APPROVAL LETTER

डॉ. सुनीलचन्द्रदुबे
सहायकमहानिदेशक
(पादप संरक्षण एवं जैवसुरक्षा)

Dr. S. C. Dubey
Assistant Director General
(Plant Protection and Biosafety)

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F.No.CS- 14-1/23-PP

Dated 19th Sept, 2023

To,

Dr. Arjun Singh Baloda,
Project Coordinator,
AINP on Soil Arthropod Pests, Division of Entomology, RARI
Durgapura, Jaipur-302018,
Rajasthan

Sub: Approval for proceedings of 24th Annual Review Group Meeting of AINP on Soil Arthropod Pests & Technical Programme at RARI, Durgapur, Jaipur during July 13-14, 2023 in Hybrid mode

Sir,

Please refer to your e-mail dated 24th August, 2023 on the subject mentioned above. The Competent Authority has approved the proceedings of 24th Annual Review Group Meeting of AINP on Soil Arthropod Pests & Technical Programme at RARI, Durgapur, Jaipur during July 13-14, 2023 in Hybrid mode.

Kindly acknowledge receipt of the letter.

(S.C.Dubey)

APPROVED COPY

PROCEEDINGS OF
TWENTY-FOURTH ANNUAL REVIEW MEETING OF
ICAR- ALL INDIA NETWORK PROJECT ON SOIL ARTHROPOD PESTS
&
TECHNICAL PROGRAMME 2023-2024

ORGANIZED BY

ICAR RAJASTHAN AGRICULTURAL RESEARCH INSTITUTE,
DURGAPURA, JAIPUR

DURING JULY 13-14, 2023 IN HYBRID MODE

NETWORK UNIT

S.K.N. AGRICULTURE UNIVERSITY
RAJASTHAN AGRICULTURAL RESEARCH INSTITUTE, DURGAPURA,
JAIPUR 302018

Acknowledgments

I wish to express my deep sense of gratitude to Dr. Himanshu Pathak, Director General and Secretary, Department of Agricultural Research and Education, New Delhi and Dr. Tilak Raj Sharma, Deputy Director General, Indian Council of Agricultural Research for sponsoring the 24th Annual Review Meeting of All India Network Project on Soil Arthropod Pests at RARI, Durgapura, Jaipur on 13-14 July 2023.

I am obliged to Dr. Balraj Singh, Hon'ble VC, SKNAU Jobner-Jaipur, Rajasthan for being the Inaugural session's Chief Guest and for his abundant encouragement and support and Dr. S.C. Dubey, ADG (PP & B) ICAR, New Delhi for his suggestions for strengthening the research work on soil arthropod pests under AINP on SAP.

I also want to express my sincere gratitude for active participation of the subject expert members by PAMC, Dr. V V Ramamurthy, former professor Entomology, IARI, New Delhi and Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka for suitable suggestions and also for reviewing the progress of the project of AINP on SAP for the year 2022-2023.

I place on record my gratitude to Dr. Gautam Chawla, Project Coordinator, AICRP on Nematodes, IARI, New Delhi and Dr. Sachin Suresh Suroshe, Project Coordinator, AICRP on Honey Bees and Pollinators, IARI, New Delhi for energetic participation and needful suggestions for shaping the future technical program.

The support extended by Dr. (Mrs) K. Rajmohana, Scientist-E & HOI, Dr. Badal Bhattacharyya, Head, Department of Entomology, Dr. R. S. Chandel, Professor and Head, Department of Entomology and Dr. Sharad Mohan Principal Scientist, Division of Nematology is also gratefully acknowledged. Your input played a crucial role in evaluating our progress, identifying areas for improvement and setting new goals for the upcoming years.

I thank Mr. Amit Paschapur, VPKAS Almora UK, Dr. Sudhanshu Bhagwati, AAU Jorhat-Assam, Dr. D. Rajanna, Principal Scientist UAS GKVK Bengaluru, Karnataka; rapporteurs of different sessions for the presentation of recommendations.

I place on record my gratitude to Dr. B.L. Kakralia, Director Research and all staff members of the SKNAU Jobner for attending and extending their support in the group meeting.

The support extended by Dr. Vipin Kumar, Unit Head, Division of Entomology, RARI, Durgapura and staff members in the organization of the workshop is gratefully acknowledged.

I also thank to Dr. Swati Bugalia and Dr. Anita for compilation of the annual report, proceeding of the meeting and technical programme for year 2023-2024.

We express our heartfelt gratitude to all the participants, scientists, guests, progressive farmers, for attending the group meeting and making it a grand success.

Last, but not the least the special thanks to the Industrialists from Dhanuka, IFFCO, Khandelwal, Sulpher Mills and Sumitomo for their financial support.

Prof. Arjun Singh Baloda
Director RARI and Project Coordinator
Rajasthan Agricultural Research Institute, Durgapura, Jaipur

PROGRAMME

24th ANNUAL REVIEW MEETING ON JULY 13-14, 2023 (THURSDAY - FRIDAY) AT RARI, DURGAPURA, JAIPUR IN HYBRID MODE (PHYSICAL & VIRTUAL)

Day1, July13, 2023 (Thursday) 9:00-10:00AM Registration

SESSION I: INAUGURAL SESSION (10:00-12:00 AM)

Time	Programme	Speaker
10:00-10:30 AM	Welcome & Brief Presentation	Dr. A. S. Baloda, Network Coordinator, AINP on SAP
10:30-10:40 AM	Remarks by ADG (PP & BS)	Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi
10:40-10:50 AM	Remark by Hon'ble VC	Dr. Balraj Singh, VC, SKNAU, Jobner, Rajasthan
10:50-11:00 AM	Inaugural Address by Chairman	Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi

HIGH TEA

SESSION II: PRESENTATION OF PROGRESS REPORT 2022-23 (12:30-02:05 PM)

Chairman: Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi

Co-Chairman: Dr. S. C. Dubey, ADG (PP & BS), ICAR, New Delhi

EXPERT MEMBERS BY PAMC

Dr. V.V. Ramamurthy, Former Professor , IARI, Entomology, New Delhi

Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka

Rapporteurs	Dr. Amit Paschapur, VPKAS, Almora, UK	Dr. C. Sankarnarayanan, ICAR-SBI, Coimbatore, Tamilnadu
Time	Presenter	Designation and Centre
12:30-12:45 PM	Dr. Arup Kumar Sarma/ Dr. Sudhanshu Bhagwati	Senior Scientist & Principal Investigator AINP on SAP, AAU-Jorhat, Assam
12:45-01:00 PM	Dr. D. Rajanna / Dr. K.V. Prakash	Principal Scientist & Investigator, AINP on SAP,UAS, GKVK, Bengaluru, Karnataka
01:00-01:15 PM	Dr. R. S. Chandel / Dr. K. S. Verma	Principal Scientist & Principal Investigator AINP on SAPCSK HPKV, Palampur, HP
01:15-01:30 PM	Dr. B. L. Jakhar	Associate Professor, Entomology RARI, Durgapura, Jaipur, Rajasthan
01:30-01:45 PM	Dr. A. K. Pandey	Professor & Principal Investigator AINP on SAP GB, Pant Univ. of Ag. & Tech. Pantnagar, UK
01:45-01:55 PM	Remark by Expert Members	

01:55-02:00 PM Remark by Co-Chairman

02:00-02:05 PM Remark by Chairman

LUNCH

SESSION III: PRESENTATION OF PROGRESS REPORT 2022-23 (3:00-6:05 PM)

Chairman: Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi

Co-Chairman: Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi

EXPERT MEMBERS BY PAMC

Dr. V.V. Ramamurthy, Former Professor , IARI, Entomology, New Delhi

Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka

Rapporteurs	Dr. Sudhanshu Bhagwati, AAU, Jorhat, Assam	Dr. K.V. Prakesh, UAS, G.K.V.K, Bengaluru, Karnataka
Time	Presenter	Designation and Centre
03:00-03:15 PM	Dr. Amit Paschapur	Scientist (Ag. Entomology) & PI AINP on SAP VPKAS, Almora, UK
03:15-03:30 PM	Dr. U. B. Hole	Professor of Entomology & PI AINP on SAP RCSM, College of Agriculture, MPKV-Rahuri, Kolhapur, MH
03:30-03:45 PM	Mr. J. P. Singh /Dr. Seema Rani	Secretary FARMER- PI AINP on SAP, Ghaziabad, UP, Research Associate
03:45-04:00 PM	Dr. Dharmraj Singh	Scientist, Junagadh Agriculture University, Gujarat
04:00-04:15 PM	Dr. C. Sankaranarayanan	Principal Scientist-Nematology, ICAR-Sugarcane Breeding Institute, Coimbatore, Tamilnadu
04:15-04:30 PM	Dr. A. Kandan	Principal Scientist (Plant pathology), Division of GermplasmConservation and Utilization, NBAIR, Bengaluru, Karnataka
04:30-04:45 PM	Dr. P. S. Prathibha	Senior Scientist (Entomology), ICAR-CPCRI, Kasaragod, Kerala
04:45-05:00 PM	Dr. Sarad Mohan	Principal Scientist, Nematology, IARI, New Delhi
05:00-05:15 PM	Dr. K. Rajmohana	Scientist-E ZSI and Coordinator ENVIS ZSI, Zoological Survey of India (Ministry of Environment, Forest and Climate Change, Government of India) Kolkata

05:15-05:30 PM	Dr. Kolla Sreedevi	Principal Scientist & Head, NBAIR, Bengaluru, Karnataka
05:30-05:45 PM	Dr Deepa Bhagat	Principal Scientist (Organic Chemistry), NBAIR, Bengaluru, Karnataka
05:45-05:55 PM	Remark by Expert Members	
05:55-06:00 PM	Remark by Co-Chairman	
06:00-06:05 PM	Remark by Chairman	

Day 2, July 14, 2023 (Friday)

SESSION IV: DISCUSSION BETWEEN INSTITUTES. INDUSTRIES, PROGRESSIVE FARMERS, KVK SCIENTISTS, STATE DEPARTMENT ETC. (10:00-02:00 AM)

Chairman: Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi

Co-Chairman: Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi

Expert Members By PAMC

Dr. V.V. Ramamurthy, Former Professor, IARI, Entomology, New Delhi

Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka

Reporters	Dr. A. K. Pandey, Professor GBPUA&T, Pantnagar, UK Dr. D. Rajanna, PS, UAS, GKVK, Bengaluru, Karnataka
Remark by Expert Members PAMC	Dr. V.V. Ramamurthy, Former Professor, IARI, Entomology, New Delhi Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka
Remark by Co-Chairman	Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi
Remark by Chairman	Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi

LUNCH

SESSION V: VALEDICTORY & PLENARY (03:00-05:00 PM)

Chairman:	Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi
Co-Chairman:	Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi
Reporters	Dr. Amit Paschapur, VPKAS, Almora, UK Dr. C. Sankarnarayanan, ICAR-SBI, Coimbatore, Tamilnadu Dr. Sudhanshu Bhagwati, AAU, Jorhat, Assam Dr. K.V. Prakesh, UAS, G.K.V.K, Bengaluru, Karnataka Dr. A. K. Pandey, Professor GBPU of A&T, Pantnagar, UK Dr. D. Rajanna, PS, UAS, GKVK, Bengaluru, Karnataka
Remarks by Expert Members PAMC	Dr. V.V. Ramamurthy, Former Professor , IARI, Entomology, New Delhi Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka
Remark by Co-Chairman	Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi
Remark by Chairman	Dr. T. R. Sharma, DDG (CS), ICAR, New Delhi
Vote of Thanks	Dr. A. S. Baloda, Network Coordinator, AINP on SAP

PROCEEDINGS OF THE TECHNICAL SESSIONS

The Significant achievements and recommendations of the various sessions are as follows.

