

Farmer-centric ICT-based approach for integrated pest management in India

Tamoghna Saha^{1*}, Nithya Chandran² and Priya Ranjan Kumar¹

¹ICAR-Indian Agricultural Research Institute, Regional Station, Pusa, Samastipur, Bihar 848 125

²ICAR-Indian Agricultural Research Institute, New Delhi 110 012

Pests cause substantial losses to crop production in India. However, the indiscriminate use of chemical pesticides not only harms the environment but also poses serious health risks due to pesticide residues in food and water. Integrated Pest Management (IPM) being a knowledge-intensive approach to crop protection, emphasises informed decision-making based on an understanding of the interactions among crops, pests, beneficial organisms, and various other ecological factors. For effective implementation, IPM practitioners require timely access to relevant pest management information, knowledge, and expert guidance. Hence, the improved Information and Communication Technology (ICT) tools such as decision support systems play a vital role which are discussed in detail in this article.

Keywords: Decision-making process, Decision support systems, Expert systems, Pest information

OVER the past four decades, agricultural production in India has increased significantly, leading the country to achieve self-sufficiency in food grains. The current challenges to food grain production in India include technological limitations associated with high-yielding varieties, erratic and insufficient rainfall, and the emergence of previously minor pests as major threats. Additionally, the effects of climate change have led to the resurgence and increased intensity of pest outbreaks, further complicating crop protection efforts. Hence, there is an urgent need to mitigate these challenges especially pest infestations that cause substantial yield losses. Notably, these losses continue to rise despite the increased use of chemical pesticides.

This give rise to the use of biotechnology, information technology, and eco-friendly practices. These technologies should be effectively disseminated by extension functionaries to facilitate adoption by farmers. This approach not only protects the environment but also supports the conservation of

natural enemies of pests. However, for the successful implementation of Integrated Pest Management (IPM), farmers require timely access to accurate pest management information, understanding, and skills.

In this context, pest surveillance or monitoring is a keystone of pest management rather than calendar-based treatments. It gives field-specific information on pest pressure and crop injury leading to take suitable decision about selection and application of pest management procedures. The decisions such as selection and timing of pest management intervention if necessary are always contingent on correct information about the pests and its biology, level of pest incidence and available management options. Use of Information and Communication Technology (ICT- Internet and mobile) in pest surveillance constitutes e-pest surveillance i.e. a web-based Decision Support System (DSS) for timely collection of data with regard to pest population and preparation of reports which greatly assists the implementation of pest

management activity. ICT provides a wide range of DSS tools which can be used, and in fact many of them are being used extensively in IPM all over the world.

Decision support systems in IPM

DSS integrate user-friendly interfaces with complex models, knowledge bases, expert systems, and database technologies. In the context of IPM, DSS serve as a crucial component of information technology. DSSs are designed to support decision-making by collecting, organising, integrating, and analysing diverse data relevant to pest management. They have emerged as essential tools for bridging the gap between science-driven innovations and end-users who are responsible for daily pest management decisions. The decision-making process typically involves several key steps: identifying the problem, collecting and analysing relevant data, evaluating alternative solutions, and selecting the most effective course of action. Effective IPM DSS should provide users with comprehensive information on pests, sampling

methods, economic threshold levels, pest and disease development models linked to weather data, and recommended pest management strategies. It should also include details on currently available pesticides, along with their safety considerations and environmental impacts.

Decision-making process in pest management

Pest identification: Proper identification of specific insects or disease in the field is important for pest management decision-making. Each pest has different management strategy. It is also very important for pest management practitioners to recognise harmful insects and beneficial insects.

Pest surveillance: Pest identification alone is not sufficient to take up remedial measures; it is essential to determine the extent of the pest problem prevalent in each farm. Regular pest monitoring is the cornerstone of pest management. For this purpose, there are intuitively built pest-specific survey forms to quantify damage caused by various pests. Pest surveillance helps to determine whether pests are present in the field at a level to initiate pest management intervention [based on economic threshold level (ETL)] or can be managed by the presence of natural enemies.

Selection of pest management strategy: After thorough assessment of the pest situation, there will be numerous options to grab for pest management such as physical control, cultural control, biological control or chemical control. But to take appropriate and right decision for selection of suitable option that is readily available, economical and applicable at field level, farmers need expert advice.

