ALL INDIA NETWORK PROJECT ON SOIL ARTHROPOD PESTS

Proceedings & Technical Programme (2021-22)

22th Annual Review Workshop of All India Network Project on Soil Arthropod Pests 20th July, 2021

NETWORK UNIT
(S.K.N. AGRICULTURE UNIVERISTY)
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At the very outset, we would like to express our sincere gratitude to ***Dr. T.R. Sharma,*** *Deputy Director General (Crop Science), ICAR, New Delhi for gracing his crucial work and kind suggestions to improve the activity of the project.*

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We would like to express our gratitude to Dr. Subhash Chander, Director NCIPM, New Delhi and Dr. N. Bakthavatsalam, Director, NBAIR, Bengaluru for gracing their crucial work and kind suggestions.

It is our humble duty to thank to most valued expertise, Dr. R.D. Gautum, Professor & Head (Retd.), Division of Entomology, IARI, New Delhi, Dr. P.K. Mehta, (Retd.) Dean College of Agriculture & PS, Entomology, CSKHPKV-Palampur, Dr. Ashok Bhatnagar, Ex-Network Coordinator, AINP on SAP, RARI Durgapura and Dr. G.K. Mahapatro, Head, ICAR-IARI, Regional Station, Pune, National Fellow ICAR & Principal Scientist for their generous encouragement and cordial support, gracing your crucial work and sharing with us your opinion today.

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Last, but not the least, we express our special indebtedness and obligation to all the participants, scientists and guests for attending the group meeting and making it a grand success.

(A. S. Baloda)
Network Coordinator
AINP on Soil Arthropod Pests
Rajasthan Agricultural Durgapura, Jaipur

Contents

Page No.

22th Annual Review Workshop of All India Network Project on Soil Arthropod Pests on 20th July, 2021

Introductory session

The 22th Annual Review Workshop of All India Network Project on Soil Arthropod Pests was held on 20th July, 2021 through zoom meet at Project Coordinating Cell, RARI, Durgapura, Jaipur. Dr. A.S. Baloda, Network Coordinator, AINP on Soil Arthropod Pests welcomed the participants in the introductory session. The list of participants is annexed as **Annexure I.**

Dr. A.S. Baloda presented the overview of the project highlighting its mandate, objectives and significant achievements. In his address, he briefed the house about the current status of different soil insect pests throughout the country as well as strategies that have already been initiated under the aegis of the project and discussed about future thrust of project.

He said that white grubs, termites, cutworms, root borer, wireworms, red ants, field & mole crickets and phytophagous snails have become increasingly difficult pests throughout India with their intensifying damage every year as evidenced by the several outbreaks that occurred over large areas during the recent past. Since inception, this project has developed species specific as well as area specific IPM packages for the management of white grubs and successfully implemented in various crops. Efforts are in progress to develop such eco-friendly management strategies for other soil insect pests too.

In India several species have been observed to cause serious damage throughout the country right from Himalaya to Kerala and Gujarat to North Eastern regions infesting groundnut, sugarcane, millets, chillies, pulses, upland paddy, potato and vegetables, tea, coffee, arecanut, cashewnut, rubber and forest nursery. In India major whitegrub species causing damage to various crops includes, *Holotrichia consanguinea*, *Holotrichia serrata*, *Brahmina coriacea*, *Holotrichia longipennis*, *Holotrichia reynaudi*, *Schizonycha ruficollis*, *Anomala dimidiata*, *Anomala bengalensis*, *Lepidiota stigma*, *Lepidiota mansueta*, *Leucopholis lepidophora*, *Leucopholis burmeisteri*, *Leucopholis coneophora*, *Maladera insenabilis* etc. and *Holotrichia fissa*

becoming predominant in South India as well as *Phyllognathus dionysius* becoming predominant in groundnut ecosystems in last few years. The white grub species diversity is not much worked out in Gujarat so, there is need of evaluation. The five white grub species i.e. *Asactopholis microsquamosa* (Frey), *Holotrichia assamensis* Brenske, *Polyphylla fullo* (Linnaeus), *Anomala aureoflava* Arrow and *Anomala variivestis* Arrow are new records from Himachal Pradesh. Except these 2142 beetles belonging to 14 species of Scarabaeidae family were collected from 14 locations in 4 districts of Western UP and out of 14 species one new white grub species *Alissonotum* sp. (F.), Dynastinae, Scarabaeidae were also recorded, prevailing in Western UP. He highlighted also cutworm species prevalent throughout the country and losses caused by them in different crops.

To achieve control, Durgapura centre has prepared Methoxy benzene based Neno-gelled dispenser for the management of beetles of white grub, *Holotrichia consanguinea* and the technology has been demonstrated at 300 farmers field and KVKs and found effective in aggregation of beetles up to one month and now daily loading of new septa wouldn't be required upto one month. At Almora centre pheromone of scarab beetle, *Holotrichia seticollis* is isolated and identified as (1,2 1,3 and 1,4 diethyl benzene). The pheromone compound "Diethyl benzene" was found to attract 70.83% of male beetles. The VL white grub beetle trap was patented (IN290170), commercialized and about 1960 pieces sold and used for management of scarab beetles. At AAU-Jorhat five already identified pheromonal compounds (Cis-9 Hexadecenoic acid, Octadec-9-enoic acid, 1-Tetradecene, 1- Hexadecane, 1- Octadecenol) in pure form and their blends (5 nos.) along with male & female body wash were tested at Majuli, Assam. Out of all the treatments, Octadec-9- enoic acid showed promising results in trapping of L. mansueta beetles. This technology will be availlable by 2023. Necessary facilities for further pheromonal research on other insect pests have been developed at AAU through DBT sponsored multiinstitional project on "Chemical Ecology" in collaboration with IIHR, Bengaluru (Fund sanctioned to AAU Jorhat Centre: 1.85 Crore; Total Project Outlay: 4.76 Crore). Other centres are also doing *viz.,* Bengaluru centre, identified the pheromones of *Holotrichia serrata* with the help of National Chemical Laboratory (NCL) from Pune, Palampur centre on *B. Coriacea* and Almora centre on *Anomala dimidiata*.

The Bangalore Centre is entrusted with taxonomic studies on the Indian Scarabaeids and presently this centre houses more than 30,000 specimens representing various taxa collected from across the country as well provides identification service. Development of a "Digital Repository of the Scarabaeids" is in progress. A mobile data collection tool will be adopted to generate the raw data of the entire collection and will be linked to the website of AINP on SAP.

Geographical distribution maps of almost all major species of white grubs have been prepared. Concept of "Social engineering/ Farmers Participatory Approach" was introduced from 2010 by involving 400 farmers in 40 endemic villages. This programme received overwhelming responses and was exceedingly successful leading to massive collection and killing of approx. 12.43 lakhs of beetles during 2010-21. This non chemical approach of managing the huge population of beetles has saved approx. Rs. 2.0 crores that would have otherwise required for the purchase of insecticide, insecticide application equipment, spraying and other costs etc. The other centres are also pursuing social engineering for management of white grubs in their regions.