SESSION I: INAUGURAL SESSION

The 24th AINP on SAP Annual Review Meeting was organized under the aegis of the Indian Council of Agricultural Research, New Delhi at Rajasthan Agricultural Research Institute, Durgapura, Jaipur during July 13-14, 2023 in hybrid mode. The inaugural session was started with the playing of ICAR song and University song followed by lighting of lamp by Prof. Balraj Singh Hon'ble Vice Chancellor, SKNAU Jobner, Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi, Dr. V.V. Ramamurthy, Former Professor, IARI, Entomology, New Delhi, Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka, Dr. B.L. Kakralia, Director Research, SKNAU, Jobner and Prof. Arjun Singh Baloda, Director RARI, Durgapura and Network Coordinator AINP on SAP. The delegates and the dignitaries were welcomed in Rajasthan's traditional culture.

Two Scientists namely Dr. R. S. Chandel, Head Entomology, CSK-HPKV, Palampur, Himachal Pradesh and Dr. Badal Bhattacharya, Head Entomology, AAU, Jorhat, Assam privileged for their outstanding contribution were honoured during the inaugural session. The delegates and invitees from AINP on SAP Centres, ICAR Institutes, Agricultural Universities, Representatives of Private Commercial Production Units, progressive farmers and Staff of members of SKNAU, Jobner attended the Inaugural Session.

The programme was as follows:

Welcome Address and Project Coordinator's Report	Prof. Arjun Singh Baloda, Director RARI (SKNAU, Jobner) Durgapura, Jaipur and Network Coordinator AINP on SAP
Remarks by Expert Member PAMC	Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka
Remarks by Expert Member PAMC	Dr. V. V. Ramamurthy, Former Professor, IARI, Entomology, New Delhi
Inaugural Address by Chairman	Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi
Remark by Chief Guest	Prof. Balraj Singh, Hon'ble VC, SKNAU Jobner
Vote of Thanks	Dr. Vipin Kumar, Unit Head, Entomology, RARI, Durgapura

Prof. Arjun Singh Baloda, Network Coordinator AINP on SAP & Director, RARI, (SKNAU, Jobner) Durgapura, Jaipur, welcomed all the participants and presented the significant achievements of the AINP on SAP for the year 2022-23.

Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka, Expert Member PAMC in his remark appreciated Dr. Balraj Singh, Hon'ble VC, SKNAU Jobner and Dr. A.S. Baloda, Director RARI for the strengthening of RARI, Durgapura Institute. He appreciated the AINP on SAP team for doing admirable work on soil arthropod pests throughout the country. He assured for the support

from NBAIR to the Project on DNA based taxonomic identification viz., molecular characterization and finger printing of predominant species of white grubs in immature stage which is responsible for economic losses in various crops and in Pheromone identification of various white grub species. He suggested for addition of more Voluntary Centers in this project from the white grub endemic areas. For evaluation of any new technology on microbial bio-pesticides, he suggested for evaluation of it at least at three different agro-climatic zones to meet the regulatory requirement before commercialization. He appealed for use of label claimed insecticides only for soil arthropod pest management as a last resort..

Dr. V. V. Ramamurthy, Former Professor, IARI, Entomology, New Delhi, Expert Member PAMC in his remarks valued Dr. A. S. Baloda, Network Coordinator and his entire team for the excellent work conducted by scientific team of all centers of the group.

Dr. S. C. Dubey, ADG (PP&B), ICAR in his address valued the accomplishment of team work of AINP on SAP. He emphasized to develop a road map for one year by coordinating all centers to conduct pest survey with GPS based technology and develop a national map of white grub, termite and cutworm. He highlighted to emphasize more on eco-friendly pest management approaches by demonstrating bio-control technologies at large scale and by coordination between SAUs and ICAR. He also emphasized the role of label claim pesticides, quality biocontrol agents, light traps and pheromone traps in managing the soil arthropod pests and importance of uniform field experiments methodology at each climatic zone of country, DNA based taxonomic identification, Nutritional profiling of soil arthropod pests and more research work on slugs infestation in country. He valued Dr. Balraj Singh, Hon'ble VC, SKNAU Jobner and Dr. AS Baloda, Director RARI for the fast developments made at RARI, Durgapura. He conveyed his regards to the entire staff of SKNAU.

Prof. Balraj Singh, Hon'ble VC, SKNAU Jobner, Chief Guest of the Inaugural session, while delivering key note address, appreciated the contribution of Soil Arthropod Pests' researcher in managing these gregarious pests. He also emphasized the need to strengthen SAP research and effective extension activities for final outcome of the project.

A total of six Publications from ICAR-NBAIR Bengaluru, AAU, Jorhat-Assam and FARMER, Ghaziabad centers were released by the chief guest and other dignitaries.

SIGNIFICANT ACHIEVEMENTS OF AINP ON SAP DURING 2022-23

Prof. Arjun Singh Baloda,
Network Coordinator, Director, RARI, Durgapura, Jaipur, Rajasthan

The soil arthropods - white grubs, termites, wireworms, ants, earwigs, cricket, cutworm, armyworm, root borer, grasshoppers, chafer beetle, blister beetle, myriapod, polyphagous snails, etc. though none of these is specific to any crop infestations but when they do occur, can cause miserable economic losses. At times damage due to these pests goes up to 100% resulting in crop failures and sometimes necessitating re-sowing of the crop. The phytophagous white grub species cause serious damage resulting in up to 30-50% yield loss in several parts of the country. Losses due to termites run to several millions of rupees in agricultural crops alone. Soil Arthropod Pests damage to Rabi crops is as high as 37-40% and 12-40% tuber damage by cutworms was also experienced. In western UP, 16-25% of sugarcane crop losses were reported due to root borer. Certain species of snails and slugs are becoming serious pests of the crops causing economic losses, mainly in vegetables, cereal, potatoes, carrots, maize, etc.

Realizing the yield losses inflicted and the seriousness of the white grub problem in several agricultural crops, the ICAR started the All India Network Project on Soil Arthropod Pests. The mandate of the project is to develop simple, economical, safe and practical integrated technology for the management of soil arthropod pests under different agro-climatic conditions and cropping systems.

The Network Coordinating unit of AINP on SAP works with the mission of serving as the nodal agency for the pilot survey of soil arthropod pests in different crops and applying an effective "Integrated Approach" for their management, Isolating and identifying biocontrol agents from different climatic zones of the country; evaluating their efficacy against soil arthropod pests viz., white grub, termites and cutworms coordinating research on soil arthropod pests at the national level, disseminating information and impart training on soil arthropod pests management.

A thorough knowledge of morphology, nature of damage, vulnerable stage of pest, damaging stage, pre-disposing factors, susceptible stages of host, natural enemies/predators and evaluation of new molecules against these pests help in preventing and controlling them effectively. Thus, the ICAR-AINP on SAP scientific team at 10 centers engaged throughout the year to monitor these pests at different crops and invents new solutions for their better management.

Before planning any strategy for the management of insect pests, monitoring the pest is a prerequisite to understanding the distribution and their species profiling. A total of 28,786 specimens of white grub beetles were collected during the season at 8 centers of AINP on SAP. Out of them, 11 species are found in abundance in the country. The first record of *Bunbunius hartmanni* Keith, 2009 from India; reported by GBPUA &T Pantnagar.

The 9 species of scarabaeid beetles were recorded on 6 host trees in Rajasthan. Four species were found feeding on 8 host plants at Himachal Pradesh. The GKVK Bengaluru center reported the 3 plants, which were the preferred hosts for *H. serrata*, *H. rufoflava*, *Brahmina mysoreensis*,

Adoretus sp. A total of 31 species of Scarabaeidae beetles were recorded on 16 host trees in Uttarakhand. The two species were noticed on Neem, Babul, Ber, Mango, Guava and Moringa in Maharashtra. The 5 species were preferred to feed on 8 host trees in western Uttar Pradesh.

In addition, information have been received regarding damage by different species of white grubs to various crops in different parts of the country such as Maharashtra, Gujarat, Madhya Pradesh, Kerala, Jammu, etc. Scientists from Jammu, Madhya Pradesh Andhra Pradesh, Maharashtra and Kerala. Several Agricultural Universities also want to be a part of the coordinated project.

This indicates the severity of damage and expansion of white grub infestation to newer areas and regions. Therefore, to overcome the menace of white grubs and other soil arthropod pests, continuous surveillance and monitoring are required.

Pheromones are highly species-specific and are safe to non-target organisms and the environment. Durgapura Centre has already isolated and identified the aggregating pheromone, Methoxy Benzene, of the predominant species, *Holotrichia consanguinea*. The technologies developed in the project have been transferred to farmers from time to time, to manage the adult beetles of *H. consanguinea*. The invention of a slow-release nano gel formulation of Methoxy Benzene for aggregation of groundnut beetle with NBAIR, Bengaluru was achieved. It has been included in the Package of Practices of Rajasthan. The cost per sample is ₹ 10 only. The product is available at ICAR AINP on Soil Arthropod Pests, Division of Entomology, RARI, Durgapura, Jaipur, Rajasthan. About 10,000 septa were distributed among farmers to popularise the technology. Now, the technology is becoming popular which helps in reducing the cost of cultivation.

The extent of damage due to white grub, termites, red ants, cutworm and mole cricket were recorded in 588-acre cropping areas by 6 centers of AINP on SAP during 2022-23. The extent of damage due to Scarabidae fauna was recorded between 10-70% at different locations in some specific crops.

To monitor the prevalence of natural enemies of white grub, seasonal soil sampling was collected in the endemic pockets; EPF infected white grubs in Assam and Karnataka; Tiphia ectoparasitoid infected white grubs in Himachal Pradesh and Predatory flies feeding on termite foragers in the bamboo ecosystem at Assam were reported.

Novel bioagents that serve as alternatives to pesticides should be a priority goal for the future in pest management. In this context, an investigation was carried out at VPKAS Almora to isolate, identify and molecularly characterize the chitinase-producing bacterial isolates from the guts of four pleurostict scarab beetle larvae through 16S rRNA sequencing. The scarab beetle larvae noticed great potential to be a source of novel chitinolytic bacteria.

During the period CSK-HPKV Palampur center used drone technology to monitor adult beetles of *A. lineatopennis* on peach and other preferred hosts in Himachal Pradesh.

Taxonomic studies give us various pieces of information such as locality, distribution, hosts, diagnostic features, natural enemies, ecology, behavior etc. and these will give leads to understanding the weak links of the pest and thus help in formulating strategies in managing the pest. A surveys and surveillance of white grub species were carried out in seven states viz., Himachal Pradesh, Chhattisgarh, Maharashtra Andhra Pradesh, Tamil Nadu, Karnataka and Kerala

during 2022-2023. The faunistic composition of collected phytophagous scarabaeids comprised 93 species representing 21 genera of three subfamilies, Melolonthinae, Rutelinae and Dynastinae of Scarabaeidae. The preliminary surveys at several locations in five districts in the Western Ghats range in Kerala districts revealed around 67 species representing 19 genera, whereas in Melolonthines were species followed by Rutelines. Similarly, five districts lying in the Western Ghats region of Karnataka have 79 white grub species representing 18 genera.

A total of 9 species of termites were recorded from Golaghat, Jorhat and Majuli districts of Assam by AAU Jorhat centre and 10 genera belonging to 5 families were recorded in Himachal Pradesh by Palampur centre.