Decision support system for IPM in India

In India, numerous DSSs have been developed in the field of plant protection by various public and private organisations across the country. Most of these are web-based databases and information systems focused primarily on cereal, pulse, and oilseed crops. However,

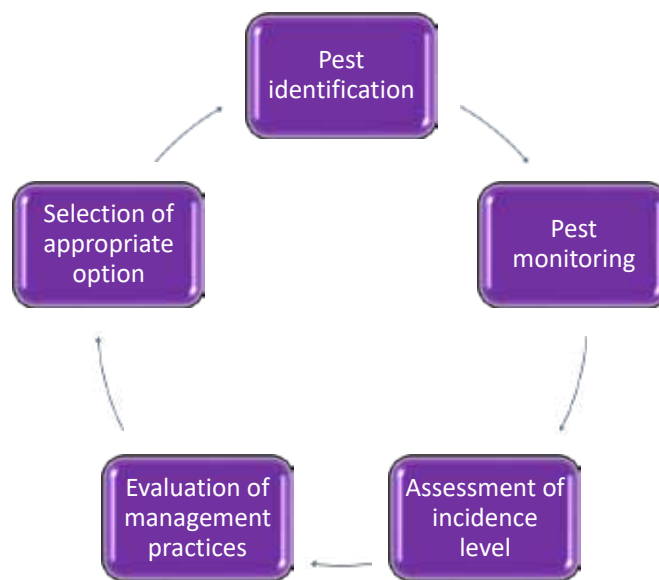
only a limited number of DSS initiatives have been developed for vegetables, despite vegetables being the second-largest crop group in terms of pesticide consumption. At present, there are no published reports available on the adoption percentage of ICT-based IPM tools among farmers in India. However, a National Association of Software and Services Companies (NASSCOM) report revealed that only about 2% of farmers in India use mobile applications for farm-related activities and real-time advisory services. Below are some of the programmes implemented in the country in the field of pest management.

SOYPEST: A network-based fuzzy expert system, SOYPEST, was developed with the objective to provide internet-based IPM decision support to soybean farmers. It assists in identifying active pests, assessing their activity levels, and facilitating accurate diagnosis. The diagnosis and identification process are information-driven and relies on inputs such as damage symptoms, insect morphology, and pest images. SOYPEST utilises knowledge-based inference mechanisms to calculate pest activity and support timely pest management decisions. Its diagnostic information system has been integrated with the soybean Gyan app. This app provides information related to soybean farming besides pest identification.

Electronic solutions against agricultural pests (e-SAP): e-SAP is an ICT-based system developed with the aim of assisting farmers by delivering real-time solutions directly in the field. It also supports extension workers by enhancing their efficiency in pest management, a critical component of the crop production cycle. e-SAP integrates farmers, extension personnel, scientists and policymakers onto a common platform, enabling quicker, more practical problem-solving. The system allows for field-level surveys of pest attacks and related issues, which are then automatically processed into graphical and tabular formats for easy interpretation and decision-making.

iKisan: This is an ICT-based information system initiative by one of the largest private enterprises serving the agricultural needs of Indian farmers. This online platform provides comprehensive agricultural information, including tools to diagnose, analyse, and offer recommendations for managing insect-pests. The website covers 20 major crop, including rice, chilli, cotton, soybean, maize, groundnut, turmeric, banana, citrus, coconut, tomato, red gram, Bengal gram, green gram, black gram, sunflower, sugarcane, castor, and mango.

Crop Doctor: Crop Doctor is a mobile-based agricultural advisory application designed to assist farmers in the identification



Decision-making process in pest management

Table 1. Main features and weaknesses of DSSs developed in India

Name of DSS	Developed by	Main features	Weakness of IPM
SOYPEST	ICAR-National Research Centre for Soybean, Indore, in collaboration with the Institute of International Management and Technology, Gurugram	• Web based expert system • Assists in identification and management of soybean pests • Utilises artificial intelligence technique vague logic for estimation of pest activity	• System developed for extension workers as target user, not the farmers • No choice for pest surveillance so as to advice the farmers • No interface to farmers for expert advice
e-SAP	University of Agricultural Sciences, Raichur	• Web based decision support system for crop pest management • Developed for extension workers • Consists image-based pest identification option • Have option for quantitative and pest-specific survey plan-based pest surveillance	• No use of AI techniques for pest identification • No option for qualitative pest surveillance by farmers
iKisan	Nagarjuna Group of Companies	• Web based information system • Provides crop production information for 20 crops	• No option for farmer interactions • No use of AI techniques for estimation of pest activity • No option for pest surveillance so as to advice the farmers
Crop Doctor	Indira Gandhi Krishi Vishwavidyalaya-National Informatics Centre Raipur, Chhattisgarh	• Helps in rapid identification of crop pests and diseases through images and symptom descriptions • Provides real-time advisory services for pest and disease management • User-friendly mobile interface suitable for smartphone-based advisory services	• Limited regional language support reduces accessibility for farmers from different states • Field-level validation and location-specific recommendations are sometimes inadequate
Pest Management Information System (PMIS)	National Centre for Integrated Pest Management, New Delhi	• A separate database application for Krishi Vigyan Kendras and extension workers • Gives A-Z information about production of selected crops	• No option for crop pest surveillance • No option of farmers interaction • No option for pest surveillance-based advisory to the farmers

Source: Niranjana and Neha (2016)

