisteri* and November, 2021 for *L. lepidophora*. The grubs sampled in ¼ area around the palm upto 30-45 cm depth.

Results:

The post treatment counts were recorded from four gardens in Thirthahally taluk. All the insecticides performed better in reducing the grub population. The per cent reduction of grubs over control ranged from 35 to 55. However, in one of the fields (Halyapura) insecticides did not show any impact on grub population. The results of the trials are given in the **Tables**.

Table 65. Results of the insecticidal trials against *L. lepidophora* at Kanukoppa, Thirthahalli taluk, Shivamogga District

Insecticide	Dose	No. of grubs per palm	% Reduction over control
Imidacloprid 17.8 SL	178 g a.i	4.13 ± 1.78	29.64
Chlorantraniliprole 18.5 % SC	30 g a.i	3.56 ± 2.64	39.35
Chlorpyriphos 20 % EC	800 g a.i	3.21 ± 1.54	45.31
Untreated control	-	5.87 ± 2.31	-

Pre-treatment counts: 7.47 ± 2.32 /sq.m (n=30)

Table 66. Results of the insecticidal trials against *L. lepidophora* at Madalu, Thirthahalli taluk, Shivamogga District

Insecticide	Dose	No. of grubs per palm	% Reduction over control
Imidacloprid 17.8 SL	178 g a.i	3.84 ± 1.56	47.68
Chlorantraniliprole 18.5 % SC	30 g a.i	3.29 ± 2.21	55.17
Chlorpyriphos 20 % EC	800 g a.i	3.53 ± 1.13	51.90
Untreated control	-	7.34 ± 2.16	-

Pre-treatment counts: 11.27 ± 2.42/ sq.m (n=30)

Table 67. Results of the insecticidal trials against *L. lepidophora* at Halyapura, Thirthahalli taluk, Shivamogga District

Insecticide	Dose	No. of grubs per palm	% Reduction over control
Imidacloprid 17.8 SL	178 g a.i	2.34 ± 1.32	- 6.36
Chlorantraniliprole 18.5 % SC	30 g a.i	2.76 ± 1.19	-25.45
Chlorpyriphos 20 % EC	800 g a.i	2.54 ± 2.21	-15.45
Untreated control	-	2.2 ± 1.81	

Pre-treatment counts: 5.47 ± 2.64 / sq.m (n=30)

Table 68. Results of the insecticidal trials against *L. burmeisteri* at Laxmipura, Thirthahalli taluk, Shivamogga District.

Insecticide	Dose	No. of grubs per palm	% Reduction over control
Imidacloprid 17.8 SL	178 g a.i/ha	2.67 ± 1.45	57.41
Chlorantraniliprole 18.5 % SC	30 g a.i	4.13 ± 1.42	34.13
Chlorpyriphos 20 % EC	800 g a.i	3.16 ± 1.34	49.60
Untreated control	-	6.27 ± 1,78	-

Pre-treatment counts: 9.53 ± 2.22 / sq.m (n=30)

Conclusion:

Despite reduction in the larval density of white grubs due to insecticides in the fields the constraints associated with chemical applications have prompted farmers to adopt non-chemical method of management ie., digging and removal of grown-up larvae from the soil.

FARMER - GHAZIABAD

Evaluation of some insecticides against white grub as drenching in standing crop

Methodology:

The surveys for monitoring of white grub population on sugarcane crop were conducted after 30 days of sowing at Dabana village, Ghaziabad district in Uttar Pradesh (GPS location: N 28^0 50'12.4908" E $77^0$30'00.4140) at farmers' field (Name: Mr. Gagender Choudhary). Infestation of white grub (*Holotrichia serrata*) was recorded from each point in target experimental field. The per square meter 6-9 grub population was recorded. After this observation, one experiment for the management of white grub through drenching in standing crop (post sowing) by using chemicals have been laid down in sugarcane crop field as per technical programme 2021-22.

Experimental details:

Test insect: *H. serrata*

Location: Ghaziabad (Post sowing) GPS location: N 28^0 50'12.4908" E $77^0$30'00.4140

Sowing time: As per recommended package of practices (April 2021)

Design: RBD

Replication: 3

Crop: Sugarcane, Variety: 0238

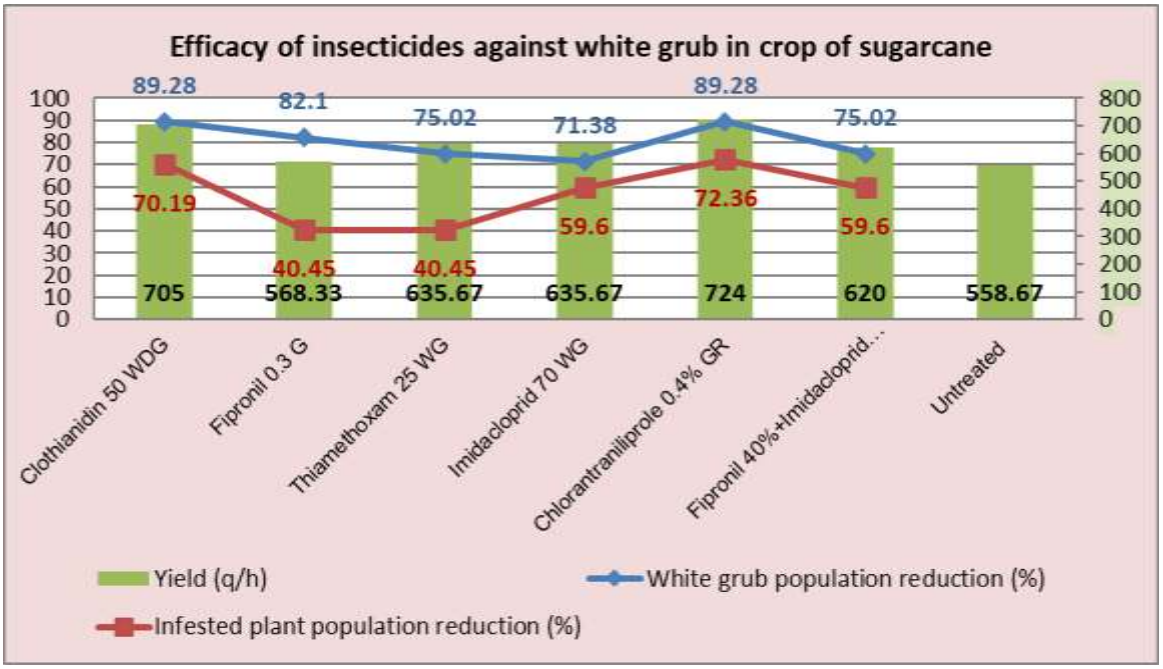
Fertilizers: at recommended doses
Treatments: 7 in standing crop after 30 days of sowing
Observations: Plant mortality (%), Larval population/m^2, Yield (q/ha)
Data subjected to analysis of variance

Evaluation of six insecticides against white grub as drenching in standing crop of sugarcane

S.N.	Treatments	Active ingredients/ha
T1	Clothianidin 50 WDG	500 g a.i. ml/ha
T2	Fipronil 0.3 G	80 g a.i./ha
T3	Thiamethoxam 25 WG	100 g a.i./ha
T4	Imidacloprid 70 WG	80 g a.i./ha
T5	Chlorantraniliprole 0.4% GR	500 ml/ha
T6	Fipronil 40%+Imidacloprid 40% WG	3 g/kg seed
T7	Untreated check	

Table 69. Efficacy of six insecticides against white grub as drenching in standing crop of sugarcane

Treatments	White grub population (BT)	White grub population (AT)	White grub population reduction (%)	Infested plant population (BT)	Infested plant population (AT)	Infested plant population reduction (%)	Yield (Q/H)
Clothianidin 50 WDG	8.00	1.00	89.28	12.67	4.67	70.19	705.00
Fipronil 0.3 G	7.00	1.67	82.10	13.67	9.33	40.45	568.33
Thiamethoxam 25 WG	8.00	2.33	75.02	10.33	9.33	40.45	635.67
Imidacloprid 70 WG	8.00	2.67	71.38	11.33	6.33	59.60	635.67
Chlorantraniliprole 0.4% GR	7.00	1.00	89.28	11.67	4.33	72.36	724.00
Fipronil 40%+Imidacloprid 40% WG	8.33	2.33	75.02	13.00	6.33	59.60	620.00
Untreated check	8.00	9.33		13.33	15.67		558.67
SE(m)	0.49	0.30		1.05	0.53		26.58
C.D.	N/A	0.93		N/A	1.65		82.81
C.V.	10.89	17.88		14.86	11.46		7.25



Results:

After 15 days of treatment the reduction in white grub population and reduction in infested plant population was recorded in all treatment with increase in yield in comparison to control.

The reduction in white grub population was maximum 89.28% in Clothianidin 50 WDG and Chlorantraniliprole 0.4% GR, 82.10% in Fipronil 0.3G,75.02% in Thiamethoxam 25 WG &Fipronil 40%+Imidacloprid 40% WG, 71.38% in Imidacloprid 70 WG.

Reduction in infested plant population was maximum 72.36% in Chlorantraniliprole 0.4% GR, 70.19% in Clothianidin 50 WDG, 59.60% in Fipronil 40%+Imidacloprid 40% WG & Imidacloprid 70 WG, 40.45% in Fipronil 0.3G & Thiamethoxam 25 WG.

Sugarcane crop yield 724.00 q/h was also recorded higher in Chlorantraniliprole 0.4% GR, 705.00 q/h in Clothianidin 50 WDG, 635.67q/h in Thiamethoxam 25 WG&Imidacloprid 70 WG, 620 q/h in Fipronil 40%+Imidacloprid 40% WG and 568.33q/h in Fipronil 0.3G whereas it was only 558.67 q/h in control.

Summary/Conclusion:

On the basis of reduction in white grub population (89.28%), reduction in infested plant population (72.36%) and crop yield (724 q/h), Chlorantraniliprole 0.4% GR showed best results among the 6 insecticides tested against white grub in sugarcane crop field followed by Clothianidin 50 WDG with 89.28% white grub population reduction, 70.19% plant population reduction and higher 705 q/h crop yield.

Evaluation of some insecticides against white grub as seed dresser application and drenching in standing crop

Methodology:

An experiment was conducted at Dabana village of Ghaziabad district (GPS Location: N 28^0 50'15.864" E $77^0$30'04.032) in farmers' (Name: Mr. Gagender Choudhary) field to investigate the comparative efficacy of seven insecticides against the grub of *H. serrata* during 2021-2022. The desired amounts of insecticides were used for setts treatment at the time of sowing and drenching in standing crop after 50 days of sowing. Sugarcane crop (variety: 0238) was raised by following all the recommended package of practices. The setts were planted in April 2021 and harvested March 2021. The efficacy of different treatments was recorded on the basic of plant mortality (%), larval population/m^2, yield (q/ha).

Experimental details:

Test insect: *H. serrata*
Location: Ghaziabad (Post sowing)
Sowing time: As per recommended package of practices (April 2021)
Design: RBD
Replication: 3
Crop: Sugarcane, Variety: 0238
Fertilizers: at recommended doses
Treatments: Sett's treatments by 7 chemicals were done at the time of sowing and drenching in standing crop done after 30 days of sowing
Observations: Plant mortality (%), Larval population/m^2, Yield (q/ha)
Data subjected to analysis of variance.

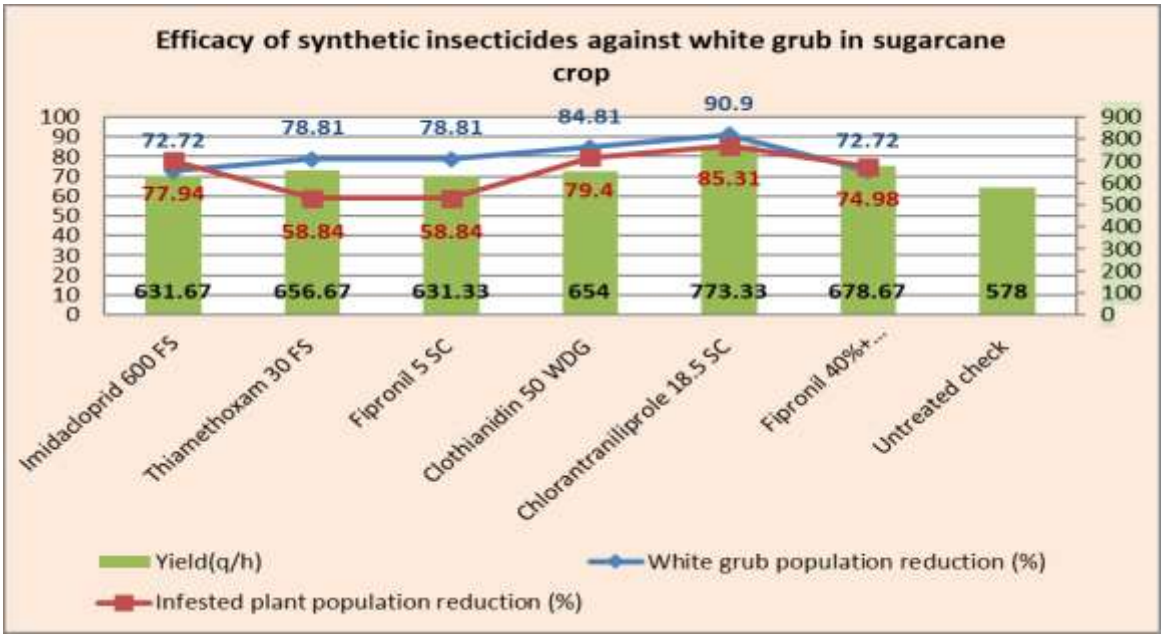
Chemicals used for setts treatment and drenching in standing crop of sugarcane

S.N.	Treatments	Sett's treatment At the time of sowing	Drenching in standing crop after 30 days of sowing
T1	Imidacloprid 600 FS	500 g a.i. ml/ha	1000g a.i. ml/ha
T2	Thiamethoxam 30 FS	80 g a.i./ha	150 g a.i./ha
T3	Fipronil 5 SC	100 g a.i./ha	150 g a.i./ha
T4	Clothianidin 50 WDG	80 g a.i./ha	125 g a.i./ha
T5	Chlorantraniliprole 18.5 SC	500 ml/ha	500 ml/ha
T6	Fipronil 40%+ Imidacloprid 40% WG	3 g/kg seed	300 g /ha
T7	Untreated check		

Fig. 37. Sugarcane sowing after setts treatments by insecticides in Ghaziabad

Table 70. White grub population, infested plant population and yield after setts treatment and drenching in standing crop of sugarcane

Treatments (Dose)	White grub population (BT)	White grub population (AT)	White grub population reduction (%)	Infested plant population (BT)	Infested plant population (AT)	Infested plant population reduction (%)	Yield (Q/H)
Imidacloprid 600 FS	8.33	3.00	72.72	11.33	5.00	77.94	631.67
Thiamethoxam 30 FS	7.00	2.33	78.81	13.67	9.33	58.84	656.67
Fipronil 5 SC	8.00	2.33	78.81	10.33	9.33	58.84	631.33
Clothianidin 50 WDG	7.33	1.67	84.81	12.67	4.67	79.40	654.00
Chlorantraniliprole 18.5 SC	6.33	1.00	90.90	13.00	3.33	85.31	773.33
Fipronil 40%+ Imidacloprid 40% WG	8.00	3.00	72.72	11.67	5.67	74.98	678.67
Untreated check	8.00	11.00		13.33	22.67		578.00
SE(m)	0.36	0.30		1.00	0.75		2.60
C.D.	1.11	0.95		N/A	2.32		8.09
C.V.	8.15	15.16		14.86	15.06		0.68



Results:

After 15 days of treatment the reduction in white grub population and reduction in infested plant population was recorded in all treatment with increase in yield in comparison to control.

The reduction in white grub population was maximum 90.90% in Chlorantraniliprole 18.5SC GR followed by 84.81% in Clothianidin 50 WDG, 78.81% in Thiamethoxam 30 FS & Fipronil 5SC and 72.72% in Imidacloprid 600 FS and Fipronil 40%+Imidacloprid 40% WG.

Reduction in infested plant population was highest 85.31% in Chlorantraniliprole 18.5 SC, 79.40% in Clothianidin 50 WDG, 77.94% in Imidacloprid 600 FS, 74.98% in Fipronil 40%+Imidacloprid 40% WG, 58.84% in Thiamethoxam 30FS and Imidacloprid 600 FS.

Sugarcane crop yield 773.33 q/h was also recorded higher in Chlorantraniliprole 18.5 SC, 678.67 q/h in Clothianidin 50 WDG, 656.67q/h in Fipronil 40%+Imidacloprid 40% WG. 654q/h in Imidacloprid 600 FS, 631.67q/h in Fipronil 5 SC, 631.33 q/h in Thiamethoxam 30 FS whereas it was only 578.0 q/h in control.

Summary /conclusion:

On the basis of reduction in white grub population (90.90%), reduction in infested plant population (85.31%) and crop yield (773.33q/h), Chlorantraniliprole 18.5 SC showed best results among the 6 insecticides tested against white grub in sugarcane crop field

followed by Clothianidin 50 WDG with 84.81% white grub population reduction, 79.40% plant population reduction and higher 678.67q/h crop yield.

KOLAHAPUR, MAHARASHTRA

Evaluation of some insecticides against white grub

Experimental details:					
Crop	:	Sugarcane			
Season	:	*Suru*			
Design	:	RBD			
No. of replications	:	03			
No of Treatments	:	08			
Plot size	:	5 x 5 m^2			
Treatment details	:				

Treatments		Plains g.a.i./ha		Formulation / ha	
		Seed / soil furrow application (At sowing)	Drenching in standing crop (post sowing)	Soil furrow application (At sowing)	Drenching in standing crop (post sowing)
T_1	Imidacloprid 17.8 SL	-	-	500 ml	500 ml
T_2	Thiamethoxam 30 FS	80	150	2.67 kg	5.00 kg
T_3	Fipronil 5SC	100	150	0.20 kg	0.30 kg
T_4	Clothianidin 50WDG	80	125	26.67 kg	41.67 kg
T_5	Imidacloprid 600 FS	500	1000	2.00 kg	4.00 kg
T_6	Chlorantraniliprole 18.5 SC	500 ml/ha	500 ml/ha	500 ml	500 ml/ha
T_7	Fifronil 40% + Imidacloprid 40 %WG	3 g/kg seed	300 g/ha	3 g/kg seed	300 g/ha
T_8	Untreated check	--	--	--	--

Seed rate /ha	:	10,000 sets
Date of sowing / transplanting	:	12.01.2021
Date of application	:	01.03.2021
Date of termination of experiment	:	15.03.2022
FYM & Fertilizer	:	25 t & 250:150:150 NPK kg/ha

Method of recording observations:

The granular application of insecticides was done at planting of sugarcane and drenching was done in standing crop at the time of earthling up i.e., 75 days after planting. The observations on damaged clump were recorded 30, 45, 60 and 75 DAP. The number of white grub per m^2 was recorded after harvest of the crop. The clump mortality data and number of grubs per m^2 were angularly transformed and subjected to analysis of variance.

Results:

The clump mortality ranged from 2.51 to 8.54 per cent in various treatments as compared to 11.17 in untreated control when observations were recorded at 40 DAT. All the insecticidal treatments found significantly superior over untreated control. The treatment

with Fifronil 40% + Imidacloprid 40 %WG @ 3 g/ha was found to be superior where 2.51 per cent clump mortality was recorded. However, it was on par with the treatment with Chlorantraniliprole 18.5 SC @ 500ml/ha (4.30 %).

The mortality of the sugarcane clump ranged from 3.43 to 10.77 per cent in various treatments as compared to 15.01 per cent in untreated control when observations were recorded 60 DAT. The treatment with Imidacloprid 40% + Fipronil 40%-80WG 3g/ha was found to be consistently superior over all other insecticidal treatments and recorded 3.43 per cent clump mortality and was on par with Chlorantraniliprole 18.5 SC @ 500ml/ha and Clothianidin 50 WDG @ 80 g a.i./ha with 5.27 per cent and 6.47 per cent clump mortality, respectively. Treatment with Thiamethoxam 70WS @ 80 g. a.i./ha, Fipronil 5% SC@ 100 g.a.i./ha and Imidacloprid 600 FS @500 g a.i./ha were next in order of efficacy.

Treatment with Imidacloprid 40% + Fipronil 40%- 80WG @ 3g/ha and Chlorantraniliprole 18.5 SC @ 500ml/ha were found to be equally effective at 80 DAT where 4.46 and 6.33 per cent clump mortality was recorder, respectively. Treatment with Clothianidin 50 WDG @ 80 g a.i./ha. and Thiamethoxam 70WS @ 80 g. a.i./ha were next in order of efficacy.

Among the treatments Imidacloprid 40% + Fipronil 40%WG 3g/ha recorded highest yield (95.57 t/ha) followed by 84.72 t/ha in the treatment with Chlorantraniliprole 18.5 SC @ 500ml/ha, 83.56 t /ha in Clothianidin 50 WDG @ 80 g a.i./ acre and Imidacloprid 600 FS @500 g a.i./ha (81.93t / ha) as compared to 70.13t / ha in untreated control.

Table 71. Management of white grub, *Leucopholis lepidophora* in Sugarcane through soil treatment /soil furrow application of insecticides

Treatment and dose	Initial plant popln	Per cent Clump mortality (DAS) *				% protection over control	Yield t/ha	No. of grubs/m^2**
		40	60	80	Mean			
Imidacloprid 17.8 SL	634	6.20 (14.42)	7.38 (15.76)	8.42 (16.87)	7.33 (15.71)	52.96	81.93	2.67 (1.78)
Thiamethoxam 30 FS	653	8.54 (16.90)	10.77 (19.16)	12.46 (20.67)	10.59 (18.99)	32.07	79.87	3.00 (1.87)
Fipronil 5SC	645	5.37 (13.40)	7.07 (15.42)	8.40 (16.85)	6.95 (15.28)	55.44	82.6	2.67 (1.78)
Clothianidin 50WDG	642	5.57 (13.65)	6.47 (14.74)	7.50 (15.89)	6.51 14.79)	58.22	83.56	2.33 (1.68)
Imidacloprid 600 FS	598	7.83 (16.25)	9.83 (18.27)	10.53 (18.94)	9.40 (17.85)	39.73	80.58	3.33 (1.96)
Chlorantraniliprole 18.5 SC	647	4.30 (11.67)	5.27 (13.27)	6.33 (14.57)	5.30 (13.31)	66.00	84.72	2.00 (1.58)
Fifronil 40% + Imidacloprid 40WG	658	2.51 (9.10)	3.43 (10.67)	4.46 (12.19)	3.43 (10.73)	77.76	95.57	1.33 (1.35)
Untreated check	644	11.17 (19.52)	15.01 (22.79)	20.60 (26.99)	15.59 (23.26)	0.00	70.13	5.67 (2.48)
S.Em ±	42	1.24	1.48	1.04	1.25	--	2.10	0.05
CD at 5%	NS	3.71	4.45	3.12	3.76	--	6.29	0.16
CV %	10.67	11.78	14.27	12.99	13.76	--	10.72	15.49

*Figures in parenthesis are arcsine transformed values. ** Square root transformed values

SECTION 4

MANAGEMENT OF WHITE GRUBS THROUGH BIOCONTROL AGENTS

RARI, Durgapura

Efficacy of different Entomopathogenic fungi against *H. consanguinea* in groundnut crop during 2021-22

To investigate the field efficacy of different Entomopathogenic Fungi (EPF) against *H. consanguinea***,** a field trial was conducted at RARI, Durgapura during 2021-22. The experiment was conducted in 3 RBD and the individual plot size measured 4×6 sqm. Three different EPF *viz*., *Beauveria brongniartii*, *Metarhizium anisopliae* and *B. bassiana* in unadulterated form along with their combination with farm yard manure (FYM) and an additional insecticidal check were evaluated against *H. consanguinea***,** in groundnut crop. The crop (Variety: RG-510) was raised by following all the recommended package and practices. The efficiency of different treatments was assessed on the basis of plant mortality at 30 and 60 days after sowing (DAS), number of grubs per sq.m. at harvesting and pod yield.

Data revealed that among all the EPF-tested, the combined application of *Metarhizium anisopliae* with FYM registered lowest plant mortality (17.98 and 40.66 per cent at 30 and 60 DAS, respectively) and found significantly superior over rest of the EPF treatments. The plots treated with *Beauveria bassiana* with FYM exhibited 18.55 and 46.33 per cent of plant mortality at 30 and 60 DAS, respectively and this treatment was followed by *Beauveria brongniartii* + FYM (20.45 and 52.00%) and *M. anisopliae* alone (22.21 and 43.00%) treated plots. Comparatively higher plant mortality was observed in the plots treated with *Beauveria brongniartii* sole which recorded 26.23 & 55.00 per cent at 30 and 60 DAS, respectively. The insecticidal check *i.e.* clothianidin 50 WDG @ 2 g / kg seed registered lowest plant mortality (3.99 and 9.33% at 30 and 60 DAS respectively) over all the EPF treatments. The control plots recorded 20.06 and 92.33 per cent of plant mortality caused by *H. consanguinea***,** grubs at 30 and 60 DAS, respectively.

While assessing the mean grub population in different EPF treatments, it was found that the population was ranged between 0.33-7.33 nos./sq. m. The mean grub population recorded in *Metarhizium anisopliae* + FYM, *Beauveria bassiana* + FYM, *Beauveria brongniartii* + FYM *M. anisopliae*, *B. bassiana* and *Beauveria brongniartii* was 2.66, 3.33, 3.33, 3.00, 3.66 /sq. m. The lowest grub population (0.33/ sq.m.) was recorded in the plots treated with clothianidin 50 WDG @ 2 g / kg seed.

Considering the pod yield recorded in different treatments, highest yield was recorded in clothianidin 50 WDG @ 2 g / kg seed (20.16 q/ha) followed by *Metarhizium anisopliae* + FYM, (13.00 q/ha) and *Beauveria bassiana* + FYM, (10.66 q/ha) treated plots. The control plots registered yield of 2.03 q/ha.

Table 72. Efficacy of different Entomopathogenic fungi against *H. consanguinea* in groundnut crop during 2021-22

Treatments	Doses	Initial plant population (Numbers)	Plant mortality (%)		Grub popl^{n}. (No/sqm.)	Pod Yield (q/ha)
			30 DAS	60 DAS		
Metarhizium anisopliae	1×10^{9} CFU per gm/m^{2}	289	22.21 (28.50)*	43.00 (40.95)	3.00	11.00
Metarhizium anisopliae + FYM		299	17.98 (25.07)	40.66 (39.59)	2.66	13.00
Beauveria bassiana		300	24.34 (29.54)	50.33 (45.17)	3.00	10.33
Beauveria bassiana + FYM		291	18.55 (25.50)	46.33 (42.87)	3.33	10.66
Beauveria brongniartii		295	26.23 (30.80)	55.00 (47.86)	3.66	9.50
Beauveria brongniartii + FYM		298	20.45 (26.87)	52.00 (46.12)	3.33	10.13
Clothianidin 50 WDG	2 g./ kg seed	296	3.99 (11.45)	9.33 (17.74)	0.33	20.16
Control	-	293	20.06 (26.59)	92.33 (74.82)	7.33	2.03
S.Em (±)	-	-	0.50	**1.84**	**0.27**	1.72
CD (p=0.05)	-	-	1.53	5.65	**0.81**	5.29

**Figures in parentheses are angular transformed values*

Evaluation of entomopathogenic bacterial strains against *H. consanguinea* in groundnut crop during 2021-2022

Field efficiency of three entomopathogenic bacterial strains against *H. consanguinea* in groundnut crop was studied at farm of RARI, Durgapura during 2021-22. The experiment was conducted 5 RBD and the individual plot size was 4×6 sqm. Variety "RG-510" was grown by following all recommended package and practices. Finally, the efficiency of different treatments were assessed on the basis of per cent plant mortality caused by the grubs, number of grubs per sq. m at the time of harvest and pod yield.

Experimental results indicated that all the treatments were significantly superior over untreated control in reducing the per cent plant damage, number of grubs/ sq. m at the time of harvest and pod yield.

Among the entomopathogenic bacterial strains, the plot treated with NBAIR-BtAN4 strain of *Bacillus thuringiensis* applied @ 3 lit/acre registered lowest plant damage (15.26 & 44.20%) at 30 and 60 DAS followed by NBAIR-Bt25 strain of *B. thuringiensis*

@ 3 lit/acre (17.30 & 49.20%) and NBAIR-BATP strain of *B. albus* @ 2.5 kg of talc + 100 kg of FYM (18.56 & 54.20%). The plots treated with imidacloprid 17.8 SL @ 360 ml./ha and untreated control plots recorded 4.12 & 8.60 % and 29.14 & 93.00 per cent of plant damage at 30 and 60 DAS respectively.

At the time of harvest, imidacloprid 17.8 SL @ 360 ml./ha treated plots effectively reduced the grub population (0.33 nos./sq. m). The number of grubs recorded in NBAIR-BtAN4, NBAIR-Bt25 @ 3 lit/acre and NBAIR-BATP @ 2.5 kg of talc + 100 kg of FYM were 3.33, 3.66 and 3.66 nos./sq. m, respectively. The untreated control plot recorded highest (6.00) number of grubs per sqm.

Among the entomopathogenic bacterial strains tested, NBAIR-BtAN4 strain of *B. thuringiensis* @ 3 lit/acre recorded considerably higher pod yield (10.40 q/ha) as compared to NBAIR-Bt25 strain of *B. thuringiensis* @ 3 lit/acre (9.40 q/ha) and NBAIR-BATP strain of *B. albus* @ 2.5 kg of talc + 100 kg of FYM (9.20 q/ha). However, significantly highest pod yield was recorded in imidacloprid 17.8 SL @ 360 ml./ha treated plots (20.72 q/ha) whereas the untreated control plot registered lowest pod yield of 1.73 q/ha.

Table 73. Evaluation of entomopathogenic bacterial strains against *H. consanguinea* in groundnut crop during 2021-2022

Treatments	**Doses**	**Initial plant population (Numbers)**	**Plant mortality (%)**		**Grub popl^{n}. (No/sqm.)**	**Yield (q/ha)**
			30DAS	**60DAS**		
NBAIR-BtAN4 strain of *Bacillus thuringiensis*	3 lit./acre	291	15.26 (22.98)*	44.20 (41.64)	3.33	10.40
NBAIR-Bt25 strain of *Bacillus thuringiensis*	3 lit./acre	295	17.30 (24.56)	49.20 (44.52)	3.66	9.40
NBAIR-BATP strain of *Bacillus albus*	2.5 kg of talc + 100 kg of FYM	298	18.56 (25.50)	54.20 (47.39)	3.66	9.20
Imidacloprid 17.8 SL	360ml./ha	296	4.12 (11.67)	8.60 (16.92)	0.33	20.72
Untreated control	-	293	29.14 (32.66)	93.00 (75.42)	6.00	1.73
S.Em (±)	-	-	0.31	1.54	0.37	1.11
CD (p=0.05)	-	-	0.92	5.12	1.10	5.35

**Figures in parentheses are angular transformed values*

Evaluation of the bioefficacy of promising EPN's strains against *H. consanguinea* in groundnut crop during 2021-22

Field efficiency of three entomopathogenic nematode strains against *H. consanguinea* in groundnut crop was studied at farm of RARI, Durgapura during 2021-22. The experiment was conducted 4 RBD and the individual plot size was 4×6 sqm. Variety "RG-510" was grown by following all recommended package and practices. Finally, the efficiency of different treatments were assessed on the basis of initial grub population (No/sqm.), grubs population at 15 and 30 days after of EPNs application and pod yield.

Data revealed that among all the EPN strain tested, the strain SBITND78 of *Heterorhabditis indica* @ 10^8 IJs/ac significantly reduced the grubs population by 4.66 and 2.66 at 15 and 30 days after application respectively followed by the EPN strain SBIPS of *Heterorhabditis indica* bacteriophora (4.33 and 3.00), *Steinernema surkhetense* strain SBIP3 (4.66 & 3.33) and lowest grubs population (0.66) was recorded in crop application of imidacloprid 17.8 SL @ 360 ml./ha where the maximum grub population (8.00) was recorded in untreated check.

Considering the pod yield recorded in different treatments, highest yield was recorded in imidacloprid 17.8 SL @ 360 ml./ha (20.90 q/ha) followed *Heterorhabditis indica* strain SBITND78 @ 10^8 IJs/ac, (13.78 q/ha) and *Heterorhabditis indica* bacteriophora strain SBIPS@ 10^8 IJs/ac (12.53 q/ha) treated plots. The control plots registered yield of 1.06 q/ha.

Table 74. Evaluation of the bioefficacy of promising EPN's strains against *H. consanguinea* in groundnut crop during 2021-22

Treatment	Grub popl^n. (No/sqm.) (Before EPNs Application)	Grub popl^n. (No/sqm.) (15 days after EPNs application)	Grub popl^n. (No/sqm.) (30 days after EPNs application)	Pod Yield (q/h)
Heterorhabditis indica strain SBITND78@ 10^8 IJs/ac	7.33	4.66	2.66	13.78
Heterorhabditis indica bacteriophora strain SBIPS@ 10^8 IJs/ac	6.66	4.33	3.00	12.53
Steinernema surkhetense strain SBIP3@ 10^8 IJs/ac	7.00	4.66	3.33	9.31
Steinernema siamkayai strain SBITNT@ 10^8 IJs/ac	7.33	4.33	3.66	8.02
Imidacloprid 17.8 SL @ 360ml./ha	7.00	4.66	0.66	20.90
Control	6.66	7.33	8.00	1.06
S.Em (±)	0.30	0.47	0.24	0.36
CD (p=0.05)	N/A	1.43	0.73	1.07

AAU, Jorhat

Evaluation of different entomopathogenic fungi against *Lepidiota mansueta* in green gram at Majuli during 2021

To investigate the field efficacy of different Entomopathogenic Fungi (EPF) against *L. mansueta*, a field trial was conducted at Maharichuk village, Majuli during 2021. The experiment was conducted in 3 RBD and the individual plot size measured 2×3 sq.m. Three different EPF *viz*., *Beauveria brongniartii*, *Metarhizium anisopliae* and *B. bassiana* in unadulterated form along with their combination with farm yard manure (FYM) and an additional insecticidal check were evaluated against *L. mansueta* in green gram. The crop (Variety: Pratap) was raised by following all the recommended package and practices of Assam. The efficiency of different treatments was assessed on the basis of plant mortality at 30 and 60 days after sowing (DAS), number of grubs per sq.m. at harvesting and yield.

Among all the EPF tested, the combined application of *B. brongniartii* with FYM registered lowest plant mortality (6.18 and 7.41 per cent at 30 and 60 DAS, respectively) and found significantly superior over rest of the EPF treatments (Table and Fig.). The plots treated with *B. brongniartii* alone exhibited 7.34 and 8.37 per cent of plant mortality at 30 and 60 DAS, respectively and this treatment was followed by *M. anisopliae* + FYM (7.99 and 9.11%) and *M. anisopliae* (8.18 and 9.42%) treated plots. Comparatively higher plant mortality was observed in the plots treated with *B. bassiana* in combination with FYM and sole application of *B. bassiana* which recorded 9.73 & 10.83 and 10.14 & 11.10 per cent at 30 and 60 DAS, respectively. The insecticidal check *i.e.* clothianidin 50 WDG @ 120 g *a.i.*/ha registered lowest plant mortality (2.62 and 3.84% at 30 and 60 DAS, respectively) over all the EPF treatments. The control plots recorded 12.99 and 14.16 per cent of plant mortality caused by *L. mansueta* grubs at 30 and 60 DAS, respectively.