Efficacy of isolated bioagents was conducted at Durgapura, Jorhat and Palampur centres and reported positive results. Two novel *Bacillus thuringiensis* (Bt) isolates isolated from ICAR Sugarcane Breeding Institute, Coimbatore along with cry8Sa was bio-assayed against field-collected 2^{nd} and 3^{rd} instar grubs of *H. consanguinea* at (RARI), Durgapura. Isolate Bt62 and Cry8Sa toxin were found effective in producing mortality. To investigate an efficient alternative to synthetic chemical insecticides for the management of termites in organic cultivation; a laboratory experiment was carried out in the Laboratory AAU, Jorhat and reported that combined application of *B. bassiana*+neem oil@0.20% concentration caused highest mortality of termites after 120 hours of treatment. The infected grubs of *Brahmina coriacea* species were collected from potato fields at Himachal Pradesh.

For the management of soil arthropod pests through chemicals, a total of 16 field experiments were conducted in 10 different crops at 6 centers by using 14 insecticides. The labeled insecticides were used in three different modes viz., soil application of granules, seed/setts treatments and drenching in standing crops against white grub, termites and cutworms.

A field experiment was conducted at Palampur to evaluate the efficacy of commercially available GRAB NASH (entomopathogenic nematode) against white grub in potatoes. Two field trials were conducted at AAU, Jorhat 1^{st} to evaluate the efficacy of bioagents and 2^{nd} experiment to know the synergistic interactions of EPN with insecticides. All experiments showed positive results in soil arthropod pest management.

The application of scientific research through social engineering and demonstration of new inventions to agricultural practices through farmers were carried out in 37 districts of the country and 6400 beneficiaries benefited from these activities.

Dissemination and popularization of Nanogel -Slow Release Pheromone Technology was done amongst the farmers and approximately 4200 traps were distributed to farmers and good results were received by RARI Durgapura centre.

Advanced nutritional analysis of edible soil-dwelling insects of Assam, Acute oral toxicity of *L. mansueta* beetle powder and Nutritional analysis of *Lepidiota mansueta* pupal powder was conducted in detail. Exploration of Indigenous Technical Knowledge (ITKs) against different soil insect- pests practiced by different tribal farming communities of Assam during 2022-23 was also conducted.

Mr. Himanshu Thakur, a Ph.D. student from the Department of Entomology, CSK-HPKV Palampur visited the Okinawa Institute of Science and Technology, Japan under the CAAST, National Agricultural Higher Education Project (NAHEP) and worked on the topic "DNA sequencing techniques in termites and their gut organisms".

A mass production unit of entomopathogenic fungi, *Beauveria brongniartii* has been established in the Bengaluru and supplied fungus material to all the centers.

During the year, 31 publications were made in esteemed journals by the scientific team of All India Network Project; out of them 9 research papers were published with NAAS rating of 6 to 10 and 10 research papers were published with NAAS rating of 5 to 6.

Thrust Areas

- Preparation of Nanogel-Pheromone Septa for mass collection of other dominant species is a prerequisite as it is successful in *H. consanguinea* management throughout the country.
- The bioagents are effective, IPM-compatible alternatives to standard insecticides and offer long-lasting solutions for soil arthropod pests management. There is a need to isolate, identify and evaluate local bioagents against major soil arthropod pests.
- The standardized mass production technology of several known bioagents is essential to make them available in large quantities.
- Evaluation of novel molecules with modified application protocol viz., pest, crop, climatic zone and time of application is a prerequisite.
- Biology studies of major soil arthropod pests are a must for their better management.
- Generation of DNA barcodes and molecular characterization of white grubs in order to assess the nature and extent of genetic diversity present in the scarabaeid fauna of India is yet to be done for many species.
- Taxonomic studies to identify specimens of white grub and prepare a database that provides information on taxon status, distribution and host range of white grubs in the country.
- The generated technology is not transferred to end users properly by the extension agencies so the scientists of the project are validating the technology on a few farmer's fields so that it is conveyed to adjoining areas and benefits the farmers.

Lot of research work has been conducted for IPM of soil arthropod pests, particularly on white grub being used by the farmers but still there is a need to give more emphasis on the dissemination of generated technologies to end users. The cumulative efforts by the scientific team of AINP on SAP in the development of several technologies and their meticulous integration is the need of the hour for impressive control of soil arthropod pests.

SESSION II: PRESENTATION OF PROGRESS REPORTS BY THE AINP ON SAP CENTERS

Chairman	Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi
Co-Chairman	Prof. R. S. Chandel, Head Entomology, CSK-HPKV Palampur, HP
Subject Expert by PAMC	Dr. V.V. Ramamurthy, Former Professor Entomology, IARI, New Delhi
Subject Expert by PAMC	Dr. S. N. Sushil, Director ICAR NBAIR, Bengaluru, Karnataka
Special invitees	Dr. Gautam Chawla, Project Coordinator AICRP on Nematode ICAR-IARI, Division of Nematology, LBS Building, New Delhi
Special invitees	Dr. Sachin Suresh Suroshe, Project Coordinator, AICRP on Honey bees & Pollinators, Division of Entomology, IARI, New Delhi
Rapporteurs	Dr. Amit Paschapur, Scientist, ICAR-VPKAS, Almora Dr. C. Sankarnarayanan, ICAR-SBI, Coimbatore, Tamil Nadu

Speakers:

Dr. Sudhanshu Bhagwati, Senior Scientist	AAU-Jorhat, Assam
Dr. D. Rajanna, Principal Scientist	UAS, GKVK, Bengaluru, Karnataka
Dr. K.V. Prakash, Senior Scientist	UAS, GKVK, Bengaluru, Karnataka
Dr. K. S. Verma, Principal Scientist	CSK HPKV, Palampur, HP
Dr. B. L. Jakhar, Associate Professor	RARI, Durgapura, Jaipur

Dr. A. S. Baloda, Network Coordinator, AINP on Soil Arthropod Pests, RARI, Durgapura, Jaipur, Rajasthan welcomed Dr. S. C. Dubey, ADG (PP & BS), New Delhi, ICAR & Chairman of the session along with Dr. R. S. Chandel, CSK HPKV, Head Entomology, Palampur, Co Chairman of the session, Dr. V.V. Ramamurthy, Former Professor, IARI, Division of Entomology, New Delhi and Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka who acted as expert members of the session and handed over the session to the Chairman Dr. S. C. Dubey, ADG (PP & BS), New Delhi, ICAR. Chairman remarks welcomed all the participants of the session and allowed to make centre wise presentations.

Achievements:

All major achievements of AINP on SAP during 2022-23 from all centers have been summarized above by Dr. A. S. Baloda, Network Coordinator.

During the course of presentations few centre-wise recommendations and suggestions were made which were mentioned below:

Remark by Special Invitees

Dr. Sachin Suresh Suroshe, Project Coordinator, AICRP on Honey bees & Pollinators, Division of Entomology, IARI, New Delhi

1. Identifying tolerant sources of crops against white grubs can be focused.
2. Studies to exploit other biocontrol agents like parasitoids and predators can be initiated.

Dr. Gautam Chawla, Project Coordinator AICRP on Nematode, ICAR-IARI, Division of Nematology, LBS Building, New Delhi

1. Digitalization of white grub data of the entire country can be initiated.
2. Automated, software based white grub damage, identification and management software can be developed.

Remark by Subject Expert Members by PAMC

Dr. V.V. Ramamurthy, Former Professor Entomology, IARI, New Delhi

1. White grub biodiversity and distribution studies should be carried out by all centers with standard methodology.
2. Host plant resistance (HPR) studies on white grubs can be planned.
3. Develop and follow common SOP's for management of white grubs through biocontrol agents.
4. Take up area wise pest management and large scale demonstration of white grub management technologies for increasing the impact of the project.

Dr. S. N. Sushil, Director ICAR NBAIR, Bengaluru, Karnataka

1. White grub biodiversity and distribution analysis studies need to be taken up on long term basis.
2. Systematic and regular survey and surveillance of white grubs to be carried out to analyze the population dynamics in different parts of the country.
3. Focus on pooled data analysis to obtain reliable results.
4. Potential microbial biocontrol agents identified in the schemes can be registered under CIBRC.
5. All the products (traps, pheromones, biocontrol agents etc.) should reach to the farmers timely for better pest management and the visibility of the project.
6. Wide area pest management and community level white grub management need to be focused.

Remark by Co-Chairman: Prof. R. S. Chandel, Head Entomology, CSK-HPKV, Palampur

1. Uniform treatments for management of white grubs should be followed by all the centers.
2. Alpha and Beta diversity analysis studies of white grubs to be carried out throughout the country.
3. Extensive field surveys have to be conducted to analyse the biodiversity and distribution of white grubs in the country.
4. Develop a predictive model for estimating the population dynamics of white grubs by utilizing the data of white grub population and weather parameters.
5. Can focus on resolving the termite's taxonomy, by collaborating with the experts.

Remark by Chairman: Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi

1. Software can be developed for real time survey and data up gradation on white grub population throughout the country.
2. Success stories on white grub management should be published and updated on the website.
3. Obtaining certification for the technology is necessary from ICAR.
4. All the centers were asked to submit the annual reports in-time for timely conduction of the annual group meeting (preferably April to May every year)

SESSION III: PRESENTATION OF PROGRESS REPORTS BY THE AINP ON SAP CENTERS, COLLABORATING CENTERS AND SPECIAL INVITEES

Chairman	Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi
Co-Chairman	Prof. R. S. Chandel, Head Entomology, CSK-HPKV, Palampur H P
Subject Expert by PAMC	Dr. V.V. Ramamurthy, Former Professor Entomology, IARI, New Delhi
Subject Expert by PAMC	Dr. S. N. Sushil, Director ICAR NBAIR, Bengaluru, Karnataka
Special invitees	Dr. Gautam Chawla, Project Coordinator AICRP on Nematode ICAR-IARI, Division of Nematology, LBS Building, New Delhi
Special invitees	Dr. Sachin Suresh Suroshe, Project Coordinator, AICRP on Honey bees & Pollinators, Division of Entomology, IARI, New Delhi
Rapporteurs	Dr. Sudhanshu Bhagwati, AAU, Jorhat, Assam Dr. K.V. Prakesh,UAS, G.K.V.K, Bengaluru, Karnataka

Speakers:

AINP on SAP Centers

Mr. Amit Paschapur, Scientist & PI AINP on SAP	VPKAS, Almora, UK
Dr. U. B. Hole, Professor of Entomology & PI AINP on SAP	RCSM, Kolhapur, MH
Mr. J. P. Singh, Secretary FARMER- PI AINP on SAP	FARMER VC, Ghaziabad, UP

Collaborating Centers

Dr. Kolla Sreedevi Principal Scientist & Head	Division of Germplasm Collection and Characterization, NBAIR, Bengaluru, Karnataka
Dr. Deepa Bhagat Principal Scientist (Organic Chemistry)	Division of Germplasm Conservation and Utilization, NBAIR, Bengaluru, Karnataka

Special Invitees

Dr. C. Sankaranarayanan, Principal Scientist-Nematology	ICAR- Sugarcane Breeding Institute, Coimbatore, Tamil Nadu
Dr. B. Singaravelu, Principal Scientist	Sugarcane Breeding Institute, Coimbatore
Dr. A. Kandan Principal Scientist (Plant pathology)	Division of Germplasm Conservation and Utilization, NBAIR, Bengaluru, Karnataka
Dr. Sarad Mohan Principal Scientist	Nematology, IARI, New Delhi
Dr. K. Rajmohana Scientist-E ZSI and	Zoological Survey of India (Ministry of

Coordinator ENVIS ZSI	Environment, Forest and Climate Change, Government of India) Kolkata

Dr. A. S. Baloda, Network Coordinator, AINP on Soil Arthropod Pests, RARI, Durgapura, Jaipur, Rajasthan welcomed Dr. S. C. Dubey, ADG (PP & BS), New Delhi, ICAR & Chairman of the session along with Dr. R. S. Chandel, CSK HPKV, Head Entomology, Palampur, Co-Chairman of the session, Dr. V.V. Ramamurthy, Former Professor, IARI, Division of Entomology, New Delhi and Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka who acted as expert members of the session and handed over the session to the Chairman Dr. S. C. Dubey, ADG (PP & BS), New Delhi, ICAR. In his chairman remarks, he welcomed all the participants of the session and allowed to make centre wise presentations.