AAU-Jorhat, developed AAU Jatropha oil 50 EC formulation which was found effective against termites, cutworms, bruchids, mosquitos, ticks and veterinary microbes and this technology is under process of commercialization. At GKVK- Bengaluru, entomopathogenic fungi, *Beauveria brongniartii* UASBBb16, a native isolate found to be highly virulent for different species and stages of white grubs. Mass production of entomopathogenic fungi UASBBb16 is in progress and will be available for commercial use by 2022. At volunteer centre FARMER Ghaziabad a low cost WP formulation of EPN (*H. indica*) has been developed, its IJs storage stability and effectiveness was recorded up to four months at ambient temperature. Two new strain of EPN isolated from sugarcane crop field in Muzaffarnagar district. Forwarded to IARI for identification and laboratory evaluation of efficacy of new strains is being undertaken in laboratory. At RARI, Durgapura biocontrol agent's viz., *Metarhizium anisopliae, Beauveria bassiana* mixed with compost and applied in furrows at the time of sowing of ground nut has been found to be effective against white grubs. VPKAS-Almora centre developed a two pronged strategy of white grub management and showed 65% reduction in beetle catches in five years. Total economic value of this technology is Rs. 15.03 crore in five years. AAU Jorhat centre developed insecticidal mixture against soil insect pests

consists of different organic materials (Mustard oil cake + cow urine + wood ash + pongamia seed powder + saw dust @ 1:1:1:1:1) has been prepared and tested against soil insect pests and found promising results. This Insecticidal mixture can be used as an alternative of Malathion 5% dust. Also acts as bioenhencer.

COA-Kolhapur Invented Metarhizium Applicator. COA-Kolhapur also developed new Crow Bar technique of drenching for application of insecticides in ratoon sugarcane for management of whitegrubs in Maharashtra. AAU Jorhat centre standardized a saw dust based formulation of local strain of EPN, *H. bacteriophora* against soil insect pests.

GKVK Bengaluru developed a model to predict the adult emergence patterns of *Holotrichia serrata in karnataka.*

Molecular characterization of Melolontha cuprescens, *M. furcicauda, M. indica* and *Polyphylla fullo* was carried out at Palampur by using mitochondrial gene (COX1) and nuclear gene (28s rRNA). COX1 is a better DNA barcode for identification of Melolontha species and Polyphylla species, whereas 28S rRNA gene sequences showed limited utility in taxonomic identification of these species.

Under studies on gut microflora of major white grub species of Uttarakhand Himalayas. VPKAS-Almora isolated endosymbiotic cellulolytic and chitinolytic bacteria from different regions *i.e.*, midgut, anterior hindgut, fermentation chamber and posterior hindgut of the gastrointestinal tract of white grub species. 11 bacterial isolates were identified by phylogenetic analysis of 16S rRNA gene fragments. The result of BLAST-N showed that cellulolytic bacteria isolated from white grub gut were *Bacillus subtilis*, *Bacillus velezensis*, *Nonumuraea* sp., *Paenibacillus* sp., *Streptomyces* sp. and rest 6 isolates belongs to *Bacillus* sp. 21 chitinolytic bacteria were also isolated from the gut of white grub. Based on the 16S rDNA sequence, 7 isolates were identified as *Bacillus* sp., 2 as *Bacillus subtilis*, 2 as *Bacillus licheniformis*, 1 as *Actinobacterium* sp. and 1 as *Micromonospora* sp.

The technology of using soil drenching of imidacloprid 17.8 SL @ 60 g a.i/ha in standing crop after 21 days of sowing recorded lowest termite and white grub incidence at harvest, recorded highest grain and fodder yield in pearl millet. (RARI, Durgapura). For the management of termite in Groundnut crop treat the seeds with Imidacloprid 600 FS @ 6.5 ml or Fipronil 5Sc @ 10 ml per kg seed. (RARI, Durgapura). For the

management of white grub beetles slow release nanogel of pheromone methoxy benzene (anisole) is effective up to 25 days of installation (RARI, Durgapura). Management of termites through clothianidin 50 WDG @ 1g/ lit. in preserved setts of sugarcane (KVK: Golaghat, Dhemaji & Nagaon). Pre sowing soil application of clothianidin 50 WDG @ 120g *a.i.*/ ha (0.5g/lit of water) in seed furrows against white grubs in potato (KVK: Udalguri, Karimganj, Diphu & Dibrugarh). Use of oil based bait (Rice bran oil + Boric acid @ 50:50 parts) to attract red ants, *Dorylus orientalis* in Potato (KVK: Bongaigoan, Karimganj, Nagaon & Golaghat). In potato, clothianidin 50WDG (120 g a.i./ ha) was found most effective with least tuber damage on number basis (3.91%) in Shimla hills. (CSK HPKV, Palampur). In rajma, seven chemicals were tested as seed treatment against white grubs in Barot valley. The minimum (5.9%) plant damage was in case of Fifronil 40% + Imidacloprid 40%WG @ 3 g/kg seed followed by Clothianidin 50 WDG (1.5 g /kg seed) with 7.9% plant damage. (CSK HPKV, Palampur). In cabbage, five insecticides were evaluated as pre sown application against cutworms. The per cent plant infestation was minimum (1.5%) in clothianidin 50WDG (120 g a.i./ ha). (CSK HPKV, Palampur). Among different insecticides tested against termites in wheat, minimum tiller damage (3.4%) was recorded in in clothianidin 50 WDG treatment applied @ 1.5 g/ kg seed. (CSK HPKV, Palampur).

The Jorhat centre has made concerted efforts for the complete nutritional profiling of some commonly available edible insect of NE India since 2013. Under the aegis of the project, a predominant and economically important scarab beetle, *L. mansueta* has already been completely converted into an edible insect. This effort has been credited as the first ever attempt for large scale conversion of a serious soil insect pest into cuisine in Majuli river island, Assam. Of late, this centre has successfully carried out complete nutritional profiling of 18 predominant species of edible insects including 5 scarab beetles, 5 aquatic edible insects, 2 crickets, 2 grasshoppers and 2 silk worm species of Assam. Moreover, concerted efforts to prepare some value added products by exploring “Insect powder” prepared from *L. mansueta* adults and field cricket is also in progress. Advance nutritional studies on edible insect powders aiming toxicological and microbial studies, sensory evaluation, impact of cooking and preparation on the nutritional quality, post-harvest aspects etc. will be undertaken. Development of commercially marketable processed food products/animal feed exploring different “Insect powder” at an industrial scale will be attempted by engaging Self Help Groups operated by Women Tribal

farmers of Majuli, Assam through TSP programme. Entomophagy popularized and already showcased in Majuli will be linked with rural Agri-tourism since the island is trying to get the tag of world heritage site from UNESCO. The concept of "Insect Farming" or "Mini-livestock" among the stakeholders will be explored as bioprospecting to improve both nutritional and the rural livelihood security of rural people in NEH region. During last five years, a total of 29 of research papers were published in peer reviewed journals and one "Hand Book of Soil Insect Pests", eight book chapter, monograph, five books, one Technology manual, thirty five extension bulletin and twenty four popular articles 16 abstracts were published and two lead paper presentation. Since inception of the project guided several MSc. Students and Ph.D. Students under this project.