While assessing the mean grub population in different EPF treatments, it was found that the population was ranged between 1.33-2.67 nos./sq.m. The mean grub population recorded in *B. brongniartii* + FYM, *B. brongniartii*, *M. anisopliae* + FYM, *M. anisopliae*, *B. bassiana* + FYM and *B. bassiana* was 1.33, 1.67, 2.00, 2.00, 2.67 and 2.67/sq.m. The lowest grub population (0.67/sq.m.) was recorded in the plots treated with clothianidin 50 WDG @ 120 g *a.i.*/ha.

Considering the yield recorded in different treatments, highest yield was recorded in clothianidin 50 WDG @ 120 g *a.i.*/ha (5.45 q/ha) followed by *B. brongniartii* + FYM (5.15 q/ha) andsole application of *B. brongniartii* (5.08 q/ha) treated plots. The control plots registered yield of 4.35 q/ha.


Experimental layout


Mixing of EPF with FYM


View of experimental plots

Fig. 38. Effect of different EPFs against *L. mansueta* in green gram during 2021

Table 75. Efficacy of different Entomopathogenic fungi against *L. mansueta* in green gram at Majuli during 2021

Treatments	Doses	Initial plant population/ plot (Numbers)	Plant mortality (%)		Grub popl^{n}. (No./sq.m.)	Yield (q/ha)
			30 DAS	60 DAS		
Metarhizium anisopliae	1×10^{9} CFU per gm/m^{2}	187.67	8.18 (16.62)	9.42 (17.88)	2.00	4.67
Metarhizium anisopliae + FYM		179.33	7.99 (16.43)	9.11 (17.57)	2.00	4.76
Beauveria bassiana		207.33	10.14 (18.57)	11.10 (19.47)	2.67	4.40
Beauveria bassiana + FYM		181.67	9.73 (18.18)	10.83 (19.22)	2.67	4.51
Beauveria brongniartii		206.33	7.34 (15.73)	8.37 (16.83)	1.67	5.08
Beauveria brongniartii + FYM		189.00	6.18 (14.39)	7.41 (15.80)	1.33	5.15
Clothianidin 50 WDG	120 g *a.i.*/ ha	191.00	2.62 (9.29)	3.84 (11.30)	0.67	5.45
Control	-	201.00	12.99 (21.06)	14.16 (22.05)	3.33	4.35
S.Ed (±)	-	-	0.51	0.43	0.22	0.07
CD (p=0.05)	-	-	1.10	0.91	0.46	0.15

Figures in parenthesis are angular transformed values

DAS: Days after sowing

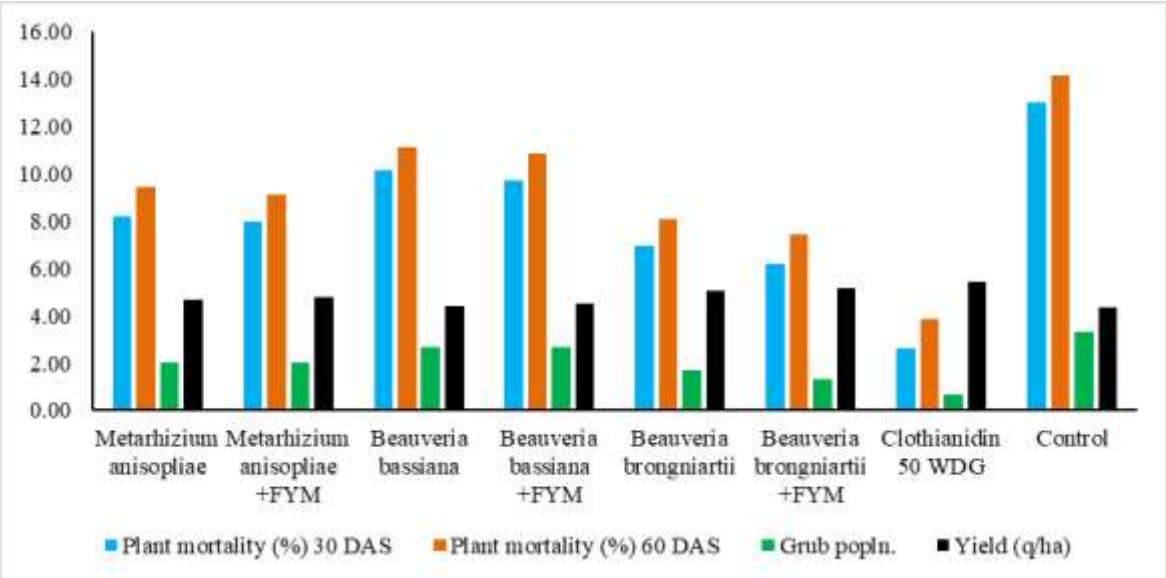


Fig. 39. Evaluation of different Entomopathogenic fungi against *L. mansueta* in green gram during 2021

Scaling up of effective dose of EPN, *Heterorhabditis indica* and *H. bacteriophora* against *Lepidiota mansueta* in potato

Altogether six different doses of the Entomopathogenic Nematode (EPN), *Heterorhabditis indica* and one dose of local isolate EPN were tested against the 3rd instar grubs of *Lepidiota mansueta* in potato cropat farmer's field of Maharichuk village of Majuli during 2021-22. The experiment was conducted in 3 RBD and the individual plot size was 4×3 sq.m. Potato (variety: Kufri khyati) was raised by following all the recommended package and practices of Assam. The crop was sown on 6th Nov., 2021 and harvesting was done on 10th Feb., 2022. The effectiveness of different doses of EPN were recorded on the basis of per cent tuber damage caused by the grubs both in weight and number basis, number of grubs/sq.m. and yield.

Experimental results revealed that all the doses of EPN tested were significantly superior over the untreated control in reducing the per cent tuber damage (weight and number basis) as well as number of grubs/sq.m. and increasing the tuber yield. On weight basis, the lowest per cent of tuber damage (1.61%) was recorded in plot treated with *H. indica* (WP) @ 2.5 lakhs IJS per 5 gm/sq.m. and this treatment was found to be significantly superior over rest of the treatments. The plot treated with local isolate @ 2.5 lakh IJS/sq.m.recorded 2.48 per cent of tuber damage on weight basis which was followed by *H. indica* (WP) @ 1.87 lakhs IJS per 3.75 gm/sq.m.(3.24%) and *H. indica* infected galleria larvae @ 1 galleria/1 sq.m. (4.02%). Other treatments *viz*., *H. indica* (WP) @ 1 lakhs IJS per 2 gm/sq.m., *H. indica* infected galleria larvae @ 1 galleria/1.5 sq.m., *H. indica* infected galleria larvae @ 1 galleria/2 sq.m. registered 5.33, 6.31 and 7.23 per cent of tuber damage, respectively. The untreated control registered 11.17 per cent of tuber damage.

Similar trend was observed while assessing the tuber damage on number basis. The plot treated with *H. indica* (WP) @ 2.5 lakhs IJS per 5 gm/sq.m.recorded statistically lowest per cent tuber damage (1.40%) as compared to the other treatments. The plot treated with Local isolate @ 2.5 lakh IJS/sq.m, *H. indica* (WP) @ 1.87 lakhs IJS per 3.75 gm/sq.m., *H. indica* infected galleria larvae @ 1 galleria/1 sq.m., *H. indica* (WP) @ 1 lakhs IJS per 2 gm/sq.m., *H. indica* infected galleria larvae @ 1 galleria/1.5 sq.m., *H. indica* infected galleria larvae @ 1 galleria/2 sq.m. recorded 2.33, 3.11, 4.00, 5.02, 6.08 and 7.04 per cent, respectively. The untreated control recorded the highest tuber damage on number basis (10.60%).

At the time of harvesting, the grub population ranged between 0.67-2.00 nos./sq.m.in all the EPN treated plots in which *H. indica* (WP) @ 2.5 lakhs IJS per 5 gm/sq.m.recorded the least number of grubs. The number of grubs recorded in untreated control plot was 2.67 nos./sq.m.

Among all the treatments, highest tuber yield (137.00 q/ha) was recorded in *H. indica* (WP) @ 2.5 lakhs IJS per 5 gm/sq.m.treated plots which was significantly higher as compared to rest of the treatments. The plots treated with Local isolate @ 2.5 lakh IJS/sq.m. and *H. indica* (WP) @ 1.87 lakhs IJS per 3.75 gm/sq.m. recorded tuber yield of 134.44 and 129.39 q/ha. The untreated control plot registered the yield of 112.22 q/ha.

Table 76. Scaling up of effective dose of EPN, *H. indica* and *H. bacteriophora* against 3rd instar grubs of *L. mansueta* in potato during 2021-22

Treatments	Per cent tuber damage (%)		No. of grubs/sq.m.	Yield (q/ha)
	Weight basis	Number basis		
Heterorhabditis indica (WP) @ 1 lakhs IJS per 2 gm/sq.m.	5.33 (13.35)	5.02 (12.95)	1.67	124.36
Heterorhabditis indica (WP) @ 1.87 lakhs IJS per 3.75 gm/sq.m.	3.24 (10.37)	3.11 (10.15)	1.33	129.39
Heterorhabditis indica (WP) @ 2.5 lakhs IJS per 5 gm/sq.m.	1.61 (7.30)	1.40 (6.80)	0.67	137.00
Heterorhabditis indica infected galleria larvae @ 1 galleria/2 sq.m.	7.23 (15.61)	7.04 (15.36)	2.00	118.00
Heterorhabditis indica infected galleria larvae @ 1 galleria/1.5 sq.m.	6.31 (14.55)	6.08 (14.24)	2.00	119.17
Heterorhabditis indica infected galleria larvae @ 1 galleria/1 sq.m.	4.02 (11.58)	4.00 (11.53)	1.33	127.79
Local isolate @ 2.5 lakh IJS/sq.m.	2.48 (9.06)	2.33 (8.78)	1.00	134.44
Untreated control	11.17 (19.53)	10.60 (19.00)	2.67	112.22
S.Ed (±)	0.16	0.35	0.23	0.53
CD (p=0.05)	0.36	0.77	0.49	1.15

Data in parenthesis are angular transformed values

DAS: Days after sowing

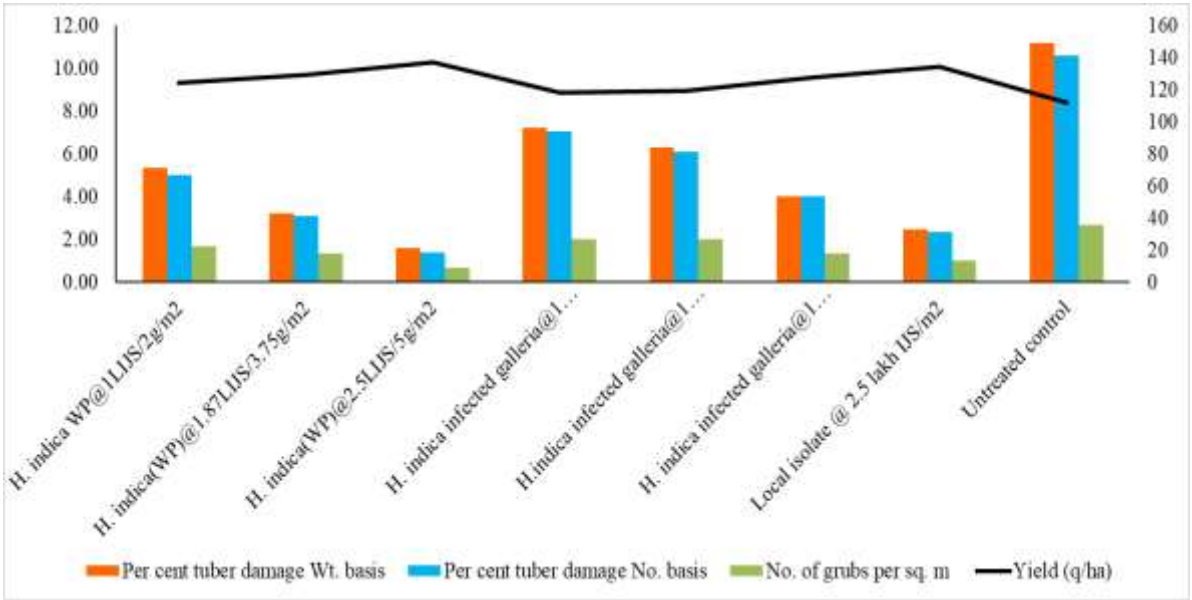


Fig. 40. Standardization of the dose of *H. indica* and *H. bacteriophora* against *L. mansueta* in potato during 2021-22

Sowing of potato tubers

Experimental layout

Harvesting and data collection

Infested tubers

Healthy tubers

Fig. 41. Standardization of the dose of *H. indica* and *H. bacteriophora* against *L. mansueta* in potato during 2021-22

Effect of a native entomopathogenic fungi, *Beauveria bassiana* on total haemocyte counts (THC) of the 3rd instar grubs of *Lepidiota mansueta*

The effect of a native entomopathogenic fungi, *B. bassiana* on the Total Haemocyte Counts of the 3rd instar grubs of *L. mansueta* was studied in the Laboratory of Network Project on Lac Insect Genetic Resources, Department of Entomology, AAU, Jorhat during 2021 (Plate 8). The grubs were treated with the *B. bassiana* formulation (1×10^7 conidia/ml) by dipping method for five seconds by holding loosely at the leg portion with the help of a forcep. After treatment, the grubs were released in individual disposable cups filled with 50 g of soil along with a piece of cut potato as food source. Alongside, a set of untreated grubs were also reared to establish the differences in the THC of the grubs. The haemolymph from the grubs were collected from tips of the legs by cutting with fine pointed scissors and was directly put onto a clean glass slide which was then diluted up to the 20 marks by using Thoma white blood cell pipette with physiological saline water. The obtained diluted sample was filled in the Levy double line haemocytometer with improved Neubauer ruling in all the four 1 mm squares and the data on the total haemocyte counts was recorded at 0, 6, 24, 48, 96, 120, 144 and 170 hours after treatment by following the formula:

$$\text{THC/mm}^3 = \frac{\text{Total no. of haemocytes counted in four corner chambers} \times \text{Depth of chambers (10)} \times \text{Dilution factor (20)}}{\text{No. of chambers counted (4)}}$$

The total number of circulating haemocytes in treated grubs was found to be significantly different at various time intervals after post treatment with *B. bassiana* in comparison with the untreated grubs, however the THC of treated grubs (15520±736.13 cells/mm^3) showed no significant difference with that of the control (15345±324.76 cells/ mm^3) at 0 Hours After Treatment (HAT). No statistical differences were recorded in the THC of control grubs over time. The THC in the control group increased to 16875±625.57 cells/mm^3 after 6 hours of *B. bassiana* infection, which however declined subsequently. The increase in haemocyte number might be due to the replication of prohaemocytes at the initial stages in treated grub. The THC reduced to 14240±417.91 cells/mm^3, 13930±626.68 cells/mm^3, 13070±654.31 cells/mm^3, 12495±581.68 cells/mm^3 and 11955±737.12 cells/mm^3 at 24, 48, 96, 120 and 144 HAT, respectively. The lowest THC was observed at 170 HAT (11325±504.32 cells/mm^3). The significant variation in THC and the relative number of haemocytes might be due to different stress conditions. The entomopathogens infects the midgut epithelial cells, multiplies and eventually invades the haemolymph. During this process, the circulating haemocytes in the haemolymph tend to resist the infection so as to defend the host, which in acute stages of infection tend to lose their ability to resist leading to the death of the host.

Table 77. Effect of *Beauveria bassiana* on THC (cells/mm^3) of 3rd instar grubs of *L. mansueta*

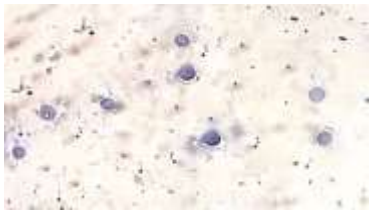
Post treatment period (HAT)	Control (Mean% ± SE)	Treated (Mean% ± SE)	t-value (P<0.05)	Significant (2-tailed)
0	15345±324.76a	15520±736.13cd	0.231	0.823 (NS)
6	15490±229.46a	16875±625.57d	2.360	0.043 (S)
24	15265±378.59a	14240±417.91bcd	2.625	0.028 (S)
48	15515±251.00a	13930±626.68abc	2.782	0.021 (S)
96	15090±290.47a	13070±654.31abc	2.950	0.016 (S)
120	15305±231.47a	12495±581.68ab	5.45	0.0001 (S)
144	15420±250.68a	11955±737.12ab	5.087	0.001 (S)
170	15910±409.59a	11325±504.32a	8.957	0.0001 (S)
P<value	0.727	0.0001	-	-
F-value	0.633	9.049	-	-

Treating of grubs

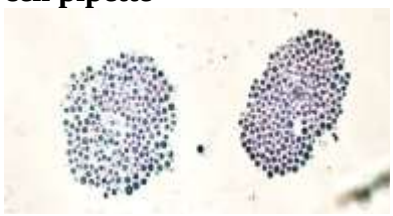
Rearing of grubs

Dilution of haemolymph with Thoma white blood cell pipette

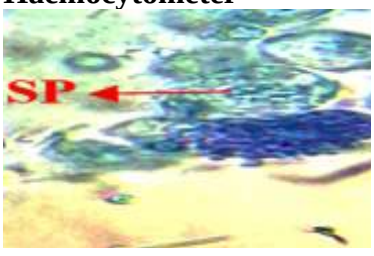
Haemocytometer



Prohaemocyte (PR)

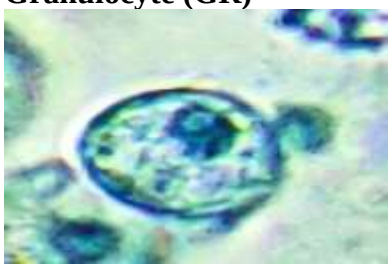


Granulocyte (GR)



Spherulocyte (SP)

Plasmatocyte (PL)



Oenocytiod (OE)

Fig. 42. Effect of a native entomopathogenic fungi, *B. bassiana* on total haemocyte counts (THC) of the 3rd instar grubs of *L. mansueta*

CSK-HPKV, Palampur

Evaluation of entomopathogenic fungi *B. brongniartii* (BbUASB$_{16}$ isolate) against third instar grubs of *H. longipennis* and *B. coriacea*

To prepare suspension of *B. brongniartii*, 500g of formulated product (contaminated soil) was dissolved in 1 litre of water. 100g of sterilized soil was put in each cup along with maize seedlings and one grub each of *B. coriacea* and *H. longipennis* were released in the respective cups. After that 10 ml suspension was put in each cup with the help of a dropper. The mortality data were recorded at weekly interval and mortality data got stabilized after five weeks of treatment. In *B. coriacea* grubs, observed mortality ranged from 16.23-65.86 per cent in subsequent weeks. In case of *H. longipennis*, grubs exhibited mortality of 14.03, 29.56 and 62.90 per cent in first, second and third week of treatment, respectively.

Table 78. Laboratory mortality of third instar grubs of *H. longipennis* and *B. coriacea* due to *B. brongniartii* (BbUASB$_{16}$ isolate)

Species	No. of grubs treated	Observed mortality (%) after indicated weeks			Mean (%)
		1	3	5	
H. longipennis	45	16.233	31.833	65.867	37.978
B. coriacea	45	14.033	29.567	62.900	35.500
T_{cal} 0.19 T_{tab}(0.05) 2.78					

Field evaluation of *H. indica* received from FARMER, Ghaziabad against white grubs in potato during 2021

Field efficacy of *H. indica* against potato white grubs during 2021 was done in Shimla district of H.P. The cadavers were placed near the base of potato plant. A small hole which was 3-4 cm deep was dug near the base of the plant with the help of a stick and in each hole one cadaver of *G. mellonella* infested with *H. indica* was gently placed, and it was covered with soil. Total 15 plots were treated with these nematodes and equal number of untreated plots was maintained for comparison. In a plot of 3 x 4 m^2, total 14 cadavers were placed. The treatment was imposed in row I, III and V near to plants 1, 5, 10, 15 and 20 in rows I and V, whereas in row III, the cadavers were imposed near to plants 3, 8, 12 and 17. The cadaver to plant ratio was 1:7.

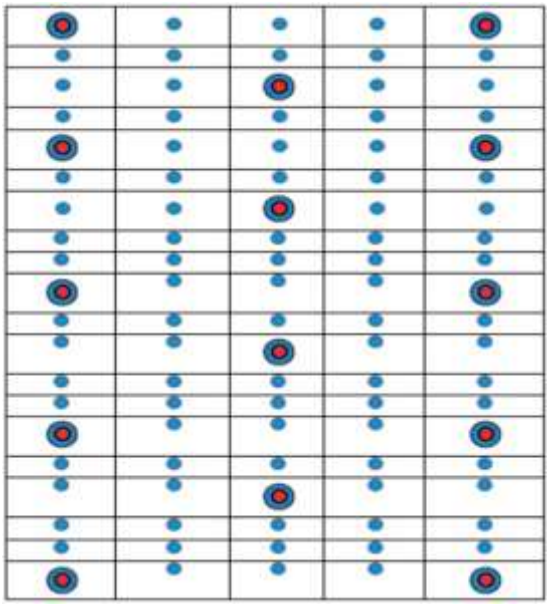


Fig. 43. Distribution of cadavers in a plot

Indicates the location of treated plants in a plot where *G. mellonella* cadavers were applied

There was about 50 % reduction in tuber damage due to white grubs as shown in the table. There was 13.5 % tuber damage in treated plots as compared to 22.4 % in control plots**.**

Table 79. Field evaluation of *H. indica* against potato white grubs in HP during 2021

Treatment	Per cent infestation of white grubs		Number of grubs/feet^2
	Number basis	Weight basis	
Treated plots (n=15)	13.5	14.9	2.1
Untreated plots (n=15)	22.4	23.5	3.0

Interaction effects of entomopathogens with insecticides against third instar grubs of *H. longipennis*

For evaluating the interaction effects among nematodes and insecticides, entomopathogenic nematode was tested in combination with commonly used insecticides viz. imidacloprid, chlorpyriphos, clothianidin, flubendiamide, spinosad and chlorantraniliprole against third instar grubs of *H. longipennis*. The mortality increased when *H. indica* was applied with different insecticides and observed mortality ranged between 50.5-57.8 for clothianidin, imidacloprid, chlorpyriphos, flubendiamide, spinosad

and chlorantraniliprole. The χ^2 values varied between 3.72 and 9.03 and signified additive and synergistic interactions.

Table 80. Interaction of *H. indica*, with different insecticides against third instar of *H. longipennis*

Treatment	Observed mortality	Expected mortality	$\chi 2$	Interaction type
Clothianidin	23.4	-	-	-
Imidacloprid	21.8	-	-	-
Chlorpyriphos	21.1	-	-	-
Chlorantraniliprole	25.7	-	-	-
Flubendiamide	26.7	-	-	-
Spinosad	22.4	-	-	-
H. indica	20.4	-	-	-
H. indica+Clothianidin	57.8	39.0264	9.03	Synergistic
H. indica+Imidacloprid	55.6	37.7528	8.44	Synergistic
H. indica+Chlorpyriphos	52.1	37.1956	5.97	Synergistic
H. indica + Chlorantraniliprole	54.2	40.8572	4.36	Synergistic
H. indica+Flubendiamide	54.1	41.6532	3.72	Additive
H. indica+ Spinosad	50.5	38.2304	3.94	Synergistic

Field evaluation of *H. indica* cadavers and WP supplied by FARMER, Ghaziabad in potato in Nawar valley in Shimla hills

Field efficacy of *H. indica* against potato white grubs during 2021-22 was done in Shimla district of H.P. The potato crop was sown in first week of April. The treatments were applied during earthing-up in first week of July. Two types of formulations were applied: wettable powder and infected cadavers of *G. mellonella*. The WP formulation was applied by mixing with FYM and then applied in the channels. The cadavers were placed near the base of potato plant. A small hole which was 3-4 cm deep was dug near the base of the plant with the help of a stick and in each hole one cadaver was gently placed, and it was covered with soil. Each plot was of 3 x 4 m^2 size, and different treatments were applied accordingly. In total, there were seven treatments which were replicated three times. Minimum number of damage was recorded in the treatment 6 i.e.1 cadaver/1m^2 with 10.8 % tuber damage and recorded 35.71 % decrease over control. Minimum number of grubs were also recorded in Treatment 6 with 3.6/grubsm^2 which was 61.25 % less over control.

Table 81. Field evaluation of *H. indica* against potato white grubs in HP during 2021-22

Treatment	Dose	Applied at the time of earthing up			
		Damage (%) number basis	Per cent decrease over control	No. of grubs/m^2	Per cent decrease over control
H. indica (WP)	T_1: 2g/m^2	15.500	7.74	8.600	7.43
	T_2: 3.75 g/m^2	14.100	16.07	7.100	23.57
	T_3:5 g/m^2	12.200	27.38	6.400	31.11
H. indica infected *Galleria* cadaver	T_4:1cadver/2m^2	14.043	16.41	5.097	45.13
	T_5:1 cadver/1.5m^2	11.283	32.84	4.500	51.56
	T_6:1 cadver/1m^2	10.800	35.71	3.600	61.25
	T_7: Control	16.80	-	9.29	-
CD (0.05)		0.945		0.524	

Field valuation of entomopathogenic fungi against whitegrub in potato

Field efficacy of *H. indica* against potato white grubs during 2021-22 was done in Shimla district of H.P. The potato crop was sown in first week of April. The treatments were applied during earthing-up in first week of July. In total, there were six treatments which were replicated four times. Minimum number of damage was recorded in the treatment 2 i.e. *M. anisopliae*(WP)mixed withFYM @ 1x10^9 CFU per gm/ m^2 with 10.60 % tuber damage and recorded 45.37 % decrease over control. Minimum number of grubs was also recorded in Treatment 2 with 4.7 grubs/m^2 which was 56.48 % less over control.

Table 82. Field evaluation of entomopathogenic fungi against whitegrub in potato

Treatment	Appliedatthetimeof Planting/sowing			
	Whitegrub damage		Whitegrub population	
	Damage (%)	Per centdecrease over control	No. ofGrubsper m^2 Area	Per centdecrease overControl
T_1: *M. anisopliae* (WP) @ 1x10^9 CFU per gm/ m^2	11.80	39.18	5.29	50.94
T_2: *M. anisopliae* (WP)mixed withFYM @ 1x10^9 CFU per gm/ m^2	10.60	45.37	4.70	56.48
T_3: *B.bassiana* (WP) @ 1x10^9 CFU per gm/ m^2	12.70	34.55	5.80	46.30
T_4: *B.bassiana* (WP)mixedwithFYM @ 1x10^9 CFU per gm/ m^2	11.89	38.68	5.10	52.78
T_5: Chlorpyriphos (Recommendedinsecticide) @ 400g a.i./ ha	3.50	81.96	1.80	83.33
T_6: Control	19.40		10.80	
CD(P=0.05)	0.26		0.18	
CV %	1.47		2.12	

GKVK, Bengaluru

Field evaluation of Entomopathogenic Fungi against white grubs, *Holotrichia serrata* in sugarcane

Methodology:

Location	: Gunnanayakanahalli, Mandya Tq and Dist
Farmer Name	: Sri Mudde Gowda
Design	: RBD
No. of Treatments	: 08
Replication	: 03
Variety	: Co 86032
Individual Plot size	: 5 m x 5 m=25 m^2
Total Experimental plot size	: 600 m^2
Date of Planting	: 18.01.2021
Date of adult beetles emergence	: 31.03.2021
Date of treatment imposition	: 30.06.2021

1 kg powdered formulation of different EPF were mixed with 100 kg soil or FYM as per treatments and placed near root zone as per the dose. Immediately after application, irrigation was provided to maintain soil moisture and also for proper distribution of spores

Results:

The data on the efficacy of different of EPF against white grub, *H. serrata* in sugarcane are presented in table. Application of different EPF were significantly reduced the population of white grubs and the damage compared to untreated control.

Conclusion:

Application of *Beauveria brongniartii* @ 1 x 10^9 per g/m^2 with or without FYM recorded significantly lowest population of 2.25-2.58 third instar grubs per m^2 with 77.60 to 80.46 per cent decrease in population compared to recommended insecticide Chloropyriphos @ 3 ml per liter (6.22/m^2 with 46.00 per decrease in population).

Table 83. Efficacy of different of EPF against white grub, *H. serrata* in sugarcane

Tr. No.	Treatments	Dose	Incidence of white grubs before application of treatments		White grub damage		White grub population		Cane yield (t/ha)
			No. of grubs /m2	% damage	% damage	% decrease over Control	No. of Grubs/ m^2	% decrease over Control	
T1	*Metarhizium anisopliae* (WP)	$1x10^9$ CFU per gm/m^2	10.52	15.25(22.98)	22.34(28.20)	37.14	8.52	26.04	115.00
T2	*M. anisopliae* (WP) mixed with FYM	$1x10^9$ CFU per gm/m^2	9.25	18.50(25.47)	21.25(27.45)	40.20	8.12	29.51	118.00
T3	*Beauveria bassiana* (WP)	$1x10^9$ CFU per gm/m^2	10.25	16.53(23.98)	19.60(26.27)	44.85	7.95	30.98	110.00
T4	*B. bassiana* (WP) mixed with FYM	$1x10^9$ CFU per gm/m^2	9.85	17.55(24.75)	19.21(25.99)	45.94	7.50	34.89	115.00
T5	*B. brongniartii* (Soil Formulation)	$1x10^9$ CFU per gm/m^2	11.25	18.45(25.43)	5.70(13.81)	83.96	2.58	77.60	145.00
T6	*B. brongniartii* (Soil Formulation) mixed with FYM	$1x10^9$ CFU per gm/m^2	11.00	16.88(24.24)	6.40(14.65)	81.99	2.25	80.46	146.00
T7	Chloropyriphos 50 EC	3 ml/lt	10.75	17.56(24.77)	16.79(24.19)	52.75	6.22	46.00	112.00
T8	Untreated Control	-	11.25	18.85(25.73)	35.54(36.59)	-	11.52	-	92.00
	S.Em $\pm$		1.12	1.86	0.98	-	0.41	-	9.10
	CD (P=0.05)		NS	NS	2.61	-	1.09	-	23.32

Values in parentheses are angular transformed values

Evaluation of the bio-efficacy of promising EPN strains against white grubs in sugarcane

Methodology*:*

Location : Gunnanayakanahalli, Mandya Tq and Dist
Farmer Name : Sri Mudde Gowda
Design : RBD
No. of Treatments : 06
Replication : 04
Variety : Co 86032
Individual Plot size : 5 m x 5 m=25 m^2
Total Experimental plot size : 600 m^2
Date of Planting : 18.01.2021
Date of adult beetles emergence : 31.03.2021
Date of treatment imposition : 30.06.2021

Treatments were imposed after taking initial population of III instar grubs per meter row. Application of different strains of EPN was applied to the root zone and maintained soil moisture for one week.

Results:

The Application of different strains of EPN did not show any reduction in grubs population compared to insecticidal application.

Table 84. Efficacy of different strains of EPN against white grub, *H. serrata* in sugarcane

Treatment	3rd instar white grub population/m row				White grub damage			Cane yield (t/ha)
	PTC	15 DAA	30 DAA	% Decrease Over control At 30 DAA	Pre Treatment damage	% Damage At 30 DAA	% decrease Over Control	
Heterorhabditis indica strain SBITND78 @ 10^8 IJs/ac	10.18	10.52	9.98	1.96	19.02	36.25	6.23	90.00
Heterorhabditis bacteriophora strain SBIP5@ 10^8 IJs/ac	10.58	11.01	9.02	11.39	17.95	30.25	21.75	102.00
Steinernema surkhetense strain SBIP3@ 10^8 IJs/ac	11.02	10.54	10.11	0.68	19.02	34.25	11.40	94.00
Steinernema siamkayai strain SBITNT1@ 10^8IJs/ac	9.94	11.51	10.22	-0.40	18.00	38.66	0.00	91.00
Recommended insecticides (Chloropyriphos 20 EC @ 3 ml/lt)	10.04	7.80	7.02	31.04	19.25	22.25	42.44	108.00
Untreated Control (No EPN)	11.00	10.87	10.18	-	18.50	38.66	-	88.00

S.Em±	0.68	1.12	1.01	-	-	-	-	3.66
CD (P=0.05)	NS	3.02	2.89	-	-	-	-	9.58

Conclusion:

Application of *Heterorhabditis indica strain* SBITND78 @ 10^8 IJs/ac, *Heterorhabditis bacteriophora* strain SBIP5@ 10^8 IJs/ac, *Steinernema surkhetense* strain SBIP3@ 10^8 IJs/ac and *Steinernema siamkayai* strain SBITNT1@ 10^8IJs/ac did not show any promising effect in reducing III instar grubs of *H. serrata* in sugarcane.

FARMER - GHAZIABAD

Evaluation of different entomopathogenic fungi against white grub in sugarcane crop at Muzaffarnagar during 2021-22

Experimental details:

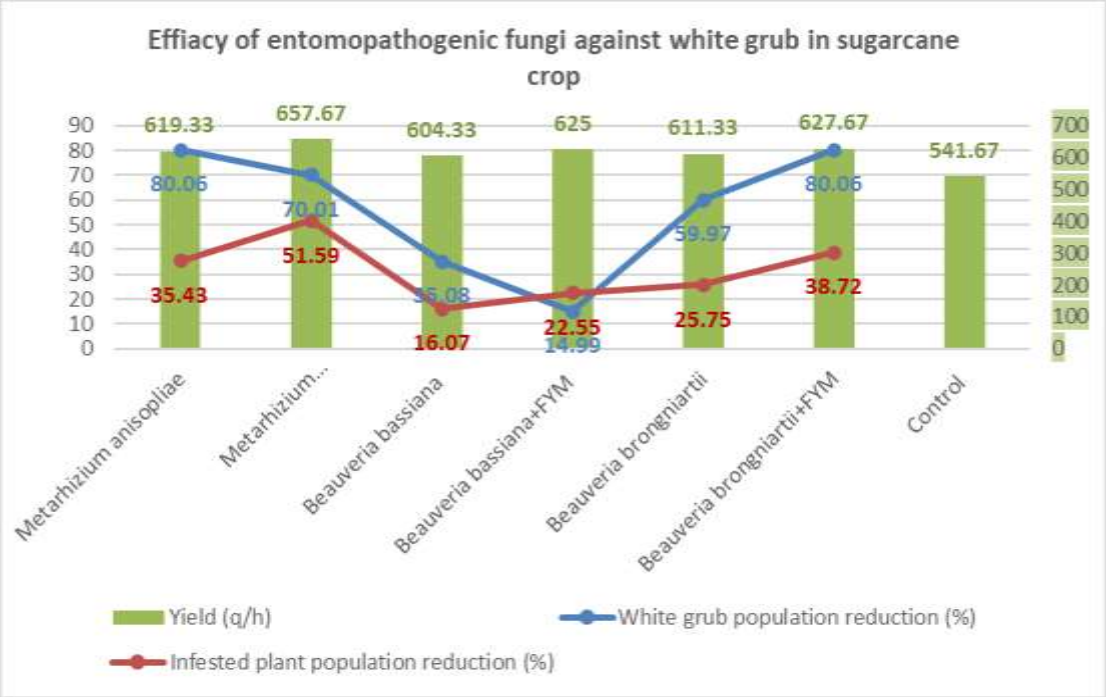
Test insect : white grub
Location : Muzaffarnagar (Post sowing)
Sowing time : As per recommended package of practices Design
: RBD
Replication : 3
Crop : Sugarcane, Variety: 0238
Fertilizers : at recommended doses
Treatments : 7

Observations: Plant mortality due to white grub (%), no of white grubs in root zone at 30 days after treatment (DAT), percent decrease due to white grub and white grub population. Data subjected to analysis of variance.