Achievements:

All the major achievements of AINP on SAP during 2022-23 from all centers have been summarized above by Dr. A. S. Baloda, Network Coordinator.

Dr. C. Sankaranarayanan, Principal Scientist-Nematology ICAR-SBI Coimbatore reported that they isolated and deposited a total of 29 species of entomopathogenic nematodes in GenBank. All the EPN species shown 20-100% mortality against *Holotrichia serrata.* He commercialized the technology and sale the biopesticide to 6 licensed companies.

Dr. B. Singaravelu, Principal Scientist, Entomologist, ICAR-SBI Coimbatore reported the scope of *Bacillus thuringiensis* (isolated toxins Cry8 gene Bt41 & Bt62) in white grub management on the basis of the laboratory experiments conducted against various phytophagous species of white grub at Durgapura and Palampur during 2022-23.

Both the Scientists from ICAR SBI Coimbatore solicited association with the AINP on SAP as voluntary centre for collection of soil samples, isolation of Bt strains, PCR screening for Cry 8 toxic gene, bioassay against white grub species, mass production of EPN in vivo and vitro methodology and field trials at different locations. They also require financial assistance from ICAR-AINP on SAP to conduct the research work against white grub management by using biopesticides.

Dr. A. Kandan Principal Scientist (Plant pathology), NBAIR, highlighted the importance of bioproduct in white grub management. He reported toxicology data generated as per CIBRC guidelines for 9(3B) registration of ICAR-NBAIR Ma4 (*Metarhizium anisopliae*) bioproduct. He recorded LC_{50} values as $5.75x10^4$, $6.67x10^4$ and $2.46x10^4$ spores/ml; 1.76g/lit, 1.72 g/lit and 1.84 g/lit talc formulation against *H. consanguinea*, *H. serrata* and *Leucopholis lepidoptera* respectively. He declared that 75-90% reduction in white grub population, 40-50% increase in yield and 1:2.25 B:C recorded in sugarcane crop field experiment by 2 times application in the furrow near the clumps of 2.5kg of talc formulation (2%WP) mixed in 250 Kg FYM. He also stated that the technology sold to 4 private firms and one Government organization.

Dr. Sarad Mohan, Principal Scientist, Nematology, IARI, New Delhi, shared his experience on role of entomopathogenic nematodes in white grub management. He stated that local strains are more effective against local pest species and pest stage, soil PH, temperature & moisture parameters impact on its effectiveness.

Dr. (Mrs) K. Rajmohana, Scientist-E ZSI and Zoologist briefed the economic importance of termite in India. She reported that only 12.34% of the total termite species responsible for economic losses. In India, 27 genera of termites are major pest that causes 35 million US dollars losses every year. She awaked that the termites attack are seasonal also. She assured for the support from ZSI to the Project on DNA based taxonomic identification viz., molecular characterization and finger printing of predominant species of termites which is responsible for economic losses in various crops.

During the course of presentations few centre-wise recommendations and suggestions were made which were mentioned below:

Remark by Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi

Dr. S. C. Dubey, ADG (PP & BS), New Delhi, ICAR & Chairman of the session in his concluding remark appreciated all the presenters for their extensive works carried out at different stations and urged the centres to carry forward the research activities as per the technical programme within a proper timeframe.

SESSION IV: DISCUSSION BETWEEN INSTITUTES, INDUSTRIES, PROGRESSIVE FARMERS, KVK SCIENTISTS, STATE DEPARTMENT AND SPECIAL INVITEES

Chairman	Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi
Subject Expert by PAMC	Dr. V.V. Ramamurthy, Former Professor Entomology, IARI, New Delhi
Subject Expert by PAMC	Dr. S. N. Sushil, Director ICAR NBAIR, Bengaluru, Karnataka
	Dr. Gautam Chawla, Project Coordinator AICRP on Nematode ICAR-IARI, Division of Nematology, LBS Building, New Delhi
	Dr. Sachin Suresh Suroshe, Project Coordinator, AICRP on Honey bees & Pollinators, Division of Entomology, IARI, New Delhi
Subject Expert	Prof. R. S. Chandel, Head Entomology, CSK-HPKV Palampur H P
Rapporteurs	Dr. D. Rajanna ,UAS, G.K.V.K, Bengaluru, Karnataka

The session started with the welcome address by Dr. Arjun Singh Baloda. He shared his ICAR – Institution experience and presented the current scenario, challenges, scope and opportunities in ICAR- Institute - Industry interaction. He told that the institute and industry interactions (I-I-I) is the most preferred activity for mutual benefit and growth of both. This type of workshop provides the best platform for showcasing the best advancements, implementation and impact

for the institute and industry. He highlighted the key role of native strains of different bioagents in crop protection.

The industrialist Mr. Khandelwal briefed about the activities being undertaken towards enhancing bioagents use in various agricultural activities. He requested the scientists of different institutions that after product development and recommendation; they should assist them in registration of the final product by sharing toxicological data of the product. To fulfill the need of funds in institutes to develop a product or technology, he offered public-private collaborations.

One farmer from Rajasthan appreciated the farmer's meet programs conducted by ICAR for farmer's awareness and demand for more such activities on a large scale.

Remark by Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi

Dr. S. C. Dubey, ADG (PP&B), ICAR, New Delhi thanked all the participations for participating in a healthy and active discussion for the improvement in AINP on SAP technical programme 2023-24.

All valuable suggestions and recommendations will be incorporated into the technical programme 2022-24.

SESSION V: VALEDICTORY AND PLENARY

Chairman:	Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi
Rapporteurs	Dr. Amit Paschapur, VPKAS, Almora, UK
	Dr. C. Sankarnarayanan, ICAR-SBI, Coimbatore, Tamilnadu
	Dr. Sudhanshu Bhagwati, AAU, Jorhat, Assam
	Dr. K.V. Prakesh, UAS, G.K.V.K, Bengaluru, Karnataka
	Dr. A. K. Pandey, Professor GBPU of A&T, Pantnagar, UK
	Dr. D. Rajanna, Principal Scientist, UAS, GKVK, Bengaluru, Karnataka
Remarks by Expert Members PAMC	Dr. V.V. Ramamurthy, Former Professor , IARI, Entomology, New Delhi
	Dr. S. N. Sushil, Director, NBAIR, Bengaluru, Karnataka
Remark by Chairman	Dr. S. C. Dubey, ADG (PP&BS), ICAR, New Delhi
Vote of Thanks	Dr. A. S. Baloda, Network Coordinator, AINP on SAP

- **Remark by Expert Members PAMC**
  Dr. V.V. Ramamurthy Former Professor Entomology, IARI, New Delhi
  He appreciated the teamwork done under ICAR-AINP on SAP and blessed for the future.
- **Remark by Expert Members PAMC**
  Dr. S. N. Sushil, Director NBAIR Bengaluru, Karnataka
  He cherished the AINP on SAP team for exclusive work done at each centre. He also showed extreme happiness to rejoining the AINP on SAP team and assuring for any help in the future also.
- **Remark by Chairman**
  Dr. S. C. Dubey, Assistant Director General (PP&B), ICAR, New Delhi
  He appreciated the healthy discussion mode in two days. He was hopeful to incorporate all suggestions and recommendations in the technical program 2023-24. He suggested that the monthly review of project progress with centre Incharge will work as a catalyst. He advised all presenters for the pinpoint presentations. The presentation should be output-oriented as technology developed and publications. He thanked Prof. Balraj Singh, VC, SKNAU Jobner, Dr. B.L. Kakralia, Director, Research, SKNAU for support, encouragement, extraordinary hospitality, successful organization of the program, Dr. A. S. Baloda and his entire team, all dignitaries, Industrialist and farmers for valuable inputs and make the successful event.

Suggestions

1) Uniform treatments for management of white grubs should be followed by all the centers. **(Network Coordinator, AINP on SAP)**

2) Make a common treatment combination for all the chemical and biocontrol-based field experiments and check across the locations. **(Network Coordinator, AINP on SAP)**

3) Emphasis should be given on community-based management of soil insect pests by adopting at least one village in a year **(Action: All centers of AINP on SAP)**

4) Crop specific white grub damage data has to be generated by following standard SOP's. **(Action: RARI, Durgapura)**

5) Significant achievements of the year should be presented through PowerPoint Presentation. **(Network Coordinator, AINP on SAP)**

6) Alpha and Beta diversity analysis studies of white grubs to be carried out throughout the country. **(Network Coordinator, AINP on SAP)**

7) Software can be developed for real time survey and data up gradation on white grub population throughout the country. **(Network Coordinator, AINP on SAP)**

8) Success stories on white grub management should be published and updated in the website. **(Network Coordinator, AINP on SAP)**

9) Prepare a Standard Operating Procedure for the light trap experiment and then inclusion in the technical programme. **(Network Coordinator, AINP on SAP)**

10) More emphasis should be given on grub fauna as grubs are more damaging and also to correlate the grub population of field with the beetle catches through light traps. **(Action: All centers of AINP on SAP)**

11) Annual Report should be submitted on or before 15th April of every year along with the technical programme to be carried out in next year **(Action: All centers of AINP on SAP)**

12) Develop a predictive model for estimating the population dynamics of white grubs through light and pheromone traps. **(Action: RARI, Durgapura)**

13) Community based white grub management demonstrations have to be taken up. **(Action: RARI, Durgapura)**

14) The white grubs molecularly characterized should be obtained with DNA barcode from BOLD database. **(Action: RARI, Durgapura)**

15) Develop a comprehensive management package for *Lepidiota* sp. through use of pheromone traps. **(Action: AAU, Jorhat)**

16) Install farmer friendly and efficient light traps for management of white grubs. **(Action: AAU, Jorhat)**

17) Correlate the pest reduction and per cent damage caused after manual collection of the beetles in study areas. **(Action: AAU, Jorhat)**

18) Drone technology can be further used for survey and surveillance of white grubs. **(Action: AAU, Jorhat)**

19) *Holotrichia* sp. type specimens can be collected and submitted to avoid the complications. **(Action: GKVK, Bengaluru)**

20) Collaborate with ICAR-NBAIR, Bangalore and solve the taxonomic complications associated with white grubs. **(Action: GKVK, Bengaluru)**

21) Workout the economic damage caused by any insect before terming it as a pest. Can focus on *Leucopholis bermesteri* pheromone studies. **(Action: GKVK, Bengaluru)**

22) *Beauveria* sp. isolated at the centre can be registered and recommended for field use. **(Action: GKVK, Bengaluru)**

23) Combine molecular and morphological data for species identification. **(Action: HPKV, Palampur)**

24) Studies on *Tiphia* sp. can be continued to estimate its effectiveness against white grubs. **(Action: HPKV, Palampur)**