Dr. S.C. Dubey, Assistant Director General (PP&B), ICAR, appreciated the achievements and performance of the project and made the suggestions to the soil arthropod group. He suggested that both state and district wise population map of key white grub and other soil arthropod species has to be prepared. Countrywide species profiling of cutworms needs to be undertaken and the collected specimens should be deposited to NBAIR repository. The action taken on this aspect has to be reflected in annual report of the respective centres. To study complex species diversity, further multilocus DNA fingerprinting technique should be attempted in addition to existing COX1 gene barcode technology. Digitization of diagnostic keys for the identification of white grub species should start immediately. While conducting the field experiments, all centres must strictly follow uniformity in respect of bio agents and their doses with same statistical experimental design to draw logistic conclusion on the experiments. All potential strains of bio-agents should be converted either to liquid or talc based formulation for the end users. There is need to develop special technologies/devices for the placement of bio-agents near the rhizosphere or any other hiding areas of soil insect pests. There is a need to develop an effective holistic management of termites in different crop ecosystem since most of the insecticides are showing only suppressing effect but not the permanent solution.

At the outset, Dr. T.R. Sharma, H'ble DDG (CS), ICAR, New Delhi has expressed his satisfaction over the achievements of all the centres of AINP on SAP despite it's a very small group of scientists working across the country. H'ble DDG sir has asked the coordinator to commercialize the already proven and highly effective slow

release nanogel based aggregation pheromone technology in collaboration with NCIPM so that, the technology can be handed over to industry for the large scale distribution of the traps for the management of *Holotrichia consanguinea* to the end users. He has also directed the Coordinator to make a high quality HD video clip so that, the same can be uploaded in project website. He has asked to quantify the proven technologies developed by all the centres so that, the extent of diffusion of the technology outside the periphery of AINP centres can be judged or assessed. Since the area covered by the technology is also equally important. Studies on endo-symbiotic bacteria for their possible cellulolytic and lignolytic activity needs to be extensify for the whole insect gut micro-biome analysis in collaboration with NBAIR, Bengaluru. Critical analysis of data for new species of gut bacteria and building of barcode of new species should be done in collaboration with NBPGR, New Delhi. Molecular documentation of scarab beetles needs to be initiated to ascertain the genetic variability of the targeted species by making small group of insects specimen for further DNA fingerprinting and sequencing. He has also suggested to collaborate AINP-SAP Project with DBT and other Govt. agencies to build up university/institute/industry linkage for faster technology dissemination. Mating disruption technique has to be showcased in large scale with proper methodology. There is a need of proper disposal of insects trapped through semiochemicals used in various traps. If possible the collected insects can be explored as animal feed. The relationship between host trees and extent of damage of scarab beetles, assessment on yield loss incurred due to the infestation of different soil insect pests and studies on population dynamic of the insects needs to be thoroughly study. High quality research papers should be published in international journals with high impact points and citations record. Finally H'ble DDG sir has requested to all the esteemed experts to thoroughly examine the presentation made by the respective centres, for their further refinement in respect of methodology and application.

The four invited experts; Dr. P.K. Mehta, (Retd.) Dean College of Agriculture & PS, Entomology, CSKHPKV-Palampur, Dr. RD Gautum (Retd.) Head, Entomology, IARI, New Delhi, Dr. Ashok Bhatnagar, Ex-Network Coordinator, AINP on SAP, RARI Durgapura and Dr. G.K. Mahapatro, Head, ICAR-IARI, Regional Station, Pune, national Fellow ICAR & Principal Scientist gave their introductory remarks.

Technical Session

Technical Session-I

The first technical session was chaired by Dr. P.K. Mehta, (Red.) Dean College of Agriculture & PS, Entomology, CSKHPKV-Palampur and co-chaired Dr. G.K. Mahapatro, Head, ICAR-IARI, Regional Station, Pune, National Fellow, ICAR & Principal Scientist Dr. Badal Bhattacharyya, Dr. K.V. Prakash & Dr. K.S. Verma were the rapporteurs for the session.

The centre in-charges of the coordinated centres namely, Dr. Badal Bhattacharyya (AAU-Jorhat), Dr. D. Rajanna (GKVK-Bengaluru), Dr. R.S. Chandel (CSKHPKV, Palampur) and Dr. B.L. Jakhar (RARI, Durgapura, Jaipur) presented the progress of their centre as per the assigned technical programme for the year 2020-21.

Dr. Badal Bhattacharyya, PI, AINP- SAP has presented the following significant achievement's of last year experiments. Four technologies have been recommended by TCM, AAU to conduct as "On Farm Trial" in different KVKs of Assam

- ✓ Management of termites through clothianidin 50 WDG @ 1g/ lit. in preserved setts of sugarcane
- ✓ Presowing soil application of clothianidin 50 WDG @ 120g a.i./ ha (0.5g/lit of water) in seed furrows against white grubs in potato
- ✓ Use of oil based bait (Rice bran oil + Boric acid @ 50:50 parts) to attract red ants, Dorylus orientalis in Potato.
- ✓ Application of Insecticidal mixture @ 250 kg/ha in seed furrows against various soil insect pests in potato

The infectivity of two native Entomopathogenic Nematodes (EPNs), *Heterorhabditis bacteriophora* and *Steinernema aciari* were evaluated against worker termites, Odontotermes obesus and larvae of potato cutworm, Agrotis ipsilon. Standardized an saw dust based formulation of local strain of EPN, *H. bacteriophora* against soil insect pests. Prepared Distribution Map for 8 Key Species during 2015-2021 both in Assam & Arunachal Pradesh. Identified 8 species of termite from Assam and the Biodiversity studies and development of distribution maps of termites of Assam. Concept of "Social engineering/ Farmers Participatory Approach" was introduced from 2010 by involving 400 farmers in 40 endemic villages. This programme received overwhelming responses and was exceedingly successful leading to massive collection and killing of

approx. 12.43 lakhs of beetles during 2010-21. Impact: This non chemical approach of managing the huge population of beetles has saved approx. Rs. 2.0 crores that would have otherwise required for the purchase of insecticide, insecticide application equipment, spraying and other costs etc. Negative impact of synthetic chemical insecticide application was also avoided in respect of insecticide residue, ground water contamination, contamination of mighty Brahmaputra river. An "Insecticidal Mixture" consists of different organic materials (Mustard oil cake+ cow urine + wood ash + pongamia seed powder + saw dust @ 1:1:1:1:1) has been prepared and tested against soil insect pests and found promising results. This mixture can be used as an alternative of Malathion 5% dust. Also acts as bioenhencer. Scanning Electron Microscopy & Energy Dispersive X-ray (EDX analysis of the mixture also revealed the presence of 2 numbers of macro elements and 7 numbers of microelements showing its pesticidal and bio-enhancer properties. Furthermore, twelve numbers of Volatile Organic Compounds (VOCs) having potential role in insect-pests and disease management were detected. Developed AAU Jatropha oil 50 EC formulation and found effective against termite workers, cut worms, bruchids, ticks, mosquito larvae. Nutritional composition of four edible orthopteran insect species *viz.,* field cricket (mole cricket rice grasshopper and cone headed grasshopper were assessed Nutritional profiling of desert locust is also in progress.