Table 85. Efficacy of Entomopathogenic fungi against white grub in sugarcane crop at Muzaffarnagar during 2021-22

Treatments (Dose)	White grub population (AT)	White grub population reduction (%)	Infested plant population (AT)	Infested plant population reduction (%)	Yield (Q/H)
Metarhizium anisopliae ($1x10^9$ CFU per gm/m^2)	1.33	80.06	6.67	35.43	619.33
Metarhizium anisopliae (WP) mixed with FYM ($1x10^9$ CFU per gm/m^2)	2.00	70.01	5.00	51.59	657.67
Beauveria bassiana (WP) ($1x10^9$ CFU per gm/m^2)	4.33	35.08	8.67	16.07	604.33
Beauveria bassiana (WP) mixed with FYM ($1x10^9$ CFU per gm/m^2)	5.67	14.99	8.00	22.55	625.00
Beauveria brongniartii (Soil Formulation) ($1x10^9$ CFU per gm/m^2)	2.67	59.97	7.67	25.75	611.33
Beauveria brongniartii (Soil Formulation) mixed withFYM ($1x10^9$ CFU per gm/m^2)	1.33	80.06	6.33	38.72	627.67
Untreated check	6.67		10.33		541.67
SE(m)	0.24		0.45		1.84

C.D.	0.73		1.40		5.72
C.V.	11.91		10.32		0.52



Results:

Metarhizium anisopliae, *Beauveria bassiana*, *Beauveria brongniartii* alone and mixed with FYM @ $1x10^9$ CFU per gm/m^2 applied in sugarcane crop against white grub. The results of decrease in infested plant population were recorded as 51.59%, 38.72%, 35.43%, 25.75%, 22.55% and 16.07% in *Metarhizium anisopliae* + FYM, *Beauveria brongniartii* + FYM, *Metarhizium anisopliae*, *Beauveria brongniartii*, *Beauveria bassiana* + FYM and *Beauveria bassiana*, respectively.

Reduction in white grub population were as 80.06% in *Metarhizium anisopliae* & *Beauveria brongniartii* + FYM, 70.01% in *Metarhizium anisopliae* + FYM, 59.97% in *Beauveria brongniartii*, 35.08% in *Beauveria bassiana* and 14.99% in *Beauveria bassiana* + FYM.

Crop yield also recorded higher in all treated plots as compared to control it was recorded in descending order as 657.67q/h in *Metarhizium anisopliae* + FYM, 627.67q/h in *Beauveria brongniartii* + FYM, 625.0q/h in *Beauveria bassiana* + FYM, 619.33q/h in *Metarhizium anisopliae*, 611.33q/h in *Beauveria brongniartii*, 604.33 q/h in *Beauveria bassiana*; whereas it was only 541.67q/h in untreated plot.

Summary /conclusion:

On the basis of percentage decrease in infested plant population over control, percentage decrease in white grub population over control and crop yield basis; *Metarhizium anisopliae* and *Beauveria brongniartii* shows superior results over control when applied with FYM.

Scaling up of dose of Entomopathogenic nematodes (*H. indica*) for white grub management in sugarcane crop

Test insect : white grub
Location : Muzaffarnagar (at the time of sowing)
Sowing time : As per recommended package of practices
Design : RBD
Replication : 3
Crop : Sugarcane
Variety : 0238
Fertilizers : at recommended doses
Treatments : 7
Observations : Plant mortality due to white grub (%), no of white grubs in root zone at 30 days after treatment (DAT), percent decrease in infestation due to white grub and white grub population.
Data subjected to analysis of variance.

Evaluation of effective dose of EPN (*H. indica*) against white grub in sugarcane crop

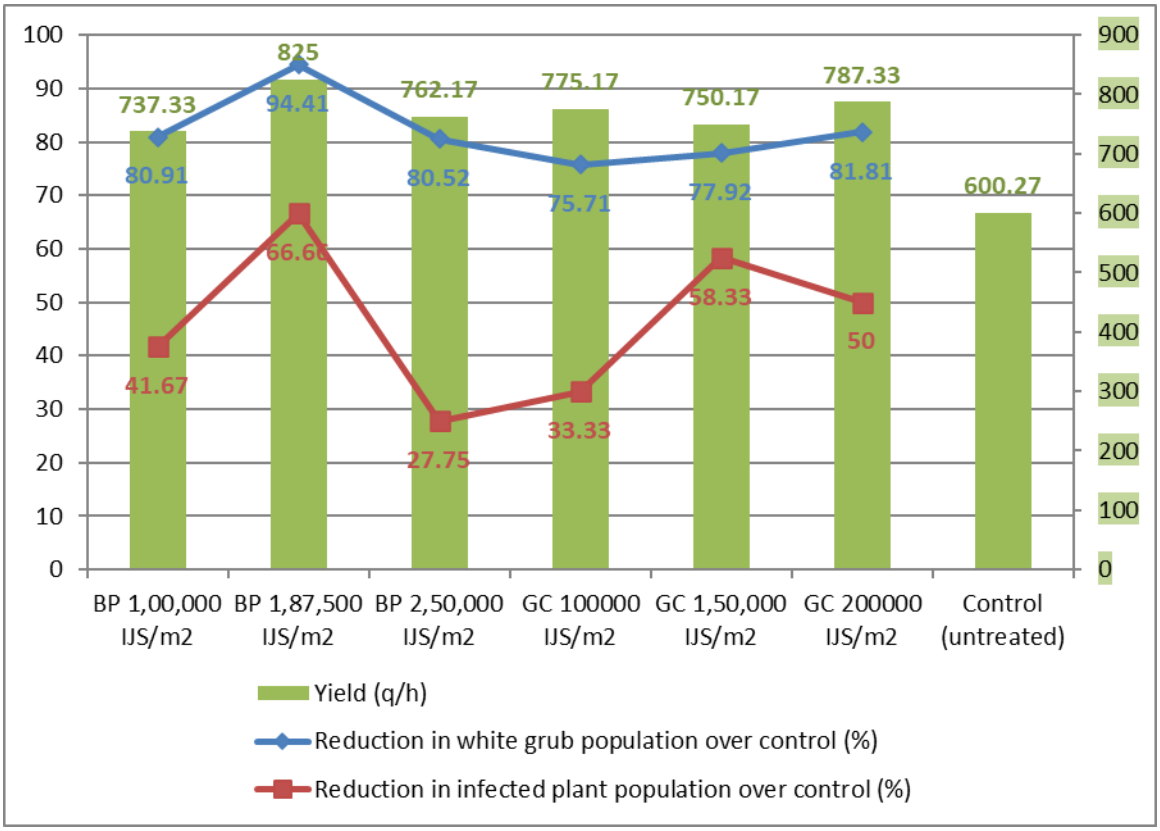
Treatments	Bioagents details
T_1	*Heterorhabditis indica* (BP) (2.00g/m^2) (1,00,000 IJS/m^2)
T_2	*Heterorhabditis indica* (BP) (3.75g/m^2) (1,87,500 IJS/m^2)
T_3	*Heterorhabditis indica* (BP) (5.00 g/m^2) (2,50,000 IJS/m^2)
T_4	*H. indica* infected *Galleria* Cadavers (GC) (1.0 GC/m^2) (100000 IJS/m^2)
T_5	*H. indica* infected *Galleria* Cadavers (GC) (1.5 GC/m^2) (1,50,000 IJS/m^2)
T_6	*H. indica* infected *Galleria* Cadavers (GC) (2.0 GC/m^2) (200000 IJS/m^2)
T_7	Control

One infected *Galleria* (GC) =1 lakhs IJs, One gm Biopowder (BP) = 50,000 IJS

Methodology:
One experiment for the Scaling up of effective dose of entomopathogenic nematodes (*H. indica*) against white grub by using different doses of *H. indica* in two different forms was laid down in sugarcane crop field as per technical programme 2021-22 allotted to different centers by All India Network Project on Soil Arthropod pests.

Table 86. Percentage decrease in white grub population over control in different treatment

Treatments	White grub population/m^2 (30 Days after treatment)	Reduction in white grub population over control (%)	Infected plant population (30 Days after treatment)	Reduction in infected plant population over control (%)	Yield (q/h)
T_1	1.47	80.91	7.00	41.67	737.33
T_2	0.43	94.41	4.00	66.66	825.00
T_3	1.50	80.52	8.67	27.75	762.17
T_4	1.87	75.71	8.00	33.33	775.17
T_5	1.70	77.92	5.00	58.33	750.17
T_6	1.40	81.81	6.00	50.00	787.33
T_7	7.70		12.00		600.27
SE(m)	0.13		0.56		2.08
CD	0.40		1.73		6.49
C.V.	9.69		13.31		0.48



Results:

Decrease in infested plant population over control in descending order was recorded as 66.67% in T_2, 58.33% in T_5, 50.00% in T_6, 41.67% in T_1, 33.33% in T_4 , 27.75% inT_3 treated plots of sugarcane crop. Decrease in white grub population was recorded in descending order was as 94.41% in T_2, 81.81% in T_6, 80.91% in T_1 and 80.52% in T_3, 77.92% in T_5 and 75.71% in T_4 treatments. Higher crop yield (737.33-825.0 q/h) was recorded in all treatments as compared to control (600.27q/h). Sugarcane crop yield in all treatments was recorded as 825.0q/h, in T_2, 787.33q/h in T_6, 775.17q/h in T_4, 762.17q/h in T_3, 750.17q/h in T_5, 737.33q/h in T_1 and 600.27q/h in T_7, untreated control plot.

Summary /conclusion:

Bio-Powder (*Heterorhabditis indica*) treated plot at the dose of 1,87,500 IJS/m^2 shows best results with maximum reduction in infested plant population (66.67%), maximum reduction in white grub population (94.41%) after 30 days of treatment and highest crop yield (825.00q/h) followed by *Galleria* Cadavers (*Heterorhabditis indica*) treated plot at the dose of 2,00,000 IJS/m^2 in which reduction in infested plant population (50.33%), reduction in white grub population (81.81%), and crop yield (787.33q/h) after 30 days of treatment.

KOLHAPUR, MAHARASHTRA

Biological control of white grub by entomopathogenic fungi in sugarcane

Experimental details:

Crop	:	Sugarcane
Season	:	*Suru*
Design	:	RBD
No. of replications	:	03
No of Treatments	:	08
Plot size	:	5 x 5 m^2
	:	

Treatment details

Name of bio-agent	:	Dose/m^2
Metarhizium anisopliae (WP) 1x10^9	:	0.5g
Metarhizium anisopliae (WP) 1x10^9+ FYM	:	0.5g
Beauveria bassiana (WP) 1x10^9	:	0.5g
Beauveria bassiana (WP) 1x10^9+ FYM	:	0.5g
Beauveria brongniartii 1x10^9 (Soil	:	0.5g

Formulation)		
Beauveria brongniartii $1x10^9$ (Soil Formln) + FYM	:	0.5g
Fifronil 40%+Imidacloprid 40%WG	:	300 g/ha
Check	:	--
Seed rate /ha	:	10,000 sets
Date of sowing / transplanting	:	12.01.2021
Date of application	:	01.03.2021
Date of termination of experiment	:	15.03.2022
FYM & Fertilizer	:	25 t & 250:150:150 NPK kg/ha

Method of recording observations:

White grub infested sugarcane field in Tarali village was selected as the test site for the conduct of field experiments with EPF wherein the grubs were found to occur at ETL per m^2 .Size of the trial plot was $4000m^2$. Talc based EPF formulations were applied as per the treatments with 100 kg FYM and without FYM in 5cm wide by 5cm deep furrow extending front to back. The raised soil beside the furrow was pushed back to cover the formulations. The field was irrigated immediately after application. Control plots were kept as such with application of plant protection measures. The treatments were randomized and three replicates were maintained. On 10 and 15 days after treatment, the grub population per square meter was taken and observed for mortality by the EPF. The mortality percentage due to EPF was calculated for each treatment and compared. Data were subjected to analysis of variance. Yield will be recorded at the time of harvesting.

Results:

Experimental results indicated that the treatment with Imidacloprid 40% + Fipronil 40%WG 3g/ha was found to be significantly superior over all other EPF treatments where 3.37 per cent clump mortality was recorded at 40 DAT. Among EPF treatments, the treatment with *Beauveria brongniartii* (Soil Formln) + FYM was found significantly superior over all other EPF treatments (5.57 % clump mortality). However, the treatment with *Beauveria bassiana* (WP) + FYM, *Metarhizium anisopliae* (WP) + FYM and *brongniartii* (Soil Formln) were found to be equally effective where 5.61, 5.79 and 6.73 per cent clump mortality was recorded. At 60 DAT, the treatment with *Beauveria brongniartii* (Soil Formln) + FYM, *Metarhizium anisopliae* (WP) + FYM, *Beauveria bassiana* (WP) + FYM and *brongniartii* (Soil Formln) alone found significantly superior over other treatments and were at par with each other where 6.32, 6.79, 7.05 and 7.11 per cent clump mortality was recorded.

The clump mortality was found to be increased at 80 DAT. The treatment with *Beauveria brongniartii* (Soil Formln) + FYM found significantly superior and recorded 7.11 per cent clump mortality and was on par with *Metarhizium anisopliae* (WP) + FYM, *Beauveria bassiana* (WP) + FYM and *brongniartii* (Soil Formln) alone where 7.15, 7.67 and 7.87 per cent clump mortality was reported, respectively. The significant difference did not exist among rest of the treatment. The treatment with *Beauveria brongniartii* (Soil Formln)+ FYM recorded 89.57 t/ha yield followed by 88.83 t/ha in *Metarhizium anisopliae* (WP) + FYM and 88.72 t/ha in *Beauveria bassiana* (WP) + FYM.Due to the cold temperature at harvesting, the grubs goes 2 feet deep in the soil and rarely only few

grubs were in the upper strata.

Conclusion:

The treatment with *Beauveria brongniartii* (Soil Formulation) + FYM was found effective in the management of white grub on the banks of river which will minimize risk of water pollution in river.

Table 87. Biological control of white grub by entomopathogenic fungi in sugarcane

Treatment and dose	Initial plant popln	Per cent clump mortality (DAS)*			% protection over control		Yield (t/ha)	No. of grubs /m^2**
		40	60	80	Mean			
Metarhizium anisopliae (WP) 1x10^9 cfu	647	7.18 (15.54)	7.62 (16.02)	8.53 (16.98)	7.78 (16.19)	52.09	83.45	1.33 (1.35)
Metarhizium anisopliae (WP) + FYM	672	5.61 (13.70)	6.79 (15.10)	7.15 (15.51)	6.52 (14.79)	59.86	88.83	0.67 (1.08)
Beauveria bassiana (WP) 1x10^9 cfu	598	7.93 (16.36)	8.17 (16.61)	8.84 (17.30)	8.31 (16.76)	48.79	82.47	1.72 (1.49)
Beauveria bassiana (WP) 1x10^9+ FYM	668	5.79 (13.52)	7.05 (15.40)	7.67 (16.08)	6.84 (15.16)	57.89	88.72	0.67 (1.08)
Beauv brongniartii (Soil Formulation)	664	6.73 (15.04)	7.11 (15.46)	7.87 (16.29)	7.24 (15.61)	55.42	84.32	1.00 (1.22)
Beauveria brongniartii (Soil Formln) + FYM	612	5.57 (13.65)	6.32 (14.56)	7.11 (15.46)	6.33 (14.58)	60.99	89.57	0.67 (1.08)
Fifronil 40% + Imidacloprid 40% WG	643	3.37 (10.58)	4.43 (12.15)	4.67 (12.48)	4.16 (11.76)	74.39	93.08	0.33 (0.91)
Check	652	11.93 (20.21)	15.85 (23.46)	20.92 (27.52)	16.23 (23.76)	0.00	70.78	4.65 (2.27)
S.Em ±	37	0.56	0.54	0.60	0.57	--	2.10	0.06
CD at 5%	NS	1.67	1.62	1.80	1.70	--	6.29	0.19
CV %	11.46	12.69	15.38	13.47	14.35	--	9.97	11.82

*Figures in parenthesis are arcsine transformed values. ** Square root transformed values

Management of white grubs through bio-control agents

Experimental details:

Crop	:	Sugarcane
Season	:	*Suru*
Design	:	RBD
No. of replications	:	03
No of Treatments	:	08
Plot size	:	5 x 5 m^2
Treatment details	:	
Name of bio-agent	:	Dose kg / ha
Heterorhabditis indica	:	20
Metarhizium anisopliae	:	20
Beauveria bassiana	:	20
H. indica + M. anisopliae	:	10 + 10
H. indica + B. bassiana	:	10 + 10
EPN infected galleria larvae supplied by FARMER	:	4 IG
Check	:	--
Seed rate /ha	:	10,000 sets
Date of sowing / transplanting	:	12.01.2020
Date of application	:	01.03.2020
Date of termination of experiment	:	15.03.2021
FYM & Fertilizer	:	25 t & 250:150:150 NPK kg/ha

Method of recording observations:

White grub infested sugarcane field in Tarali village was selected as the test site for the conduct of field experiments with *M. anisopliae* wherein the grubs were found to occur at ETL per m^2. Size of the trial plot was 4000m^2. Liquid Formulations, talc and lignite formulations were applied @ $3x10^{12}$conidia /ha and application in 5cm wide by 5cm deep furrow extending front to back. The raised soil beside the furrow was pushed back to cover the formulations. The field was irrigated immediately after application. Control plots were treated with sterile distilled water with 0.01 % Tween 80 alone. The treatments were randomized and three replicates were maintained. On 10 and 15 days after treatment, the grub population per square meter was taken and observed for mortality by the *M. anisopliae*. The mortality percentage due to *M. anisopliae* was calculated for each treatment and compared. Data were subjected to analysis of variance. Yield will be recorded at the time of harvesting.

Results:

Experimental results indicated that the treatment with *Heterorhabditis indica* + *Beauveria bassiana* @ 20 kg/ha was found to be significantly superior over all other microbial treatments where 5.61 per cent clump mortality was recorded at 40 DAT. However, the treatment with *Heterorhabditis indica* + *Metarhizium anisopliae* @ 50%+50% and *Beauveria bassiana* alone found to be equally effective where 6.57 and 6.59 per cent clump mortality was recorded. The significant difference did not exist among the rest of the treatments.

At 60 DAT, the treatment with *Heterorhabditis indica* + *Beauveria bassiana* @ 20 kg/ha (50%+50%), *Heterorhabditis indica* + *Metarhizium anisopliae* @ 50%+50% and *Beauveria bassiana* alone found significantly superior over other treatments where 6.79, 7.73 and 8.93 per cent clump mortality was recorded. The treatment with EPN infected galleria larvae supplied by FARMER and *H. indica* + *B.*

Bassiana @ 50%+50% combination were on par with each other where 9.62 and 10.55 per cent clump mortality was recorded.

The clump mortality was found to be increased at 80 DAT. The treatment with *Heterorhabditis indica* found significantly superior and recorded 8.89 per cent clump mortality and was on par with *Heterorhabditis indica* + *M. anisopliae* @50%+50%, *Metarhizium anisopliae* alone where 9.11 and 11.55 per cent clump mortality was reported, respectively. The significant difference did not exist among rest of the treatment.

The treatment with *Heterorhabditis indica* + *Beauveria bassiana* @ 20 kg/ha (50%+50%), recorded 90.57 t/ha yield followed by 88.72 t/ha in *Heterorhabditis indica* + *Metarhizium anisopliae* @ 50%+50% and 85.61 t/ha in EPN infected galleria larvae supplied by FARMER. Due to the cold temperature at harvesting the grubs goes 2 feet deep in the soil and rarely only few grubs were in the upper strata.

Conclusion:

The treatment with *Heterorhabditis indica* + *Beauveria bassiana* @ 20 kg/ha (50%+50%), *Heterorhabditis indica* + *Metarhizium anisopliae* @ 50%+50% and *Beauveria bassiana* alone found effective in the management of white grub on the banks of river which will minimize risk of water pollution in river.

Table 88. Biological control of white grub, *Leucopholis lepidophora* in sugarcane

Treatment and dose	Initial plant popln	Per cent Clump mortality (DAS)*				% protection over control	Yield (t/ha)	No. of grubs /m^2**
		40	60	80	Mean			
Heterorhabditis indica	668	8.43 (16.88)	10.55 (18.95)	12.94 (21.08)	10.64 (19.04)	35.75	84.92	2.00 (1.58)
Metarhizium anisopliae	672	7.68 (16.09)	9.29 (17.75)	10.35 (18.77)	9.11 (17.56)	45.01	86.47	1.67 (1.47)
Beauveria bassiana	598	6.59 (14.87)	8.93 (17.39)	9.70 (18.15)	8.41 (16.85)	49.24	87.32	1.33 (1.35)
H. indica + M. anisopliae	664	6.57 (14.85)	7.73 (16.14)	9.11 (17.57)	7.80 (16.22)	52.88	88.72	1.00 (1.22)
H. indica + B. bassiana	612	5.61 (13.70)	6.79 (15.10)	7.05 (15.40)	6.48 (14.75)	60.85	90.57	0.67 (1.08)
EPN infected galleria larvae supplied by FARMER	647	8.18 (16.62)	9.62 (18.07)	10.53 (18.94)	9.44 (17.90)	42.98	85.61	2.00 (1.58)
Check	652	11.93 (20.21)	15.85 (23.46)	21.90 (27.90)	16.56 (24.01)	0.00	73.45	4.69 (2.28)
S.Em ±	37	0.59	0.82	1.02	0.81	--	2.10	0.07
CD at 5%	NS	1.78	2.46	3.06	2.43	--	6.29	0.22
CV%	10.26	13.49	11.68	12.74	12.64	--	9.97	14.28

Management of white grubs through IPM

Experimental details:	
Design	RBD
Plot size	4000m^2
Spacing	90x90cm
Variety / Cultivar	Co-86032
Treatment details	3 IPM modules

S.No.	Treatments		Dose
IPM-I	1	Application of *Beauveria bassiana* (mix with FYM and apply in furrow before sowing)	0.5 g/m^2
	2	Seed treatment with imidacloprid 600 FS	5.0 g/kg seed
	3	Drenching of Imidacloprid 17.8SL (50 days after sowing)	600 ml/ha
IPM-II	1	Application of *Metarhizium anisopliae* (mix with FYM and apply in furrow before sowing)	0.5 g/m^2
	2	Seed treatment with imidacloprid 600 FS	5.0 g/kg seed
	3	Drenching of Fifronil 5 SC (50 days after sowing)	3.0 lit./ha
IPM-III	1	Application of *Heterorhabditis indica* (mix with FYM and apply in furrow before sowing)	0.5 g/m^2
	2	Seed treatment with imidacloprid 600 FS	5.0 g/kg seed
	3	Drenching of Fifronil 40% + Imidacloprid 40% WG (50 days after sowing)	500ml/ha
IPM-IV	:	Untreated check	-
Seed rate /ha		:	10,000 sets
Date of sowing / transplanting		:	15.01.2021
Date of application		:	28.02.2022
Date of termination of experiment		:	28.02.2022
FYM & Fertilizer		:	25 t & 250:150:150 NPK kg/ha

Method of recording observations:

Evaluation of the IPM module was carried out in area of 0.4 ha and compared with farmer's practice in an area of 0.4 ha. The commonly grown sugarcane cultivar of the region Co 86032 was used in all the locations. Selection of experimental fields was made with the assistance of Regional Extension Centre, College of Agriculture, Kolhaur, KVKs and District Department of Agriculture, Kolhapur. The observations on per cent clump damage; yield and number of grubs per m^2 were recorded at harvest. The experimental data was subjected to analysis of variance (ANOVA) for determining the level of significance (Gomez and Gomez 1984) of each module. In each location, the plots were serving as replicates for each treatment and observations in each location were compared statistically by paired *t*-test. The mean values of white grub incidence (% clump damage), yield and economics of each location were treated as replications and the overall mean of four locations were compared statistically.

Results:

The IPM module No. 2 i.e. application of *Metarhizium anisopliae*, set treatment with imidacloprid 600 FS and drenching of fipronil 5 SC (50 days after sowing)found effective

in the management of white grub on the banks of river which will minimize risk of water pollution in river.

Table 89. Management of white grub in sugarcane through IPM

IPM Module	Initial plant popln	Per cent Clump mortality * (Days after planting)				% protection over control	Yield (t/ha)	No. of grubs /m^2**
		40	60	80	Mean			
IPM-I	644	13.76 (21.77)	12.82 (20.98)	11.89 (20.17)	12.82 (20.98)	33.41	90.65	1.00 (1.22)
IPM-II	657	12.34 (20.57)	11.22 (19.57)	10.77 (19.16)	11.44 (19.77)	40.57	93.42	0.67 (1.08)
IPM-III	648	15.87 (23.48)	14.76 (22.59)	13.89 (21.88)	14.84 (22.66)	22.94	88.45	1.33 (1.35)
IPM-IV	652	25.18 (30.12)	16.66 (24.09)	15.93 (23.52)	19.26 (26.03)	0.00	85.39	2.33 (1.68)
S.Em ±	59	0.69	0.74	0.62	0.68	--	1.14	0.08
CDat 5%	NS	2.06	2.23	1.87	2.05	--	3.42	0.23
CV%	10.91	14.08	12.64	13.82	13.51		11.05	14.36

*Figures in parenthesis are arcsine transformed values, ** Square root transformed values

VPKAS- Almora

Bio-efficacy of entomopathogenic nematodes against native white grub species

The present study was carried out to determine the pathogenicity of various entomopathogens against first instars of two notorious and economically important white grub species, (*Anomala bengalensis* and *Sophrops* sp.) of Indian Himalayan region. The entomopathogenic bacteria and fungi tested against the white grubs recorded mortality of less than 25% while, two strains of entomopathogenic nematode (*Heterorhabditis indica*) recorded mortality of more than 70%. The median lethal dose and median lethal time estimation showed LD_{50} value of 1230.27 Infective Juveniles (IJs)/ml and 891.25 IJs/ml against the grubs of *A. bengalensis* for commercial and native strain of EPN respectively .

While, for the grubs of *Sophrops* sp. LD_{50} value of 1023.29 IJs/ml and 954.99 IJs/ml were obtained for commercial and native strains, respectively.The obtained LT_{50} values were 70.79 hrs and 91.20 hrs for *A. bengalensis* grubs and 74.13 hrs and 77.62 hrs for *Sophrops* sp. grubs with commercial and native strains of EPN, respectively.Overall, among all the tested entomopathogens, the *H. indica* (both commercial and native strain) showed good potential for biological control of grubs of *A. bengalensis* and *Sophrops* sp. under NW Himalayan conditions.

Table 90. Lethal dose of entomopathogenic nematodes against first larval instars of white grubs at Experimental farm, ICAR-VPKAS, Hawalbagh, Almora, Uttarakhand

White grub species	Entomopathogenic nemtode	Linear equation (Y= ax+b)	Slope±SE	χ^2	LD_{50} (IJs)	LD_{90} (IJs)
Anomala bengalensis	*H. indica* (Commercial strain)	Y=1.95x-1.02	1.95±0.2	0.91	1230.27	5495.41
	H. indica (Native strain)	Y=2.69x-2.93	2.69±0.06	0.99	891.25	2630.27
Sophrops sp.	*H. indica* (Commercial strain)	Y=1.67x-0.02	1.67±0.11	0.96	1023.29	5888.44
	H. indica (Native strain)	Y=2.09x-1.23	2.09±0.12	0.97	954.99	3890.45

Table 91. Lethal time of entomopathogenic nematodes against first larval instars of white grubs at Experimental farm, ICAR-VPKAS, Hawalbagh, Almora, Uttarakhand

White grub species	Entomopathogenic nemtode	Linear equation (Y= ax+b)	Slope±SE	χ^2	LT_{50} (in hrs)	LT_{90} (in hrs)
Anomala bengalensis	*H. indica* (Commercial strain)	Y=2.71x-0.02	2.71±0.08	0.99	70.79	208.93
	H. indica (Native strain)	Y=2.54x+0.01	2.54±0.22	0.93	91.20	295.12
Sophrops sp.	*H. indica* (Commercial strain)	Y=2.64x+0.06	2.64±0.11	0.98	74.13	229.09
	H. indica (Native strain)	Y=3.26x-1.16	3.26±0.2	0.97	77.62	190.55

SECTION 5
WHITE GRUB TAXONOMY (NBAIR, BANGALORE AND UAS & GKVK, BENGALURU)

- **Compilation of literature on Scarabs of India- Continued**

  About 2000 bibliographies published on scarabs have been complied. Accessing literature is one of the impediments in the taxonomic studies of scarabs. Hence, in order to enable the timely availability of the publications to scientists/research scholars, the Bengaluru centre is planning to digitize these literatures with the help of ICAR.

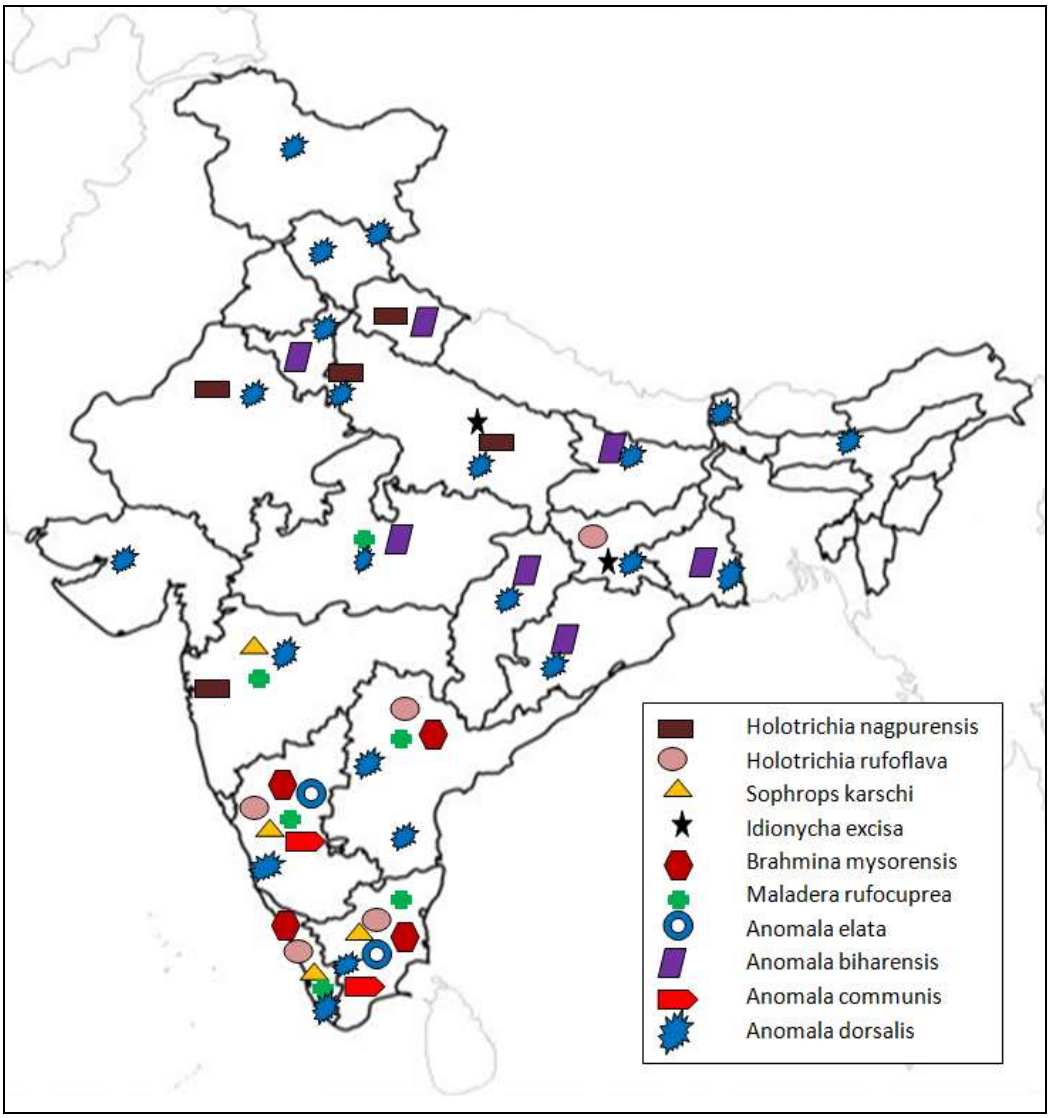
- **Development of Taxonomic keys for Scarabs of India**

  Development of pictorial taxonomic keys for species of the genus *Miridiba* and *Anomala* is in progress.

- **Description of White grubs of Karnataka, Tamil Nadu, Telangana, Kerala, Himachal Pradesh, Uttarakhand, Uttar Pradesh and Rajasthan in phased manner**

  Re-description of species of the genus *Apogonia* Kirby is in progress. Prepared the checklists for 83 species of the genus *Holotrichia* Hope (Scarabaeidae: Melolonthinae) from India and SriLanka; 36 species of the tribe Hopliini Latreille, 1829 (Scarabaeidae: Melolonthinae) from India. The checklists have been sent to experts for the comments. Until recently, the genus *Holotrichia* had been a large genus including approximately 250 species, Matsumoto in 2017, revised the genus and transferred many species to genera- *Eotrichia, Pedinotrichia, Nigrotrichia* and *Rufotrichia* retaining large groups under *Holotrichia*. A good number of species of *Holotrichia* are widely distributed in India causing serious damage to many economically important crops. Hence, a taxonomic study has been initiated to delimit the Indian *Holotrichia*. A tentative checklist of species belonging to India and Sri Lanka has been prepared. Morphological description of Indian *Holotrichia* was continued.

Major Whitegrub Species of India



Distribution of Major Whitegrub Species of India

S. No.	Species	Distribution
1	Holotrichia nagpurensis	Delhi, Uttar Pradesh, Uttarakhand, Rajasthan, Maharashtra
2	Holotrichia rufoflava	Andhra Pradesh, karnataka, Tamil Nadu, Kerala, Jharkand
3	Sophrops karschi	Kerala, Tamil Nadu, Karnataka, Maharashtra
4	Idionycha excisa	Uttar Pradesh, Jharkhand,
5	Brahmina mysorensis	Andhra Pradesh, karnataka, Tamil Nadu, Kerala
6	Maladera	Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, Maharashtra, Madhya Pradesh

	rufocuprea	
7	Anomala elata	Karnataka, Tamil nadu
8	Anomala biharensis	Bihar, Chattisgarh, Madhya Pradesh, Haryana, Odisha, Uttarakhand, West Bengal
9	Anomala communis	Tamil Nadu, Karnataka
10	Anomala dorsalis	Assam, Sikkim, Bihar, Delhi, Chattisgarh, Jharkhand, Jammu and Kashmir, Gujarat, Haryana, Himachal Pradesh, Rajasthan, Uttarakhand, Uttar Pradesh, West Bengal, Madhya Pradesh, Maharashtra, Telangana, Andhra Pradesh, Karnataka, Tamil Nadu

SECTION 6
DEVELOPMENT OF DISTRIBUTION MAPS OF WHITE GRUB AND TERMITE IN INDIA

RARI, Durgapura

White grub

In order to meet the objectives of the study on biodiversity of whitegrub and development of maps on distribution of whitegrub species, extensive surveys and collection of samples of different termite species were conducted in the five districts of Rajasthan *viz*., Dausa (26.8558° N, 76.179° E), Jaipur (26.8136° N, 76.0696° E), Ajmer (26.5455° N, 74.6430° E), Sikar (27.3384° N, 75.6052° E), Tonk and Nagaur. Whitegrub samples were collected from a diversity of habitats *viz*., forest area, agricultural land and homestead area. Further identification of these whitegrub samples will be carried out in collaboration with Dr. Kolla Sreedevi Principal Scientist, ICAR- National Bureau of Agricultural Insect Resources, Bangaluru, Karnataka, India.