25) It was suggested to be followed Clone Sequencing for the phylogenetic analysis along with morpho-taxonomy to study the white grub fauna of Uttarakhand. **(Action: ICAR-VPKAS, Almora)**

26) The reported potential gut microbials of white grubs should be clearly checked for pathogenicity against human and if safe then go for commercialization. **(Action: ICAR-VPKAS, Almora)**

27) Adoption of crop rotation for the management of white grubs and further varietal preferences of white grubs for different crops needs scientific validation. **(Action: MPKV-Rahuri, Kolhapur)**

28) Validation of area centric management of white grubs in sugarcane by adopting best available technologies from other centres of AINP on Soil Arthropod Pests. **(Action: FARMER, Ghaziabad)**

29) Can focus on resolving the termite's taxonomy by collaborating with the experts. **(Dr. K. Rajmohana, Scientist E, ZSI Kolkata)**

30) Synergistic effect and compatibility study of the available strains of entomopathogenic nematodes need to be studied and most virulent strains can be included in the technical programme for recommendation. **(Action: Dr. C. Sankaranarayanan, Principal Scientist, ICAR- SBI, Coimbatore)**

31) Development of formulation and standardization of application procedure of Bt 62 strain having Cry 8 gene and tested against 3rd instar grubs at various locations to test its virulence.**(Action: Dr. B. Singaravelu, Principal Scientist, ICAR- SBI, Coimbatore)**

32) Revisit the application dose of *Metarhizium anisopliae* (Ma4) against white grubs in terms of colony forming unit prior to registration of the strain. **(Action: Dr. A. Kadan, Principal Scientist, ICAR- NBAIR, Bangaluru)**

33) Initiation on EPN research to solve the issues related to its large-scale production. **(Action: Dr. Sarad Mohan, Principal Scientist, Nematology, IARI, New Delhi)**

Recommendations:

1. Slow release nanogel formulation of methoxy benzene founds beneficial and effective for management of white grub (*Holotrichia consanguinea)* problems in Kharif crops in Rajasthan. The cost per septa/ sample is Rs. 10/- only, which is available at ICAR-AINP on Soil Arthropod Pest Project, RARI, Durgapura-Jaipur and the recommendation included in packages & practices. **(Network Coordinator, AINP on SAP)**

2. Soil drenching of Clothianidin 50 WDG @ 250g/ha (125g a.i./ha or 1g/2 lit of water) during 2nd fortnight of Decemb*er found effective for man*agement of termite in tea in Assam and included in packages & practices. **(Network Coordinator, AINP on SAP)**

3. In potato, application of Clothianidin 50WDG @ 125g a.i./ha during 2nd week of June found ef*fe*ctive for the control of *Brahnima coriacea* grub in Himachal Pradesh and included in packages & practices. . **(Network Coordinator, AINP on SAP)**

4. The locally isolated Entomopathogenic fungi, *Be**auveria brongniartii* sh*owed prom*is*ing result against all the life stages *of the major white grubs ver*satile of Karnataka centres and included in packages & practices. .**(Network Coordinator, AINP on SAP)**

5. The technology for mass multi*plication (in vivo) of Entomopathoge*nic nematode *H. indica* has been standardized. Application of *H. Indica* GC@ 2000/acre in soil just before sowing of

sugarcane found effective against management of white grub in sugarcane ecosystem in western UP and included i*n packages* & practices. **(Network Coordinator, AINP on SAP)**

6. Transfer the IPM m*odules dev*eloped in the scheme to ICAR- NCIPM, New Delhi for field evaluation and recommendation. **(Action: RARI, Durgapura)**

7. Biocontrol agents have to be tested in multi-locations before recommending to farmers. **(Action: GKVK, Bengaluru)**

8. Pooled data analysis should be carried out to assess the accurate crop loss caused by white grub species. **(Action: HPKV, Palampur)**

9. Reanalysis of white grub fauna of Uttarakhand by separating the phytophagous and non-phytophagous group of scarab beetles. **(Action: ICAR-VPKAS, Almora)**

10. Preparation of identification catalogue for the major scarab species of India for utilizing as ready reckoner by different stakeholders of the country. (**Action: Dr. Kolla Sreedevi Principal Scientist, NBAIR, Bengaluru**)

Annexure I

ACTION TAKEN REPORT OF THE RECOMMENDATIONS & SUGGESTIONS OF 23RD ANNUAL REVIEW MEETING OF ALL INDIA NETWORK PROJECT ON SOIL ARTHROPOD PESTS

S.N.	Action taken by	Recommendations & Suggestions	Implementation & Accomplishment
1.	Network Coordinator	All the AINP on SAP centres will include their validated technologies in the package of practice of various states pest protection programme.	Implemented
2.	Network Coordinator	Crop loss assessment with respect to economic values due to soil arthropod pests should be included in technical programme of 2022-24.	Implemented
3.	Network Coordinator and All PIs of centres	White/yellow light with 250-350 micrometer wavelength or bright 160 watt mercury vapor lamps are ideal for beetle's collection at any areas. All data collection of beetles & their natural enemies through light trap/pheromone trap should be on GPS location and climatic correlation based.	Implemented
4.	Network Coordinator and All PIs of centres	Studies on population monitoring of beetles on host trees has to be studied in more details as host preference, host resistance, ETL etc.	The studies have been carried out successfully and the results have been presented during the review meeting.
5.	Network Coordinator and All PIs of centres	Isolated and identified native strains of natural enemies of white grub by different centers were evaluated initially in laboratory following suitable bioassays techniques and after that large scale field studies will be conducted.	Implemented

6.	Network Coordinator and All PIs of centres	To update farmers about soil arthropod pest biology and management through ecofriendly advanced technology; field days, farmers meetings and farmer fairs should be organized or participated on a regular basis.	Ongoing and continuous
7.	Network Coordinator and All PIs of centres	After proper identification and biodiversity studies of termites, a distribution map in different states should be developed.	Implemented by RARI Durgapura and AAU Jorhat during the period
8.	Network Coordinator and All PIs of centres	The Bio-agent-based management strategies for termites have to be developed along with meticulous preliminary laboratory bioassays	Implemented by AAU Jorhat, Assam Centre
9.	All PIs of centres	A pheromone for one predominant species of white grub should be developed.	Ongoing and continuous
10.	All PIs of centres	A comprehensive note on use of drones for surveillance, diagnostic and recommendation of management practices against soil arthropod pests at various climatic zones locations should be prepared by each center.	Implemented only at CSKHPKV Palampur Centre
11.	All PIs of centres	For management of white grubs through chemical methods, only label claimed insecticides have to be tested and the promising results should be included in the package of practices of different states and the B:C ratio of insecticides also calculated.	Implemented except FARMER VC Ghaziabad
12.	All PIs of centres	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	Implemented except FARMER VC Ghaziabad

		clearly detailed in the manual and all AINP centres should follow uniform data recording procedures with replicable tables, data spread sheets etc.	
13.	SBI, Coimbatore, NBAIR & GKVK Bengaluru and FARMER, Ghaziabad	Different strains of bioagents viz., EPN, EPF, EPB etc. and their commercial formulations make available for evaluation in laboratory and field conditions against target pest with proper protocol.	Implemented
14.	CSK-HPKV, Palampur	After proper identification and biodiversity studies of cutworm'; a distribution maps and IPM strategies for its management will be developed.	A distribution map of cutworm in India developed Formulation of IPM strategies for its management is on progress
15.	GKVK and NBAIR, Bengaluru, Karnataka	To make easy the identification of major white grub species; a well developed illustrative diagrammatic presentation and taxonomic keys of dominant white grub species will be developed	An illustrated key for diagnosis of predominant white grub species is being prepared and will be made available to all centres in forthcoming AINP meeting.
16.	GKVK, Bengaluru	The entomopathogenic fungi *Beauveria brongniartii* will be provided to other centers along with proper bioassays methodology.	Ongoing and continuous
17.	Dr. Kolla Sreedevi, Principal Scientist, NBAIR, Bengaluru, Karnataka	The morphological characterization of white grub collections by each center of AINP on SAP should be done at NBAIR.	The specimens have been sent to NBAIR by CSK HPKV, Palampur centre and Farmer, Ghaziabad centre for morphological identification and the identification reports are being sent to them.
18.	Dr. K. V. Prakash, Entomologist, NBAIR, Bengaluru, Karnataka	A standard protocol for uniform data collection on genetic variability, infestation, population structure of white grub, in different crops at different climatic zones of	A standard protocol has been developed but not shared with all the centres as it requires some modification

		the country should be developed and followed by each center	
19.	Dr. K. V. Prakash, Entomologist, NBAIR, Bengaluru, Karnataka	Digitalization of identified white grub species data should be completed within one year.	In progress
20.	AAU-Jorhat, Assam	The sawdust based bio-formulation should be supplied to different centres for confirming its efficacy against various insect pests.	Large scale production of insecticidal mixture is in progress. It can be supplied to each centre after sufficient production for testing against major soil insects pests of potato.
21.	VPKAS, Almora	The work on the utilization of white grub gut-flora for decomposition of organic matter and crop residues will continue at Almora center and the standardized pheromone collection apparatus should be supplied to other centers	The work on utilization of white grub gut-flora for decomposition of organic matter and crop residues is under progress and a total of 10 potent cellulolytic and chitinolytic bacterial isolates have been isolated and used for field studies. Due to non-availability of Porapak (Pheromone adsorbent), the design of pheromone apparatus was delayed. The apparatus will be supplied to all the centers personally during the annual review meeting in the month of June, 2023.
22.	Dr. Deepa Bhagat, Principal Scientist, NBAIR, Bengaluru	A 7-10 days training programme on isolation and characterization of insect semio-chemicals will be organized at NBAIR, Bangalore.	Dr. Kirtideepan, Assistant Professor at AAU Jorhat was trained in the isolation and characterization of insect semio-chemicals and has successfully completed with the training for three weeks.

Annexure II

LIST OF PARTICIPANTS

INDIAN COUNCIL OF AGRICULTURAL RESEARCH, HQ, NEW DELHI

Dr. T. R. Sharma, Deputy Director General (Crop Science) ICAR, New Delhi
Dr. S.C. Dubey, Assistant Director General (PP & B), ICAR, New Delhi
Dr. D. R. Suman, Asstt. Chief Technical Officer (Plant Protection), New Delhi

EXPERTS

Dr. S. N. Sushil, Director, ICAR- NBAIR, Bengaluru, Karnataka
Dr. V. V. Ramamurthy, Former Professor Entomology, IARI, New Delhi

SPECIAL INVITIES

Dr. Balraj Singh, Hon'ble Vice Chancellor, SKNAU, Jobner
Dr. K. Rajmohana, Scientist-E ZSI and Coordinator ENVIS ZSI, Kolkata
Dr. Badal Bhattacharyya, Principal Scientist, Head, AAU, Jorhat, Assam
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Dr. A. Kandan, Principal Scientist, Plant Pathology, NBAIR, Bengaluru, Karnataka
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Annexure III

THE TECHNICAL PROGRAMME 2023-24

1. Species profiling of soil arthropod pests, white grub, termites, cutworm etc. through traps

Trap selection:

Choose appropriate traps that are effective in capturing the target soil arthropod pests. Different traps may be suitable for different locations and for different species collection.

Trap placement:

Determine the optimal locations to place the traps within the target area. Consider factors such as pest behavior, known activity patterns and areas with high pest occurrence or damage. Ensure that the traps cover a representative sample of the field or site.