Dr. D. Rajanna, Principal Investigator and Dr. K. V. Prakash, Assistant Professor jointly presented the salient achievements as follows:

- Collected beetles of *Hoplia* sp., a unique melolonthine from south India for the first time.
- Developed biogeography maps for major white grub species of Karnataka.
- Developed a weather based model to predict emergence of adult beetles of *H. serrata* in Karnataka.
- Efforts were made to popularization of insecticide free management of arecanut white grubs in ~25 ac in coastal and Western Ghats of Karnataka.
- Documented the success stories and also published popular articles in local language to encourage and inspire the farming community.
- Isolated microflora associated with labial secretion of larvae of arecanut white grubs.
- Recorded five species of termites infesting cereals and trees in Karnataka.

- Estimated the yield loss due to infestation of Giant African Snail, *Lissachatina fulica* (Bowdich) in vanilla (*Vanilla planifolia* Andrews).
- Studied the integrative taxonomy of arecanut white grubs, *Leucopholis* spp., using morphological and molecular approaches.
- Initiated the digitization of scarab species maintained in the repository of AINP-SAP, Bengaluru.
- Tested a native fungal bioagent, *Beauveria brongniartii* (UASBBb16 Isolate) against major white grubs and mass production is in progress. Dr. P.K. Mehta, Chairman of the session appreciated the centre for their commendable research works.

Dr. R. S. Chandel, PI of the centre presented the research achievement 2020-21 as follows:

- Total 28 species of scarab beetles were collected from 11 locations of Himachal Pradesh by Palampur centre. The predominant species were *Brahmina coriacea, Holotrichia longipennis, Maladera insanabilis, M. Thomsoni, A. varicolor.*
- *Asactopholis microsquamosa*, *Holotrichia assamensis*, *Polyphylla fullo*, *Anomala aureoflava* and *Anomala variivestis* are new records from Himachal Pradesh.
- Studied the biology of *Maladera thomsoni* and *Polyphylla fullo* and described their raster patterns and male genitalia.
- Molecular characterization of *Melolontha cuprescens*, *M. furcicauda, M. indica* and *Polyphylla fullo* was carried out at Palampur by using mitochondrial gene (*COX1*) and nuclear gene (*28s rRNA*). *COX1* is a better DNA barcode for identification of *Melolontha* species and *Polyphylla* species, whereas *28S rRNA* gene sequences showed limited utility in taxonomic identification of these species.
- In potato, clothianidin was found most effective with least tuber damage on number basis (3.91%) as compared to untreated check (21.12%) in Shimla hills.
- In cabbage, five insecticides were evaluated as pre sown application against cutworms. The per cent plant infestation was minimum (1.5%) in clothianidin 50WDG (120 g a.i./ha) whereas, in control 13.25% plant infestation was recorded.

- Among different insecticides tested against termites in wheat, minimum tiller damage (3.4%) was recorded in in clothianidin 50 WDG treatment applied @ 1.5 g/ kg seed as compared to 12.3 per cent in untreated check.

Dr. P.K. Mehta, Chairman praised the research works carried out in Palampur centre and stressed upon the importance of biocontrol agents in the management of soil insect pests and also advised to isolate and incorporate more native potential microbial strains at all the centres.

Dr. B. L. Jakhar, Associate Professor presented the salient research achievements (2020-21) of the centre.

- The already isolated and characterized pheromone "Methoxy benzene" explored earlier for managing *H. consenguniea* in ground nut ecosystem was found highly volatile and required daily loading of new septa on host trees. This problem is overcomed by using slow release "Nano gel 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.
- Soil drenching of imidacloprid 17.8 SL @ 60 g a.i/ha in standing crop after 21 days of sowing recorded lowest termite and white grub incidence at harvest, recorded highest grain and fodder yield in pearl millet.
- For the management of termite in Groundnut crop treat the seeds with Imidacloprid 600 FS @ 6.5 ml or Fipronil 5Sc @ 10 ml per kg seed.
- Biocontrol agents *viz., Metarhizium anisopliae, Beauveria bassiana* mixed with compost and applied in furrows at the time of sowing of ground nut has been found to be effective against white grubs.

Dr. P.K. Mehta, Chairman praised the centre for their creditable research works on nanogel formulation of already synthesized pheromonal compounds. Furthermore, the chairman suggested the centre to incorporate more clear data on the population density of scarab beetles. He also urged the centre to develop some mechanical management strategies as well as to embrace more social engineering approaches for managing the white grubs.

Dr. A. K. Pandey presented the work of G.B. Pant Agriculture University & Technology, Pantnagar Centre.

- In Pantnagar (Udham Singh Nagar district), *Holotrichia serrata, Holotrichia rosettae, Adoretus simplex and Heteronychus lioderes* was found to be dominating species of white grub.
- Among the various host plants, Neem was found to be most preferred host Jackfruits, Mango and Guava of *H. serrata*.
- Pre sown as well as post sown application of Fipronil 40%+ Imidacloprid 40% WG @ 300g/ha followed by Clothianidin 50 WDG @120g *a.i.* found effective against the management of white grub in sugarcane.
- Application of Fipronil 40%+ Imidacloprid 40% WG @ 300g/ha followed by Clothianidin 50 WDG @120g *a.i.* found effective against the management of white grub in sugarcane.
- *Agrotis ipsilon* was found to be major species of cut worm and emergence starts from March with peak period of April.
- Application of *M. anisopliae* 5g/m^2+seed treatment+ drenching of Fipronil 5 SC 3 l/ha at 50 days after sowing found effective for the management of white grub in potato.

Dr. P.K. Mehta enquired about the status of white grub damage in Terai region of Uttarakhand which was reported to be less severe in this part.

Dr. Amit Paschapur presented the work of VPKAS, Almora centre.