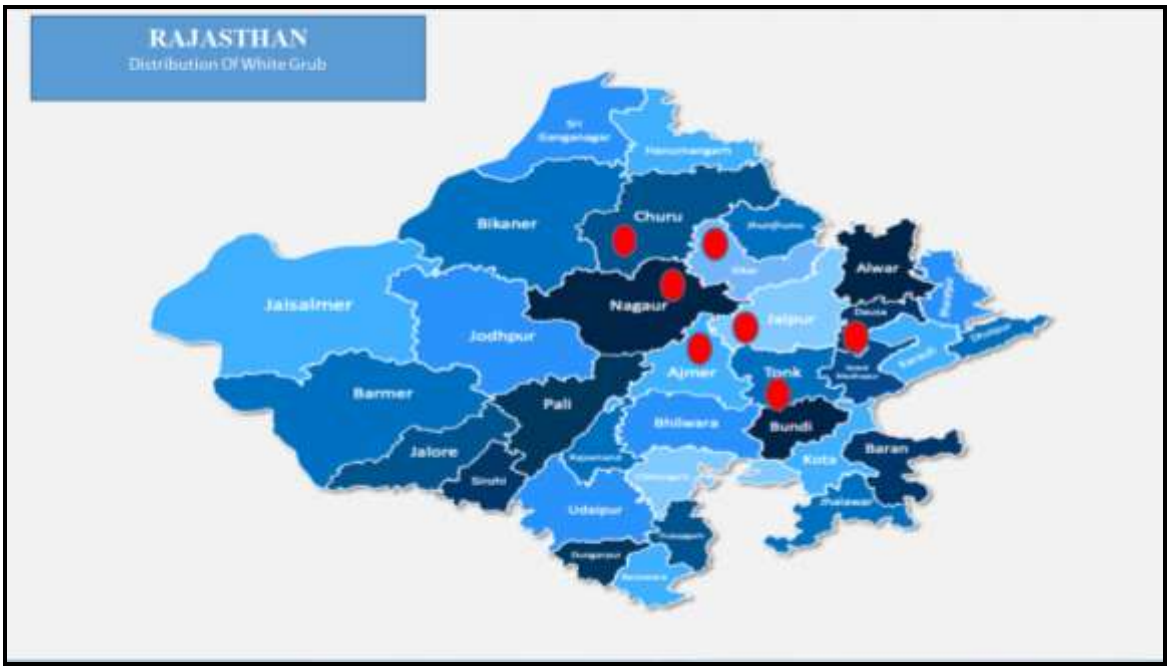


Fig. 44. Distribution map of whitegrub species in different districts of Rajasthan

Termite

In order to meet the objectives of the study on biodiversity of termites and development of maps on distribution of termite species, extensive surveys and collection of samples of different termite species were conducted in the three districts of Rajasthan *viz*., Ajmer, Jaipur, Tonk and Alwar. Termite samples were collected from a diversity of habitats *viz*., forest area, agricultural land and homestead area. The collected samples were preserved at 70-80 per cent alcohol for further identification. Further identification of these termites sample will be carried out in collaboration with Dr. Kolla Sreedevi Principal Scientist, ICAR- National Bureau of Agricultural Insect Resources, Bangaluru, Karnataka, India.

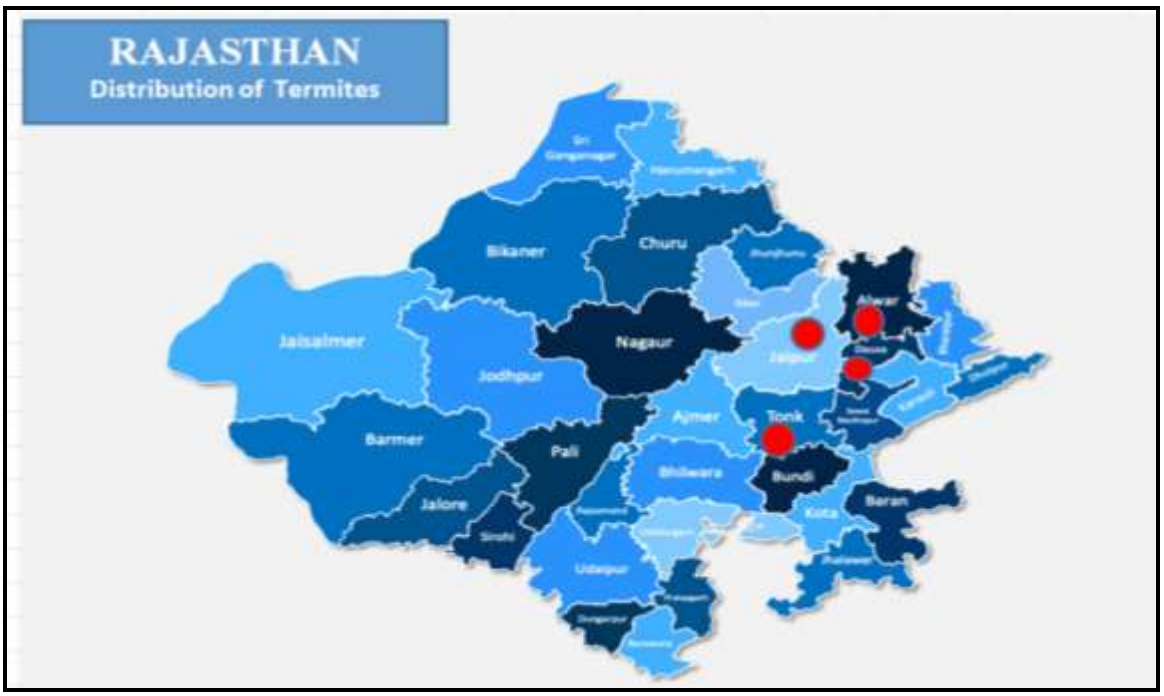


Fig. 45. Distribution map of termite species in different districts of Rajasthan

AAU, Jorhat

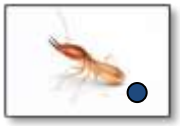
In order to meet the objectives of the study on biodiversity of termites and development of maps on distribution of termite species, extensive surveys and collection of samples of different termite species were conducted in the three districts of Assam *viz*., Jorhat (26.7509° N, 94.2037° E), Golaghat (26.5239° N, 93.9623° E) and Majuli (32.2432° N, 77.1892° E).Termite samples were collected from a diversity of habitats *viz*., forest area, agricultural land and homestead area. The collected samples were preserved at 70-80 per cent alcohol for further identification. Preliminary observations of these collected samples were found to be morphologically different. Further identification of these termites ample will be carried out in collaboration with Dr. Kalleshwara Swamy CM, University of Agricultural and Horticultural Sciences, Shivamogga, Karnataka, India.

Fig. 46. Collection of termites from different habitats of Jorhat district

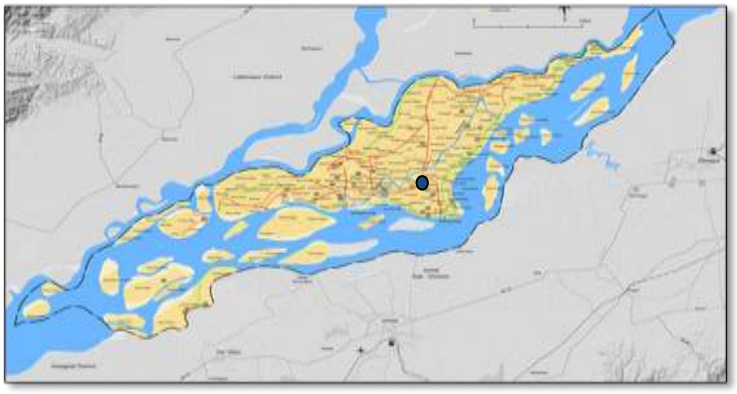
Fig. 47. Collection of termites from SRS, Buralikson, Golaghat

Fig. 48. Collection of termites from different habitats of Majuli district

Distribution map of termite species of Jorhat, Assam



Distribution map of termite species of Golaghat, Assam



Distribution map of termite species of Majuli, Assam

Fig. 49. Distribution map of termite species collected from three districts of Assam

GKVK, Bengaluru

The distribution map of *H. serrata* and *Leucopholis* spp. with respect to ecological factors such as elevation, soil type and annual rainfall in Karnataka has been generated. During the current reporting year species distribution maps for 12 species of the genus *Protaetia* Burmeister (Scarabaeidae: Cetoniinae) have been generated.

SECTION 7
SOCIAL ENGINEERING

RARI, Durgapura

Survey for beetle management in endemic areas of white grub

Surveys carried out in white grub endemic areas and created awareness among the farmers. As many as 25 training programmes were conducted in groundnut fields. The scientists of AINP-SAP also participated as resource persons in training programmes organized by various departments/NGOs/farmers'. During field demonstrations, farmers were educated about adult emergence, host range, feeding and breeding behaviour in groundnut fields.


राजस्थान कृषि अनुसंधान संस्थान

बोबाड़ी में लगा शिविर

किसानों को वैज्ञानिक तकनीक से खेती का दिया प्रशिक्षण

बोबाड़ी में आयोजित प्रशिक्षण शिविर में मौजूद किसान व कृषि अधिकारी।

पत्रिका न्यूज नेटवर्क
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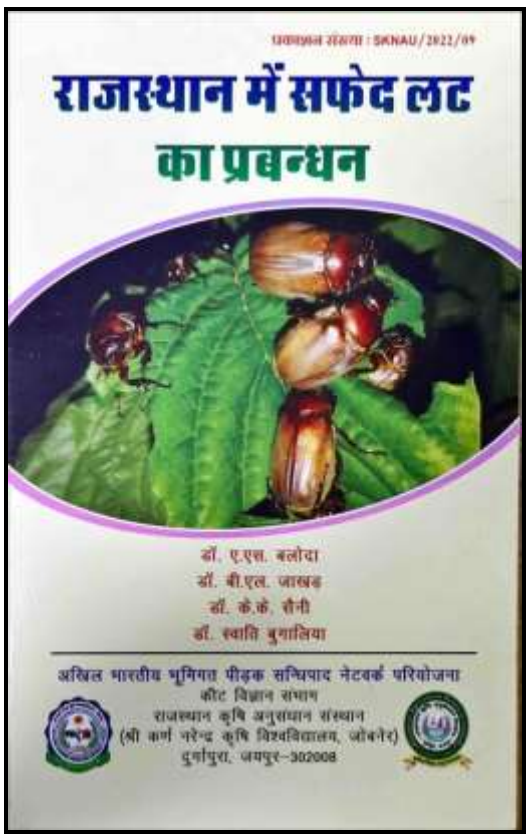
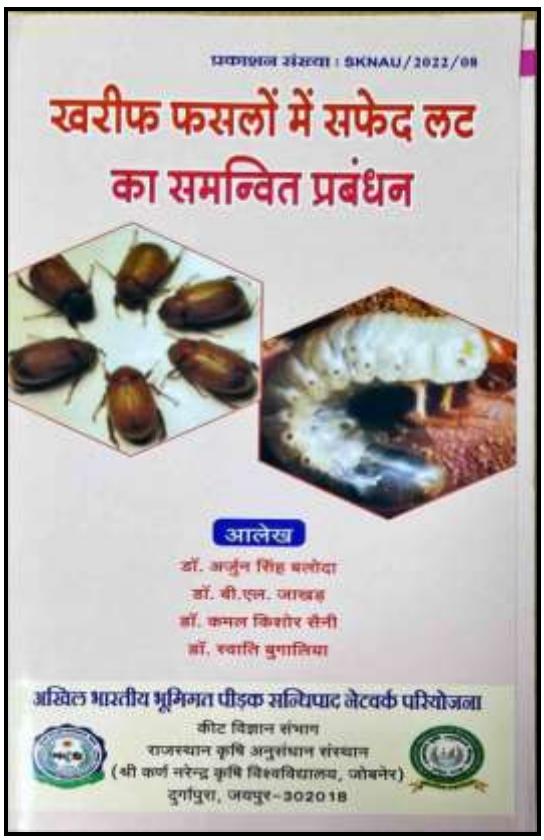
गढ़वाड़ी. कृषि विज्ञान केन्द्र गोनेड़ा व राजस्थान कृषि अनुसंधान संस्थान के संयुक्त तत्वावधान में बोबाड़ी गांव में मूंगफली में सफेद कीट का प्रबंधन पर एक दिवसीय प्रशिक्षण शिविर आयोजित हुआ। इसमें कृषि विज्ञान केन्द्र के डॉ.सुर्पण सिंह शेखावत ने खरीफ की फसलों में सफेद लट से होने वाले नुकसान के बारे में बताते हुए प्रबंधन पर जोर दिया। राजस्थान कृषि अनुसंधान केन्द्र के सह आचार्य डॉ.भंवरलाल जाखड़ व डॉ.वसुधा गौतम ने सफेद कीट की विभिन्न प्रजातियों के बारे में जानकारी दी।

अनुसंधान केन्द्र के वैज्ञानिक डॉ.रामप्रताप व डॉ.रेणु गुप्ता ने मूंगफली की उन्नत किस्मों के बारे में बताया। मूंगफली की वैज्ञानिक तकनीक से खेती करने की जानकारी दी। प्रशिक्षण शिविर में कई किसानों ने भाग लिया।(निसं)

Fig. 50. Demonstration of Pheromone anisol and nanogel pheromone trap at farmer's fields

To develop handouts on white grub Pest management





AAU, Jorhat

Social Engineering/Farmers Participatory Approach for the adult management of *L. mansueta* through light trap and scouting was continued in Majuli river island of Assam during April, 2021. This mass campaigning programme was conducted by involving 35 numbers of *Lepidiota* Management Group (LMG) in collaboration with district administration, State Department of Agriculture, NGOs etc. This mass campaigning programme received overwhelming response and was exceedingly successful leading to massive collection and killing of about 75000 beetles with a total of 12.43 lakhs of beetles during 2011-21. The mass collection of beetles was carried out in both cultivated and non-cultivated areas of endemic villages, however approximately 90 per cent of the beetles were collected from the non-cultivated areas such as the breeding ground located in bare land and sandbar areas having enough wild host plants (Plate 10 A-B). By observing the acceptance of *L. mansueta* beetles as culinary delight by the populace of Majuli, extensive efforts were also made to demonstrate the exploration of these beetles for entomophagy purposes at different strategic locations.

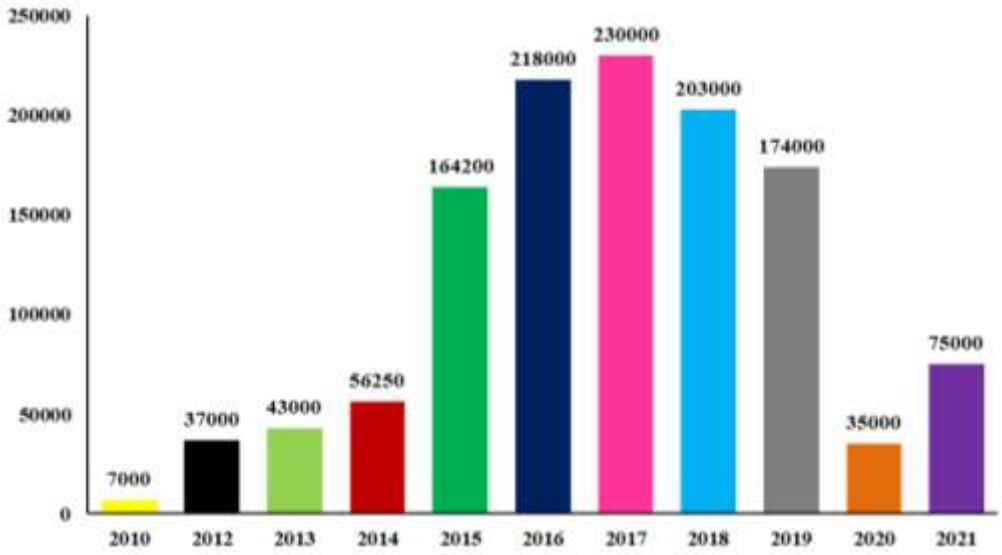


Fig. 51. *Lepidiota* beetles collected and destroyed during 2010-21
(Unsuccessful collection in 2011 due to heavy rain and low emergence of beetles)

Table 92. Day wise collection of *Lepidiota* beetles during mass campaigning programme conducted at Majuli

Date	Weather				Beetles Collected	Remarks
	Morning	Noon	Evening	Night		
01-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	3000	Heavy emergence
02-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	5500	Heavy emergence
03-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	13700	Heavy emergence
04-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	8000	Heavy emergence
05-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	8000	Heavy emergence
06-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	6500	Heavy emergence
07-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	4600	Moderate emergence
08-04-2021	Clear sky	Windy	Partly Cloudy	Rainfall	0	No emergence
09-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	6000	Moderate emergence
10-04-2021	Rainfall	Cloudy	Clear sky	Clear sky	4800	Moderate emergence
11-04-2021	Hazzy	Clear sky	Clear sky	Clear sky	3700	Moderate emergence
12-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	2800	Moderate emergence
13-04-2021	Hailstorm	Clear sky	Clear sky	Rainfall	0	No emergence
14-04-2021	Clear sky	Clear sky	Clear sky	Rainfall	0	No emergence
15-04-2021	Storm	Clear sky	Clear sky	Clear sky	4400	Moderate emergence
16-04-2021	Cloudy	Clear sky	Clear sky+ windy	Rainfall	0	No emergence
17-04-2021	Drizzle	Clear sky	Clear sky	Clear sky	1500	Moderate emergence
18-04-2021	Clear sky	Rainfall	Clear sky	Rainfall	0	No emergence
19-04-2021	Rainfall	Cloudy	Clear sky	Rainfall	0	No emergence
20-04-2021	Gloomy	Clear sky	Clear sky	Rainfall	0	No emergence
21-04-2021	Clear sky	Clear sky	Clear sky	Hazzy	1100	Moderate emergence
22-04-2021	Cloudy	Clear sky	Cloudy	Clear sky	700	Low emergence
23-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	400	Low emergence
24-04-2021	Cloudy	Clear sky	Clear sky+ windy	Rainfall	0	No emergence
25-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	130	Low emergence
26-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	100	Low emergence
27-04-2021	Clear sky	Clear sky	Clear sky	Clear sky	70	Low emergence
Total:					**75000**	

Fig. 52. Glimpses of mass campaigning programme against *L. mansueta* at various endemic villages in Majuli during April, 2021

Fig. 53. Glimpses of mass campaigning programme against *L. mansueta* at various endemic villages in Majuli during April, 2021

CSK-HPKV, Palampur

Details of training programmes and field days organized for the farmers of Himachal Pradesh

Particulars	No.	Beneficiaries (No.)
Farmer training	5	130
Field days	3	95

Details of training programmes organized for the farmers of tribal areas under TSP

Three training programs were organized for the farmers of tribal area in Lahaul & Spiti district of Himachal Pradesh and 125 farmers were benefitted**.**

S. N.	Date	Locations	No. of beneficiaries contacted	Inputs distributed
1.	18.09.2021	Gondhla, Lahaul & Spiti	40	Vegetable transplanter, pruning saw, Pruning Secateur, literature
2.	18.09.2021	Khangsar, Lahaul & Spiti	45	Vegetable transplanter, pruning saw, Pruning Secateur, literature
3.	30.03.2022	Tino, Lahaul & Spiti	40	Vegetable transplanter, pruning saw, Pruning Secateur, literature

Visit of Expert Delegate on Termite Ecology

Dr. Jan Sobotnik, Associate Professor, Czech University of Life Sciences, Prague, Czech Republic, visited CSKHPKV Palampur for a period of 10 days w.e.f. 16th September, 2021 to 26th September, 2021. Dr. Jan along with the lab members did sampling of the termites and termite associated arthropods at Dhaulakuan, Palampur, Bajaura and Manali. A guest lecture was also organized for the students of CSKHPKV Palampur on "Ecology of termites" on 22nd September 2021. Whitegrub laboratory of Department of Entomology along with Dr Jan Sobotnik is working on the chemo-ecology of some termite species of north western Himalaya.

Training on termite taxonomy

Mr. Himanshu Thakur, Ph.D student from Department of Entomology, CSKHPKV Palampur visited Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga w.e.f. 28-02-2022 to 12-03-2022, to learn, taxonomy of termites

from Dr CM Kalleshwaraswamy, Associate Professor, Department of Entomology, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga.

Mr Himanshu Thakur attending training on termite taxonomy at UAHS Shivamogga, Karnataka, with Dr CM Kalleshwaraswamy from 1st to 10th of March 2022

GKVK, Bengaluru

For beetle management all centres will survey and suggest endemic areas of white grub infested districts.

The scientists of AINP-SAP carried out the following activities to create awareness among the farming community, NGOs and the line department personnel. The details are furnished in Table below.

Table 93. Number of farmers training programmes organized/attended during 2020-21

Targeted white grub species	Farmers training programmes	Training for extension functionaries	Field days	Exhibition organized/ participated	Method demonstration	Technology showcasing
Holotrichia serrata	19	11	4	7	2	Collection and destruction of adult beetles

Leucopholis spp.	10	9	3	5	6	Digging and removal of grown up larvae

FARMER - GHAZIABAD

- Sugar Mills, District Cane Officers, farmers, Krishi Vegan Kendra falling under western UP have been sensitized from time to time by issuing advisory through webinar, emails and WhatsApp to keep watch on emergence of beetles and share information with FARMER organization for future studies and its better management practices.
- Sugar mill functionaries sprayed insecticides such as imidacloprid 17.8SL @ 1.5 ml/lit and others duringthe evening hours on host trees and shrubs immediately after the first summer rain to kill white grub beetles as per FARMER organization circulated advisory to all Sugar Mills and District Cane Officers falling under western UP in the month of April 2021.

Fig. 54. Spraying of host trees at different locations

- AINP VC FARMER Ghaziabad organized a one-day training programme on "Integrated pest management (IPM) for sugarcane crop with special reference to of white grub on 23 September 2021 in Sabitgarh Sugar Mill in Bulandshahar district. The training programme was attended by 64 participants. The participants were from nearby villages. The training covered various management techniques as light trap, pheromone traps, entomopathogenic nematodes, entomopathogenic fungus for justifying white grub threat. Techniques also included the use of safer insecticides and bio-pesticides; mass production of EPN & EPF; and strengthening monitoring and surveillance for early detection. The training emphasized the need to create awareness on early monitoring of the white grub incidence on sugarcane and to advice the farmers to initiate timely management techniques in a sustainable manner. The training also emphasized prevention through combining effective monitoring and early warning systems, encouraging the use EPN and EPF as the basis to support farmers in managing the white grub threat. This training will help the participants to adopt IPM practices in sustainable manner in the respective sugarcane agro ecological regions. Literature published under AINP project to control soil arthropod pests also distributed to the attendees.

One day training programme at Bulandshahar

- The FARMER VC Ghaziabad displayed low-cost technologies developed by FARMER at stall number A-54 during three days of Pusa Krishi Vigyan Mela represented by team of scientists. About 5,000 people visited the FARMER VC Stall and 340farmers made entry in FARMER visitor's book. FARMER VC Ghaziabad demonstrated various technologies to the farmers:*In vivo* (inside the wax moth) mass multiplication of EPN for soil arthropod pest management, management of white grub and others soil arthropod pests in sugarcane and other

important crops by using EPN infected wax moth larvae (*Galleria mellonella*) Cadavers, EPN bio-powder (*Heterorhabditis indica*), EPF powder formulation (*Metarhizium anisopliae, Beauveria bassiana*),Mass multiplication of Bio-agents (Bio-fertilizers and Bio-pesticides), Light Traps, Pheromone Traps for adult beetle of white grub collection. The literature published by FARMER on soil arthropod pest management was distributed among visitors during these days.

Honorable Shri Kailash Choudhary, Minister of State for Agriculture and Farmers Welfare with Dr. A K. Singh, Director, IARI and dignitaries visited the FARMER Stall and impressed with the EPN technology for soil arthropod pests management developed by FARMER under All India Network Project on Soil Arthropod pests.

FARMER stall in IARI PUSA Kisan Mela organized from 9-11 March 2022

- The technology for the management of white grub by Entomopathogenic nematode *H. indica* infected *Galleria mellonella* cadavers and *H. indica* Bio-powder formulation developed by FARMER under All India Network project on Soil Arthropod pests was displayed in ICAR – IARI Krishi Mela 2022 and covered by media & telecasted by Sansad TV (Rajya Sabha) on 10th April 2022.

SECTION 8
MANAGEMENT OF TERMITES

RARI, Durgapura

Management of termites through seed treatment

Experiment 1: Evaluation of some insecticides used as seed dresser against termites, in groundnut crop during *kharif* (2021-22)

In groundnut crop most of the time termite damage appears in later stage of the crop. To protect the crop of groundnut seed treatments were applied. It was observed that fipronil 5 SC (10 ml/kg seed) and imidacloprid 600FS provided maximum protection 6.07 and 6.86 percent and maximum yield 18.93 and 18.19 q/ha pod yield, respectively. In untreated control 45.02 per cent plant damage and 5.47 q/ha pod yield was recorded.

Table 94. Evaluation of some insecticides used against termite in standing crop of groundnut crop

Sr. No.	Treatments	Dose per ha	Plant mortality (%)	Pod yield (q/ha)
1	Thiamethoxam 25 WDG	3.2 g	13.35 (21.36)	15.53
2	Imidacloprid 17.8 SL	3.0 ml	9.57 (17.96)	16.32
3	Acephate 50% + Imidacloprid 1.8%	4.0 g	20.82 (27.12)	12.90
4	Fipronil 5 SC	10.0 ml	6.07 (14.21)	18.93
5	Thiamethoxam 30 FS	3.0 ml	12.65 (20.82)	17.11
6	Imidacloprid 600 FS	6.5 ml	6.86 (15.15)	18.19
7	Clothianidin 50 WDG	1.5 g	10.61 (18.99)	16.28
8	Fipronil 40% + Imidacloprid 40%	3.0 g	18.62 (25.53)	13.15
9	Chlorantraniliprole 18.5 SC	2.0 ml	18.01 (25.05)	14.28
10	Control	-	45.02 (48.32)	5.47
	SE(m)	-	0.892	1.10
	C.D. at 5%	-	2.66	3.31

	C.V. %		5.58	13.54

Fig. 55. Evaluation of insecticides as seed dresser against termites

Management of termites through drenching

Experiment 2: Evaluation of some insecticides used against termite in standing crop of groundnut during kharif (2021-22)

In groundnut crop most of the time termite damage appears in later stage of the crop. To protect the standing crop of groundnut some insecticides were applied by broadcasting after mixing them with soil. It was observed that fipronil 5 SC (3 l/ha) and imidacloprid 17.8 SL provided minimum plant damage 10.61 and 11.68 percent and maximum yield 16.09 and 15.68 q/ha pod yield, respectively. In untreated check 55.25 per cent plant damage and 5.15 q/ha pod yield was recorded.

Table 95. Evaluation of some insecticides used against termite in standing crop of groundnut crop during *kharif* (2021-22)

Sr. No.	Treatments	Dose per ha	Plant mortality (%)	Pod yield (q/ha)
1	Thiamethoxam 25 WDG	600 g	17.97 (25.05)	15.19
2	Imidacloprid 17.8 SL	360 ml	11.68 (19.94)	15.68
3	Acephate 50% + Imidacloprid 1.8%	1250g	23.64 (29.03)	12.41
4	Fipronil 5 SC	3.0 lit.	10.61 (18.99)	16.09
5	Thiamethoxam 30 FS	600ml	16.75	14.34

			(24.08)	
6	Imidacloprid 600 FS	1042ml	12.52 (20.69)	9.44
7	Clothianidin 50 WDG	300g	12.98 (21.06)	15.06
8	Fipronil 40% + Imidacloprid 40%	500 g	16.52 (23.86)	12.29
9	Chlorantraniliprole 18.5 SC	500 ml	21.55 (27.63)	12.06
10	Control	-	55.25 (48.01)	5.15
	SE(m)	-	1.324	1.67
	C.D. at 5%	-	3.963	4.99
	C.V. %		8.87	12.57

Management of termite through some chemicals in chick pea crop

Management of termite damage through broadcasting of insecticides in standing chickpea crop during (2021-22) at Durgapura Jaipur.

The experiment for the control of termite through seed treatment was carried out at the Rajasthan Agriculture Research Institute, Durgapura. The data further revealed that termite damage was maximum in untreated check (30.56%), whereas it was minimum in the treatment of Imidacloprid 17.8 SL (5.33%). The grain yield data computed on the basis of q / ha from different treatments indicated that maximum yield was observed in Imidacloprid 17.8 SL (26.13 / ha) and lowest yield was observed in untreated check (11.25 q / ha).

Table 96. Management of termite damage through broadcasting of insecticides in standing chickpea crop during 2021-22 at Durgapura, Jaipur

Sr. No.	**Treatment**	**Dose/kg seed**	**Per cent Plant Damage**	**Yield (q/ha)**
			2020-21	**2020-21**
1	Fipronil 40% +Imidacloprid 40%	400g	7.33 (15.59)	21.01
2	Fipronil 40% +Imidacloprid 40%	500g	6.07 (14.21)	23.09
3	Imidacloprid 17.8 SL	360ml	5.33 (13.33)	26.13
4	Fipronil 5SC	3.0 lit	6.70 (14.98)	23.90
5	Clothianidin 50 WDG	300g	9.33 (17.43)	19.55
6	Imidacloprid 600FS	700ml	10.61 (18.99)	19.70

7	Imidacloprid 600FS	900ml	9.57 (17.96)	22.08
8	Imidacloprid 600FS	1042ml	8.12 (16.48)	23.11
9	Chlorantraniliprole 18.5 SC	100ml	13.99 (21.93)	16.07
10	Control	-	30.56 (32.89)	11.25
SEm+			0.591	0.867
CD @ 5%			1.76	2.57
CV%			5.66	7.07

*Figures in parenthesis are angular transformed value

AAU, Jorhat

Management of termite through sett treatment in sugarcane crop

Out of nine different insecticides evaluated against termites during 2017-20, the application of clothianidin 50 WDG @1g/lit.of water in preserved setts of sugarcane recorded lowest per cent of setts infestation as well as maximum germination percentage. Hence, this technology has already been approved and recommended for the inclusion in the Package of Practices for *kharif* crops of Assam.

Drenching in standing tea crop through water

An experiment was conducted to evaluate six insecticides against termites (*Odontotermesobesus*) in tea cropat Charaibahi village of Jorhat during December, 2021 to February, 2022. The experiment was conducted as 3 RBD by following all the recommended package and practices of Assam. The required amounts of insecticides were drenched in standing tea crop through water. The treatments were applied on 23rd December, 2021 and the observations were taken at 30 and 60 days after treatment (DAT). The efficacy of different treatments was recorded on the basis of per cent infestation on number and portion basis.

Experimental results indicated that all the insecticidal treatments were found to be significantly superior over the untreated control in reducing both number and portion of infestation. Significantlylowest number of infestations was recorded in clothianidin 50 WDG @ 250 g/ha (3.48 and 4.88% at 30 and 60 DAT, respectively) which was found to be statistically *at par* with the plots treated with chlorantraniliprole 18.5 SC @ 500 ml (4.85 and 6.42% at 30 and 60 DAT, respectively). The plots treated withimidacloprid 600 FS @ 800 ml, imidacloprid 17.8 SL@ 350 ml, imidacloprid 70 WS@ 160 ml and fipronil 5 SC@ 2 lit. registered 6.32 & 8.82, 10.28 & 11.50, 11.83 & 13.13 and 13.48 & 16.49 per

cent at 30 and 60 DAT, respectively. The untreated control plots registered 20.51and 27.59 per cent of infestation on number basis by the termites at 30 and 60 DAT, respectively.

While considering the portion of infestation, it was revealed that clothianidin 50 WDG @ 250 g/ha treated plots recorded lowest infestation (5.51 and 7.20% at 30 and 60 DAT, respectively) which was statistically superior over rest of the treatments. This treatment was followed by chlorantraniliprole 18.5 SC @ 500 ml (7.31 and 8.68% at 30 and 60 DAT, respectively) and imidacloprid 600 FS @ 800 ml (9.48 and 11.52% at 30 and 60 DAT, respectively) treated plots. The per cent infestation on portion basis in imidacloprid 17.8 SL @ 350 ml, imidacloprid 70 WS@ 160 ml and fipronil 5 SC@ 2 lit. registered 12.07 & 13.17, 14.55 & 16.81 and 17.31 and 19.51 per cent at 30 and 60 DAT, respectively. The untreated check plots registered 26.56 and 32.02 per cent portion of infestation by termites at 30 and 60 DAT, respectively.

Infestation of termites in tea

Experimental plots

Fig. 56. Evaluation of some insecticides against termite in tea during 2021-22

Table 97. Evaluation of some insecticides against termite in tea during 2021-22

Treatment	Doses/ ha	30 DAT*		60 DAT*	
		No. of infestation (%)	Portion of infestation (%)	No. of infestation (%)	Portion of infestation (%)
Imidacloprid 600 FS	800 ml	6.32 (14.58)	9.48 (17.93)	8.82 (17.30)	11.52 (19.86)
Imidacloprid 17.8 SL	350 ml	10.28 (18.73)	12.07 (20.34)	11.50 (19.87)	13.17 (21.29)
Fipronil 5 SC	2 lit	13.48 (21.57)	17.31 (24.60)	16.49 (23.95)	19.51 (26.24)
Imidacloprid 70 WS	160 ml	11.83 (20.11)	14.55 (22.44)	13.13 (21.25)	16.81 (24.22)
Clothianidin 50 WDG	250 g	3.48 (10.61)	5.51 (13.56)	4.88 (12.77)	7.20 (15.56)
Chlorantraniliprole 18.5 SC	500 ml	4.85 (12.62)	7.31 (15.67)	6.42 (14.61)	8.68 (17.12)
Untreated control	-	20.51	26.56	27.59	32.02

		(26.97)	(31.03)	(31.66)	(34.48)
SEd (±)		0.92	0.33	0.73	0.35
CD (P=0.05)		2.01	0.73	1.59	0.77

(Figures in parenthesis are angular transformed values)

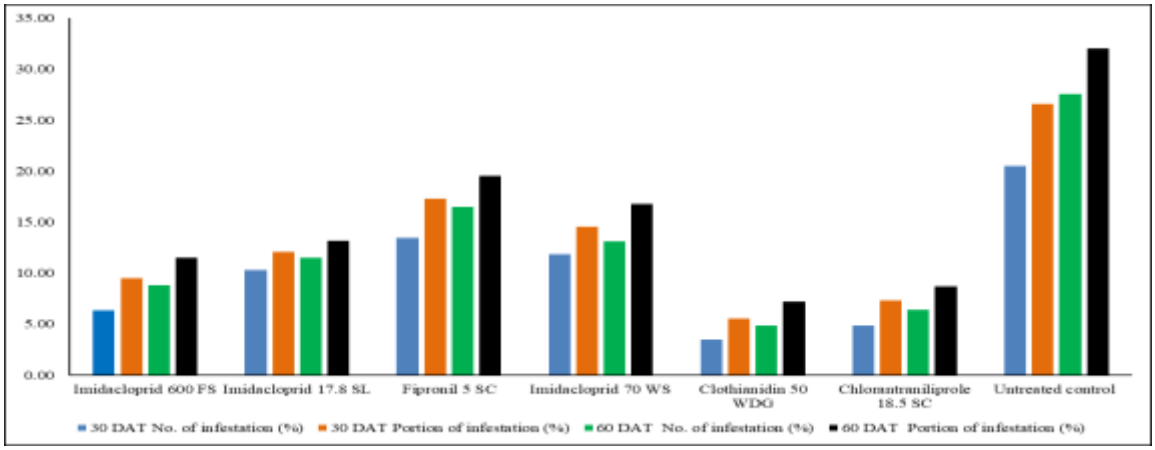


Fig. 57. Evaluation of some insecticides against termite in tea during 2021

CSK-HPKV, Palampur

Management of termites in wheat through chemicals treatment of seed during 2021

The field trials was conducted in randomized block design comprising 6 treatments and 4 replications with a plot size of 4 x 3 m^2 having row spacing of 22 cm at Berthin in Bilaspur district, which is an endemic area for termites**.** The treated seed were sown on 20-11-2021. Wheat seeds were treated with different chemical insecticide treatments at recommended dose before sowing. The data were recorded on per cent tiller damage. The infested tillers start drying up and become light straw coloured. Such infested tillers if pulled come out very easily from the ground. Their underground parts are completely eaten up by the termites resulting in very thin or no Grains in the ears which hampers the overall yield of the crop. Perusal of data presented in table showed significant differences in the tiller damage in different treatments. Minimum tiller damage (3.9%) was recorded in in clothianidin 50 WDG treatment applied @ 1.5 g/ kg seed as compared to 10.90 per cent in untreated check.