Trap installation:

Set up the traps according to the manufacturer's instructions or established guidelines. Ensure that the traps are properly secured and positioned to prevent disturbance.

Trap monitoring:

Regularly monitor the traps to check for captured pests. The frequency of monitoring can depend on the pest's life cycle, activity patterns and duration of the study. Daily monitoring is commonly practiced.

Pest identification:

Identify and record the captured pests to the species level. This may require the assistance of taxonomic experts or entomologists familiar with the target pest groups (Dr. Kolla Sreedevi, NBAIR). Use appropriate field guides, reference materials, or consult local resources to aid in accurate identification.

Data collection:

Record relevant data for each trap, including trap type, trap location with GPS, date and time of placement and collection and the number of individuals captured for each identified pest species. Maintain a systematic record-keeping process to ensure data accuracy.

Data analysis:

Analyze the collected data to generate species profiles. Calculate species abundance, frequency and diversity metrics. Use appropriate statistical methods or indices to assess the community structure and composition of the captured soil arthropod pests.

Interpretation and reporting:

Interpret the results of the species profiling analysis. Present the findings in a clear and concise manner, highlighting the dominant pest species, their relative abundance and any notable patterns or trends observed. Provide recommendations or insights based on the results obtained.

It's worth noting that the specific details and protocols for trap-based sampling can vary depending on the target pests, geographical region and research objectives.

Table format for species profiling of soil arthropod pests:

Trap Type	Trap Location GPS	Date & Time of Placement	Date & Time of Collection	Pest Species	Number of Individuals

In this example table, each row represents a specific trap that was deployed to capture soil arthropod pests. Here are the column headers and their descriptions:

- Trap ID: Unique identifier for each trap used in the study.
- Trap Type: The type of trap used (e.g., pitfall, pheromone, light).
- Trap Location: The specific location with GPS where the trap was placed (e.g., Field, Building etc.).
- Date & Time of Placement: The date and time when the trap was set up.
- Date & Time of Collection: The date and time when the trap was collected or checked.

- Pest Species: The identified species of the captured pest.
- Number of Individuals: The count of individuals captured for each identified pest species.

You can expand this table by adding more rows for additional traps and include additional columns if desired, such as environmental parameters, weather conditions, or any other relevant information specific to your study.

2. Population monitoring on host trees

Selection of Monitoring Sites:

Identify the specific sites or areas where the beetle population monitoring will take place. Consider factors such as known beetle activity, presence of host trees and representative sampling across different locations.

Establish Monitoring Schedule:

Determine the frequency and duration of monitoring sessions. The schedule can be daily, weekly, or at specific intervals depending on the beetle species, seasonality and research objectives.

Data Collection:

Record the date, time and relevant environmental conditions (e.g., temperature, humidity). Count and identify the captured beetles to species level using appropriate guides/expert assistance/identification keys.

Beetle Abundance and Diversity:

Calculate the abundance of beetles by summing the counts of captured individuals for each species. Assess beetle diversity using appropriate indices such as species richness or Shannon-Wiener index.

Data Analysis and Interpretation:

Analyze the collected data to interpret beetle population trends and dynamics. Examine temporal variations, spatial patterns and correlations with environmental factors. Statistical methods, such as regression analysis or ANOVA, can help identify significant relationships.

Reporting and Communication:

Summarize the results of the beetle population monitoring in a clear and concise manner. Include information on beetle species composition, abundance and any notable patterns or trends observed. Provide recommendations or insights based on the findings.

Repeat Monitoring:

To gain a comprehensive understanding of beetle populations, repeat the monitoring over multiple seasons or years. Long-term monitoring allows for the detection of population fluctuations, cyclical patterns, or the impact of management interventions.

Remember to entomologists, experts, or research publications specific to your target beetle species and geographic region. They can provide valuable guidance and insights on appropriate monitoring techniques and interpretation of the results.

Here's an example of a table format for population monitoring of white grub beetles on host trees:

Tree ID	Date	Time	GPS Location	Pest Species	Number of Beetles

In this example table, each row represents a specific tree where the population of white grub beetles was monitored. Here are the column headers and their descriptions:

- Tree ID: Unique identifier for each monitored tree.
- Date: The date of the monitoring activity.
- Time: The time at which the monitoring was conducted.
- Location: The specific location where the tree is situated (e.g., Orchard, Garden, Road side etc.).
- Pest Species: The identified species of the monitored pest.
- Number of Beetles: The count of white grub beetles observed on the tree during the monitoring session.

You can expand the table by adding more rows for additional trees and monitoring sessions. Including additional columns, such as environmental conditions (e.g., temperature, humidity), tree characteristics, or any other relevant data, can provide a more comprehensive understanding of the population dynamics of white grub beetles on host trees.

3. Pheromone isolation from predominant white grub beetles

Isolating pheromones from white grub beetles typically involves a complex and specialized process. It's important to note that the specific details may vary depending on the target species and available resources. Here's a general methodology for pheromone isolation from predominant species of white grub beetles:

Species Identification:

Identify the predominant species of white grub beetles in the target area through field surveys, literature review, or consulting with entomologists.

Collection of Adult Beetles:

Collect adult beetles of the target species using appropriate sampling methods. The collection should aim to obtain a representative sample of adult beetles.

Pheromone Extraction:

Use various extraction techniques to isolate the pheromone compounds from the adult beetles. Common methods include solvent extraction, headspace extraction, or solid-phase microextraction (SPME). Optimization of extraction methods may be required based on the specific chemical properties of the pheromone compounds.

Pheromone Analysis:

Analyze the extracted pheromone samples using techniques such as gas chromatography (GC) or high-performance liquid chromatography (HPLC) coupled with mass spectrometry (MS). These analytical methods help identify and quantify the specific pheromone compounds present in the samples.

Bioassays and Behavioral Studies:

Conduct bioassays and behavioral studies to confirm the biological activity of the identified pheromone compounds. This involves testing the synthesized or extracted compounds on target species to evaluate their attractiveness and behavioral responses.

Synthesis or Replication:

Based on the identified pheromone compounds and their activity, replicate or synthesize the compounds for further use. This ensures a reliable and consistent source of pheromones for future studies or practical applications.

Field Testing and Application:

Validate the synthesized or replicated pheromones through field trials and monitoring. Assess their effectiveness in attracting or repelling white grub beetles and evaluate their potential for practical applications such as integrated pest management (IPM) strategies.

It's important to note that pheromone isolation and identification can be a highly specialized and technical process. Researchers often require expertise in organic chemistry, analytical techniques and insect behavior. Consultation with experts, access to well-equipped laboratories and thorough literature review are crucial for successful pheromone isolation studies.

4. Population monitoring and their extent of damage in different crops due to soil arthropod pests

The process for population monitoring of soil arthropod pests and assessing the extent of damage in different crops involves several key steps. Here's a general outline of the process:

Pest Identification:

Identify the soil arthropod pests that are relevant to the target crops. Determine the pest species or groups that commonly affect the crops in your region. Field guides, expert advice, or local agricultural resources can assist in identifying the pests.

Sampling Design:

Design an appropriate sampling strategy to monitor the population of soil arthropod pests. Consider factors such as field size, crop type, pest distribution patterns and economic thresholds. Random or systematic sampling methods may be used, depending on the pest and crop characteristics.

Sampling Technique:

Select the appropriate sampling technique for each pest species. Choose a method that captures the target pests effectively and provides representative data.

Sample Collection:

Collect soil or plant samples at regular intervals according to the sampling design. Ensure consistency in sample collection methods and locations across different crops and fields. Record relevant information such as field location, date and sample details.

Population Assessment:

Process the collected samples in the laboratory or field station. Count and identify the captured pests to species level. Calculate pest population densities (e.g., number of pests per unit area or

weight of soil) or use appropriate indices (e.g., pest abundance, diversity) to assess population dynamics.

Damage Assessment:

Conduct field observations and assess the extent of damage caused by the soil arthropod pests in different crops. Evaluate damage symptoms, such as leaf damage, stem girdling, root feeding, or plant wilting. Rate the severity or quantify the damage using visual scoring systems or measurement techniques.

Data Analysis:

Analyze the population and damage data using appropriate statistical methods. Determine trends, correlations, or patterns in pest populations and damage levels across different crops, fields, or time periods. Statistical tests, such as ANOVA or regression analysis, can provide insights into significant differences or relationships.

Assessing crop loss with respect to economic values due to soil arthropod pests involves estimating the monetary impact of the damage caused by pests on crop production. Here are some key formulas that can be used for this assessment:

1. Percent Crop Loss (PCL) = Unaffected-Affected/Unaffected x100

Where:

- Unaffected: the yield from pest-free or adequately managed fields
- Affected: the yield from fields affected by soil arthropod pests

2. Crop Loss in Monetary Value (CLMV) = PCL x V

Where:

- PCL is the percentage crop loss (calculated using the formula above)
- V is crop is the monetary value of the crop (e.g., market price per unit)

3. Economic Impact of Pests (EIP) = CLMV-C

Where:

- CLMV is the crop loss in monetary value (calculated using the formula above)

- C is the cost of pest management/control practices (e.g., cost of pesticides or other methods)

Interpretation and Reporting:

Interpret the results of the population monitoring and damage assessment. Summarize the findings in a clear and concise manner. Present the data, trends and significant observations. Provide recommendations for pest management strategies, such as cultural practices, biological control, or chemical interventions.

Long-term Monitoring:

Repeat the population monitoring and damage assessment over multiple seasons or years to capture variations and identify trends. Long-term monitoring enables the evaluation of pest dynamics, impact of management practices, or climate influences.

Remember to consult with experts, entomologists for guidance on specific sampling techniques, pest identification and data analysis methods relevant to your region and crops. Their expertise and knowledge of local pest dynamics can enhance the accuracy and applicability of your monitoring process.

Example table-

Crop	Arthropod Pest	Population Monitoring	Extent of Damage

Please note that this table provides a general idea of the arthropod pests and their effects on different crops. The specific pests, monitoring methods and damage can vary depending on the region and crop type. Feel free to customize the table as per your requirements and add more rows for additional crops and soil arthropod pests.

5. Survey of natural enemies of soil arthropod pests

The survey of natural enemies of soil arthropod pests viz., isolation, identification and evaluation of local strains against local pest for better management of soil arthropod pests in local areas is essential in concern of environment. The survey involves a systematic approach to identify and assess the presence and abundance of beneficial organisms in the soil ecosystem. Here's a general methodology for conducting such a survey:

Define Objectives:

Clearly define the objectives of the survey, such as identifying and documenting natural enemies, understanding their population dynamics or evaluating their effectiveness in pest control.

Select Sampling Sites:

Choose representative sampling sites within each crop field or area of interest. Consider factors like different soil types, pest management practices and previous pest incidence.

Determine Sampling Methods:

Select appropriate sampling methods based on the natural enemies being targeted. Common methods include soil sampling, bait traps and visual observations. Choose methods that are practical, efficient and suitable for the target organisms.

Sampling Procedure:

a. Soil Sampling: Collect soil samples using a soil auger or shovel. Take multiple samples from each sampling site, combining them to obtain a representative composite sample.

b. Pitfall Traps: Set up pitfall traps by burying containers at ground level and filling them with a preservative liquid (e.g., water with detergent). Place traps in different locations within the sampling site.

c. Bait Traps: Deploy bait traps by placing appropriate baits (e.g., pieces of fruit or plant material) at regular intervals in the soil. Check and collect traps periodically.

d. Visual Observations: Conduct visual surveys to directly observe natural enemies in the soil or on plants. Look for signs of predation or parasitism.