- Pheromonal technology for the management of *H. seticollis* has been perfected and demonstrated in the field.
- Endosymbiotic cellulolytic and chitinolytic bacteria were isolated from different regions *i.e*. midgut, anterior hindgut, fermentation chamber and posterior hindgut of the gastrointestinal tract of four white grub species (*Anomala bengalensis, Holotrichia seticollis, Anomala dimidiata* and *Holotrichia longipennis*) by cultural method.
- Eleven bacterial isolates were identified by phylogenetic analysis of 16S ribosomal RNA (rRNA) gene fragments. The result of BLAST-N (Basic Local Alignment Search Tool for Nucleotides) showed that cellulolytic bacteria isolated from white grub gut were *Bacillus subtilis, Bacillus velezensis, Nonumuraea* sp., *Paenibacillus* sp., *Streptomyces* sp. and rest six isolates belong to *Bacillus* sp.

- Twenty one chitinolytic bacteria were also isolated from the gut of white grub. Based on the 16S rDNA sequence, 07 isolates were identified as *Bacillus* sp., 02 as *Bacillus subtilis*, 02 as *Bacillus licheniformis*, 01 as *Actinobacterium* sp. and 01 as *Micromonospora* sp.
- Out of the total 83 species of Scarabaeids available in the Uttarakhand, Himalayas, 60 species have been morphologically characterized and 45 species have been molecularly characterized using two universal primers specific to insects (COI and Cyt B).

Dr. A.S. Baloda, Network Coordinator, appreciated the work of the centre and assured to provide additional financial support to the centre to meet out their expenses and said that Dr. Amit is new scientist associated with the project. Work presented by him seems worth to the project.

Dr J.P. Singh presented the work of the FARMMER, Ghaziabad as follows

- Large scale multiplication field trials for application of EPNs; *Heterorhabditis indica* strains for the management of different species of white grub at least one acre each.
- Field trials for application of EPNs; *Heterorhabditis indica* strains for the management of other soil arthropods; cutworm, termite, root borers.
- Large scale multiplication Field trials for application of EPNs; *Heterorhabditis indica* strains + *Metarhizium anisopliae*, *Beauveria bassiana* for management of different species of white grub at least one acre each.
- Dissemination of technology of rearing of host insect; *Galleria mellonella* (Wax moth) by rural youths and women entrepreneurs for in vivo multiplication of EPN.

Technical session-II

The second session was chaired by Dr. R.D. Gautum, Professor & Head (Retd.), Division of Entomology, IARI, New Delhi and co-chaired by Dr. Ashok Bhatnagar, Ex-Network Coordinator, AINP on SAP, RARI Durgapura. Dr. R.S. Chandel & Dr. Rajanna Dr. B.L. Jakhar were the rapporteurs for the session.

The session started with introductory remarks of the chairman and Co-chairman. During the session, Dr. Kolla Sreedevi, Senior Scientist, NBAIR, Bengaluru, Dr. Deepa Bhagat, Senior Scientist, NBAIR, Bengaluru, Dr. U. B. Hole, Professor, Entomology, RCSM College of Agriculture, MPKV-Rahuri, Kolhapur and Dr. Dharmrajsinh Jethva Associate Research Scientist, Junagarh Agriculture University (New proposed centre) were made the presentation of their respective centres.

Dr. U. B. Hole, Professor of Entomology, RCSM College of Agriculture, MPKV-Rahuri, Kolhapur briefed the activities of the centre. He presented the survey and surveillance report of white grubs incidence in Maharashtra during 2020-21, their host range, extent of damage. He also presented the work carried out in respect of social Engineering activities and Invented Metarhizium Applicator. Also developed new Crow Bar technique of drenching for application of insecticides in ratoon sugarcane for management of whitegrubs in Maharashtra. Dr. A.S. Baloda, Network coordinator suggested to enhance the progress of the centre since white grubs are attaining major biotic factor under sugarcane ecosystem in Maharashtra. Dr. Bhatnagar said that centre is required to do some innovative research to manage white grub causing lot of damage to crops.

Dr. Kolla Sreedevi presented the progress of species diversity, documentation, diagnostic and description of dominant species white grubs across India. Mapping of pestiferous Melolonthinae, molecular characterization for 40 predominant Sericine beetles, Phylogenetic analysis of Sericine group were the important contribution made by her. Dr. R.D. Gautum complimented for her excellent work on molecular taxonomy work.

Dr. Deepa Bhagat presented Application of Nanotechnology for the management of *Holotrichia consanguinea* through Nanotechnologically made Nanogel of Methoxy Benzene, an aggregation pheromone which is more stable in environment. Dr. A.S. Baloda, Network coordinator suggested for its commercialization.

Dr. Dharmrajsinh Jethva Associate Research Scientist, Junagarh Agriculture University (New proposed centre) was made the presentation of his centre and highlighted the white grub problem in Gujrat.

Technical session-III
Valedictory & Plenary session

The plenary session was chaired by Dr. T. R. Sharma, DDG-CS and co-chaired by Dr. S.C. Dubey, ADG-PP&B. Dr. R.S. Chandel & Dr. Rajanna Dr. B.L. Jakhar were the rapporteurs for the session. The experts gave their critical inputs for the improvement of the project and future course of action.

Critical comments/recommendations of the experts/mentors

Dr. S.C. Dubey, ADG (PP&BS) has made the following suggestions/ recommendations

- Effect of climate change and its possible impact on population dynamics of soil arthropod pests needs to be studied.

(Action: Network Coordinator and All PIs Centers)

- Crop losses inflicted by the key species of white grubs and other soil insect pests needs to be estimated.

(Action: Network Coordinator and All PIs Centers)

- Population studies of white grubs under diverse cropping systems needs to be undertaken.

(Action: Network Coordinator and All PIs Centers)

- Efforts are to be made to develop talc based formulations of different potential local strains of Entomopathogenic Nematode (EPN), Entomopathogenic Fungi (EPF) etc. to manage various soil insect pests.

(Action: Network Coordinator and All PIs Centers)

✓ Slow release nanogel pheromone is a potential technology and needs to be commercialised.

(Action: Network Coordinator)

✓ The social engineering work can be taken up by all the centres involved in the project so that an effective management of the whitegrubs and other soil arthropod pests can be attained over large areas.

(Action: Network Coordinator & All PIs of centres)

Dr. T. R. Sharma delivered the concluding remarks and made the following suggestions.

- Drone as a means of artificial intelligence in pesticide application as well as for the monitoring of white grub infestation areas should be explored.

(Action: AAU-Jorhat and CSKHPKV-Palampur)

- Insecticides having label claim against various soil insect pests only to be included in management programme.

(Action: Network Coordinator & All PIs of centres)

- Bio-pesticides used in soil insect pest management programme should be collected from the known sources.

(Action: All PIs of centres)

- All scientists should be proactive to bring externally funded collaborative research projects from DBT, DST and other funding sources.

(Action: Network Coordinator & All PIs of centres)

- More emphasis should be given on identifying and describing new white grub species.