Table 98. Management of termite in wheat at village Berthin through seed treatment during 2021

Treatment	Dose (per kg seed)	Tiller Damage (%)
T_1:Thiamethoxam 25WG	3.2 g	6.20
T_2: Imidacloprid 17.8 SL	3.0 ml	5.00
T_3: Acephate 50%+ Imidacloprid 1.8% SP	4.0 g	4.30
T_4: Fipronil 5SC	10 ml	4.60
T_5: Clothianidin 50 WDG	1.5 g	3.90
T_6: Untreated check	-	10.90

CD (P=0.05)		0.24

Wheat trial for termite management at Berthin

Incidence of termite causing white tillers in wheat

GKVK, Bengaluru

Management of termite through seed treatment in Groundnut

Methodology:

Experimental plot was selected based on previous history of endemic area for termite damage

Location	: Mullahalli, Chintamani Tq, Chikkaballapur Dist
Farmer Name	: Sri Venkatesh, M.
Variety	: GKVK-5
Design	: RBD
No. of Treatments	: 10
Replication	: 3
Individual Plot size	: 3.5 m x 3.5 m=12.25 m^2
Total Experimental plot size	: 368 m^2
Date of Sowing	: 18.07.2021
Date of Treatment	: 18.07.2021

Results:

Seed treatment with different insecticides significantly reduced the incidence of termites in groundnut as shown in table below.

Conclusion:

The results revealed that seed treatment with Thiamethoxam 30 FS @ 3.0 ml per kg of seeds or Imidacloprid 600 FS @ 6.5 ml per kg of seeds recorded least termites damage (5.00 to 6.00%) with significantly highest pod yield (6138-6225 kg/ha) compared to untreated control (31.00% and 5212 kg/ha).

Table 99. Efficacy of different seed treatment insecticides on termites in groundnut

S.N.	Treatments	Dose (per kg seed)	% Plant damage	% protection over untreated check	Pod Yield (kg/ha)
1.	Thiamethoxam 25 WG	3.2 g	9.00(17.45)	70.96	5933
2.	Imidacloprid 17.8 SL	3.0 ml	11.00(19.36)	64.51	5902
3.	Acephate 50% + imidacloprid 1.8%	4.0 g	14.00(21.97)	54.84	5800
4.	Fipronil 5 SC	10.00 ml	13.00(21.13)	58.06	5895
5.	Thiamethoxam 30 FS	3.0 ml	5.00(12.92)	83.87	6225
6.	Imidacloprid 600 FS	6.5 ml	6.00(14.17)	80.64	6138
7.	Clothianidin 50 WDG	1.5	14.00(21.97)	54.84	5811
8.	Fipronil 40%+Imidacloprid 40%WG*	3.0 g	11.00(19.36)	64.51	5888
9.	Chlorantraniliprole 18.5 SC*	2.0 ml	15.00(22.78)	51.61	5765
10.	Untreated check	-	31.00(33.83)	-	5212
S.Em+			1.52	-	36.88
CD at 5%			4.02	-	97.77

Values in parentheses are angular transformed values

Management of termites through drenching in Groundnut

Methodology:

Location	: Mullahalli, Chintamani Tq, Chikkaballapur Dist
Farmer Name	: Sri Venkatesh, M.
Variety	: GKVK-5
Design	: RBD
No. of Treatments	: 10
Replication	: 3
Individual Plot size	: 3.5 m x 3.5 m=12.25 m^2
Total Experimental plot size	: 368 m^2
Date of Sowing	: 18.07.2021
Date of Treatment	: 20.08.2021

Results:

Soil drenching with different insecticides significantly reduced the incidence of termites in groundnut as shown in table below.

Conclusion:

The results revealed that seed treatment with Thiamethoxam 30 FS @ 3.0 ml per kg of seeds or Imidacloprid 600 FS @ 6.5 ml per kg of seeds recorded least termites damage (5.00 to 6.00%) with significantly highest pod yield (6138-6225 kg/ha) compared to untreated control (31.00% and 5212 kg/ha).

Table 100. Efficacy of soil drenching with different insecticides on termites incidence in groundnut

S.N.	Treatments	Dose per ha	% Plant Damage Before drenching	% Plant Damage at 15 days after drenching	% protection over untreated check	Pod Yield (kg/ha)
1.	Thiamethoxam 25 WG	600 g	22.66(28.42)	8.66(17.11)	73.48	5771
2.	Imidacloprid 17.8 SL	360 ml	24.00(29.33)	6.66(14.95)	79.60	5885
3.	Acephate 50% + imidacloprid 1.8%	1250 g	21.33(27.50)	6.00(14.17)	81.62	5902
4.	Fipronil 5 SC	3000 ml	29.33(32.79)	7.00(15.34)	78.56	5880
5.	Thiamethoxam 30 FS	600 g	22.66(28.43)	10.66(19.05)	67.36	5632
6.	Imidacloprid 600 FS	1042 g	28.00(31.94)	10.33(18.74)	68.37	5702
7.	Clothianidin 50 WDG	300 g	24.00(29.33)	8.66(17.11)	73.48	5662
8.	Fipronil 40%+Imidacloprid 40%WG*	500 g	29.33(32.79)	9.33(17.78)	71.43	5800
9.	Chlorantraniliprole 18.5 SC*	500 ml	22.66(28.42)	15.66(23.31)	52.05	5155
10.	Untreated check	-	24.00(29.33)	32.66(34.85)	-	5012
S.Em+			2.18	0.85	-	34.12
CD at 5%			NS	2.21	-	90.72

Values in parentheses are angular transformed values

Management of termite through sett treatment in sugarcane crop

Methodology:

Experimental plot was selected based on previous history of endemic area for termite damage in sugarcane

Location	: Mahadeswarapura, Pandavapura Tq, Mandya Dist.
Farmer Name	: Sri Venkateshappa
Variety	: Co 86032
Design	: RBD
No. of Treatments	: 10
Replication	: 3
Individual Plot size	: 5 m x 5 m=25 m^2
Total Experimental plot size	: 750 m^2
Date of sett treatment	: 25.01.2021
Date of planting	: 25.01.2021

During summer cropping season at Cauvery command area, the trial was implemented. 2 eye budded setts were dipped as per treatments in plastic drums for 30 min and planted in main filed. Dried Maize cobs were placed to attract termites.

Results:

Sett treatment with different insecticides resulted in significant reduction of termites damage in sugarcane crop as shown in table below.

Conclusion:

The results revealed that sett treated with Thiamethoxam 30 FS @ 1 ml per liter or Imidacloprid 600 FS @ 1 ml per liter of water recorded least termites damage (5.07 to 6.01 %) with highest cane yield of 138 to 142 t/ha compared to untreated control (30.31% damage with 106t/ha)

Table 101. Efficacy of different insecticides on the incidence of termites through sett treatment in sugarcane

S.N.	Treatments	Dose (per litre water)	% germination	% plant damage	% protection over untreated check	Cane yield (t/ha)
1	Thiamethoxam 25 WG	1 g	82.66	10.15(18.57)	66.51	125.00
2	Imidacloprid 17.8 SL	1ml	89.33	8.82 (17.27)	70.90	131.00
3	Acephate 50% + imidacloprid 1%	1 g	86.33	8.12 (16.55)	73.21	132.00
4	Fipronil 5 SC	1 ml	86.00	8.75(17.20)	71.13	131.00
5	Thiamethoxam 35 FS	1 ml	89.00	6.01 (14.19)	80.17	138.00
6	Imidacloprid 600 FS	1 ml	89.66	5.07 (13.01)	83.27	142.00
7	Clothianidin 50 WDG	1 g	87.66	8.43 (16.87)	72.18	130.00
8	Fifronil 40%+Imidacloprid 40%WG	1 g	86.33	7.81 (16.22)	74.23	130.00
9	Chlorantraniliprole 18.5 SC	0.5ml	80.33	8.04 (16.47)	73.40	134.00
10	Untreated check	-	64.33	30.31 (33.41)	-	106.00
	S.Em+		0.69	0.57	-	2.32
	CD at 5%		2.05	1.71	-	5.88

Values in parentheses are angular transformed values

Management of termite through Drenching in standing sugarcane crop

Methodology:

Location : Mahadeswarapura, Pandavapura Tq , Mandya Dist.
Farmer Name : Sri Venkateshappa
Variety : Co 86032
Design : RBD
No. of Treatments : 07
Replication : 03
Individual Plot size : 5 m x 5 m=25 m^2
Total Experimental plot size : 525 m^2
Date of planting : 28.01.2021
Date of treatment : 02.05.2021 (3 months old crop)

Results:

Application of different insecticides through soil drenching resulted in significant reduction of termite damage in standing sugarcane crop.

Conclusion:

The results revealed that soil drenching Imidacloprid 17.8 SLS @ 350 ml/ha recorded least termites damage (11.33 %) with highest cane yield of 125 t/ha compared to untreated control (30.66% damage with 102 t/ha).

Table 102. Efficacy of different insecticides on the incidence of termites through soil drenching in standing sugarcane crop

S.N.	Treatments	Dose (per ha)	% Plant Damage Before drenching	% Plant Damage at 25 days after drenching	% protection over untreated check	Cane yield (t/ha)
1	Imidacloprid 600 FS	800 ml	26.33 (30.87)	15.66 (23.11)	48.92	116.00
2	Imidacloprid 17.8 SL	350 ml	24.66 (29.77)	11.33 (19.66)	63.04	128.00
3	Fipronil 5 SC	2000 ml	26.00 (30.65)	12.66 (20.84)	58.70	122.00
4	Imidacloprid 70 WS	160 ml	22.33 (28.19)	13.66 (21.69)	55.44	122.00
5	Clothianidin 50 WDG	250 g	25.66 (30.43)	14.66 (22.51)	52.18	118.00
6	Chlorantraniliprole 18.5 SC	500 ml	24.33 (29.55)	18.33 (25.34)	40.21	114.00
7	Untreated check	-	25.33 (30.21)	30.66 (33.62)	-	102.00
	S.Em±		1.52	1.48	-	2.36
	CD at 5%		NS	3.62	-	4.28

Note: Values in parentheses are angular transformed values

Studies on species diversity of termites in Karnataka

Recorded five species of termites infesting cereals and trees in Karnataka and developed species distribution maps for *Odontotermes anamallensis* Holmgren & Holmgren, *O. horni* (Wasmann), *O. obesus* (Rambur), *Trinervitermes biformis* (Wasmann) and *Macroterms convulsionarius* König.

SECTION 9
MANAGEMENT OF CUTWORMS AT PALAMPUR CENTRE

CSK-HPKV, Palampur

Monitoring of cutworms on light trap during 2021 at Palampur:

Light trap was installed at Palampur for monitoring the adult activity of *A. ipsilon* and *A. segetum* during 2021. The emergence of *A. ipsilon* was started in first week of April with a peak catch (19 moths/ week) in the second week of May, 2021. *A. segetum* was also caught in the light trap with maximum catch (14 moths/ week) observed in first week of May.

Table 103. Monitoring of cutworms on light trap during 2021 at Palampur

Month	Week	*A. ipsilon*	*A. segetum*
April	13	3	0
	14	6	3
	15	6	6
	16	11	8
May	17	13	14
	18	19	10
	19	14	6
	20	10	6
	21	5	5
June	22	10	6
	23	13	10
	24	3	2
	25	2	2
July	26	0	0
	27	0	0
	28	0	0

Testing of natural products against *A. segetum*

The natural products namely *Brahmastra*, *Neemastra*, garlic + chilli extract and *Agniastra* were tested against 3rd and 6th instar larvae of *A. segetum* under laboratory conditions to know their detergence. The order of feeding inhibition (FI) of 3rd instar larvae on the basis of FI_{50} values was obtained as *Brahmastra* >*Neemastra* > garlic + chilli extract >*Agniastra*. *Brahmastra* was found to be the most inhibiting natural product as for as feeding is concerned among the tested ones and it is about 1.11 times more inhibiting than the least toxic *Agniastra.*

Table 104. Relative feeding inhibition of natural products to 3rd instar larvae of *A. segetum*

Sr. No	Natural products	FI_{50} (%)	Regression equation (Y=a+bX)	Slope (b)	Heterogeneity (χ^2_{cal})	Relative feeding inhibition
1.	*Brahmastra*	5.81	4.03+1.27X	1.27	0.08	1.11
2.	*Neemastra*	6.12	4.03+1.23X	1.23	0.21	1.05
3.	Garlic+chilli extract	6.39	4.01+1.23X	1.23	0.21	1.01
4.	*Agniastra*	6.44	4.03+1.20X	1.20	0.21	1.00

In case of 6th instar larvae, the order of feeding inhibition of on the basis of FI_{50} values was obtained as *Brahmastra* >*Neemastra* > garlic + chilli extract >*Agniastra* with FI_{50} values per cent, respectively. *Brahmastra* was found most inhibiting feeding among the tested natural products and it is about 1.30 times more inhibiting than the least toxic *Agniastra*.

Table 105. Relative feeding inhibition of natural products to 6th instar larvae of *A. segetum*

Sr. No	Natural products	FI_{50} (%)	Regression equation (Y=a+bX)	Slope (b)	Heterogeneity (χ^2_{cal})	Relative feeding inhibition
1.	*Brahmastra*	6.61	3.96+1.24X	1.24	0.20	1.30
2.	*Neemastra*	7.04	3.93+1.24X	1.24	0.20	1.22
3.	Garlic+chilli extract	7.49	3.91+1.23X	1.23	0.09	1.15

Chemical control of cutworms in cabbage during 2021

Location : Research Farm, Department of Entomology, Palampur
Crop : Cabbage
Plot size : 4x3 m^2
Date of transplanting : 9.11.2021
Treatments : 6
Replications : 4

Evaluation of different chemicals was done against cutworms in cabbage as pre sown at post sown application. Imidacloprid 0.3 GR, clothianidin 50 WDG, fipronil 0.3G and thiamethoxam 25WG were applied before transplanting of the cabbage seedlings in the pits. Imidacloprid 17.8SL, clothianidin 50WDG, fipronil 0.3G, thiamethoxam 25WG and chlorpyriphos 20EC were applied one day after the transplanting of cabbage seedlings. Observations on plant mortality were recorded after one and two weeks after treatment. In pre

sown application, the per cent plant infestation was minimum (1.90%) in clothianidin 50WDG in the 2nd week of observation after treatment, whereas, in control 13.25% plant infestation was recorded.

Table 106. Field evaluation of pre sown application of different insecticides against cutworms at Palampur 2021

Treatments	Dose (g a.i./ ha)	Per cent plant infestation after week of treatment	
		1st week	2nd week
Imidacloprid 0.3 GR	45 g a.i./ha	5.100	8.300
Clothianidin 50WDG	120 g a.i./ha	1.900	4.200
Fipronil 0.3G	50 g a.i./ha	2.900	6.798
Thiamethoxam 25WG	80 g a.i./ha	4.600	8.400
Untreated check	-	8.690	13.600
CD Factor (A): 0.146 Factor (B): 0.092 Factor (A X B): 0.207			

Table 107. Field evaluation of post sown application of different insecticides against cutworms at Palampur 2021

Treatments	Dose (g a.i./ ha)	Per cent plant infestation after week of treatment	
		1st week	2nd week
Imidacloprid17.8.SL	60 g a.i./ha	4.800	7.600
Clothianidin50WDG	120 g a.i./ha	1.600	3.80
Fipronil 0.3G	50 g a.i./ha	3.1	7.10
Thiamethoxam 25WG	80 g a.i./ha	5.0	8 00
Chlorpyriphos20EC	500 g a.i./ha	1.690	3.80
Untreated check	-	13.40	15.89
CD Factor (A): 0.146 Factor (B): 0.092 Factor (A X B): 0.207			

SECTION 10

LOCATION SPECIFIC ACTIVITIES

RARI, Durgapura

Transfer of technology

Under transfer of technology programme of the project, training programmes were organized in collaboration with govt. officials of Department of Agriculture, Govt. of Rajasthan for the farmers to educate them about whitegrub management and distribution of nanogel pheromone traps to farmers for management of whitegrub. The trainings were organized at different villages of Jaipur, Dausa, Tonk, Nagour and Sikar districts. During training the farmers were apprised with the damage in various crops mainly groundnut and bajra, life cycle of the whitegrub, beetle and grub management through IPM technology including nanogel pheromone technology of beetle management, chemical and cultural control of grubs in the soil. At all locations farmers showed their keen interest and promised to adopt the nanogel pheromone technology in coming *kharif* season.

The beetle management was done on pre and post monsoon rain for three consecutive days by using nanogel pheromone traps. This operation was followed by sowing of groundnut after seed treatment with imidacloprid 600FS 6.5ml/kg seed. Standing crop treatment was also done on fields where sowing was done earlier without seed treatment with imidacloprid 17.8 SL at 300 ml/ha dose. Regarding impact of the technology, the compilation of the data is in progress.

Management of soil arthropods in groundnut crop through IPM

Soil arthropods management in groundnut crop through integrated pest management practices were carried out with four IPM modules including one control module. Mean minimum plant mortality and maximum pod yield was recorded in IPM module I with 3.77 % plant mortality and 32.01 q/ha pod yield followed by IPM module II and IPM module III. In untreated control 98.0 per cent plant mortality was recorded.

Table 108. Effect of IPM modules (treatments) on per cent plant mortality, larval population of white grub per square meter and yield of groundnut

Sr. No.	Treatments	Per cent plant mortality of groundnut				Larval population of white grub per square meter				Yield of groundnut				
		Kharif-2019	*Kharif*-2020	*Kharif*-2021	Mean	*Kharif*-2019	*Kharif*-2020	*Kharif*-2021	Mean	*Kharif*-2019	*Kharif*-2020	*Kharif*-2021	Mean	ICBR ratio
IPM-I	Soil application of Neem cake 250kg/ha Seed treatment with imidacloprid 600 FS-@ 6.5 ml/kg seed *Application of Beauveria bassiana* –0.5g/m^2 Application of imidacloprid 17.8 SL@ 300 ml/ha	3.37 (10.32)	4.43 (12.13)	3.53 (10.58)	3.77 (11.18)	0.00	0.00	0.00	0.00	31.00	33.20	31.83	32.01	1:13.42
IPM-II	Soil application of Neem cake 250kg/ha Seed treatment with imidacloprid 600 FS-@ 6.5ml/kg seed *Application of Metarhizium anisopliae-0.5*g/m^2 Application of Fifronil 5 SC-3.0 lit./ha	6.68 (14.78)	7.33 (15.63)	6.50 (14.63)	6.83 (15.14)	0.17	0.20	0.33	0.23	29.05	27.45	29.88	28.79	1:9.38
IPM-III	Soil application of Neem cake 250kg/ha Seed treatment with imidacloprid 600 FS-@6.5ml/kg seed *Application of H.indica-0.5*g/m^2 *Application of* Fifronil40%+Imidacloprid 40%WG@ 300g/ha	14.91 (22.55)	16.21 (23.72)	15.41 (22.97)	15.51 (23.18)	0.50	0.55	0.66	0.57	26.33	25.00	27.49	26.27	1:8.24
IPM-IV	Untreated control	100.00 (90.00)	100.00 (90.00)	94.00 (76.05)	98.00 (85.26)	7.00	7.15	6.83	6.99	0.00	0.00	0.86	0.28	-
	SE(m)	1.095	0.545	1.243	2.309	0.149	0.272	0.141	0.063	1.128	0.779	1.104	0.593	
	C.D. at 5%	3.32	1.699	3.78	8.14	0.45	0.84	0.43	0.22	3.43	2.42	3.35	2.09	
	C.V. %	7.79	8.02	9.80	11.87	12.05	14.18	11.65	9.63	12.78	11.05	12.00	14.70	

Recommendation:

For the management of soil arthropods in groundnut crop, soil application of Neem cake@250kg/ha, seed treatment with Imidacloprid 600 FS @ 6.5 ml per kg seed, application of Beauveria bassiana –0.5g/m 2 and application of imidacloprid 17.8 SL@ 300 ml/ha at 20-25 DAS is most effective.

Fig. 58. Management of soil arthropods in groundnut crop through IPM

Management of soil arthropods in groundnut crop through chemicals

To protect the groundnut crop against soil arthropod pests with different insecticides were evaluated by using them as seed dresser and standing crop treatments. Perusal of the data in table indicated that Imidaclprid 600 FS at 6.5 ml/kg seed followed by standing treatment at 21 days after sowing with imidacloprid 17.8 SL @ 500 ml/ha was found superior to all the other tested insecticides, with minimum 3.53 per cent plant mortality and maximum 31.94 q/ha pod yield, respectively. Larval population was found 0.0 larvae/m^2 in the treatment. In untreated check 100 per cent plant damage was recorded.

Table 109. **Effect of Chemical (treatments) on Plant mortality, larval population and pod yield in groundnut crop during *kharif* (2021)**

Sr. No.	**Treatments**	**Dose per kg seed**	**Treatments**	**Dose/ha**	**Plant mortality (%)**			**Larval population /m^2**			**Pod yield (q/ha)**		
					2020	**2021**	**Mean**	2020	**2021**	Mean	2020	2021	Mean
1	Clothianidin 50 WDG	2.0 g	Imidacloprid 17.8 SL	300 ml	6.31 (14.43)	5.64 (13.68)	5.97 (14.05)	0.00	0.00	0.00	25.64	26.30	25.97
2	Clothianidin 50 WDG	2.0 g	Imidacloprid 17.8 SL	500 ml	5.01 (12.93)	4.68 (12.46)	4.84 (12.69)	0.00	0.00	0.00	28.86	29.52	29.19
3	Clothianidin 50 WDG	2.0 g	Fipronil 40% + Imidacloprid 40%	500 g	10.49 (18.87)	9.48 (17.92)	9.98 (18.39)	0.13	0.10	0.11	23.09	23.76	23.42
4	Imidacloprid 600 FS	6.5 ml	Imidacloprid 17.8 SL	300 ml	4.84 (12.66)	4.50 (12.23)	4.67 (12.44)	0.00	0.00	0.00	29.23	29.90	29.56
5	Imidacloprid 600 FS	6.5 ml	Imidacloprid 17.8 SL	500 ml	3.53 (10.73)	3.19 (10.17)	3.36 (10.45)	0.00	0.00	0.00	31.94	32.61	32.27
6	Imidacloprid 600 FS	6.5 ml	Fipronil 40% + Imidacloprid 40%	500 g	9.55 (17.91)	8.88 (17.29)	9.21 (17.60)	0.13	0.13	0.13	23.90	24.57	24.23
7	Imidacloprid 600 FS	6.5 ml	Fipronil 5 SC	3.0 lit.	12.44 (20.56)	11.50 (19.73)	11.97 (20.14)	0.20	0.16	0.18	20.16	20.83	20.49
8	Clothianidin 50 WDG	2.0 g	Fipronil 5 SC	3.0 lit.	16.07 (23.50)	14.73 (22.51)	15.40 (23.00)	0.27	0.23	0.25	18.74	19.41	19.07
9	Untreated control	-	-	-	100.00 (90.00)	92.67 (74.40)	96.33 (82.20)	6.00	5.33	5.66	0.00	0.94	0.47
	SE(m)	-			1.170	0.955		0.199	0.116		0.493	0.908	
	C.D. at 5%	-			3.53	2.88		0.60	0.35		1.49	2.74	
	C.V. %	-			8.23	7.42		8.05	10.30		7.81	6.78	

Fig. 59. Evaluation of insecticdes as seed treatment followed by standing crop treatment

Comparative evaluation of pheromone, methoxy benzene (Anisole) and Nanogel of methoxy benzene at RARI, Durgapura, Jaipur on 15 meter distance during kharif, 2021

The already isolated and characterized pheromone methoxy benzene of predominant species of groundnut ecosystem *Holotrichia consenguniea* at RARI Durgapura is aggregating pheromone but it is highly volatile in nature so, daily putting of new septa on host tree does require. To overcome this problem for farmers, slow release "Nano gel formulation of Methoxy benzene" was prepared by Nano gel technology for beetle (*Holotrichia consenguniea)* management and the technology has been tested in white grub endemic areas of Rajasthan and perfected.

This slow release "Nano gel formulation is effective in aggregation of beetles up to one month and now daily loading of new septa wouldn't be required upto one month.

The beetle catcheswere started in nanogel formulation second week of July and as continue till last week of July in comparision to anisole the catches were only on day of installation.

Recommendations

- ✓ For the management of white grub beetles slow release nanogel of pheromone methoxy benzene (anisole) is effective up to 25 days of installation.

Table 110. Comparative evaluation of pheromone, methoxy benzene (Anisole) and Nanogel of methoxy benzene at RARI, Durgapura, Jaipur on 15 meter distance during kharif, 2021

Treatments	Date of traps																			Mean adult catch/ trap
	11/7	12/7	13/7	14/7	15/7	16/7	17/7	18/7	19/7	20/7	21/7	22/7	23/7	24/7	25/7	26/7	27/7	28/7	29/7	30/7	
N	36	39	31	42	21	15	10	9	5	3	1	0	32	21	13	17	11	14	7	4	16.55
N	27	29	16	23	18	11	9	7	4	1	1	0	24	18	15	11	10	6	4	3	11.85
N	29	27	17	27	14	9	8	5	3	1	0	0	19	10	9	10	11	13	7	2	11.05
N	37	19	19	23	17	11	9	6	4	2	1	1	29	22	18	12	10	9	8	3	13.00
N	21	21	15	20	19	7	5	3	1	2	1	0	28	23	10	15	11	10	9	5	11.3
A	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.25
A	28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.40
A	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.60
A	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.30
A	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.55

Field experiment of nanogel

Management of *H. consenguniea* by developed technology "slow release nanogel of pheromone methoxy benzene" has been published in ICAR news letter

AAU, Jorhat

Evaluation of some bait materials against red ant, *Dorylusorientalis*

Among the various bait materials tested, the technology on the use of oil-based bait *i.e.* rice bran oil along with boric acid @50:50 parts for the management of red ants, *Dorylusorientalis* in potato has been approved and recommended for incorporation in the Package of Practices for *rabi* crops of Assam.

Nutritional profiling of Desert Locust, *Schistocerca gregaria* powder

Laboratory experiments were carried out to assess the nutritive value of desert locust, *S. gregaria*powders based on proximate and elemental composition at the AINP on Soil Arthropod Pests Laboratory, Department of Entomology, AAU, Jorhat during 2021. The insect samples were collected from Rajasthan Agricultural Research Institute, Durgapura, Jaipur and after collecting the samples were cleaned, dried and grinded to attain a fine powder form. The data pertaining to the proximate and elemental analysis are presented in Table.

Experimental results revealed that the powdered sample contained 12.33 per cent of moisture. Considerably high amount of crude protein (48.17%) was estimated in the locust powdered sample as compared to the other proximate parameters like crude fat (44.08%), carbohydrate (17.05%), crude fibre (12.01%) and ash content (3.36%). The energy content of the studied sample was recorded to be 657.69 kcal/100g. Elemental analysis of the sample revealed the presence of 7 minerals, out of which K (49.93 mg/100g) was found to be the highest followed by Na (34.77 mg/100g) and Ca (26.15mg/100g). The Mg, Fe, Zn and Cu contents were recorded to be 20.15, 12.76, 12.18 and 4.85 mg/100g, respectively.

Table 111. Nutritional profiling of desert locust powder

Proximate analysis	
Parameters	**Mean**
Moisture (g/100g)	12.33
Crude protein (g/100g)	48.17
Carbohydrate (mg/ml)	17.05
Crude fat (g/100g)	44.09
Crude fibre (g/100g)	12.01
Ash (g/100g)	3.36
Energy content (kcal/100g)	657.69
Elemental analysis	

Elements	mg/100g
Ca	26.15
Cu	4.855
Na	34.77
Fe	12.76
Zn	12.18
K	49.93
Mg	20.15

Mean of 3 replications

Nutritional evaluation of some value-added food products enriched with *Lepidiotamansueta* flour

Laboratory experiments were carried out to evaluate some value-added food products *viz.*, biscuits, *bhujia* and cakes enriched with *L. mansueta*flour based on proximate and elemental composition in the AINP on Soil Arthopod Pests Laboratory, Department of Entomology and Post Graduate Laboratory, Department of Biochemistry and Agricultural Chemistry, AAU, Jorhat during 2021-22 (Plate 13).

Experimental results pertaining to both proximate and elemental analysis revealed that all the three value added food products enriched with different concentrations of *L. mansueta* powders (T_1: 10%, T_2: 20% and T_3: 30%) were significantly superior as compared to the products without any fortification of *L. mansueta*powders (T_4). In case of biscuits, a gradual increase in the per cent of moisture (6.79-7.76), crude protein (15.93-28.61), crude fat (23.07-25.71), crude fibre (0.61-0.83) and ash (1.12-1.62) content was recorded when the concentration of *L. mansueta* flour was increased from 10-30 per cent. On the contrary, per cent carbohydrate content showed gradual decreasing trend (62.18-42.63) with the increase in the concentration of *L. mansueta* flour. Maximum energy content (kcal/100g) was estimated in the biscuits supplemented with 20 per cent of *L. mansueta* beetle flour (534.03) followed by 10 per cent (528.07) and 30 per cent (514.37). All the estimated minerals (mg/100g) *viz.*, Na (43.256-45.273), K (41.579-46.473), Mn (0.315-0.432), Zn (1.356-4.037) and Cu (0.101-0.270) of biscuits showed a gradual increasing trend with the increasing in the concentration of *L. mansueta*flour from 10-30 per cent.

In case of *bhujia*, a gradual increase in the per cent of moisture (3.23-3.85), crude protein (17.02-29.23), crude fat (39.02-42.78), crude fibre (0.66-0.86) and ash (3.60-4.85) content was also recorded when the concentration of *L. mansueta* flour was increased from 10-30 per cent while the carbohydrate content showed a gradual decreasing trend (61.11-

44.15%). Maximum energy content (kcal/100g) was estimated in the *bhujia*supplemented with 30 per cent of *L. mansueta*beetle flour (680.19) followed by 10 per cent (665.02) and 20 (664.07). A gradual increase in all estimated minerals (mg/100g) *viz.*, Na (48.124-52.731), K (43.459-45.587), Mn (0.130-0.254), Zn (1.313-3.243) and Cu (0.112-1.891) was observed with the increase in the concentrations of *L. mansueta*flour.

A similar trend of results was also observed in the cakes where a gradual increase in the per cent of moisture (23.07-25.52), crude protein (13.30-26.43), crude fat (20.10-23.06), crude fibre (0.66-0.84) and ash (1.31-1.65) was observed with the increase in the concentrations of *L. mansueta* flour from 10-30 per cent. The per cent carbohydrate content showed a gradual decreasing trend (61.62-44.43) with the increase in the concentration of *L. mansueta*flour. Maximum energy content (kcal/100g) was estimated in the cakes supplemented with 30 per cent of *L. mansueta* beetle flour (492.67) followed by 20 per cent (483.23) and 10 per cent (481.94). All the estimated minerals (mg/100g) *viz.*, Na (43.183-46.375), K (41.721-46.676), Mn (0.882-3.361), Zn (0.701-3.041) and Cu (0.094-0.394) registered a gradual increasing trend with increase in *L. mansueta*beetle flour.