Sample Collection and Preservation:

a. Soil Samples: Transfer soil samples to suitable containers, seal them properly and label them with relevant information (sampling date, location, etc.).

b. Pitfall Traps and Bait Traps: Collect trapped organisms regularly, transferring them into vials filled with preservation fluid (e.g., ethanol). Label vials with necessary information.

c. Visual Observations: Document observations through written records, photographs, or videos, noting the location and specific natural enemy observed.

Laboratory Analysis:

a. Identify Natural Enemies: Use appropriate taxonomic keys or consult experts to identify natural enemies to the species or genus level.

b. Quantify Abundance: Count and record the number of each natural enemy species or group found in each sample or trap.

1. **Data Analysis:** Analyze the collected data to determine the abundance, diversity and distribution patterns of natural enemies. Compare the results across different sampling sites or crop fields.

2. **Interpretation and Reporting:** Interpret the survey results and prepare a comprehensive report. Discuss the findings, including the presence and potential impact of natural enemies on arthropod pest populations and make recommendations for pest management strategies.

Remember, the specific methodology may vary depending on the target pests, natural enemies and local conditions. It is essential to adapt and modify the methods to suit the specific requirements of the survey.

For example a table format for a survey of natural enemies of soil arthropod pests in various crops-

Crop	Soil Arthropod Pest	Natural Enemies Surveyed	Predatory	Parasitic	Others

Please note that this is a generalized table and the specific natural enemies and their effectiveness against soil arthropod pests may vary depending on the region and crop management practices. You can customize the table according to your survey findings and include additional natural enemies relevant to your study.

6. Surveillance of soil arthropod pests through Dynamic Remotely Operated Navigation Equipment (DRONE)

Drone Selection:

Choose a suitable drone with appropriate features for aerial surveillance. Consider factors such as flight time, payload capacity, camera quality, stability and control capabilities.

Survey Planning:

a. Define Survey Area: Determine the specific area to be surveyed, considering the size and boundaries of the field or region.

b. Identify Target Pests: Identify the specific soil arthropod pests of interest that you intend to monitor.

c. Establish Flight Path: Plan the flight path for the drone to cover the entire survey area systematically. Divide the area into grids or zones for efficient coverage.

d. Flight Parameters: Determine the appropriate altitude, speed and overlap for capturing high-resolution images or videos.

These parameters may vary depending on the drone's capabilities and the desired level of detail.

Pre-flight Preparations:

a. **Drone Calibration:** Ensure the drone is properly calibrated, including compass calibration and sensor calibration, if required.

b. Battery and Equipment Check: Ensure the drone's battery is fully charged and all necessary equipment such as the camera or sensor is functioning correctly.

c. Safety Measures: Verify that all safety protocols and regulations are followed including checking for any flight restrictions or permissions required.

Flight Execution:

a. Launch: Initiate the drone's flight according to the planned flight path and ensure a smooth takeoff.

b. Aerial Surveillance: Use the drone's camera or sensor to capture high-resolution images or videos of the soil surface while maintaining the designated altitude and speed.

c. Overlap and Grid Coverage: Ensure proper overlap between consecutive images or videos to ensure accurate mapping and analysis. Follow the planned flight path to cover the entire survey area systematically.

d. GPS Tracking: Use the drone's GPS capabilities to record the geographical coordinates of each image or video captured allowing for accurate spatial analysis.

Post-flight Data Processing:

a. Image/Video Processing: Transfer the captured images or videos from the drone to a computer for further analysis and processing.

b. Pest Identification: Review the imagery or videos to identify and mark areas with soil arthropod pests. This can be done visually or through automated image analysis techniques.

c. Data Analysis: Analyze the collected data to determine pest distribution patterns, population densities and potential hotspots. This analysis can include spatial mapping, clustering or other statistical techniques.

d. Report Generation: Summarize the findings and prepare a comprehensive report including pest distribution maps, population trends and recommendations for pest management strategies.

It's important to note that using drones for soil arthropod pest surveillance may require expertise in drone piloting, image analysis and entomology. Ensure compliance with local regulations and permissions related to drone usage and respect privacy considerations.

Table for example

Crop	Soil Arthropod Pest	Flight Path	Camera/Sensor Data	Pest Identification	GPS Coordinates

You can customize the table based on the specific crops, soil arthropod pests and surveillance strategies used in your study.

***Training: A 7 days training will be organized on "Use of Modern Technology - DRONE in Soil Arthropod Pests Management" for the scientific team members of AINP on SAP.**

7. Crop loss assessment at different climatic zones due to soil arthropod pests in sugarcane, groundnut and potato

Define Study Area:

Select representative areas within each climatic zone where sugarcane, groundnut, potato, colocasia etc. crops are cultivated. Consider factors such as geographical diversity, pest prevalence and agricultural practices specific to each zone.

Pest Identification:

Identify the soil arthropod pests that commonly affect the target crops in the study area. This can be done through visual surveys, trapping or sampling methods.

Crop Sampling:

Randomly select sample plots within each crop area in the study zone. Ensure that the sample plots are representative of the crop and pest distribution. The size and number of plots should consider the crop area and pest severity.

Yield Measurement:

Measure the crop yield in the selected sample plots. Harvest all the plants or a representative sample and record the weight or count of harvested produce for each crop type.

Pest Damage Assessment:

Assess the extent of pest damage in the sample plots for each crop. This can be done through visual inspections, rating scales or damage scoring methods specific to each soil arthropod pest. Record the severity and type of damage caused by the pests.

Control Plots:

Set up control plots in each crop area where crop damage by soil arthropod pests is minimized or prevented. These control plots allow for a comparison of crop yield between affected and unaffected areas within each crop type.

Data Analysis:

Analyze the collected data to estimate the crop loss caused by soil arthropod pests for each crop type. Compare the yield of the affected plots with the control plots to determine the percentage of crop loss. Statistical analysis can be employed to validate the significance of the observed differences.

Assessing crop loss with respect to economic values due to soil arthropod pests involves estimating the monetary impact of the damage caused by pests on crop production. Here are some key formulas that can be used for this assessment:

1. Crop Benefit Analysis (CBA) = (Economic benefit from pest management - Cost of pest management) / Cost of pest management

Where:

- CBA is the cost-benefit ratio
- Economic benefit from pest management is the monetary value of crop loss reduction due to pest management practices
- Cost of pest management includes the expenses incurred for implementing pest management strategies

2. Net Revenue (NR) = Revenue generated from unaffected fields - cost of pest management

Where:

- NR is the net revenue, representing the revenue generated from unaffected fields minus the cost of pest management

3. Return on Investment (ROI) = (Economic benefit from pest management - Cost of pest management) / Cost of pest management × 100

Where:

- ROI is the return on investment, expressed as a percentage
- Economic benefit from pest management is the monetary value of crop loss reduction due to pest management practices
- Cost of pest management includes the expenses incurred for implementing pest management strategies

It's essential to adapt and modify these formulas based on the specific objectives, data availability and conditions of the study area. Additionally, consider accounting for other factors such as environmental impacts, indirect losses and non-monetary benefits when conducting a comprehensive crop loss assessment due to soil arthropod pests.

Interpretation and Reporting:

Interpret the findings and prepare a comprehensive report on the crop loss assessment for each crop type in each climatic zone. Include information on the severity of pest damage, estimated economic losses and recommendations for pest management strategies based on the specific climatic zone and crop requirements.

Please note that the methodology can be further customized based on the specific pest species, local farming practices and available resources in each climatic zone. Collaboration with Network Unit, network centers, experts, extension services and agricultural research institutions is recommended to ensure the accuracy and relevance of the crop loss assessment in sugarcane, groundnut, colocasia and potato crops across different climatic zones.

A table format for crop loss assessment due to soil arthropod pests in sugarcane, groundnut and potato crops across different climatic zones:

Crop	Soil Arthropod Pest	Climatic Zone	Sample Plots /size/GPS	Pest Damage Assessment	Control Plots	Crop Yield (/ha)	Crop Loss (%)

Sugarcane	Sugarcane white grubs	Tropical Zone	10	Visual inspection	Yes	5000	20%

Please note that this is a sample table and the specific pests, climatic zones and assessment methods may vary based on the region and crop conditions. You can customize the table according to your specific study requirements and add more rows for additional pests, climatic zones and crops.

8. White Grub Taxonomy (NBAIR, Bengaluru) (Dr. Kolla Sreedevi)

- Development of Taxonomic keys for Scarabs of India
- All centres will be sent new species recorded at centres for identification to NBAIR
- Compilation of literature on Scarabs of India

9. Development of Distribution maps of white grub

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

S.N.	CENTRE	STATES
1.	RARI Durgapura	Rajasthan, MP and Haryana
2.	CSKHPKV Palampur	HP, Punjab
3.	AAU Jorhat	All North East States
4.	GKVK Bengaluru	Karnataka, Kerala, Telangana,
5.	GAU Gujarat	Gujarat
6.	COA Kolhapur VC	Maharashtra, Goa and Odisha
7.	VPKAS Almora VC	Uttarakhand
8.	FARMER VC	Uttar Pradesh
9.	SBI VC	Tamil Nadu
10.	J&K VC	Jammu and Kashmir

11.	Andhra Pradesh VC	Andhra Pradesh

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.

10. Development of Distribution maps of termite

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

S.N.	CENTRE	State
1.	RARI Durgapura	Rajasthan
2.	CSKHPKV Palampur	HP
3.	AAU Jorhat	Assam
4.	GKVK Bengaluru	Karnataka
5.	GAU Gujarat	Gujarat
6.	COA Kolhapur VC	Maharashtra
7.	VPKAS Almora VC	Uttarakhand
8.	FARMER VC	Uttar Pradesh
9.	SBI VC	Tamil Nadu
10.	J&K VC	Jammu and Kashmir
11.	Andhra Pradesh	Andhra pradesh

All the centres should complete the distribution map of termite under the supervision of Dr. K. Rajmohana, Scientist-E ZSI and Coordinator ENVIS ZSI, National Coordinator, Green Skill Development Program, ZSI Coordinator, PG Diploma in Integrative Animal Taxonomy-2021, ZSI Zoological Survey of India (Ministry of Environment, Forest and Climate Change, Government of India) Prani Vigyan Bhawan M-Block, New Alipore, Kolkata -700 053, Mobile: 9446303216 E-mail: mohana.skumar@gmail.com.

11. Biodiversity studies-termites

Biodiversity studies on termite species will be conducted in concerned state of the centre.

Study Area Selection:

- Define the boundaries of the study area based on the research objectives and available resources.
- Consider factors such as habitat types (forests, grasslands, agricultural fields), geographic location and accessibility.

Sampling Design:

- Determine the sampling methods based on the research objectives and feasibility.
- Consider a combination of active and passive sampling techniques to capture a comprehensive termite species assemblage.
- Sampling methods may include visual surveys, termite mound examination, baiting traps, or soil sampling.

Sampling Procedure:

- Randomly select sampling sites within the study area, ensuring representation of different habitats and vegetation types.
- Conduct sampling during appropriate seasons when termites are most active.
- Use standardized protocols for each sampling method to ensure consistency and comparability of data.

Visual Surveys:

- Conduct visual surveys to identify and record termite species encountered.
- Document species richness, abundance and behavior.
- Use field guides or taxonomic keys for accurate identification.

Baiting Traps:

- Deploy baiting traps in selected sampling sites to attract termites.
- Use appropriate baits (such as cellulose-based materials) that are attractive to termites.
- Collect termites from the traps and identify them to species level.

Soil Sampling:

- Collect soil samples from various locations within the study area.