(Action: Network Coordinator & All PIs of centres)

- The Network Coordinator has to organize the project review meeting after every three months to know the progress of the ongoing research and extension programme carried out by the different centres.

(Action: Network Coordinator)

- Project scientists should also organize meeting with NGO's, SHGs for the transfer of proven technologies to the farmers' field and other stakeholders.

(Action: All PIs of centres)

- The website of the project should be updated with success stories and other related information on the soil insect pests.

(Action: Network Coordinator)

The meeting ended with a vote of thanks by Dr. A. S. Baloda, Network Co-ordinator, AINP on Soil Arthropod Pests.

General Instructions for the centres:

1. All the coordinated centers should take good quality photographs of different experimental fields. Along with the crops, photographs should also contain the display board with the information such as date of sowing; name of the pesticide and its formulation; date of spray etc. Avoid photographs with researchers and other staff. The photographs should also be included in the hard as well as soft copies of the reports.

(Action: All PIs of the centres)

2. The hard copies of the annual progress reports may be printed on both sides of the paper to reduce the carbon footprint.

(Action: All PIs of the centres)

3. All the coordinated centers should utilize all the funds released under NRC on or before March 31st, 2021. In case of non-utilization of the funds, the allocated funds will be withdrawn. The progress regarding the utilization of funds should be intimated to the Network Coordinator on or before December 31, 2020.

(Action: All PIs of the centres)

4. The funds allotted under TSP should be utilized by the centres for conducting training programmes, organizing interactive sessions with farmers, providing farming essential equipments to farmers.

(Action: All PIs of the centres)

5. All the coordinated centers should submit their UC on or before 15th May and AUC on or before 31st August.

(Action: All PIs of the centres)

6. The monthly progress report expenditure statement should be submitted by 15th of every month as per the format provided by the Network Coordinator for its onward transmission to the Council**.**

(Action: All PIs of the centres)

7. All the coordinate centres will provide the materials area specific for website updation as the given format by the network coordinator.

(Action: All PIs of the centres)

8. Palampur centre is also very old centre of the project. Centre is doing work on Mapping of the scarab fauna in the hilly region and evolving management practices. Earlier centre worked for isolation of pheromone but could not complete. They must retry for this.

(Action: CSKHPKV-Palampur)

9. Technical Manuals must be developed for the data recording of research observations in the experiments of AINP. Tables, procedures, protocols, damage/infestation methods/methodologies should be clearly detailed in the manual, and all AINP centres should follow uniform data recording procedures with replicable tables, data spread sheets etc.

(Action: All PIs of the centres)

10. Development of IPM module for the termite and other soil arthropod pests.

(Action: All PIs of the centres)

Action Taken Report of the recommendations of 21th Annual Workshop held on March 27th July 2020

S. No.	Recommendation	Action taken
1.	Durgapura centre directed to for commercialization of nanogel formulation technology of already existing Pheromone methoxy benzene of predominant white grub species *H. consenguniea* and conduct large scale experiment trail.	Demonstrations at 300 farmers field and KVKs has been done and commercialization under process
2.	AAU-Jorhat centre directed to conduct large scale trials for two already identified pheromonal compounds (Cis-9 Hexadecenoic acids & Octadec- 9 enoic acid) of *L. mansueta* were synthesized at ATGC Biotech Pvt. Ltd., Hyderabad.	This aspect needs further study.
3.	Label claims of the insecticides needs to be looked in to while designing application strategies. (Network Coordinator)	Label claims of the insecticides were verified critically when designing application strategies.
4.	The social engineering work can be taken up by all the centres involved in the project so that an effective management of the whitegrubs and other soil arthropod pests can be attained over large areas. (Network Coordinator)	Farmer's participatory approach (Social engineering) for the adult management of white grub added in the technical programme (2020-21) for all the centres.
5.	Country wide map of different whitegrub species is to be prepared. (Network Coordinator)	Soil arthropods constitute very diverse group and so far only 45 per cent of fauna has been mapped and rest in progress.
6.	Different target pest species can be characterized using molecular systematics and barcodes. (Network Coordinator)	In progress
7.	The effect of climate change on species distribution, population dynamics and changes in species spectrum needs to be documented. (Network Coordinator)	In progress
8.	VPKAS-Almora directed to use the female pheromone of *H. seticollis* is isolated and identified as 1,2 1,3 and 1,4 diethyl benzene through GC-MS analysis for the management.	The pheromone compound "Diethyl benzene" was found to attract 70.83% of male beetles and perfected.
9.	GKVK-Bengaluru centre directed to Initiate digital documentation of scarabs maintained at	In progress

S. No.	Recommendation	Action taken
	Bengaluru centre	
10.	The funds allotted under TSP should be utilised by the centres for conducting training programmes, organising interactive sessions with farmers and providing equipment to farmers.	Complied by all Centres
11.	All the coordinated centers should submit their UC on or before 15th May and AUC on or before 31st August.	Complied by all Centres
12.	The monthly progress report should be submitted by 15th of every month for its onward transmission to the Council**.**	Complied by all Centres

Annexure I

LIST OF PARTICIPANTS

1.Indian Council of Agricultural Research, Head Quarters, New Delhi	
Dr. T. Mohapatra Director General & Secretary DARE (GOI)	Dr. T.R. Sharma Deputy Director General (Crop Sci.)
Dr. S.C. Dubey Assistant Director General (PP& B)	
2. NCIPM, New Delhi	
Dr. Subhash Chander, Director, NCIPM, New Delhi	
3. AINP-SAP Centers	
i. Rajasthan Agricultural Research Institute (SKNAU-Jobner), Durgapura, Jaipur	
Dr. A.S. Baloda Network Coordinator	Dr. B.L. Jakhar, Associate professor
Dr. K.K. Saini, SRF	
ii. Assam Agriculture University, Jorhat	
Dr. Badal Bhattacharyya Principal Scientist	Dr. Sudhansu Bhagawati Junior Scientist
Dr. Kritdeepan Sarmah, Junior Scientist	Dr. Elangbam Bidyarani Devi, SRF
Mr. Nang Sena Manpoong, SRF	Mr. Peter Shyam, SRF
iii. University of Agricultural Sciences, GKVK, Bangalore	
Dr. D. Rajanna, Principal Investigator, AINP on SAP, GKVK, Bengaluru	Dr. K.V. Prakash, Assistant Entomologist, AINP on SAP, GKVK, Bengaluru
Ms. U. Sahana, SRF	Ms. K. Nirmala, SRF
iv. CSKHPKV, Palampur	
Dr. R.S. Chandel Principal Scientist & PI AINP on Soil Arthropod Pests, CSKHPKV, Palampur	Dr. K.S Verma Co-PI, AINP on SAP, CSKHPKV, Palampur
Mr. Abhishek Rana, JRF	Dr. Suman Sanjata, JRF
v. Govind Ballabh Pant University of Agriculture and Technology, Pantnagar	
Dr. A.K. Pandey Professor, Entomology, G.B.P.A.U. & T., Pantnagar	Dr. Sanjiv Kumar, SRF
vi. ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan-Almora	
Dr. Amit Paschapur, Scientist (Agril. Entomology)	
vii. RCSM College of Agriculture, MPKV-Rahuri, Kolhapur	
Dr. U. B. Hole, Professor of Entomology	
viii. Foundation for Agricultural Resources Management and Environmental Remediation (FARMER)-Ghaziabad	
Sh. J.P. Singh, Secretary	Dr. Seema Rani, RA
Mr. Riyazuddin, SRF	
4. NBAIR, Bengaluru	
Dr. N. Bakthavatsalam , Director, NBAIR,	Dr. Kolla Sreedevi, Senior Scientist
Dr. Deepa Bhagat, Senior Scientist	
5. Expert panel	
Dr. RD Gautam Professor & Head (Retd.), Department of Entomology,IARI, New Delhi	Dr. P.K. Mehta, Red. Dean College of Agriculture & PS, Entomology,CSKHPKV-Palampur
Dr. Ashok Bhatnagar Ex-Network Coordinator, AINP on SAP, RARI Durgapura	Dr. G.K. Mahapatro, Head, ICAR-IARI, Regional Station, Pune, nationalFellow ICAR & Principal Scientist