Dried *Lepidiotamansueta* beetles

***L. mansueta* beetles powder**

Biscuits prepared from *L. mansueta* beetles

***Bhujia* prepared from *L. mansueta* beetles**

Cakes prepared from *L. mansueta* beetles

Fig. 60. Development and nutritional evaluation of some value-added products prepared from *L. mansueta* beetle flour

Table 112. Proximate composition of biscuits prepared from *L. mansueta* beetle flour

Treatment	Moisture	Crude Protein	Crude Fat	Crude Fibre	Carbohydrate	Ash	Energy
	(%)						(kcal/100g)
T_1 (10:90)	6.79±0.19	15.93±0.62	23.07±0.14	0.61±0.03	62.18±2.37	1.12±0.18	528.07±7.72
T_2 (20:80)	7.21±0.27	22.18±1.00	24.40±0.55	0.74±0.05	55.44±2.41	1.30±0.15	534.03±4.01
T_3 (30:70)	7.76±0.334	28.61±0.60	25.71±0.70	0.83±0.04	42.63±1.66	1.62±0.15	514.37±11.64
T_4 (0:100)	5.55±0.337	7.92±0.39	19.93±0.64	0.51±0.02	72.57±1.71	0.74±0.17	509.27±9.33
S. Ed (±)	0.21	0.49	0.38	0.03	1.06	0.12	6.15
CD (p=0.05)	0.44	1.04	0.81	0.06	2.26	0.25	13.12

Data are mean of four replications

Table 113. Elemental composition of biscuits prepared from *L. mansueta* beetle flour

Treatment	Sodium (Na)	Potassium (K)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
	mg/100g				
T_1 (10:90)	43.256±0.281	41.579±0.328	0.315±0.017	1.356±0.276	0.101±0.013
T_2 (20:80)	45.118±0.380	44.608±0.132	0.338±0.007	2.671±0.121	0.144±0.018
T_3 (30:70)	45.273±0.244	46.473±0.567	0.432±0.023	4.037±0.156	0.270±0.020
T_4 (0:100)	42.661±0.578	38.708±0.328	0.159±0.017	0.326±0.013	0.082±0.012
S. Ed (±)	0.278	0.252	0.012	0.120	0.011
CD (p=0.05)	0.592	0.531	0.026	0.248	0.024

Data are mean of four replications

Table 114. Proximate composition of *bhujia* prepared from *L. mansueta* beetle flour

Treatment	Moisture	Crude Protein	Crude Fat	Crude Fibre	Carbohydrate	Ash	Energy
	(%)						(kcal/100g)
T_1 (10:90)	3.23±0.23	17.02±0.89	39.02±0.31	0.66±0.04	61.11±1.14	3.60±0.32	665.02±8.93
T_2 (20:80)	3.49±0.12	21.48±0.52	40.29±0.26	0.74±0.04	53.53±1.52	4.13±0.27	664.07±8.51
T_3 (30:70)	3.85±0.16	29.23±0.59	42.78±0.15	0.86±0.04	44.15±1.04	4.85±0.10	680.19±3.79
T_4 (0:100)	2.90±0.08	09.91±0.54	35.23±0.64	0.59±0.02	69.54±1.92	3.16±0.28	633.10±14.25
S. Ed (±)	0.11	0.46	0.36	0.03	1.02	0.19	6.80
CD (p=0.05)	0.23	0.98	0.77	0.06	2.18	0.40	14.48

Data are mean of four replications

Table 115. Elemental composition of *bhujia* prepared from *L. mansueta* beetle flour

Treatment	Sodium (Na)	Potassium (K)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
	mg/100g				
T_1 (10:90)	48.124±0.342	43.459±0.571	0.130±0.021	1.313±0.04	0.112±0.023
T_2 (20:80)	50.344±0.249	44.179±0.219	0.192±0.019	2.328±0.14	0.224±0.012
T_3 (30:70)	52.731±0.205	45.587±0.252	0.254 ±0.013	3.243±0.13	1.891±0.082
T_4 (0:100)	44.581±0.694	40.482±0.318	0.072±0.012	0.295±0.04	0.024±0.015
S. Ed (±)	0.291	0.259	0.013	0.072	0.031
CD (p=0.05)	0.631	0.553	0.024	0.151	0.062

Data are mean of four replications

Table 116. Proximate composition of cake prepared from *L. mansueta* beetle flour

Treatment	Moisture	Crude Protein	Crude Fat	Crude Fibre	Carbohydrate	Ash	Energy
	(%)						(kcal/100g)
T_1 (10:90)	23.07±0.13	13.30±0.65	20.10±0.60	0.66±0.05	61.62±1.27	1.31±0.20	481.94±8.76
T_2 (20:80)	24.40±0.54	19.34±0.54	21.31±0.33	0.75±0.04	53.13±2.72	1.65±0.09	483.23±9.75
T_3 (30:70)	25.52±0.45	26.43±1.22	23.06±0.48	0.84±0.04	44.43±2.56	1.96±0.278	492.67±15.81
T_4 (0:100)	19.92±0.64	7.00±0.45	17.46±0.55	0.54±0.04	73.02±1.27	0.80±0.10	478.35±9.06
S. Ed (±)	0.39	0.55	0.35	0.029	1.47	0.13	7.93
CD (p=0.05)	0.83	1.17	0.75	0.061	3.13	0.28	16.91

Data are mean of four replications

Table 117. Elemental composition of cake prepared from *L. mansueta* beetle flour

Treatment	Sodium (Na)	Potassium (K)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
	mg/100g				
T_1 (10:90)	43.183±0.764	41.721±0.249	0.882±0.022	0.701±0.069	0.094±0.029
T_2 (20:80)	45.976±0.108	43.118±0.273	2.293±0.091	1.164±0.073	0.145±0.014
T_3 (30:70)	46.375±0.655	46.676±0.255	3.361±0.029	3.041±0.065	0.394±0.024
T_4 (0:100)	38.795±0.868	40.439±0.509	0.364±0.009	0.263±0.017	0.056±0.009
S. Ed (±)	0.472	0.240	0.031	0.041	0.013
CD (p=0.05)	1.004	0.511	0.063	0.083	0.034

Data are mean of four replications

Vitamin profiling of *Lepidiota mansueta* adult powders

Owing to the acceptance of *Lepidiota* beetles as culinary delight and by observing the possibility of *Lepidiota* beetle powders in developing and marketing of various value-added products, an attempt was made to analyze the vitamin content in the beetle powdered samples in collaboration with CSIR-Central Food Technological Research Institute, Mysore. Altogether, 12 vitamins were analyzed and results are presented in the table. Out of all the vitamins estimated, the maximum amount was recorded in case ofVit. B3 (27.2 mg/100g) followed by C (24.00 mg/100g) and B2 (4.32 mg/100g). Relatively lower amounts were recorded in case of Vit. E (3.27 mg/100g), B5 (1.25 mg/100g) and B7 (0.02 mg/100g). Rest of vitamins *viz*., A, D, B1, B6, B9 and B12 were recorded below the detection limit.

Table 118. Vitamin profiling of *Lepidiota mansueta* adult powders

Vitamin	mg/100g
Vitamin A	BDL*of 0.10
Vitamin C	24.00
Vitamin D	BDL* of 0.10
Vitamin E	3.27
Vitamin B1	BDL* of 0.10
Vitamin B2	4.32
Vitamin B3	27.2
Vitamin B5	1.25
Vitamin B6	BDL* of 0.10
Vitamin B7	0.020
Vitamin B9	BDL* of 0.10
Vitamin B12	BDL* of 0.10

*BDL-Below Detection Limit

Impact of certain newer soil insecticides on soil arthropod diversity in a vegetable growing agro-ecosystem of Assam

Field experiments were carried out in the Horticulture Experimental Farm, Assam Agricultural University, Jorhat during 2021 to study the impact of certain newer insecticides on soil arthropod diversity in a vegetable growing ecosystems. Six newer soil insecticides *viz*., clothianidin 50 WDG, fipronil 0.3 G, thiamethoxam 25 WG, imidacloprid 70 WG, chlorantraniliprole 0.4 GR and fipronil 40%+ imidacloprid 40% WG were selected for conducting the experiment. Sampling for soil macro and microarthropods were done at pre-treatment, 15, 30, 45, 60 and 75 days after treatment

(DAT). The soil macroarthropods were sampled using pitfall traps whereas the microarthropods were extracted through Tullgren Funnel.

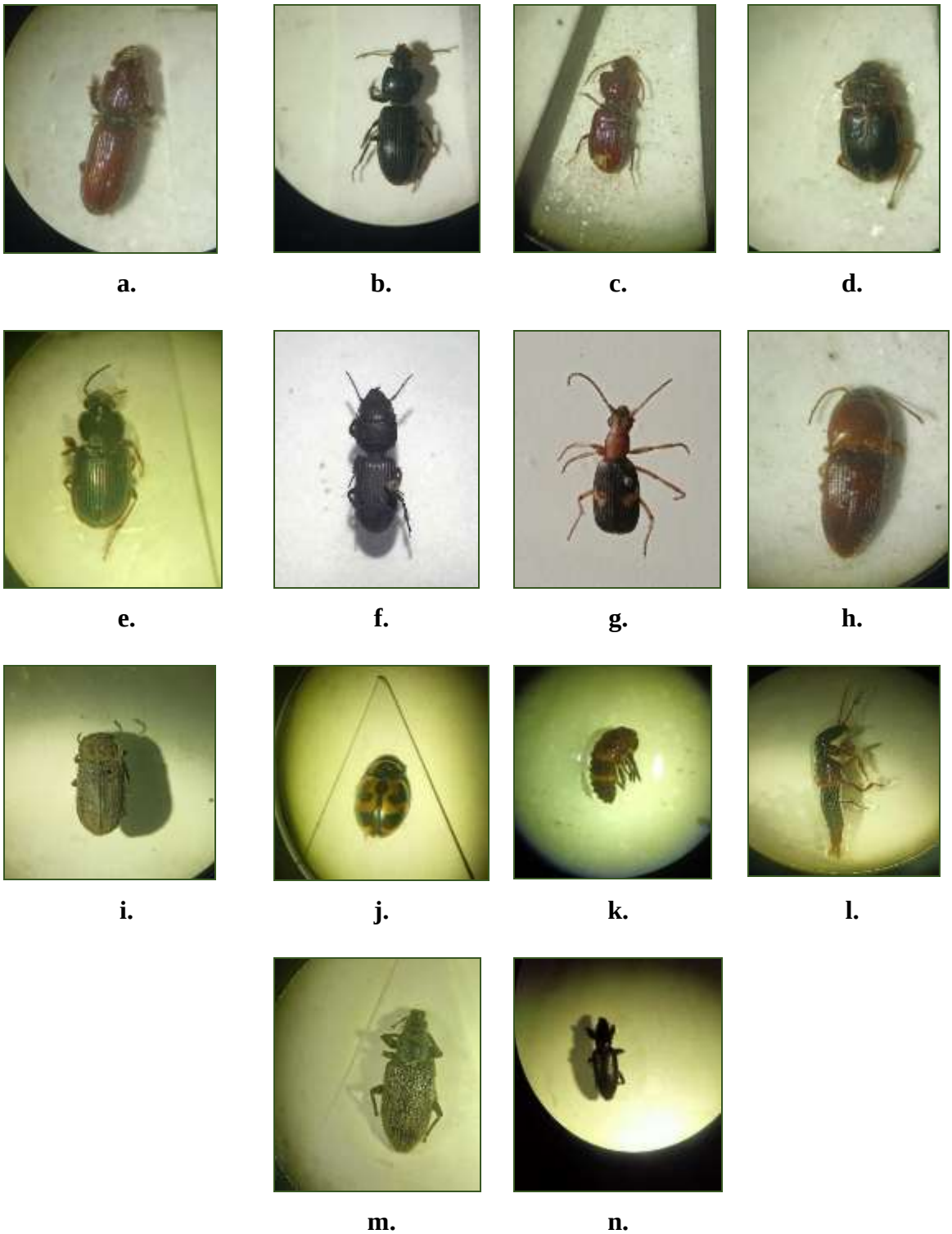
Experimental results revealed the hymenopterans as the most dominant group (54.74%) among the different soil macroarthropods observed prior to the application of insecticides followed by Coleoptera (13.68%) and Araneae (11.57%). Among the soil microarthropods, the abundance of Collembola and Oribatida were recorded to be 64.72 and 35.28 per cent, respectively in the pre-treated plots.

The number of soil macroarthropods was ranged between 89.00 to 95.33/plot prior to the application of insecticides which showed statistical parity with each other. At 15 DAT, the abundance of soil macroarthropods in all the treated plots were reduced significantly (47.33-52.67 numbers) compared to the untreated control (89.33 numbers). However, maximum number of soil macroarthropods/plot was recorded in chlorantraniliprole 0.4 GR treated plots (52.67) followed by clothianidin 50 WDG (50.33) and thiamethoxam 25 WG (49.67) treated plots. Perusal of data in respect of 30, 45, 60 and 75 days after treatment also showed a significant decrease in the numbers of soil macroarthropods as compared to the control, however, a gradual increase in the total number of soilmacroarthropods was observed in each treated plots from 30 DAT onwards. Soil microarthropods obtained in different plots prior to the application of insecticides was ranged between 458.33 to 555.56 numbers/sq.m. All the insecticidal treatments did not exhibit any significant (p=0.05) impact on soil microarthropod population during the experimental period.

Table 119. Abundance of different soil arthropods recorded in the pretreated plots

Arthropods	Order	Number of individuals	Accumulative Frequency (%)	Cumulative frequency (%)
Soil macroarthropods	Hymenoptera	50.28	54.74	54.74
	Coleoptera	12.57	13.68	68.42
	Hemiptera	4.83	5.26	73.68
	Orthoptera	3.87	4.21	77.89
	Neuroptera	2.90	3.16	81.05
	Isoptera	2.57	2.80	83.85
	Dermaptera	2.27	2.47	86.32
	Lepidoptera	1.94	2.11	88.43
	Araneae	10.63	11.57	100
Total		91.86		
Soil microarthropods	Collembola	2936.43	64.72	64.72
	Oribatida	1600.20	35.28	100
Total		4535.72		

Data are mean of 21 observations



a. **b.** **c.** **d.**

e. **f.** **g.** **h.**

i. **j.** **k.** **l.**

m. **n.**

Fig. 61. a-n, Coleopteran insects collected through pitfall traps (a-g) Ground beetles, (h) Click beetle, (i) Darkling beetle, (j-k) Lady bird beetle, (l) Rove beetle, (m-n) Weevil

a. Ants

b. Red ant, *Dorylusorientalis*

c. Termite, *Odontotermesobesus*

d. Cutworm, *Agrotisipsilon*

e. Antlion grub

f. Small black bug

g. Mole cricket, *Gryllotalpa africana*

h. Field cricket, B*rachytrupesportentosus*

Fig. 62. a-h, Other soil macroarthropods observed during the experimental period

Table 120. Effect of certain newer insecticides on soil macroarthropod population (numbers/plot) at different days intervals

Treatment	Pre-treatment	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
	(Mean± SD)					
T_1	93.67±7.57	50.33±7.23	57.67±6.81	64.00±7.21	73.67±6.66	80.67±7.57
T_2	91.67±6.51	47.67±6.03	53.00±6.24	61.33±7.57	70.00±7.21	77.33±5.51
T_3	89.33±7.09	49.67±6.66	56.33±7.23	62.00±6.56	72.33±6.03	79.33±7.02
T_4	89.00±6.24	48.33±7.37	54.67±6.11	61.67±7.64	71.67±5.86	78.67±6.66
T_5	94.33±6.03	52.67±7.57	59.00±7.21	65.67±6.81	74.33±7.09	81.33±8.08
T_6	89.67±6.35	47.33±6.81	52.67±6.11	60.67±6.66	69.33±7.37	77.00±6.24
T_7	95.33±7.37	89.33±7.23	97.67±7.09	101.33±6.51	99.00±6.56	106.33±7.02
S.Ed(±)	2.96	2.56	2.94	2.31	2.33	2.45
CD (p=0.05)	6.44	5.59	6.41	5.02	5.08	5.33

T_1= Clothianidin 50 WDG, T_2= Fipronil 0.3 G, T_3= Thiamethoxam 25 WG, T_4= Imidacloprid 70 WG, T_5= Chlorantraniliprole 0.4GR,T_6= Fipronil 40% + Imidacloprid 40% WG, T_7= Control, *Data are mean of 3 replications*,DAT: Days after treatment

Table 121. Effect of certain newer insecticides on soil microarthropod population (numbers/sq.m.) at different days intervals

Treatment	Pre-treatment	15 DAT	30 DAT	45 DAT	60 DAT	75 DAT
	(Mean± SD)					
T_1	541.67±125.00	680.56±104.86	694.44±127.29	750.00±110.24	1041.67±110.24	1097.22±104.86
T_2	513.89±120.28	611.11±63.65	666.67±110.24	736.11±127.29	958.33±83.33	1041.67±125.00
T_3	486.11±63.65	625.00±83.33	736.11±96.23	763.89±86.74	986.11±120.28	1055.56±96.23
T_4	458.33±110.24	638.89±127.29	680.56±127.29	708.33±83.33	1027.78±127.29	1069.44±63.65
T_5	472.22±127.29	694.44±104.86	750.00±83.33	777.78±104.86	972.22±104.86	1111.11±104.86
T_6	555.56±86.74	597.22±96.23	722.22±104.86	722.22±48.11	1000.00±72.17	1027.78±127.29
T_7	500.00±83.33	652.78±63.65	763.89±86.74	791.67±72.17	1013.89±86.74	1083.33±83.33
S.Ed(±)	45.36	45.66	44.78	40.02	40.59	40.47
CD (p=0.05)	98.84	99.50	97.58	87.20	88.44	88.19

T_1= Clothianidin 50 WDG, T_2= Fipronil 0.3 G, T_3= Thiamethoxam 25 WG, T_4= Imidacloprid 70 WG, T_5= Chlorantraniliprole 0.4GR, T_6= Fipronil 40% + Imidacloprid 40% WG, T_7= Control, *Data are mean of 3 replications,* DAT:Days after treatment

Participation in Farmers Fair/Farmers Day during 2021-22

Participated and showcased the technology on "Mechanical elimination of termite queen" in the 33rd Farmers Day held at Regional Agricultural Research Station, Titabar on 9th November, 2021 and bagged the 3rd best exhibit award

Demonstrating the technology on "Mechanical elimination of termite queen" to Sri Atul Bora. Hon'ble Minister ofAgriculture, Horticulture and Food Processing, Animal Husbandry and Veterinary, Govt. of Assam in the Farmers Fair held at Sugarcane Research Station, Buralikson on 18th December, 2021

Biology Of *Melolontha* Species

Eggs:

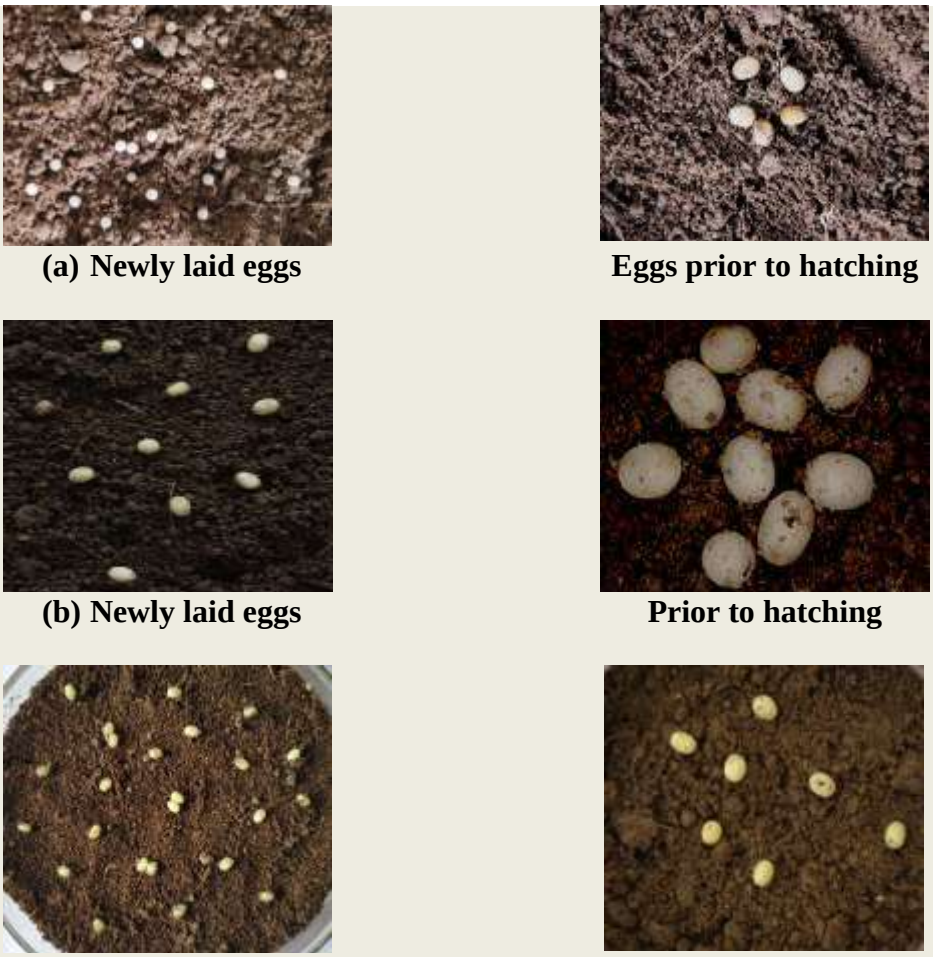
Adult emergence of *M. cuprescens* and *M. furcicauda* from soil started between second-third weeks of June, remained abundant throughout July-August months, and then perished in second week of September. The emergence of *M. indica* beetles commenced in first week of July, peak activity occurred during July-August and their activity continued up to last week of September in Himachal Pradesh. Copulation was observed under laboratory and field conditions. The male and female beetles mated in end to end position and the duration of the coital phase lasted for 16-25 minutes in *M. cuprescens, M. furcicauda* and *M. indica*. Heavy intensive swarming was seen between July-September, and during this time interval intensive egg laying into soil was recorded.

(a) **(b)** **(c)**

Fig. 63. Mating pairs (a) *M. cuprescens;* (b) *M. furcicauda*; (c) *M. indica*

Field collected beetles of *M. cuprescens, M. furcicauda* and *M. indica* started laying eggs after 5-11 days of captivity under laboratory conditions at Palampur. In *M. cuprescens* and *M. furcicauda*, the egg laying was observed during July-August, whereas in *M. indica*, the egg laying was recorded between September and October. Female beetles deposited eggs inside the soil up to a depth of 16 cm. *Melolontha cuprescens* and *M. furcicauda* deposited eggs at a depth of 8-11 and 10-11 cm, respectively, whereas *M. indica* laid eggs more deep at a depth of 13-16 cm in soil. The eggs were found without any earthen cavities in all *Melolontha* species. In deep soil layers, the eggs become less prone to desiccation and abruption, and thereby eliminate the need for earthen cavities.

The chorion of the eggs was very thin and delicate, and it was found to be damaged even at slight disturbance while removing them from the soil. They have a preference for soft soil where the female beetles quickly dug up to a depth of 15-20 cm. The egg laying occurred in batches, and 3-19 eggs per batch were observed in different *Melolontha* species. There was sufficient space between the two eggs inside the soil. The eggs were oval in all the species, but the colour of eggs was found to be variable in different species. In *M. cuprescens*, the eggs were shiny milky white, and in *M. furcicauda*, the colour was slightly dirty white. However, in case of *M. indica*, there was more tinge of yellow, and the eggs appeared creamish to slightly yellowish in colour**.** The eggs of *M. indica* were smaller in size.



(a) Newly laid eggs **Eggs prior to hatching**

(b) Newly laid eggs **Prior to hatching**

(c) Newly laid eggs **Prior to hatching**

Fig. 64. Eggs (a) *M. cuprescens;* (b) *M. furcicauda*; (c) *M. indica*

Average length x width of newly laid eggs of *M. indica* was measured to be 3.63 ± 0.02 x 2.60 ± 0.09 mm. The newly laid eggs of *M. furcicauda* measured from 3.70-4.24 mm in length and 2.63-3.16 mm in width. The eggs of *M. cuprescens* were significantly

larger in size as compared to *M. furcicauda* and *M. indica*. The average length x width of newly laid eggs of *M. cuprescens* was recorded to be 4.58 ± 0.06 x 3.33 ± 0.04 mm. With advancement in embryonic development, the shape of eggs changed from elongate to spherical prior to hatching in about 15-20 days old eggs. The length x width of 20 days old eggs of *M. cuprescens* ranged from 5.11-5.50 x 3.61-3.80 mm.

In *M. furcicauda* and *M. indica*, the average length x width prior to hatching (20 days for *M. furcicauda*; 25 days for *M. indica*) was recorded to be 5.23±0.06 x 3.81±0.02 mm and 4.49±0.05 x 3.20±0.05 mm, respectively. In *M. cuprescens*, the duration of egg stage ranged from 19-22 days with an average of 20.3±0.52 days. There was an increase in incubation period with decrease in egg size among the studied species. The mean incubation period for *M. furcicauda* was recorded to be 23.5±0.48 days (range = 22-25 days). In case of *M. indica*, the incubation period was found to be longest ranging from 24-30 days with an average of 26.5±0.92 days.

Table 122. Size of eggs of *M. cuprescens*, *M. furcicauda* and *M. indica*

Size	Stage	*M. cuprescens*		*M. furcicauda*		Stage	*M. indica*	
		Range	Mean ± SE	Range	Mean ± SE		Range	Mean ± SE
Length (mm)	Newly laid	4.31-4.89	4.58±0.06	3.70-4.24	3.94±0.06	Newly laid	3.55-3.68	3.63±0.02
	20 days old	5.11-5.50	5.29±0.05	4.99-5.46	5.23±0.06	25 days old	4.25-4.71	4.49±0.05
Width (mm)	Newly laid	3.18-3.51	3.33±0.04	2.63-3.16	2.90±0.06	Newly laid	2.22-3.01	2.60±0.09
	20 days old	3.61-3.80	3.70±0.02	3.73-3.88	3.81±0.02	25 days old	2.98-3.40	3.20±0.05

Table 123. Incubation period of *Melolontha* species

Species	Duration of egg stage in days		Period of oviposition
	Range	Mean ± SE	
M. cuprescens	19-22	20.3±0.52	July-August
M. furcicauda	22-25	23.5±0.48	July-August
M. indica	24-30	26.5±0.92	August-September

Larva:

First instar:

The first instar grubs were milky-white in colour with light yellowish head**.** After feeding for 3-4 days, all segments of the body became distinct from each other among themselves. The first instar grubs of *M. cuprescens* were observed to be comparatively larger in size as compared to *M. furcicauda* and *M. indica*.

(a) **(b)** **(c)**

Fig. 65. First instar grubs (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

The fully fed first instar larvae of *M. cuprescens* measured 13.11-16.87 mm in length. The head capsule width ranged from 3.01-4.02 mm. The average body length of first instar grubs of *M. furcicauda* and *M. indica* was recorded to be 11.15 ± 0.37 and 13.49 ± 0.70 mm, respectively. The width of head capsule for first instar grubs of *M. furcicauda* and *M. indica* was observed to be 2.99-3.95 mm and 2.23-2.52 mm, respectively. After hatching, the young grubs started to gnaw the small roots of maize after about two days. The larvae of *M. cuprescens, M. furcicauda* and *M. indica* became more active after about one week, and showed considerable horizontal movement in the soil. In laboratory, the duration of development for first instar grubs was found to be overlapping in all three *Melolontha* species. The first instar grubs of *M. cuprescens* occupied 56-64 days (mean: 59.60 ± 1.29 days). In *M. furcicauda*, first instar grubs occupied 54-56 days with a mean of 54.80 ± 0.32 days. The duration of first instar grubs of *M. indica* has been recorded to range from 53-58 days, and average duration was calculated to be of 55.90 ± 0.83 days. In the present study, the ambient temperature during the period of observations varied between 13.8^{0}C and 29^{0}C. The first instar grubs of *M. cuprescens* and *M. furcicauda* occurred from Aug-Oct, whereas, in *M. indica*, the first instar lasted from Oct-Dec. The fully fed first instar grubs stopped feeding after about 1½ month, and became inactive. In laboratory at Palampur, the first instar grubs of *M. cuprescens* and *M. furcicauda* moulted into second instar during October, whereas in case of *M. indica*, moulting of first instar was observed during December.

Second instar:

The second instar grubs resembled to that of first instar to some extent except size. The last abdominal segment was more enlarged in size to some extent. The body colour of *M. cuprescens* and *M. indica* grubs during second instar was observed to be dirty white, whereas in *M. furcicauda*, the second instar grubs appeared slightly yellowish in colour. The head capsule was dark brown in all the specie**.**

(a) (b) (c)

Fig. 66. Second instar grubs (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

The body length during second instar was almost in the same range for all three studied species. In *M. cuprescens*, the body length was observed to range from 22.29-24.18 mm for full fed second instar grubs. The head capsule width varied from 4.28-5.19 mm. The second instar grubs of *M. furcicauda* were slightly larger in size as compared to *M. cuprescens* and *M. indica*. The average length of second instar grubs of *M. furcicauda* was recorded to be 23.20 ± 0.36 mm with a range of 23.38-24.08 mm. The average head capsule width was recorded to be 5.04 ± 0.09 mm. In case of *M. indica*, the body length varied from 21.87-23.57 mm with an average of 22.61 ± 0.35 mm. The width of head capsule averaged 4.63 ± 0.20 mm (range: 4.18-5.25 mm) as shown in table 4.20. In *M. cuprescens*, the growth ratio (GR) for head capsule width was calculated to be 1.34 for second instar as compared with the first instar. The corresponding values of GR in *M. furcicauda* and *M. indica* have been computed to be 1.57 and 1.95, thus indicating that there exist considerable variations in the growth ratio in different *Melolontha* species. The ratio of body length to head capsule width has been worked out to be 4.71, 4.60 and 4.88 in *M. cuprescens, M. furcicauda* and *M. indica*, respectively. In case of *M. cuprescens* and *M. furcicauda*, the second instar grubs occurred between October, 2017 and May, 2018, while in *M. indica*, the second instar grubs were recorded between December, 2017 and July, 2018 under laboratory conditions at Palampur. The duration of second instar lasted for 226-230 days and 218-224 days in *M. cuprescens* and *M. furcicauda*, respectively. In *M. indica*, it ranged from 234-237 days with an average of 235.30 ± 0.39 days. The second instar grubs in all studied *Melolontha* species were quite active, feeding voraciously on roots of maize/rajmash, and potato tubers. In potato, the second instar grubs inflicted large deep holes in the tubers rendering them unfit for marketing. Second instar grubs constructed earthen cells and moulted inside these cells.

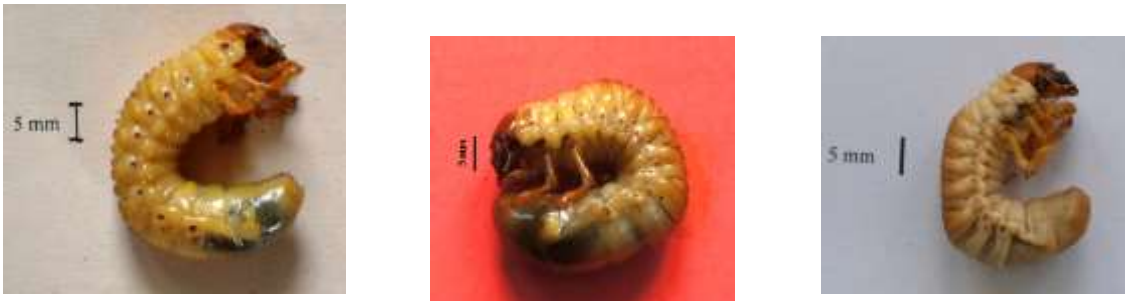
Third instar:

There was considerable increase in size in third instar. The second and third instar larvae did not show much variation in morphological characters. During this final instar, there was slight change in body colour, but the colour of head capsule remained dark brown. In *M. furcicauda*, the body colour was creamish-white to slightly yellowish, whereas third instar grubs of *M. cuprescens* were more yellowish in colour as compared to *M. furcicauda*. In case of *M. indica*, the third instar grubs appeared greyish-white in colour. The third instar grubs appeared bulky, robust and highly active. The body length of *M. cuprescens* and *M. furcicauda* showed distinct overlap, but the grubs of *M. indica* were significantly smaller in size as compared to these two species. The third instar grubs of M. cuprescens measured 51.12-58.20 mm in body length, and 7.68-8.99 mm in head capsule width. The body length of third instar grubs of *M. furcicauda* ranged from 50.11-53.39 mm with an average of 51.85 ± 0.63 mm. The head capsule width for third instar grubs of *M. furcicauda* was recorded to be 7.0 ± 0.05 mm (range: 6.89-7.13 mm). In case of *M. indica*, the third instar grubs measured 44.81 ± 1.82 mm (range: 40.13-50.03 mm), and width of head capsule was recorded to be 6.98-7.58 mm (mean: 7.34 ± 0.14) as indicated in table.

Table 124. Body length and head capsule width for grubs of different *Melolontha* spp.

Instar		Body length and head capsule width (mm)					
		M. cuprescens		*M. furcicauda*		*M. indica*	
		Length	Width	Length	Width	Length	Width
I	Range	13.11-16.87	3.01-4.02	10.01-12.33	2.99-3.95	11.94-15.75	2.23-2.52
	Mean ± SE	15.33±0.66	3.65±0.22	11.15±0.37	3.21±0.19	13.49±0.70	2.37±0.05
II	Range	22.29-24.18	4.28-5.19	22.38-24.08	4.85-5.35	21.87-23.57	4.18-5.25
	Mean ± SE	22.99±0.32	4.88±0.17	23.20±0.36	5.04±0.09	22.61±0.35	4.63±0.20
III	Range	51.12-58.20	7.68-8.99	50.11-53.39	6.89-7.13	40.13-50.03	6.98-7.58
	Mean ± SE	53.80±1.24	8.18±0.23	51.85±0.63	7.0±0.05	44.81±1.82	7.34±0.14

The growth ratio (GR) for head capsule width of *M. cuprescens* and *M. indica* was on higher side as compared to *M. furcicauda*. The GR ratio for head capsule width of *M. cuprescens* and *M. indica* was calculated to be 1.67 and 1.59 for the third instar as compared with the second instar, respectively. The corresponding value of GR for head capsule width of *M. furcicauda* has been calculated to be 1.39.



(a) **(b)** **(c)**

Fig. 67. Third instar grubs (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

The growth ratio (GR) for head capsule width of *M. cuprescens* and *M. indica* was on higher side as compared to *M. furcicauda*. (GR) has been worked out to be 1.51, 1.48 and 1.77 for *M. cuprescens*, *M. furcicauda*, and *M. indica*, respectively. Thus there exists considerable variation in growth ratio (GR) The duration of third instar grubs ranged from 325-329 days in *M. cuprescens*, 310-312 days in *M. indica* and 299-311 days in *M. furcicauda* in the present study. Average duration of third instar grubs was found to be 326.7 ± 0.58, 310.60 ± 0.29 and 305.60 ± 1.88 days in *M. cuprescens, M. indica* and *M. furcicauda*, respectively. In *M. cuprescens*, third instar grubs occurred from May, 2018 to April, 2019, and in *M. furcicauda*, the third instar grubs occurred from May, 2018 to March, 2019. In *M. indica*, the third stage grubs were recorded between July, 2018 and June, 2019 in the present study. The fully fed third instar grubs in all three species moved downward up to a depth of 15 cm, stopped feeding and constructed earthen cells near to the bottom of glass jars. The formation of earthen cells by third instar grubs was noticed in the month of December in *M. cuprescens* and *M. furcicauda*, and during January in *M. indica*. These cells provided protection against biotic and abiotic factors throughout winter months in north western Himalaya. Thus, it was the overwintering stage in these species.

Third instar grubs of *M. cuprescens* were found to be infected with *Beauveria brongniartii* (Saccardo) Petch at Chhatanseri in Kullu valley. The diseased grubs showed white mycelium growth on their body, and the ellipsoid conidia were 2-3 x 1.5-2.5 µm long. Although the duration of third instar was about 11 months, the duration of active feeding period was about seven months during May-November in *M. cuprescens* and *M. furcicauda*. The grubs remained inactive inside earthen cells for about two months from December-February. Third instar grubs of *M. indica* were found to feed actively for about five months from August-December and then hibernated for about 2½ months. The overwintering grubs of *M. furcicauda* and *M. cuprescens* resumed feeding activity during

second and last week of February, whereas in case of *M. indica*, the overwintering grubs resumed their activity during second week of March. The larval stage in the present study was recorded from August, 2017 to April, 2019 (20.63 months) for *M. cuprescens*, August, 2017 to March, 2019 (19.67 months) for *M. furcicauda*, and October, 2017 to June, 2019 (20.17 months) for *M. indica*. The total larval period ranged from 608-619 days in *M. cuprescens*, and 598-605 days in *M. indica*. In case of *M. furcicauda*, the total larval period varied from 572-590 days. Average total larval duration was little more in *M. cuprescens* (mean: 614.40 ± 1.51 days) as compared to *M. furcicauda* (mean: 581.30 ± 2.60 days) and *M. indica* (mean: 601.80 ± 0.94 days).

Table 125. Larval period of *M. cuprescens, M. furcicauda* and *M. indica*

Instar	*M. cuprescens* (Duration in days)		*M. furcicauda* (Duration in days)		*M. indica* (Duration in days)	
	Mean ± SE (Range)	Period of Year	Mean ± SE (Range)	Period of Year	Mean ± SE (Range)	Period of Year
I	59.60 ± 1.29 (54-64)	Aug - Oct	54.80 ± 0.32 (54-56)	Aug - Oct	55.90 ± 0.83 (53-58)	Oct - Dec
II	228.10 ± 0.59 (226-230)	Oct -May	220.9 ± 0.85 (218-224)	Oct -May	235.30 ± 0.39 (234-237)	Dec - July
III	326.7 ± 0.58 (325-329)	May –April (next year)	305.6 ± 1.88 (299-311)	May – March (next year)	310.60 ± 0.29 (310-312)	July - June (next year)
Total larval period	614.40 ± 1.51 (608-619)	Aug-April	581.30 ± 2.6 (572-590)	Aug-March	601.80 ± 0.94 (598-605)	Oct-June

Pre-pupa:

Pre-pupae were formed in the month of April in *M. cuprescens*, March in *M. furcicauda*, and during June in *M. indica* in third summer at Palampur. The ventral surface of the last abdominal segment became wrinkled and they assumed yellowish colouration. First to sixth segments of dorsal surface became brownish in colour. The spiracles appeared

depressed in this stage. The size of pre-pupae is given in the table. In *M. cuprescens*, the body length of pre-pupae varied from 34.16-36.86 mm, and in *M. furcicauda*, the body length was in the range of 34.97-35.17 mm.