- Extract termites from the soil samples using extraction methods like Tullgren funnels or Berlese funnels.
- Carefully observe and identify the extracted termites.

Data Analysis:

- Compile and organize the collected data, including species names, abundance and distribution information.
- Calculate species richness, diversity indices and evenness measures to assess termite biodiversity within the study area.
- Use statistical methods, such as rarefaction or species accumulation curves, to estimate total species richness.

Documentation and Reporting:

- Document all findings, including species lists, abundance data and any additional observations.
- Prepare a comprehensive report summarizing the termite biodiversity study, including the methodology, results and conclusions.

It is important to consult with termite experts as give above or others and refer to relevant scientific literature and taxonomic keys to ensure accurate identification of termite species during the biodiversity study. Additionally, compliance with local regulations and ethical considerations regarding the collection and handling of termites is essential.

12. Evaluation of local isolated strains of natural enemies (bioproduct) against soil arthropod pests in laboratory

The identified local isolates would be screened against predominant white grub species, cutworm, termite etc. and efforts should be given to determine LD_{50} value of potential strains. Calculating the lethal dose of a bioproduct for a particular soil arthropod pest involves determining the amount of bioproduct required to cause death in a significant percentage of the target pest population. This calculation is essential for effective pest control while minimizing unnecessary bioproduct usage. The lethal dose is commonly expressed as LD50, which represents the dose required to kill 50% of the test population. Here's a general step-by-step process to calculate the LD50:

Select the test insect pest:

Choose the specific insect pest you want to target with the bioproduct. Different insect species may have varying susceptibilities to the same bioproduct.

Acquire the bioproduct:

Obtain the insecticide that you want to test against the selected insect pest. Ensure that it is in the appropriate formulation and concentration for testing.

Prepare test samples:

Create different concentrations of the bioproduct that will be used in the experiment. These concentrations typically form a range, allowing you to observe a dose-response relationship.

Set up the experiment:

Design a controlled experiment to expose the test insect pest to the different concentrations of the bioproduct. The experiment should include a control group where the insects are not exposed to the bioproduct.

Apply the bioproduct:

By following appropriate protocols, carefully apply the different concentrations of the bioproduct to the test insects.

Monitor and record results:

Observe the insects over a specific period (usually a 24hrs intervals for several days) to determine the effects of the bioproduct. Record the number of insects that die at each concentration level.

Analyze the data:

Use statistical analysis to determine the LD50 value. The LD50 is the concentration at which 50% of the test insect population died during the observation period. It is usually expressed in terms of milligrams of test product per kilogram of the test insects' body weight (mg/kg).

Calculate the LD50:

To calculate the LD50, use the data from the experiment and apply appropriate statistical methods. There are various statistical techniques, such as Probit analysis or Logit analysis, that can help determine the LD50 value accurately.

Interpret the results:

The LD50 value indicates the bioproduct’s potency against the target insect pest. A lower LD50 value means the bioproduct is more toxic to the insect pest, requiring a smaller amount to achieve control.

Keep in mind that conducting these types of experiments requires expertise. It is best to consult with professionals or follow established scientific protocols and guidelines when conducting toxicity tests on insects.

13. Management of target pests through chemicals

For management of soil arthropod pests (white grub, termite, cutworm etc.) through chemical methods, only label claimed insecticides have to be tested and the promising results have to be included in the package of practices of different states and the B:C ratio of insecticides also calculated. There are several insecticides that have been labeled and registered for managing soil arthropod pests in India. It's important to note that the availability and registration status of insecticides may change over time, so it's advisable to refer to the latest information from the Central Insecticides Board and Registration Committee (CIBRC) or consult with local agricultural authorities for the most up-to-date list of labeled insecticides for soil arthropod pests in India.

A. Field evaluation of pre-sown application of different granular insecticides against soil arthropod pests

B. Evaluation of insecticides against target pest as seed dresser application

C. Drenching of insecticides in standing crop through water

Experiment Details	
Location	Durgapura, Palampur, Jorhat, Bengaluru centres only
Sowing time	As per Recommended Package of Practices
Design	RBD
Replication	3
Crop	Groundnut/Sugarcane/ Potato/Colocasia etc.,

Fertilizer	At recommended doses
Treatments	7
Observation	Plant mortality (%), Larval population/ m^2, Yield (q/h), Pesticides residues analysis and B: C ratio

*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.

14. Management of target pest through biocontrol agents

For management of soil arthropod pests (white grub, termite, cutworm etc.) through biocontrol agents, only identified and laboratory tested bioagents (EPF, EPN, Bt etc.,) have to be tested in crop field and the promising results have to be included in the package of practices of different states and the B:C ratio of bioagents also calculated. Managing soil arthropod pests in various crops through biocontrol agents involves a carefully planned and integrated approach. Here's a step-by-step process for implementing biocontrol strategies:

Identify the target pests:

Identify the specific soil arthropod pests that are causing damage to specific crops. Different crops may face different pest challenges, so understanding the pest species and their life cycles is crucial.

Select suitable biocontrol agents:

Research and select biocontrol agents that is effective against the identified pests.

Obtain quality biocontrol agents:

Source the selected biocontrol agents from reputable suppliers or laboratories to ensure their quality and viability.

Conduct on-farm trials:

Before large-scale implementation, conduct small-scale trials in representative areas of the fields. This step helps to assess the effectiveness of the chosen biocontrol agents under local conditions.

Optimize application methods:

Determine the best method of application for the chosen biocontrol agents. This may involve soil application before sowing or at the time of sowing, seed treatment, or other application techniques depending on the agents and the target pests.

Monitor pest populations:

Regularly monitor pest populations in the crops to determine the pest pressure and identify the appropriate timing for biocontrol agent application.

Introduce biocontrol agents:

Apply the biocontrol agents at the recommended rates and timings based on the results of the monitoring. Ensure proper handling and application to maximize their efficacy.

Monitor biocontrol agent establishment:

After introducing the biocontrol agents, monitor their establishment and population growth. Evaluate their impact on the target pest populations.

Implement cultural practices:

Integrate cultural practices that promote the biocontrol agents' efficacy and overall crop health. Practices such as crop rotation, intercropping and maintaining habitat diversity can support beneficial arthropods.

Evaluate efficacy:

Continuously assess the effectiveness of the biocontrol agents in managing soil arthropod pests. Adjust the strategy if needed based on the results and feedback from field observations.

Record keeping:

Maintain detailed records of biocontrol agent applications, pest monitoring data and crop performance. These records will help in future decision-making and troubleshooting.

Train and educate farmers:

Conduct training sessions to educate farmers and field workers about the benefits and proper use of biocontrol agents in pest management.

Integrate with other pest management practices:

Biocontrol should be part of an Integrated Pest Management (IPM) approach. Integrate biological control with other appropriate methods such as cultural practices, crop rotation and judicious use of chemical pesticides when necessary.

Continuous learning and improvement:

Stay updated with the latest research and developments in biocontrol methods. Participate in workshops and seminars to keep enhancing the effectiveness of biocontrol strategies.

By following these steps and maintaining a proactive and adaptive approach, farmers can effectively manage soil arthropod pests in various crops using biocontrol agents while promoting sustainable agriculture practices.

15. Social engineering/ Extension activities

Centres	Districts covered	Farmers training	Training for extension functionaries	Field day	Exhibition (organized/ Participation	Method demonstration	Technology showcasing
RARI Durgapura	10	10	5	5	5	3	3
CSKHPKV Palampur	10	10	5	5	5	3	3
AAU Jorhat	10	10	5	5	5	3	3
GKVK Bengaluru	10	10	5	5	5	3	3
GAU Gujarat	5	5	1	1	1	1	1
COA Kolhapur VC	5	5	1	1	1	1	1
VPKAS Almora VC	5	5	1	1	1	1	1
FARMER	5	5	1	1	1	1	1

VC							
SBI VC	5	5	1	1	1	1	1
J&K VC	5	5	1	1	1	1	1
KARELA VC	5	5	1	1	1	1	1

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 1acres).
- All social engineering activities should be planned / distributed throughout the year against both white grubs/adults and others soil arthropod pests in collaboration with KVKs, State Department of Agriculture, NGOs etc. to establish better linkage.
- 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.

16. Commercialization of technology

The commercializing new pest management technologies are a crucial step in bridging the gap between scientific advancements and practical implementation. The process requires collaboration between researchers, companies and regulatory bodies to ensure that effective and sustainable solutions are made available to farmers and pest management professionals worldwide. The successful commercialization of such technologies contributes to more efficient pest control, reduced reliance on harmful pesticides and greater environmental protection. The process for recommending any technology in agriculture typically involves several steps, including research and development, evaluation, testing, dissemination, extension trainings, farmers' adoption, monitoring and evaluation.

17. Publications

Each center of AINP on SAP should have to publish at least 2 research papers (NAAS rating above 6) in unpaid journals only.

18. Location specific trials

Conducting location-specific experiments on soil arthropod pests management in different crops and climatic zones is essential to understand the unique pest dynamics and optimize management strategies. Here's a list of such experiments:

Pest Diversity Surveys:

Conduct surveys in various crops (e.g., groundnut, sugarcane, maize, potato, fruit's orchard etc.) across different climatic zones to identify and quantify the diversity of soil arthropod pests.

Crop-Specific Pest Management Trials:

Implement experiments to test different pest management methods tailored to specific crops and climatic zones, considering factors like pest species, host plants and growing conditions.

Organic vs. Conventional Farming Comparisons:

Compare the effectiveness of organic and conventional farming practices in managing soil arthropod pests in diverse crops and climatic regions.

Cover Crop Trials:

Evaluate the impact of different cover crops on soil arthropod pest populations in various cropping systems and climatic conditions.

Crop Rotation Experiments:

Investigate the influence of crop rotation on soil arthropod pests in different agro ecological zones and various crop sequences.

Native Predators and Parasitoids Studies:

Identify and quantify the role of native predators and parasitoids in regulating soil arthropod pest populations in different crops and climatic zones.

Temperature and Humidity Effects:

Study the influence of temperature and humidity variations on the population dynamics of soil arthropod pests in different climatic regions.

Irrigation Management:

Assess how different irrigation methods and frequencies affect soil moisture and impact soil arthropod pest abundance in diverse crops and climatic zones.

Pest Forecasting Models:

Develop and validate location-specific pest forecasting models based on climate and ecological data to predict pest outbreaks and optimize control measures in different crops and regions.

Agrochemical Use and Resistance:

Evaluate the long-term effects of agrochemical use (insecticides) on soil arthropod pests and the development of resistance in different crops and climatic zones.

Soil Type Effects:

Compare the occurrence and abundance of soil arthropod pests in different soil types across various crops and climatic regions.

Field Margin Management:

Investigate the impact of managing field margins (border areas) with specific vegetation types or conservation practices on soil arthropod pest movement and populations in different crops and regions.

Beneficial Microbe Applications:

Study the use of beneficial microorganisms (e.g., entomopathogenic nematodes, entomopathogenic fungi, bacteria etc) in managing soil arthropod pests in diverse crops and climatic zones.

Water Management:

Assess the influence of water logging and drainage practices on soil arthropod pest occurrence in different crops and climatic zones.

These location-specific experiments will provide valuable insights into the management of soil arthropod pests in different crops and climatic zones, enabling farmers and researchers to adopt targeted and sustainable pest control strategies tailored to their specific regions.

*** All the centres should submit the annual reports in-time so that compilation of annual report being on time for timely conduction of the annual group meeting (preferably before 15th April every year).**

*** Only good quality original pictures with GPS location will be included in the report.**

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