Staff Position of AINP on Soil Arthropod Pests

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2.	AAU-Jorhat	Dr. Badal Bhattacharyya	Principal Scientist	9435648957	badalassam@gmail.com
		Dr. Sudhansu Bhagawati	Junior Scientist	9864898070	sudhansubhagawati@gmail.com
		Dr. Kritdeepan Sarmah,	Junior Scientist	8638017109	
3.	GKVK-Bengaluru	Dr. D. Rajanna,	Principal Investigator	9108562289	rajannadent@gmail.com
		Dr. K.V. Prakash,	Assistant Entomologist	9448997061	kvpento@gmail.com
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5.	GBPUA&T Pantnagar	Dr. A.K. Pandey	Principal Investigator	9927194497	drajay2002@gmail.com
6.	JAU-Junagarh	Dr. Dharmrajsinh Jethva	Associate Research Scientist, Junagarh Agriculture University (New proposed centre	-	-
Volunteer Centre					
7.	VPKAS-Almora	Dr. Amit Pashapur,	Scientist (Agril. Entomology)	9639175431	subbanna.ento@gmail.com
8.	FARMER (NGO)-Ghaziabad	Dr. J.P. Singh	Secretary	9891292444	jps.farmer@gmail.com
		Dr. Seema Rani	Research Associate		
9.	MPKV-Rahuri	Dr. U.B. Hole	Professor of Entomology	9960052852	uttamhole@gmail.com

TECHNICAL PROGRAMME FOR YEAR 2021-22

WHITE GRUBS:

1. TRAP TECHNOLOGY

A. 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 "scarabaied beetles" 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, labelled and identified upto 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 centres)

B. 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 centres)

C. 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 centres. For these studies collect the sample of preferred host of beetles and send to Dr. Deepa Bhagat, Principle Scientist, NBAIR, and Bengaluru as her suggestion/protocol.

(Allotted for all centres)

D. 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 centres)

E. 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.

Centers:

Jorhat **:** *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).

Bengaluru **:** Extraction, identification, synthesis and field testing of pheromonal compounds of *Leucopholis burmeisteri*

Palampur **:** Extraction, identification, synthesis and field testing of pheromonal compounds of *Brahmina coriacea.*

Almora **:** Extraction and identification of pheromones of *Anomala bengalensis* and their testing in both laboratory and field conditions.

Gujrat **:** Being a newly introduced centre, concerted attempts should be made to study the diversity phytophagous scarab fauna of Gujrat. 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.

F. 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 centres)

G. 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 mansson 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/ riverine areas. Attempts should be made to use drone technology to survey the termite mounds and their architecture.

(Allotted for all centres)

2. 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.

A. Evaluation of granular insecticides against white grub:

Experiment Details:

Location :Jorhat (pre-sowing), Palampur (post-sowing), Durgapura (Post sowing),

Kolhapur (Post sowing),Ghaziabad (Post sowing), Gujrat (Post sowing)

Sowing time :As per Recommended Package of Practices
Design :RBD
Replication :3
Crop :Jorhat (Potato), Palampur (Potato) , Durgapura (Groundnut), Kolhapur (Sugarcane), Ghaziabad (Sugarcane), Gujrat (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	80 g 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 Residue's Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.

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

Experiment Details:

Location :Jorhat (pre-sowing), Palampur (post-sowing), Durgapura, Kolhapur, Ghaziabad, Gujrat, Bangalore

Sowing time :As per Recommended Package of Practices
Design :RBD
Replication :3
Crop :Jorhat (Colocasia), Palampur (Potato & Rajmash), Durgapura (Groundnut), Kolhapur (Sugarcane, Groundnut & Soybean), Ghaziabad (Sugarcane), Gujrat (Groundnut), Bangalore (Arecanut)
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 Residue's Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.

3. MICROBIAL CONTROL OF WHITE GRUBS

i. Field evaluation of entomopathogenic fungi against white grub

Experiment Details:

Location :Jorhat, Palampur, Durgapura, Kolhapur, Ghaziabad, Gujrat, Bangalore

Sowing time :As per Recommended Package of Practices
Design :RBD
Replication :3
Crop :Jorhat (Green gram), Palampur (Potato & Rajmash), Durgapura (Groundnut), Kolhapur (Sugarcane) Ghaziabad (Sugarcane), Gujrat (Groundnut), Bangalore (Arecanut & Sugarcane)
Fertilizer :as per Recommended doses
Treatments :8
Treatment Application :Apply entomopathogenic fungi's powered formulation mix with 100 kg FYM and without mix with FYM in row by 5 cm deep furrow extending front to back. The raised soil beside the furrow push back to cover formulation.
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 be recorded 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	-

Table: Field evaluation of entomopathogenic fungi against white grub

Treatment	Applied at the time of Planting/sowing				Yield (q/h)
	White grub damage		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 %					

ii. **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 : **White Grub**

- No healthy tillers and dead tillers / 1 m row length before application of entomopathogens
- Per cent reduction of white grub population;
- Yield will be recorded at the time of harvesting (comparison with insecticides and control),
- CB Ratio

Method of Application:

1. *B. thuringiensis* NBAIR-BT25 @ 3 litre/acre as soil drenching for two times at the interval of 7 days.
2. *B. thuringiensis* NBAIR-BTAN4 @ 3 litre/acre as soil drenching for two times at the interval of 7 days.
3. *Bacillus albus* NBAIR-BATP @ 2.5 Kg of talc mixed with 100 kg of FYM with Intermittent water sprinkling and incubate 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 biopesticides 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.**

iii. Evaluation of the bioefficacy of promising EPN strains against white grubs

Experiment details

Location : Jorhat, Palampur, Durgapura, Kolhapur, Ghaziabad, Gujrat, Bangalore, SBI-Coimbatore