The average body length of pre-pupae in *M. cuprescens* and *M. furcicauda* has been recorded to be 35.24 ± 0.31 and 35.03 ± 0.02 mm, respectively. In *M. indica*, the average body length was observed to be 36.01 ± 0.29 mm (range: 34.80-37.11 mm). The duration of terminal portion of the third instar or pre-pupal period was relatively short. In *M. cuprescens*, the pre-pupal period ranged from 22-25 days with an average of 23.4 ± 0.4 days. The pre-pupal period was relatively short in *M. furcicauda* and *M. indica* where the duration of pre-pupal stage has been recorded to be 12-14 days (mean: 13.0 ± 0.30 days) and 11-12 days (mean: 11.5 ± 0.17 days), respectively.

Pupa:

Pupae were without any cocoon inside the hard earthen cells. The cuticle of the last larval instar was pushed to its posterior end. The pupae were light yellow with orange tinge when freshly formed. The colour gradually darkened to tan yellow during the course of development. In *M. cuprescens*, *M. furcicauda* and *M. indica*, the pupae were of exarate adecticious type. The size of the pupa was almost same in all three *Melolontha* species. In *M. cuprescens*, the average body length x width of pupae has been recorded to be 32.22 ± 0.37 mm x 14.56 ± 0.29 mm, whereas in *M. indica*, the body length x width of pupae ranged from 31.19-32.43 mm x 11.94-13.61 mm. In *M. furcicauda*, the body length x width of pupae averaged 32.47 ± 0.11 mm x 14.55 ± 0.13 mm with a range of 32.01-32.91 mm x 14.19-15.11 mm**.**

Under laboratory conditions, the pupation was observed in earthen cells at the bottom of glass jars at a depth of about 13-16 cm in the soil indicating their tendency to pupate deep into the soil. These laboratory observations were also supported by field observations where pupae were observed at a depth of about 25-35 and 20-25 cm in *M. cuprescens* and *M. indica*, respectively. The pupal period was observed to be shortest in *M. cuprescens*, followed by *M. indica* and *M. furcicauda*. The average pupal period under laboratory conditions was 20.3 ± 0.7, 30.0 ± 0.47 and 25.1 ± 0.67 days in *M. cuprescens*, *M. furcicauda* and *M. indica*, respectively. The minimum and maximum being 17 and 23 days for *M. cuprescens*, 28 and 32 days for *M. furcicauda* and 22 and 28 days for *M. indica***.**

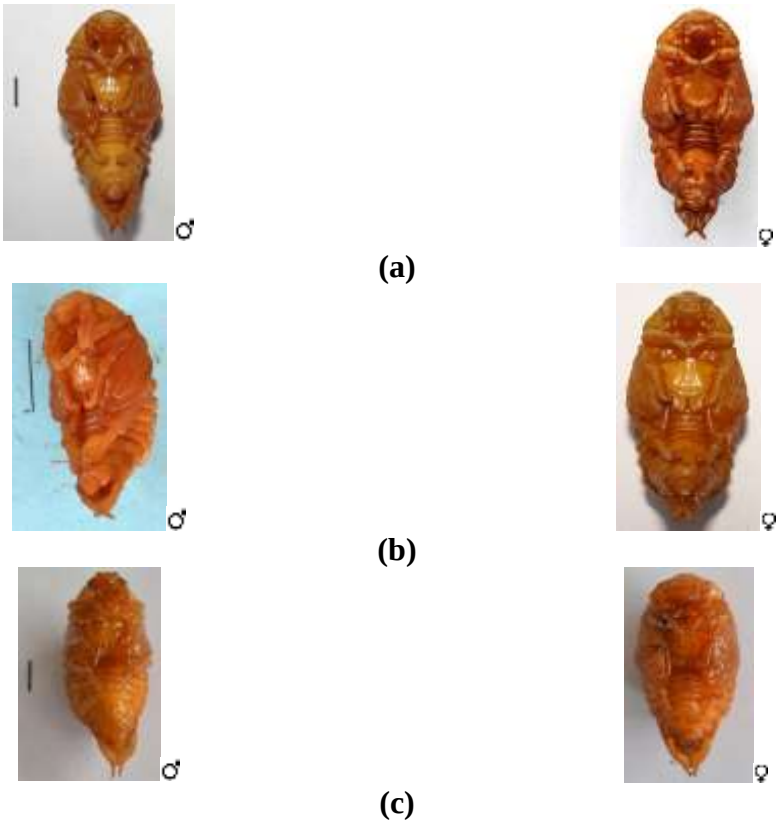


Fig. 68. Pupae (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

Table 126. Morphometric measurements of pre-pupae and pupae

Species		Pre-pupa	Pupa	
		Length (mm)	Length (mm)	Body width (mm)
M. cuprescens	Range	34.16-36.86	30.50-33.78	13.42-15.98
	Mean ± SE	35.24±0.31	32.22±0.37	14.56±0.29
M. furcicauda	Range	34.97-35.17	32.01-32.91	14.19-15.11
	Mean ± SE	35.03±0.02	32.47±0.11	14.55±0.13
M. indica	Range	34.80-37.11	31.19-32.43	11.94-13.61
	Mean ± SE	36.01±0.29	31.97±0.15	12.71±0.22

The sexual diamorphism is clearly evident in the pupal stage. The male and female pupae differed from each other in many morphological characteristics. In males of all three *Melolontha* species, the antennae are long, extending beyond the apex of maxillary palps and reaching the base of meso-coxa, whereas in females, the antennae are shorter, extended up to maxillary palps only and reaching the base of pro-coxa.

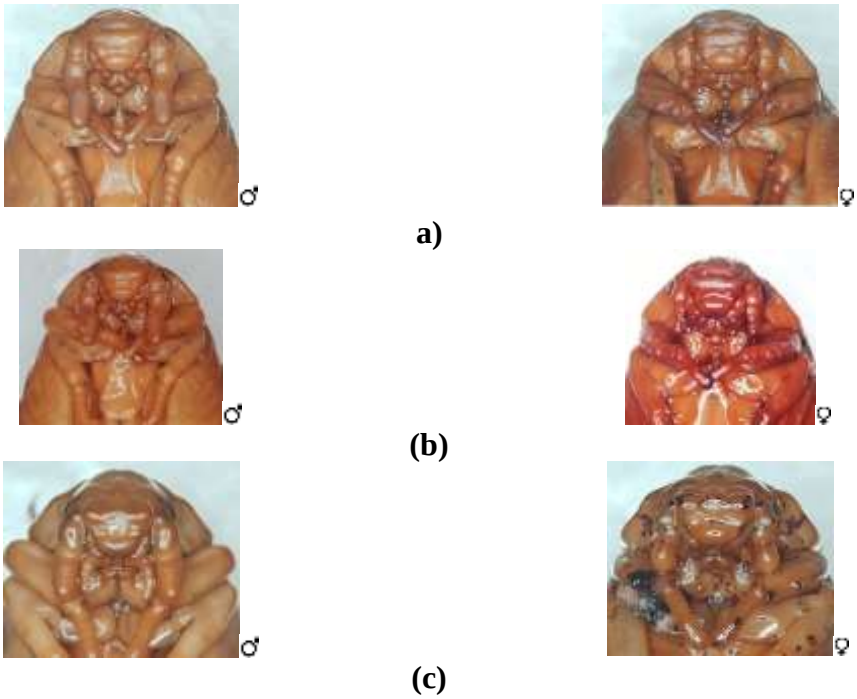


Fig. 69. Pupal antennae (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

Table 127. Duration of pre-pupa, pupa and total life cycle

Stage	Duration in days					
	M. cuprescens		*M. furcicauda*		*M. indica*	
	Range	Mean± SE	Range	Mean ± SE	Range	Mean± SE
Pre-pupa	22-25	23.4±0.4	12-14	13.0±0.30	11-12	11.5±0.17
Pupa	17-23	20.3±0.7	28-32	30.0±0.47	22-28	25.1±0.67
Total (egg-adult emergence)	672-685	678.4±1.49	640-658	647.8±1.91	660-674	664.9±1.65

In *M. cuprescens* males, the caudal appendages are widely separated, thick at the base and gradually tapering to the apical end. The tips of caudal appendages are black, sclerotised and pointed. Both caudal appendages are directed inward in a semi-circular fashion. In females, the caudal tips are directed outward in V shape. Although, tapering is gradual from base to apex, but the tips are slightly hooked and directed downward. In males of *M. furcicauda*, the caudal appendages are swollen at the base and directed outward. The caudal tips are pointed and directed inward. In females, the caudal appendages are short, less prominent and caudal tips appear rounded. In *M. indica*, the caudal appendages are gradually tapers from base to apex in males and their shape is characteristically differs

from that of *M. cuprescens* and *M. furcicauda*. The caudal appendages are directed outward at the base, run straight and then again turn outward in opposite direction.

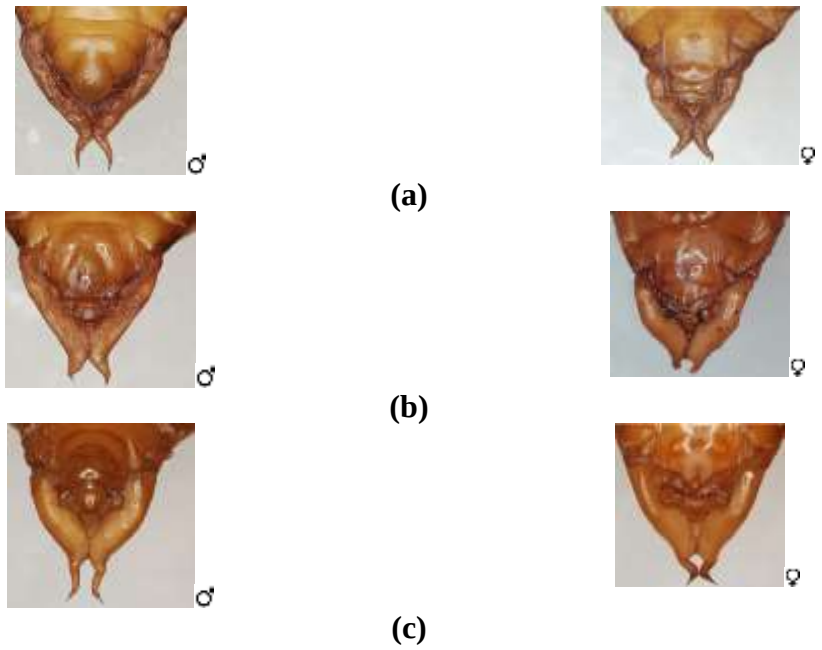


Fig. 70. Pupal tips (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

The caudal tips are sharply pointed and are directed outward. In females of *M. indica*, the caudal appendages are swollen at the base and appear to be of uniform width in the mid-posterior region. The caudal appendages are directed inward and almost touch each other at the apex end. The caudal tips are pointed and are directed outward in a characteristic manner**.**. At the end of last sternum, a median glubose projection with a median key hole shape structure is present in males of all three *Melolontha* species. In females, an anal slit is present on last sternum, which is elliptical in shape.

Adult:

In laboratory, the adult formation was noticed during first week of June in *M. cuprescens* and *M. furcicauda*, whereas in *M. indica*, the adult formation occurred during second week of July. In *M. cuprescens*, the body is elongate, convex, blackish in colour with brownish tinge, and covered all over with dirty white scales. In *M. furcicauda* and *M. indica*, the general body shape was similar to that of *M. cuprescens*, but the body colour is distinctly variable. In *M. furcicauda*, the adult beetles were reddish brown with creamish white scales, whereas in *M. indica*, the body colour was yellowish brown with pale scales.

(a) **(b)** **(c)**

Fig. 71. Adults (a) *M. cuprescens*; (b) *M. furcicauda*; (c) *M. indica*

Morphometric measurements of *Melolontha* adults

Body length x width of male beetles of *M. cuprescens* ranged from 30.0-35.20 mm x 19.2-20.30 mm, and for female beetles, length x width varied from 32.0-35.10 mm x 19.10-22.10 mm. In *M. furcicauda*, the body length x width of male and female beetles ranged from 27.81-30.72 mm x 12.78-14.35 mm and 28.90-30.80 mm x 13.70-14.56 mm, respectively. In case of *M. indica*, the body length x width has been recorded to be 25.98 ± 0.68 mm x 13.22 ± 0.21 mm in males, and 26.80 ± 0.72 mm x 14.52 ± 0.31 mm in female beetles**.** The body of freshly emerged beetles was coated with whitish scales. Initially, the density of scales was very less, but after 2-3 days, the scales became denser which could be easily rubbed off. The scales were denser in case of *M. indica* as compared to *M. cuprescens* and *M. furcicauda* as a result the ribs on elytra were less clearly visible in *M. indica*.

Table 128. Morphometric measurements of *Melolontha* adults

Sex	*M. cuprescens*		*M. furcicauda*		*M. indica*	
	Range	Mean±SE	Range	Mean±SE	Range	Mean±SE
Male						
Length (mm)	30.0-35.20	2.68±0.62	27.81-30.72	29.21±0.34	23.30-29.21	25.98±0.68
Width (mm)	19.2-20.30	9.70±0.13	12.78-14.35	13.56±0.20	12.30-14.0	13.22±0.21
Female						
Length (mm)	32.0-35.10	3.37±0.39	28.90-30.80	29.74±0.24	24.40-30.10	26.80±0.72
Width (mm)	19.10-22.10	0.74±0.39	13.70-14.56	14.01±0.08	13.30-15.90	14.52±0.31

Total life cycle:

Total life cycle from egg to adult emergence was determined to be of 672-685 days for *M. cuprescens*, 640-658 days for *M. furcicauda* and 660-674 days for *M. indica* indicating two years life cycle from oviposition to oviposition for these three species in Himachal Pradesh. The average duration of life cycle has been recorded to be of 678.4 ± 1.49, 647.8 ± 1.91, 664.9 ± 1.65 days for *M. cuprescens*, *M. furcicauda* and *M. indica*, respectively.

GKVK, Bengaluru

Demonstration and popularization of insecticide free management practices for arecanut white grubs such as digging and removal of grown up larvae

Approximately 3520 larvae and 23 yet-to-emerge adult beetles were removed from eight field infested by *Leucopholis* spp in Western Ghats and coastal Karnataka (**Table**). The above gardens were relied on insecticides for controlling white grubs. After understanding the advantages of chemical free approach and disadvantages of chemical method of controlling white grubs in ecologically fragile environments the farmers have wisely selected this economical and eco-friendly method.

Table 129. Details of arecanut white grub larval removal carried out by farmers

Name of the location	Species	Affected area	No. of grubs collected
Madalu	*L. lepidophora*	2.5 ac	~700 (from 1 ac)
Kanukoppa	*L. lepidophora*	2.5 ac	120 (from 1 ac)
Kannangi	*L. lepidophora*	6 ac	~900 ((from 3 ac)
Hulagar	*L. burmeisterei*	2 ac	~800 (from 2 ac)
Laxmipura	*L. burmeisterei*	4 ac	~400 (from 2 ac)
Iruvailu	*L. coneophora*	3 ac	~300 (from 2 ac)
Mantrady	*L. coneophora*	6 ac	~100 (from 6 ac)
Naravi	*L. coneophora*	2 ac	~200 (from 1 ac)

Creating digital repository of Indian Scarabaeidae using specimens available at Bengaluru centre

The project was initiated with the aim of digitizing the entire specimens available in the repository at Bengaluru centre. As it was cumbersome for users the objective was modified and decided to digitize the identified species only. Therefore, the project has been reoriented, and during the reporting period the details of identified species of the genera *Holotrichia*, *Miridiba*, *Schizonycha* and *Anomala* were digitized.

FARMER - GHAZIABAD

- **Scaling up of effective doze of Entomopathogenic Nematodes *H. indica* in the form of EPN infected *Galleria* Cadaver (GC) and WP formulation of EPN for the management of White Grub**

  One experiment for the Scaling up of effective dose of entomopathogenic nematodes (*H. indica*) against white grub by using different doses of *H. indica* in two different forms was laid down in sugarcane crop field. Bio-Powder (*Heterorhabditis indica*) treated plot at the dose of 1,87,500 IJS/m^2 shows best results with maximum reduction in infested plant population (66.67%), maximum reduction in white grub population (94.41%) after 30 days of treatment and highest

crop yield (825.00q/h) followed by *Galleria* Cadavers (*Heterorhabditis indica*) treated plot at the dose of 2,00,000 IJS/m^2 in which reduction in infested plant population (50.33%), reduction in white grub population (81.81%), and crop yield (787.33q/h) after 30 days of treatment.

- **Biological studies of predominant species of white grub; *Holotrichia nagpurensis, Holotrichia serrata, Holotrichia consanguinea, Anomala dimidiate and Maladera insanabilis.***

  The growth and development of predominant species of white grub; *Holotrichia serrata*, A. *dimidiata* and *M. insanabilis in* western UP was studied on live roots of maize (*Zea mays*) under controlled conditions at 30±5ºC temperature, 65±5% RH and 16:8 scoto- photo period. The biology of *Holotrichia consanguinea* and *H. nagpurensis* was completed and published in repute journals.

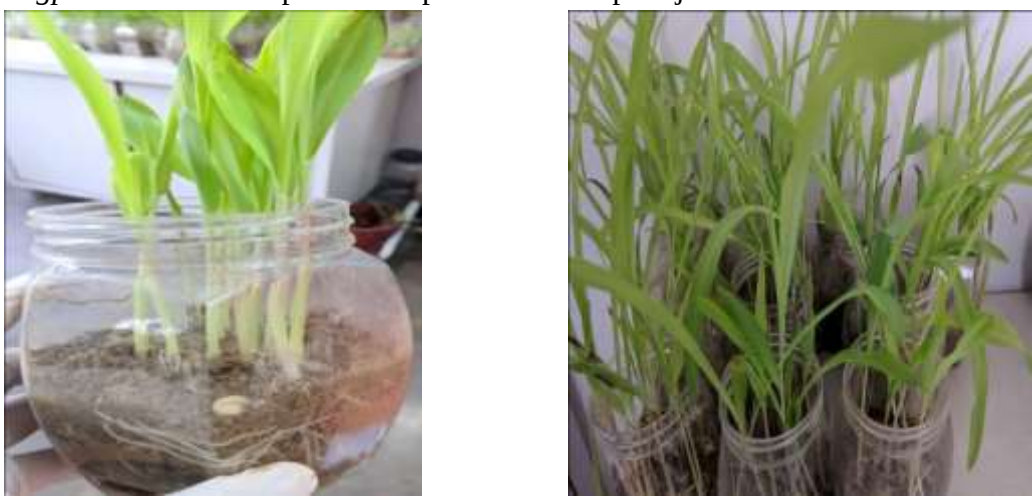


Fig. 72. White grubs feeding individually on live maize roots

Fig. 73. Reaming parts of maize plant after feeding by white

Table 130. Biological attributes of *Anomala dimidiata* reared on maize roots

Biological attributes	Replicates					Mean
	R_1	R_2	R_3	R_4	R_5	
Fecundity (eggs /female)	22	28	58	37	29	34.80
Eggs period (days)	13.5	15.25	13.00	14.33	14.00	14.01
Fertility (hatching %)	81.82	89.29	84.48	75.68	75.86	81.43
Pupation percentage (%)	77.78	64.0	51.02	53.57	81.82	65.64
Emergence percentage (%)	78.57	81.25	76.0	86.67	88.89	82.28
Survival percentage (%)	50.0	46.43	32.20	35.13	55.17	43.78
1st stage grub period (days)	20.00	21.83	17.50	19.67	19.0	19.60
2nd stage grub period (days)	39.6	36.25	38.5	36.0	47.0	39.47
3rd stage grub period (days)	92.6	126.0	98.2	126.0	123.0	113.16
Total grub period(days)	152.2	184.1	154.2	181.7	189.0	172.24
Pupal period (days)	17.5	21.0	19.0	18.3	18.0	18.76
Beetle period (days)	32.0	31.0	29.67	33.0	34.75	32.08
Developmental period (days)	169.7	205.1	173.2	200.0	207.0	191.0
Life cycle (days)	215.2	251.35	215.87	243.33	255.75	236.3

Fig. 74. Life stages of *Anomala dimidiate*, left to right eggs, larva, pupa and adult

Table 131. Biological attributes of *Maladera insanabilis* reared on maize roots

Biological attributes	Replicates					Mean
	R_1	R_2	R_3	R_4	R_5	
Cluster 1	18	15	16	17	16	16.4
Cluster 2	16	18	19	16	20	17.8
Cluster 3	14	17	18	16	19	16.8
Cluster 4	20	20	14	18	18	18.0
Cluster 5	18	00	00	20	00	7.6
Fecundity (Eggs /Female)	68	70	67	87	74	73.2

Eggs period (days)	6.00	9.00	8.67	7.75	7.50	7.78
Total grub period (days)	65.0	65.0	65.0	65.0	65.0	65.0
Pupal period (days)	15.0	16.3	13.7	17.25	17.0	15.85
Developmental period (days)	80.0	81.3	78.7	82.25	82.0	80.85
Fertility (hatching %)	83.82	84.29	74.63	79.02	85.14	81.38
Pupation (%)	76.67	63.33	73.33	66.67	53.33	66.67
Emergence (%)	78.26	73.68	50.0	60.0	62.5	64.88
Survival (%)	60.0	46.67	36.67	40.0	33.33	43.33

Fig. 75. Life stages of *Maladera insanabilis* left to right, eggs, larva, pupa, adult

Table 132. Biological attributes of *Holotrichia serrata*

Biological attributes	Replicates					Mean
	R1	R2	R3	R4	R5	
Eggs/Female Numbers)	35	37	32	45	41	38.00
Eggs period (days)	11.8	10.6	11.0	11.8	11.0	11.24
1st instar period (days)	20	21	23	22	24	22.00
2nd instar period (days)	37	35	41	42	38	38.60
3rdinstar period (days)	92	97	99	96	95	95.80
Larval period(days)	149	153	163	160	157	156.40
Pupal period (days)	20	23	25	24	22	22.80
Adult period (days)	122	110	109	115	120	115.20
Developmental period (days)	169	176	188	184	179	179.20
Life cycle (days)	302	297	308	310.8	310	305.56
Fertility (%)	100	91.89	100.0	91.11	90.24	94.65
Pupation (%)	57.14	79.41	78.12	65.85	62.16	68.54
Emergence (%)	90.0	81.48	76.0	85.18	56.52	77.84
Survival (%)	51.43	59.46	59.38	51.11	31.70	50.62
Larval growth index	0.45	0.41	0.45	0.41	0.40	0.424
Pupal growth index	4.00	3.43	2.67	3.55	2.60	3.250
Developmental index	0.32	0.28	0.25	0.28	0.18	0.262

Fig. 76. Life stages of *Holotrichia serrata*, left to right eggs, larva, pupa, adult

- **Isolation of entomopathogenic nematodes (EPN) and entomopathogenic fungi (EPF) strains from local soil**

  The identification report of two strains of entomopathogenic nematodes (EPNs) isolated by bating method from the soil samples in last season has been received from Division of Nematology, IARI, New Delhi and both strains have been identified as *H. indica*by D2/D3 marker and deposited in GenBank- **Annexure 2**.
  Further multiplication of nine isolated and identified strains of EPNs and two isolated fungi is going on in FARMER laboratory to maintain strain wise culture.

- **Capacity building of state & sugar mills functionaries, rural youths, women and farmers by organizing training on mass multiplication of bio-agents; EPN and EPF.**

  One day training on white grub management and two farmers meet organized in three different locations Muzaffarnagar, Saharanpur and Ghaziabad in the month of July and a total of 82 farmers attended.

One day training programme on "Application of EPN & other Bio-agents for the management of white grub in sugarcane and other crops" at ChandenaKoli in Saharanpur district

Farmers meet at Chandenakoli, Saharanpur district

Farmers meet at Datiyana village in Muzaffarnagar district

One day training programme conducted through virtual mode for farmers, rural youths and women on 19th January, 2022 titled "Integrated Management of Soil Arthropod Pests in Sugarcane Crop". One day Kisan Mela on Integrated management of pests and disease including white grub on potato crop was conducted at Dangarh village of Bulandshahar district by progressive farmers group in association with ICAR FARMER VC Centre

Ghaziabad on 17th February, 2022. Padam Shri Bharat Bhushan Tyagi chaired the program and emphasised for adoption of organic farming. Dr. Jagpal Singh, Secretary, FARMER explained the role of EPN in Integrated pest management of white grub. Dr. Subrata Dutta, Executive Director, FARMER, Dr. Manoj Kumar, Dr. Resu Singh, Dr. Lakshmi Kant, KVK, Bulandshahar, Dr. Manoj Kumar, Joint Director, Dr. Satish Kumar Luthara and Dr. Mahi Lal Scientists, CPRI, Meerut also explained about the disease free potato seed production in insect free net house and other agronomic/ plant protection practices for potato cultivation in scientific manner. About 150 potato farmers benefited by this event.

Padam Shri Bharat Bhushan Tyagi at Dangarh village of Bulandshahar district

Photo of one day Kisan Mela on Integrated management of pests and disease including white grub on potato crop was conducted at Dangarh village of Bulandshahar district

गोल्फ
वारु

एक दिवसीय किसान मेले का हुआ आयोजन

गाजियाबाद (करेंट क्राइम)। फाउंडेशन फॉर एग्रीकल्चरल रिसोर्सेस मैनेजमेंट एंड एनवायरमेंटल रेमेडिएशन (फारमर), गाजियाबाद के सहयोग से प्रगतिशील किसान समूह, दानगढ़, खुर्जदशहर के द्वारा कृषि यांत्रिकी केंद्र गेस्ट हाउस, ग्राम दानगढ़, खुर्जदशहर में नेट हाउस तकनीक के माध्यम से रोगमुक्त आलू के बीज का उत्पादन, समेकित कीट प्रबन्धन एवं जैविक आलू उत्पादन विषय पर एक दिवसीय किसान मेला / किसान गोष्ठी का आयोजन सफलतापूर्वक किया गया। किसान मेला / किसान गोष्ठी में भा. कृ. अनु. प. - केन्द्रीय आलू अनुसंधान संस्थान, मोदीपुरम, मेरठ एवं कृषि विज्ञान केंद्र, खुर्जदशहर सहभागी संस्थान के रूप में उपस्थित रहें। किसान मेला / किसान गोष्ठी में डॉ. जगपाल सिंह, सचिव एवं डॉ. सुब्रता दत्ता, कार्यकारी निदेशक, फारमर, गाजियाबाद, डॉ. मनोज कुमार, संयुक्त निदेशक एवं प्रधान वैज्ञानिक, डॉ. सतीश कुमार लूथरा, प्रधान वैज्ञानिक एवं डॉ. मेही लाल, वरिष्ठ वैज्ञानिक, भा. कृ. अ. प. - केंद्रीय आलू अनुसंधान संस्थान परिसर, मोदीपुरम, मेरठ, पदमश्री डॉ. भारत भूषण त्यागी, खुर्जदशहर, डॉ. लक्ष्मीकांत, अध्यक्ष, डॉ. मनोज कुमार, वैज्ञानिक (पशु पालन) एवं डॉ. रिशु सिंह, वैज्ञानिक (पादप सुरक्षा), कृषि विज्ञान केंद्र, खुर्जदशहर उपस्थित रहें। इस किसान मेले / किसान गोष्ठी के आयोजन के लिए फारमर संस्था, गाजियाबाद ने प्रगतिशील किसान समूह, दानगढ़, खुर्जदशहर को तहेदिल से धन्यवाद दिया।

FARMER's activity in news paper

Details of bioagents sent through courier to other centers of AINP as per requirement

Fig 77. *Galleria* cadavers

Table 133. Details of bioagents sent through courier to other centers of AINP as per requirement

Bio-agents	Centre /Address
July 2021	
1000 GC *H. Indica*	GKVK BENGALURU
200 *H. Indica* GC	RARI JAIPUR
500 GC *H.indica*	CSKHPKV PALAMPUR

500 gm WP*H. Indica* 500gm WP *Beauveria Bassiana* 500gm WP*Metarhizium anisopliae*	
50 GC *H. indica* 50gm WP *H. indica* 50 gm WP *Beauveria bassiana* 50 g WP *Metarhizium anisopliae*	RCSM Kolhapur
August 2021	
4000 GC	Maharashtra
500GC, 2 kg WP EPN	Maharashtra
EPN *H. indica* GC 270 EPN *H. indica* WP 645 g EPF *Beauveria bassiana* 120 g EPN *Metarhizium anisopliae* 120 g	Durgapura, Jaipur
EPN *H. indica* GC 1700 EPN *H. indica* WP 8 kg	Go Sewa Sangh, Durgapura, Rajasthan
September 2021	
EPN *Heterorhabditis indica* WP (8 kg) EPF *Metarhizium anisopliae* WP (2kg)	Durgapura Rajasthan
EPN *Heterorhabditis indica* WP (1 kg), EPF *Beauveria bassiana* WP (1kg), EPF *Metarhizium anisopliae* WP (1kg)	Assam Agricultural University, Jorhat
November 2021	
300 GC *Heterorhabditis indica* 1 kg WP *Heterorhabditis Indica* 1 kg WP *Beauveria Bassiana* 1 kg WP*Metarhizium anisopliae*	CSKHPKV PALAMPUR
December 2021	
EPN *H. indica* WP (4kg) EPF *B. bassiana* (4kg) EPF *M. anisopliae* (4kg)	Gujarat -382421
February 2022	
Metarhizium anisopliae (WP formulation)(1 kg) *Beauveria bassiana* (WP formulation) (1kg)	Jorhat, Assam centre of AINP

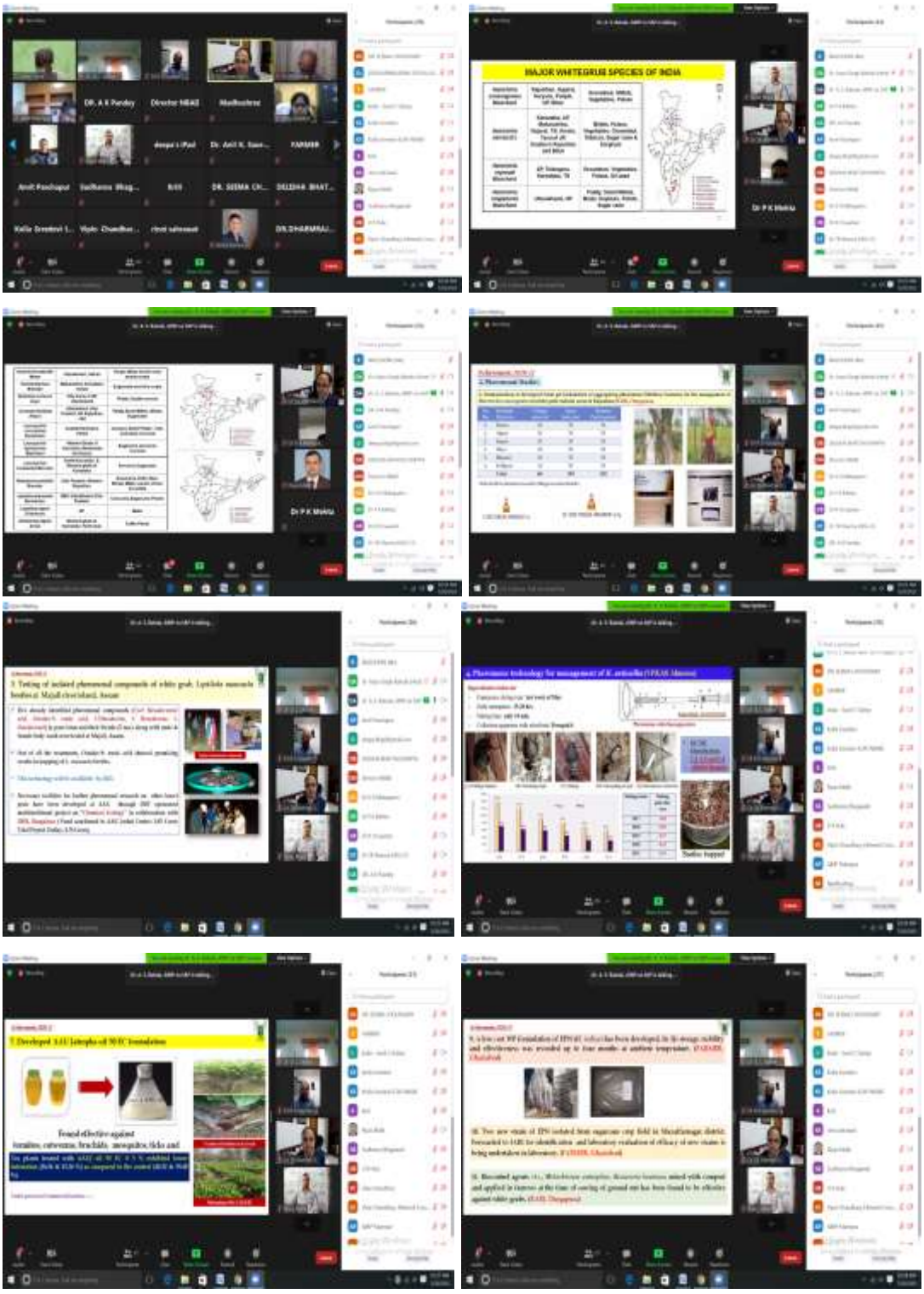
Formulation of *Heterorhabditis indica* biopowder for white grub management

A low cost modified powder formulation of EPN (*H. indica*) with a self-life of four months developed by FARMER laboratory Ghaziabad is being applied in the field by the farmers for the management of soil arthropod pests.

- **Online XXII Review Meeting of All India Network Project on Soil Arthropods Pests**

The Indian Council of Agricultural Research, New Delhi hold an online XXIIth Review Workshop of AINP on Soil Arthropod Pests on 20th July 2021 at 10:00 AM to 5:30

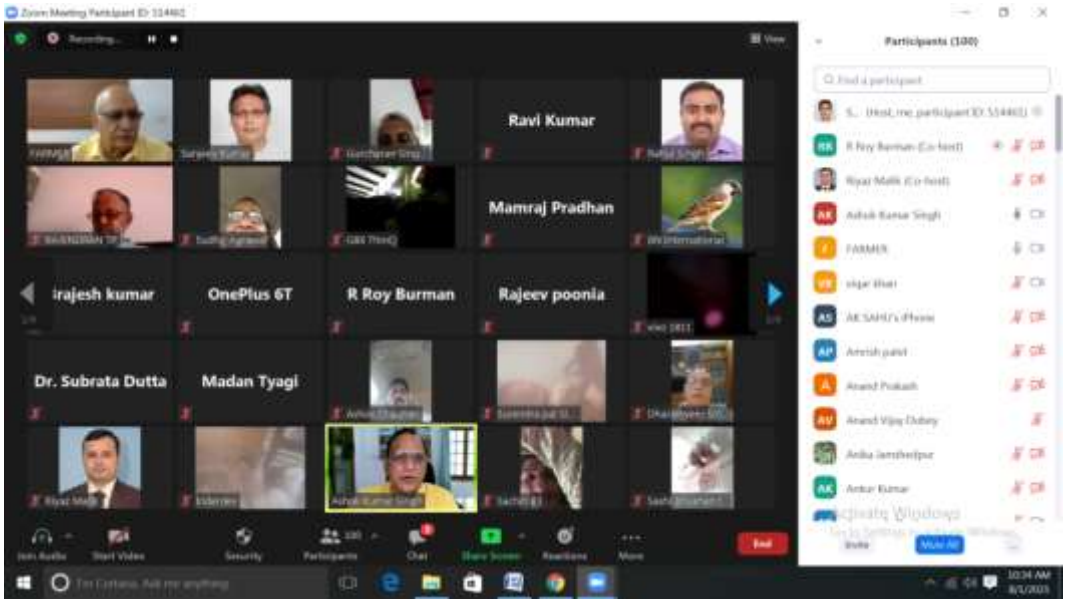
PM chaired by Dr. T. R. Sharma, DDG(CS) and Dr. SC Dubey, ADG (PP & BS) ICAR, New Delhi to review the progress made in the project and to formulate future programme. In which, participated as a speaker and presented progress report of the FARMER VC Ghaziabad centre in this review workshop.



Screen shorts of Online XXII Review Meeting of All India Network Project on Soil Arthropods Pests on 20th July, 2021

- **"*Azadi Ka Amrit Mahotsav*" on the occasion 75th Anniversary of India Independence**

  The "*Azadi Ka Amrit Mahotsav*" on the occasion 75th Anniversary of India Independence was celebrated on 1st August, 2021 by organizing a webinar at Online Platform Zoom and on 5th August, 2021 by organizing a *Kisan Gosthi* at Village SahpurKothla, Garhmukteshwar, district Hapur. The webinar was attended by 212 participants; farmers, women farmers, scientists and scholars belonging to several district of Uttar Pradesh, Haryana, Delhi, Maharashtra and other states. The *Kisan Gosthi* was attended by 83 farmers of different villages of district Hapur of Uttar Pradesh. The main expert speakers of webinar were Dr. A. K. Singh, Director and Vice Chancellor, IARI, Pusa, New Delhi and Dr. T. P. Rajendran, Former ADG (PP), ICAR & Chairman SAC-FARMER. Booklets / pamphlet published on White Grub Management by FARMER organization, were distributed among farmers belongs to Hapur districts and encouraged them to adopt practices for Integrated Management of national pest; white grub as explained in the literature. The both events held on 1st August, 2021 (Webinar) & 5th August, 2021 (Kisan Gosthi) were covered and published in print media and social media to spread the message of Government of India and Hon'ble Prime Minister Shri Narender Modi Ji to celebrate the "Azadi Ka Amrit Mahotsav" on the occasion 75th Anniversary of India Independence.



Screen shot of "*Azadi Ka Amrit Mahotsav*" on the occasion 75th Anniversary of India Independence

SECTION 11
PUBLICATIONS

RARI, Durgapura

Tara Yadav, A.S. Baloda K.K. Saini and B. L. jakhar (2022). Management of white grub, *H. consanguinea* in Groundnut using Entomopathogens. Legume Research. DOI: 10.18805/LR-4772.

Tara Yadav, A.S. Baloda and K.K. Saini, Anita Jat and Rajpal Yadav (2021). Antagonistic potential of various entomopathogens against white grub and H. consanguinea. Journal of Experimental Zoology India, 25(1): 519-524.

Nagal, G., Agarwal, V.K. and Baloda, A.S. (2021). Intrinsic toxicity evaluation of some newer insecticides against beetles of *Holotrichia consanguinea* Blanch. through adult vial test. *Journal of entomology and zoology studies* 9(1):1481-1484.

B L Jakhar, AS Baloda, MD Choudhary, K K Saini, M L Jakhar and T Yadav (2021). Biodiversity of White Grub, (Coleoptera: Scaraeidae) in Semi-AridAgro-Ecosystem of Rajasthan. Journal of AgriSearch, 8 (2): 112-116.

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डॉ. ए. एस. बलोदा, डॉ. बी. एल. जाखड़, डॉ कमलकिशोर सैनी और डॉ स्वातिबुगालिया (2022).खरीफ फसलों में सफेदलट का समन्वित प्रबंधन. ICAR-अखिल भारतीय भूमिगत सन्धिपाद पीड़क नेटवर्क परियोजना, राजस्थान कृषि अनुसंधान संस्थान (एस. के. एन. कृषि विश्वविद्यालय -जोबनेर). ISBN: SKNAU/2022/08.

डॉ. ए. एस. बलोदा, डॉ. बी.एल. जाखड़, डॉ. कमलकिशोर सैनी और डॉ. स्वाति बुगालिया (2022).राजस्थान में सफ़ेद लट का प्रबंधन. ICAR-अखिल भारतीय भूमिगत सन्धिपादपीड़क नेटवर्क परियोजना, राजस्थान कृषि अनुसंधान संस्थान (एस. के. एन. कृषिविश्वविद्यालय-जोबनेर). ISBN: SKNAU/2022/09.

AAU, Jorhat

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SECTION 12

STAFF POSITION

RARI, Durgapura

Post Sanctioned	In-position	Date of joining in the present post	Educational qualifications
Professor & Network Coordinator	Dr Arjun Singh Baloda	-	Ph.D. (Agri.)
Assoc Professor	Dr. B.L. Jakhar	21.06.2018	Ph.D. (Agri.)
Agril. Supervisor	Sh. Ashok Kumar Verma	-	Secondary
Agril. Supervisor	Sh. Amar Chand Verma	-	Secondary
Senior Research Fellow	Dr. Kamal Kishor Saini	03.01.2018	Ph.D. Plant Pathology
Young Professional-1	Dr. Swati Bugalia	08.10.2021	Ph.D. Agricultural Biotechnology

AAU, Jorhat

Post Sanctioned	In-position	Date of joining in the present position	Educational qualifications
Principal Scientist & PI	Dr. Sahidur Rahman	28.09.2021	Ph.D. (Agri.)
Junior Scientist	Dr. Sudhansu Bhagawati	01.03.2016	-do-
	Dr. Kritideepan Sarmah	24.06.2019	-do-
Senior Research Fellow	Dr. E. Bidyarani Devi	25.09.2018	-do-
	Ms. Nang Sena Manpoong	07.02.2019	M.Sc. (Agri.)

CSK-HPKV, Palampur

Name of the post	Name of the person	Working since
Principal Scientist	Dr. R. S. Chandel (PI)	01.04.2006
Professor (Entomology)	Dr. K. S. Verma (CoPI)	Feb, 2018
Assistant Professor (Entomology)	Dr. (Mrs) Suman Sanjta	23.12.2021
Junior Research Fellows	i) Dr. (Mrs) Suman Sanjta ii) Dr. Abhishek Rana iii) Dr. Saurbh Soni	12.03.2019 to 22.12.2021 06.03.2019 to 25.03.2022 24.03.2022

GKVK, Bengaluru

S. No.	Name of the posts with pay scale	No. of Posts	Date of Joining	Date of Leaving
1	**Entomologist/PI-I/c**	One		
	Dr. D. Rajanna		03-02-2018	Continuing
2	Asst. Entomologist Dr. Prakash, K.V.	One	16-07-2009	Continuing
3	U. Sahana (Senior Research Fellow)	One	18-06-2018	On contract
4	P. Nirmala (Senior Research Fellow)	One	08-06-2020	On contract

FARMER - Ghaziabad

Name of the post	Name of the person	Working since
Project Investigator	Mr. Jagpal Singh	-
Research Associate (Entomology)	Dr. Seema Rani	01.04.20218

SECTION 13
SIGNIFICANT ACHIEVEMENTS UNDER THE PROJECT

RARI, Durgapura

- **Slow release Nenogel formulation of methoxy benzene**

  ICAR-AINP on Soil Arthropod Pests has developed a slow release nanogel formulation of methoxy benzene and the technology was tested in white grub endemic areas of Rajasthan and perfected. This slow release Nanogel formulation is effective in aggregation of beetles up to one month and, thus, avoiding replacement of septa daily. The cost of per sample is ₹ 10 only and the product is available at ICAR-AINP on Soil Arthropod Pests, Division of Entomology, RARI, Durgapura, Jaipur, Rajasthan. The adult of white grub catches per trap per day was recorded a mean of 35.78/day. It has been included in Package of Practices of Rajasthan.

Recommendations:

A. In groundnut-

Beetle Management

- For the management of white grub beetles slow release nanogel of pheromone methoxy benzene (anisole) is effective up to 25 days of installation.
- For the management of soil arthropods in groundnut crop, soil application of Neem cake@250kg/ha, seed treatment with Imidacloprid 600 FS @ 6.5 ml per kg seed, application of Beauveria bassiana –0.5g/m 2 and application of imidacloprid 17.8 SL@ 300 ml/ha at 20-25 DAS is most effective.

Chickpea

- For the management of termite in chickpea, drenching the crop with Imidacloprid 17.8 SL @ 360 ml or Fipronil 40% +Imidacloprid 40% per ha is most effective.
- For the management of termite in chickpea, seed treatment with Imidacloprid 600FS @ 6 ml per kg seed is most effective.

AAU, Jorhat

- Light trap was installed at Instructional Livestock Farm, AAU, Jorhat for the collection of scarab beetles from March to September, 2021. Altogether 3,315 numbers of beetles were collected and profiled, out of which, *Apogonia ferruginea* was recorded to be the most dominant species (61.21%) followed by *Heteronychus* sp.(16.78%) and *Anomala chlorosoma* (6.74%).

- The impact of certain newer insecticides on the soil faunal diversity mainly represented by soil micro and macroarthropods, total bacterial and fungal population as well as the key soil enzyme activities were studied at 15 days interval. Prior to the application of insecticides, Hymenoptera was recorded to be the most dominant order (54.74%) among the soil macroarthropods followed by Coleoptera (13.68%) and Araneae (11.57%) whereas Collembola and Oribatida were recorded as soil microarthropods registering 64.72 and 35.28 per cent, respectively. All the insecticidal treatments recorded a significant reduction (p=0.05) in the soil macroarthropod, bacterial and fungal population as well as soil enzymatic activities up to 75 days of application indicating the detrimental effects of insecticides as compared to the untreated plots showing more stable habitats for the soil fauna. On the contrary, the insecticidal treatments did not exhibit any significant impact (p=0.05) on the population of soil microarthropods during the study period.

- Five pheromonal compounds (Cis-9 Hexadecenoic acid, Octadec- 9 enoic acid,1-Tetradecene, 1-Hexadecene and 1-Octadecenol) in pure form and their five different blends were tested along with male and female body wash at Majuli during April, 2021. Among the 13 different pheromonal and kairomonal blends tested, the maximum numbers of beetles (6.64) were recorded in the traps having Octadec-9-enoic acid @ 100%. Relatively lower attraction of beetles was observed during the experimental period and there was no statistical difference observed among the treatments. This experiment will be continued during April, 2022

Collection of beetles from the pheromonal traps

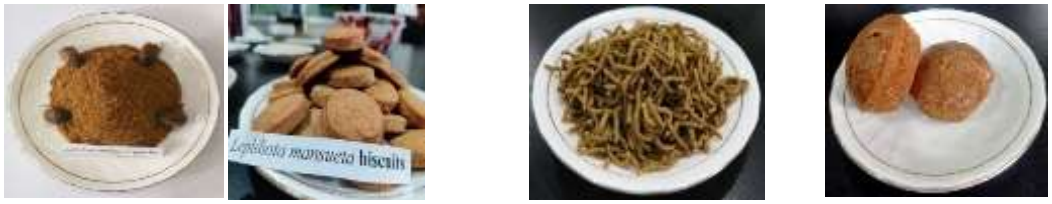
- The mass campaigning programme for the collection and destruction of white grub beetles (*Lepidiota mansueta*) was continued during April, 2022 by following the concept of "Social engineering" by involving 350 farmers under 35 Lepidiota Management Groups (LMG). The programme received overwhelming responses and

was exceedingly successful leading to the collection and killing of approximately 75000 beetles basically from the sand bar areas.

Glimpses of mass campaigning programme

- The nutritional analysis of desert locust, *Schistocerca gregaria* collected from RARI, Durgapura, Jaipur was analyzed and the results of the proximate analysis showed moisture, crude protein, carbohydrate, crude fat, crude fibre and ash content of 12.33%, 48.17%, 17.05%, 44.08%, 12.01% and 3.36%, respectively. Elemental analysis was done for 7 minerals, out of which K (49.93 mg/100g) was found to be the highest followed by Na (34.77 mg/100g) and Ca (26.15mg/100g). The Mg, Fe, Zn and Cu contents were recorded to be 20.15, 12.76, 12.18 and 4.85 mg/100g, respectively.

- Nutritional evaluation of 3 value added products prepared from *Lepidiota mansueta* powders *viz*., biscuits, *bhujia* and cakes was studied. All the value-added products recorded considerable amounts of both proximate and elemental composition as compared to the products without any fortification of *L. mansueta* powders. It was evident from the results that the per cent of moisture, crude protein, crude fat, crude fibre as well as the ash content of the products increased significantly with the increase in the level of *L. mansueta* powder, however, on the contrary the carbohydrate content was recorded in a gradual decreasing pattern with the increase in the insect powder content.



***L. mansueta* powder-based biscuits, bhujia and cakes**

GKVK, Bengaluru

- **Award/Honors/Recognition**: ***Best Oral Presentation - In*** 5^{TH} National Symposium on "Plant Protection In Horticulture (NSPPH-2021): Challenges and a road-map ahead" held from 27^{th} to 29^{th} December 2021 organised by ICAR – Indian Institute of Horticultural Research, Bengaluru – 560 089.

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- The white grub beetles collected belongs to four sub family viz., Melolonthinae (96.69%), Rutelinae (2.24%), Scarabaeinae (0.61%) and Dynastinae (0.46%). Out of 10 white grub species collected, the species namely *Holotrichia serrata* (Melolonthinae) was found in abundance during the period (73.01%).

- The eight species of white grub beetles (fam. Melolonthinae and Rutelinae) recorded on Neem (*Azadirachta indica*), Sheesham (*Dalbergia sissoo*), Poplar (Populus sp.), Guvava (*Psidiumguajava*), Jamun (*Syzgiumcumcumini*), Bakayan (*Melia azedarach*) and Tun (Meliaceae family) in western UP.
- White grub in different crop viz., 5-7 grubs/ m^2 in sugarcane, 0-2 grub/ m^2 in turmeric, 1- 4 grubs/m^2 in sorghum, 0-1 grub/m^2 in banana were recorded during April to November 2021 in western UP. Beetles, eggs, and all three 1^{st}, 2^{nd} and 3^{rd} instar stage of white grub recorded in sugarcane crop fields in the month of August 2021.
- Two new strains viz., *H. indica* Muzaffarnagar strain D2/D3 (GenBank Accession Number OM149711) and *H. indica* Saharanpur strain D2/D3 (GenBank Accession number OM149712) of entomopathogenic nematodes identified and deposited in GenBank.
- Biology of 5predominantspecies *H. serrata, H. consanguinea, H. nagpurensis, A. dimidiata, M. Insanabilis* were studied in laboratory and the biology of *H. consanguinea, H. nagpurensis* published in reputed journals NAAS rating between 5-6. The rearing technology of white grub on live maize roots in laboratory was also developed.

- Social engineering was conducted at several locations in five districts of UP for white grub species (*H. serrata, H. nagpurensis, H. consanguinea, M. insanabilis and A dimidiata*) management. During 2021-22, 6 farmers training, 1 training for extension functionaries, 1 field day, participated in 5 exhibitions, 4 technologies of bioagents application demonstrated and 1 technology showcasing in which a total of 1480 beneficiary participated.

- On the basis of percentage reduction of white grub population, percentage reduction in infested plant population and increase in crop yield; the dose of low-cost bio-formulation of *H. indica* was finalized as @ 8kg/ha (50,000 IJs/gm) against white grub in sugarcane crop by conducted several FLDs at different doses during last two seasons.

KOLAHAPUR, MAHARASHTRA

- Identified 10 new species of white grubs in western Maharashtra.
- Developed new Craw Bar technique of drenching for application of insecticides in Raton sugarcane for management of White grub and efforts are made to disseminate this technology among farmers in collaboration with Sugar Factories and Department of Agriculture.
- Recommended Fipronil 40%+Imidacloprid 40%WG @ 300 g a.i./ha or chlorantraniliprole 0.4% GR @ 100g a.i./ha for white grub control and it is widely accepted by farmers.
- Application of Clothianidin 50 WDG @ 80 g a.i./ acre or Imidacloprid 600 FS @ 500 g a.i./ha is recommended through furrow application at planting of sugarcane.
- Soil application of Imidacloprid 40% + Fipronil 40% 80WG @ 300 g.a.i. or Chlorantraniliprole 18.5 SC @ 500ml/ha or Clothianidin 50 WDG @ 80 g a.i./ha or Thiamethoxam 70WS @ 80 g. a.i./ha is recommended through crow bar technique in standing (Raton) sugarcane.
- Efforts were to popularize the technique of hand collection of adults in water light trap for control of white grub.
- Intensive efforts were made for use of Entomopathogenic fungi and Entomopathogenic nematodes and their combination with insecticides.
- Total 250 farmers group discussions were attended and delivered talk on White grub management in Sugarcane and other crops.

ALMORA, UTTARAKHAND

- A total of 8,504 scarab beetles belonging to 54 species were trapped in light trap in 2021. The collected beetles belonged to 6 subfamilies *viz*., Rutelinae, Melolonthinae, Scarabaeinae, Dynastinae, Geotrupidae and Aphodiinae of family Scarabaeidae. Members of the subfamily Melolonthinae predominated with 44.04% of the species. In case of *in-situ* sampling, A total of 9,523 pleurostict scarab beetles belonging to 32 species and 18 genera were collected. The collected beetles belonged to 03 subfamilies *viz.*, Cetoniinae (2.32%), Melolonthinae (53.92%) and Rutelinae (43.76%) of family Scarabaeidae.
- A study was carried out to determine the pathogenicity of various entomopathogens against first instars of two notorious and economically important white grub species, (*Anomala bengalensis* and *Sophrops* sp.). The entomopathogenic bacteria and fungi tested against the white grubs recorded mortality of less than 25% while, two strains of entomopathogenic nematode (*Heterorhabditis indica*) recorded mortality of more than 70%. The median lethal

dose and median lethal time estimation showed LD_{50} value of 1230.27 Infective Juveniles (IJs)/ml and 891.25 IJs/ml against the grubs of *A. bengalensis* for commercial and native strain of EPN respectively (**Table**). While, for the grubs of *Sophrops* sp. LD_{50} value of 1023.29 IJs/ml and 954.99 IJs/ml were obtained for commercial and native strains, respectively.

- The gut microbial diversity of four notorious white grub species *i.e.*, *A. bengalensis, H. longipennis, H. seticollis*, and *B. coriacea* were carried. A total of 45 bacteria (25 cellulytic and 20 chitinolytic bacteria) were isolated from the gut of white grubs and selected for identification through molecular characterization. The sequences obtained from PCR products of gut bacterial isolates were submitted to GenBank, NCBI and assigned accession numbers. Their mode of actions and role in cellulose and chitin degradation will be taken up in future studies.

SECTION 14

ANNEXURES

GKVK, Bengaluru

Annexure I

Number of individuals collected for each species of Pleurostict Scarabaeidae per ACZs in Karnataka during 2017 and 2021

Sl. No.	Subfamily: Cetoniinae	Dry Zone	Hilly Zone	Coastal Zone	Total Individuals	Relative abundance
1	*Anatona stillata* (Newm.)	7	0	0	7	0.168674699
2	*Anatona alboguttata* Burm.	1	0	0	1	0.024096386
3	*Anthracophora crucifera* (Oli.)	9	12	0	21	0.506024096
4	*Anatona* sp.	4	0	0	4	0.096385542
5	*Clinteria klugi (*Hope)	73	0	0	73	1.759036145
6	*Clinteria 14-maculata*	11	0	0	11	0.265060241
7	*Clinteria tetraspilota*	0	3	0	3	0.072289157
8	*Clinteria auronotata*	0	1	0	1	0.024096386
9	*Chiloloba acuta* (Wied.)	637	0	0	637	15.34939759
10	*Coenochilus campbelli* (Saunders)	16	21	0	37	0.891566265
11	*Coenochilus acutipes* Arrow	1	17	0	18	0.43373494
12	*Coenochilus trabecula* Schaum	0	15	0	15	0.361445783
13	*Coenochilus taprobanicus* Westwood	0	1	0	1	0.024096386
14	*Gametes versicolor* (Fabricius)	123	6	1	130	3.13253012
15	*Gametes albopunctata* (Fabricius)	4	0	0	4	0.096385542
16	*Glycyphana horsfieldi* (Hope)	0	1	0	1	0.024096386
17	*Heterorrhina elegans*	13	0	0	13	0.313253012
18	*Protaetia cinerea* (Kraatz)	149	0	0	149	3.590361446
19	*Protaetia pretiosa* (Nonfried)	1	0	0	1	0.024096386
20	*Protaetia coenosa*	38	0	0	38	0.915662651
21	*Protaetia cupripes* Wiedemann	1	0	0	1	0.024096386
22	*Protaetia terrosa* (G.& F.)	8	0	0	8	0.192771084
23	*Protaetia aurichalcea* (Fabricius)	10	3	0	13	0.313253012
24	*Protaetia peregrina* (Herbst.)	8	0	0	8	0.192771084
25	*Protaetia squamipennis* Burmeister	78	0	1	79	1.903614458
26	*Protaetia alboguttata* (Vigors)	170	0	0	170	4.096385542

Sl. No.	Subfamily: Cetoniinae	Dry Zone	Hilly Zone	Coastal Zone	Total Individuals	Relative abundance
27	*Protaetia neglecta* (Hope)	4	0	0	4	0.096385542
28	*Oreoderus argillaceus* (Hope)	4	0	0	4	0.096385542
29	*Diceros childreni* (Westw.)	1	0	0	1	0.024096386
30	*Macronota bufo* (Arrow)	0	1	0	1	0.024096386
	Total	**1371**	**81**	**2**	**1454**	**35.03614458**
	Subfamily: Dynastinae					
1	*Oryctes rhinoceros* (L.)	20	11	12	43	1.036144578
2	*Phyllognathus dionysius* Fabricius	233	0	0	233	5.614457831
3	*Xylotrupes gideon* (Linnaeus)	0	51	2	53	1.277108434
4	*Dipelicus bidens* Arrow	1	2	5	8	0.192771084
5	*Dipelicus hircus* (Fabricius)	0	0	1	1	0.024096386
	Total	**254**	**64**	**20**	**338**	**8.144578313**
	Subfamily: Melolonthinae					
1	*Brahmina mysorensis* Frey	188	18	0	206	4.963855422
2	*Holotrichia rufoflava Brenske*	258	5	0	263	6.337349398
3	*Holotrichia nilgiria Arrow*	0	80	0	80	1.927710843
4	*Holotrichia reynaudi* (Blanchard)	180	6	0	186	4.481927711
5	*Holotrichia serrata* (Fabricius)	472	31	5	508	12.24096386
6	*Holotrichia fissa* Brenske	52	23	83	158	3.807228916
7	*Maladera* sp.1	2	0	0	2	0.048192771
8	*Maladera sp.2*	1	7	0	8	0.192771084
9	*Maladera* sp. 3	0	3	0	3	0.072289157
10	*Maladera* sp. 4	3	7	0	10	0.240963855
11	*Maladera* sp. 5	4	0	0	4	0.096385542
12	*Maladera* sp. 6	8	0	0	8	0.192771084
13	*Miridiba herteli* (Frey)	0	42	0	42	1.012048193
14	*Miridiba excisa* (Moser)	0	56	0	56	1.34939759
15	*Schizonycha ruficollis* (Fabricius)	27	11	0	38	0.915662651
16	*Schizonycha fuscescens* Blanchard	9	0	5	14	0.337349398
	Total	**1204**	**289**	**93**	**1586**	**38.21686747**
	Subfamily: Rutelinae					
1	*Adoretus renardi* Brenske	9	0	0	9	0.21686747
2	*Adoretus distinguandus* Arrow	0	8	0	8	0.192771084
3	*Adoretus bicaudatus* Arrow	4	0	0	4	0.096385542
4	*Adoretus caliginosus* Burmeistri	0	17	0	17	0.409638554
5	*Adoretus decanus* Ohaus	0	2	0	2	0.048192771

Sl. No.	Subfamily: Cetoniinae	Dry Zone	Hilly Zone	Coastal Zone	Total Individuals	Relative abundance
6	*Adoretus excisus* Ohaus	13	0	0	13	0.313253012
7	*Adoretus pusillus* Arrow	2	0	0	2	0.048192771
8	*Adoretus duvauceli* Blanchard	8	0	0	8	0.192771084
9	*Adoretus corpulentus* Arrow	2	8	0	10	0.240963855
10	*Adoretus sp. nr. bicolor*	11	0	0	11	0.265060241
11	*Adoretus versutus* Harold	5	1	0	6	0.144578313
12	*Adoretus stoliczkae* Ohaus	12	1	0	13	0.313253012
13	*Mimela macleyana* (Vigors)	0	8	0	8	0.192771084
14	*Mimela marginata* Arrow	0	43	9	52	1.253012048
15	*Mimela xantherrhina*	0	68	0	68	1.638554217
16	*Anomala bengalensis* (Blanchard)	175	2	0	177	4.265060241
17	*Anomala communis* Burmeister	56	72	27	155	3.734939759
18	*Anomala dorsalis* (Fabricius)	16	6	0	22	0.530120482
19	*Anomala dussumieri* Blanchard	0	10	4	14	0.337349398
20	*Anomala elata* (Fabricius)	1	1	0	2	0.048192771
21	*Anomala ruficapilla* Burmeister	39	7	0	46	1.108433735
22	*Anomala rugosa* Arrow	0	11	0	11	0.265060241
23	*Anomala singularis* Arrow	83	11	0	94	2.265060241
24	*Anomala varicolor* (Gyllenhal)	19	1	0	20	0.481927711
	Total	**455**	**277**	**40**	**772**	**18.60240964**

Annexure II

Geographical details of the study areas Karnataka

Location	Longitude	Latitude	Altitude (m)
Shivally	12.587043	76.82164	771
Mahadeshwarapura	12.57539	76.673053	678
Gejjalagere	12.569458	76.999234	653
Gundlupet	11.808346	76.692726	816
Medini	12.211023	76.903801	653
KR Pet	12.659594	76.489716	813
Malavalli	12.385343	77.05358	632
Nanjanagudu	12.11597	76.678249	670
Palalli	12.409603	76.653544	718
Chikkaballapur	13.435498	77.731534	919
GKVK	13.080072	77.578515	945
Malur	13.003723	77.938303	910
Sira	13.765437	76.940077	651
Rajavanthi	14.029001	77.283439	678
Hassan	13.003323	76.100389	943
Bhadravathi	13.827272	75.706378	601
Kukwada	13.922944	75.871189	776
Hulagar	13.480995	75.224178	668
Shuntikatte	13.607234	75.265771	650
Araga	13.689496	75.244989	631
Naravi	13.12347	75.147355	113
Iruvail	13.011537	74.991310	71
Mantrady	13.105601	75.105403	85
Kannangi	13.796748	75.369600	655
Laxmipura	13.607234	75.265771	665

FARMER - GHAZIABAD

Annexure I

Respected Sir,

We confirmed both the EPNs by D2/D3 marker and identified them as H. indica only. We repeated the results to confirm their identity. Also, the fact that both match a strain from Meerut in GenBank confirms that we have the right identity. The Genbank accession numbers are provided for both.

H. indica Muzaffarnagar strain D2/D3 (GenBank Accession Number OM149711)

TTCCACCAGAGTTTCCTCTGGCTTCGTCCTGCTCAAGCATAGTTCACCATCTTTCG
GGTCGCAACCTACACGCTCTACCGCTGCCCATCTGCAAGCAGACAAGACAGGGCC
ATGGTGCTCCGTTTCGAAGAAGTTCAGTCGGATCCCATGTCAACCGGTTAACCGGT
CTTTACTTTCATTATGCCATAAGGTTTCCTCAGCCCTTTGACTCGCGTGTAAATTAC
ACTCCTCGGTCCGTGTTTCAAGACGGGTCGGAAAGGTGGTTAACTTTCACACTGAC
TCCCTAGAAACTAAGGCTTGACGTTAACCATGACAAACCTCCCAATAAGCAAGACA
CCACAATGTGGGCAACACTACATTGTTAGGAAAGCATGATCAACGCAGTCAGCGC
AACAACAGGTAGCGTCCACCCCCCAAAGCCACAGCTAAGCGACTATAGAGAATAT
AGCTACCAAGTTATGTTAACTCTCTCCGGTTCCACTTCAGCGATTTCACGTTCTCTT
GAACTCTCTCTTCAAAGTTCTTTGCAACTTTCCCTCCGGGTACTTTGTAGAAAATAA
AATCTCCAGGGACTTCGAAGTCGCGGGAGATCTATGACAAGTACCGTGAGGGAAA GTTG

H. indica Saharanpur strain D2/D3 (GenBank Accession number OM149712)

TTTCCTCTGGCTTCCTCCTGCTCAAGCATATTTCACCATCTTTCGGGTCGGAACCTA
CACGCTCTACCGCTGCCCATCTGCAACCAGACAAGACAGGGCCATGGTGCTCCGT
TTCCAAGAAGTTCAGTCGGATCCCATGTCAACCGGTTAACCGGTCTTTACTTTCATA
TATGCCATAAGGTTTCCTCAGCCCTTTGACTCGCGTGTAAATTACACTCCTCGGTC
CGTGTTTCAAGACGGGTCGGAAAGGTGGTTAACTTTCACACTGACTCCCTAGAAAC
TAAGGCTTGACGTTAACCATGAGCAAACCTCCCAATAAGCAAGACACCACAATGTG
GGCAACACTACATTGTTAGGAAAGCATGATCAACGCAGTCAGCGCAACAACAGGT
AGCGTCCACCCCCCAAAGCCACAGCTAAGCGACTATAGAGAATATAGCTACCAAG
TTATGTTAACTCTCTCCGGTTCCACTTCAGCGATTTCACGTTCTCTTGAACTCTCTC TTCAAA

best regards

Vishal Vishal S. Somvanshi,

Ph.D. Principal Scientist

Division of Nematology

Indian Agricultural Research Institute PUSA Campus New Delhi 110012

Annexure II

Division of Germplasm Collection and Characterization
ICAR- National Bureau of Agricultural Insect Resources, H. A. Farm Post,
Hebbal, Bellary Road, Bengaluru - 560 024, Karnataka, India

15-09-2021

Dr. Kolla Sreedevi
Principal Scientist

To,
Sri Jagpal Singh,
FARMER,
Ghaziabad- 201 002, U.P.

Sir,

Sub: Identification of the specimens received on 12-07-2021 – reg

Kindly find below the identification report of the specimens sent to us from your organization.

Code No.	**No of specimens**	**Scientific name**	**Family**
1	01	*Holotrichia serrata* (F.)	Scarabaeidae
2	01	*Holotrichia serrata* (F.)	
3	01	*Holotrichia serrata* (F.)	
4	01	*Holotrichia serrata* (F.)	
5	01	*Holotrichia serrata* (F.)	
6	01	*Holotrichia serrata* (F.)	
7	01	*Holotrichia serrata* (F.)	
8	01	*Holotrichia serrata* (F.)	
9	01	*Holotrichia serrata* (F.)	
10	01	*Holotrichia serrata* (F.)	
11	01	*Holotrichia serrata* (F.)	
12	01	*Holotrichia consanguinea* (Blanchard)	
13	01	*Holotrichia serrata* (F.)	

14	01	*Holotrichia serrata* (F.)	
15	01	*Holotrichia nagpurensis* Khan and Ghai	
16	01	*Holotrichia serrata* (F.)	
17	01	*Holotrichia serrata* (F.)	
18	01	*Holotrichia serrata* (F.)	
19	01	*Holotrichia serrata* (F.)	
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23	01	*Holotrichia serrata* (F.)	
24	01	*Holotrichia serrata* (F.)	
25	01	*Holotrichia serrata* (F.)	
26	01	*Holotrichia serrata* (F.)	
27	01	*Holotrichia serrata* (F.)	
28	01	*Holotrichia consanguinea* (Blanchard)	
29	01	*Holotrichia serrata* (F.)	
30	01	*Holotrichia serrata* (F.)	
31	01	*Holotrichia serrata* (F.)	
32	01	*Holotrichia serrata* (F.)	
33	01	*Holotrichia serrata* (F.)	
34	01	*Holotrichia serrata* (F.)	
35	01	*Holotrichia serrata* (F.)	
36	01	*Holotrichia serrata* (F.)	
37	01	*Holotrichia serrata* (F.)	
38	01	*Holotrichia serrata* (F.)	
39	01	*Holotrichia serrata* (F.)	
40	01	*Holotrichia consanguinea* (Blanchard)	

41	01	*Holotrichia serrata* (F.)	
42	01	*Holotrichia serrata* (F.)	
43	01	*Holotrichia nagpurensis* Khan and Ghai	
44	01	*Holotrichia serrata* (F.)	
45	01	*Holotrichia serrata* (F.)	
46	01	*Holotrichia serrata* (F.)	
47	01	*Holotrichia serrata* (F.)	
48	01	*Holotrichia serrata* (F.)	
49	01	*Holotrichia serrata* (F.)	
50	01	*Holotrichia serrata* (F.)	
51	01	*Holotrichia consanguinea* (Blanchard)	
52	01	*Holotrichia serrata* (F.)	
53	01	*Holotrichia serrata* (F.)	
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56	01	*Holotrichia serrata* (F.)	
57	01	*Holotrichia consanguinea* (Blanchard)	
58	01	*Holotrichia consanguinea* (Blanchard)	
59	01	*Holotrichia serrata* (F.)	
60	01	*Holotrichia serrata* (F.)	
61	01	*Holotrichia nagpurensis* Khan and Ghai	
62	01	*Holotrichia serrata* (F.)	
63	01	*Holotrichia serrata* (F.)	
64	01	*Holotrichia serrata* (F.)	
65	01	*Holotrichia consanguinea* (Blanchard)	
66	01	*Holotrichia nagpurensis* Khan and Ghai	

67	01	*Holotrichia serrata* (F.)	
68	01	*Holotrichia consanguinea* (Blanchard)	
69	01	*Holotrichia serrata* (F.)	
70	01	*Holotrichia serrata* (F.)	
71	01	*Holotrichia serrata* (F.)	
72	01	*Holotrichia serrata* (F.)	
73	01	*Holotrichia consanguinea* (Blanchard)	
74	01	*Holotrichia consanguinea* (Blanchard)	
75	01	*Holotrichia nagpurensis* Khan and Ghai	
76	01	*Holotrichia serrata* (F.)	
77	01	*Holotrichia nagpurensis* Khan and Ghai	
78	01	*Holotrichia nagpurensis* Khan and Ghai	
79	01	*Holotrichia serrata* (F.)	
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90	01	*Holotrichia serrata* (F.)	
91	01	*Holotrichia serrata* (F.)	
92	01	*Holotrichia serrata* (F.)	

93	01	*Anomala varicolor* Gyllenhal	
94	01	*Schizonycha ruficollis* (F.)	
95	01	*Schizonycha ruficollis* (F.)	
96	01	*Schizonycha ruficollis* (F.)	
97	01	*Holotrichia serrata* (F.)	
98	01	*Schizonycha ruficollis*	
99	01	*Schizonycha ruficollis* (F.)	
100	01	*Holotrichia serrata* (F.)	
101	01	*Schizonycha ruficollis* (F.)	
102	01	*Holotrichia serrata* (F.)	
103	01	*Schizonycha ruficollis* (F.)	
104	01	*Holotrichia serrata* (F.)	
105	01	*Holotrichia serrata* (F.)	
106	01	*Schizonycha ruficollis* (F.)	
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108	01	*Holotrichia serrata* (F.)	
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111	01	*Holotrichia nagpurensis* Khan and Ghai	
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137	01	*Holotrichia serrata* (F.)	
138	01	*Holotrichia serrata* (F.)	
139	01	*Holotrichia serrata* (F.)	

Yours sincerely

(K. SREEDEVI)