Sowing time : As per respected zones and centres

Crop : Jorhat (Green gram), Palampur (Potato & Rajmash), Durgapura (Groundnut), Kolhapur (Sugarcane) Ghaziabad (Sugarcane), Gujrat (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 Steinernema *surkhetense* strain SBIP3@ 10^8 IJs/ac

T_4 *Steinernema siamkayai* strain SBITNT1@ 10^8IJs/ac

T_5. Recommended insecticides

T_6 Control (No EPN)

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 equipments 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 (*Heterorhabditis* infection) or black coloured (*Steinernema* infection) dead grubs

Table: Evaluation of Bioefficacy of EPN strains against white Grub in field conditions

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 %				

iv. 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)

4. WHITE GRUB TAXONOMY (NBAIR, Bangalore and UAS, GKVK, Bengaluru.):

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.

5. 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.) Gujrat : Gujrat

(D.) Kolhapur : Maharashtra, Goa and Odessa

(E.) Bangalore : Karnataka, Andra Pradesh, Telangana, Tamil Nadu and Kerala

(F.) Jorhat : Assam, Arunachal Pradesh and Manipur

(G) Almora : Uttrakhand

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 month to her.

VII. 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**	**District(s) to be covered**	**Beneficiary farmers (Approx.)**
Durgapura	*Holotrichia consanguinea*	Jaipur, Sikar, Dausa,	5000

		Bikaner, Jodhpur, & Nagour	
AAU	*Lepidiota mansueta*	Majuli & Jorhat, Assam	5000
Palampur	*Brahmina coriacea*	Kinnaur, Lahual, Chamba	5000
Bangalore	*Holotrichia serrata, Leucopholis lepidophora L. burmestri, Leucopholis coneophora*	Mandya, Mysore, Chamarajanagar, Hassan, Belgaum, Dharwad, Bagalkot, Bijapur	5000
Kolhapur	*Leucopholis lepidophora* and *Holotrichia serrata*	Sangli, Satara, Kolhapur	5000
Gujrat	*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 insenabilis, H. consenguniea*	Ghaziabad, Hapur, Bulandsahar, Gautumbudh Nagar, Amroha, Saharnpur, Muzafarnagar	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
AAU	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, 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, Whatsup) and YouTube.

TERMITE

MANAGEMENT OF TERMITE THROUGH CHEMICALS:

A. Management of termite through seed treatment:

Experiment Details:

Location :Palampur, Durgapura, Bengaluru, Gujrat

Sowing time :As per POP
Design :RBD
Replication :3
Crop :Palampur (Wheat), Durgapura (Groundnut), Bengaluru (Groundnut), Jorhat (Moong bean) Gujrat (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 Residue's Laboratory, Division of Entomology, RARI, Durgapura, Jaipur (Rajasthan) -302018.

B. Management of termites through drenching:

Experiment details:

Location :Palampur, Durgapura, Bengaluru, Gujrat

Sowing time :As per POP
Design :RBD
Replication :3
Crop :Palampur (Wheat), Durgapura (Groundnut),
Bengaluru (Groundnut), Jorhat (Moong bean) Gujrat (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 Residue's 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.

D. 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 Residue's 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 : HP
(C.) Gujrat : Gujrat

(D.) Kolhapur : Maharashtra
(E.) Bangalore : Karnataka
(F.) Jorhat : Assam
(G) Almora : Uttrakhand
(H) Ghaziabad : UP

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 month 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

I. Monitoring of Cutworm

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

II. Management of cutworms:

(A) 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	-

(B) 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	-

(C) 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

A. **Dissemination and popularization of nanogel slow release pheromone Technology**

- The already isolated and characterized pheromone "Methoxy benzene" explored earlier for managing *H. consenguniea* in ground nut ecosystem was found highly volatile and required daily loading of new septa on host trees.
- This problem is overcomed by using slow release "Nano gel 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 disseminate through mass demonstration in white grub endemic areas of the Rajasthan.

B. **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

C. **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
	Seed treatment 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-@ 6.5ml/kg seed	At the time of sowing
	Application of *Metarhizium anisopliae-0.5*g/m^2	15 days after sowing
	Application of Fifronil 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 of Fifronil40%+Imidacloprid 40%WG@ 300g/ha	22 days after sowing
IPM-IV	Farmer practices	-

Jorhat Centre

Experiment No.1: Designing and field testing of few promising attractants against red ant, *Dorylus orientalis* in potato

Experimental Layout:

Design: Randomized Block Design
Number of treatments: 4
Replication: 5
Individual plot size: 4×3 sq.m.
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 analysed.

Experiment No. 2: Advanced nutritional analysis of edible soil dwelling insects of Assam

Species selected: White grub (*Lepidiota mansueta*) and Field Cricket (*Brachytrupes portentosus*)

The 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**).**

Experiment No.3: 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 sq.m

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 1st earthing 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 analysed through 5 RBD ANOVA.

Palampur Centre

1. 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 bioagent 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

2. Molecular characterization of *Melolontha* spp

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:

A. Studies on biogeography of major white grubs in Karnataka

B. Evaluation of bio-agents against white grubs

1. Evaluation of *Beauveria brongniartii* Isolate maintained at Bengaluru centre against sugarcane and arecanut white grubs.
2. Evaluation of NBAIR, Bengaluru isolates of *Beauveria bassiana* and *Metarhizium anisopliae* against sugarcane and arecanut white grubs and termites in sugarcane.
3. Evaluation of EPNs developed by the FARMER, Ghaziabad.

C. Demonstration and popularization of insecticide free management practices for arecanut white grubs such as digging and removal of grown up larvae.

Methodologies: 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.

D. 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.

E. Capacity building: Organizing short/long duration *hands-on-training* programmes on taxonomy of Scarabs.

Gujrat Centre

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

Kolhapur Centre

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

Ghaziabad Centre

1. 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.
2. Scaling up of effective dose of Entomopathogenic Fungus (EPF); *Metarhizium anisopliae* and *Beauveria bassiana* for the management of white grub.
3. Biological studies of predominant species of white grub; *Holotrichia nagpurensis, Holotrichia serrata, Holotrichia consanguinea, Anomala dimidiate and Maladera insenabilis.*
4. Isolation of entomopathogenic nematodes (EPN) and entomopathogenic fungi (EPF) strains from local soil
5. 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:

1. Molecular phylogeny of major Melolonthinae and Rutelinae whitegrubs 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 grubs native to Uttarakhand will be studied.

2. 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.

3. Isolation of native entomopathogens and their use in whitegrub management.

Different isolation technique and bioefficacy 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.

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