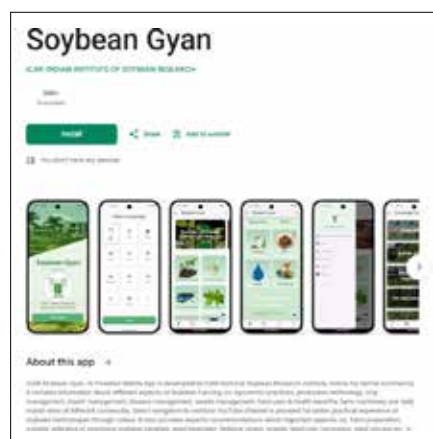
and management of crop pests and diseases. The application enables farmers to upload photographs of affected crops through smartphones and receive diagnostic information along with suitable management recommendations. It provides real-time guidance on IPM practices, including cultural, biological, and need-based chemical control measures. The app helps farmers in

timely decision-making, reducing unnecessary pesticide use and minimising crop losses. In addition, it serves as an important ICT tool for improving farmer awareness, strengthening pest surveillance, and promoting sustainable crop protection practices in agriculture. It is currently available in two languages i.e. English and Hindi.

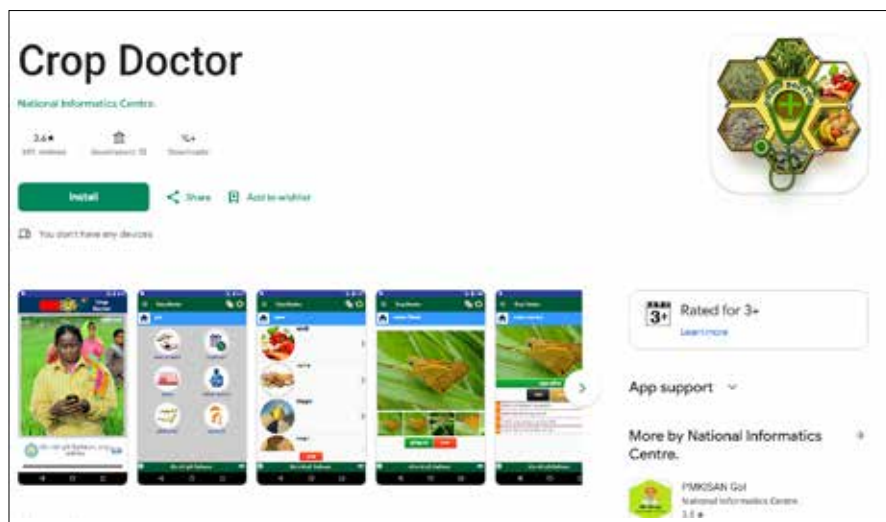
Pest Management Information System (PMIS): This is a separate generic database application created to cater the needs of master trainers, KVKs, extension workers and progressive farmers. This software provides information on all aspects of mustard, groundnut, basmati rice, cotton, brinjal, okra and tomato crops such as crop general information, agronomic practices, pests, natural enemies, nutrient disorders, resistant varieties, etc. Application of PMIS could improve the efficiency of farmers' existing production systems for making

farming more profitable.

Pesticide advisor: A separate database application for researchers and agricultural extension workers which can assists to choose right and safer pesticide at right doses and apply them correctly as well as safely. This works as an easy interactive decision-making tool giving an option of recommended curative as well as preventive pesticides as per the recommendations of Central Insecticide Board and Registration Committee, Government of India to manage key pests in major crops. Its data aim to cater the technical needs of research managers, subject matter specialists, students and environmentalists. This software has detailed information for all the 198 approved pesticides (registered under Insecticides Act, 1968) such as target pests in different crops with doses, sprayers to be used, shelf life, environmental concerns such as impact of the pesticides on non-target



Soybean Gyan app



Crop doctor app

pest advisories generated through these platforms. Language barriers, limited awareness, and reduced trust in digital recommendations also influence farmer participation. Therefore, along with technological development, greater emphasis should be placed on farmer training, user-friendly interfaces in regional languages, strengthening rural digital infrastructure, and improving data integration systems to ensure wider adoption and effectiveness of ICT-based IPM tools.

SUMMARY

The application of Information and Communication Technology (ICT) in IPM has gained widespread adoption globally and is poised to play an increasingly influential role in shaping future IPM strategies. Providing farmers with timely and accurate information for decision-making can lead to substantial benefits either through the judicious use of pesticides that save crops worth crores of rupees or by avoiding unnecessary pesticide applications, thereby reducing input costs, minimising environmental pollution, and preserving beneficial organisms. Given this transformative impact, it is becoming increasingly clear that ICT tools particularly DSS will be indispensable components of future IPM programmes. DSS applications hold immense potential to advance agricultural productivity while promoting more sustainable and informed pest management practices.

*Corresponding author email:
tamoghna1984@gmail.com

organisms, pickers, applicators, ground water contamination, MRL (Codex Standard), manufacturers, importing source, chemical formula, structure etc. for over 723 pests on 94 crops for which the approved doses are available. Information on substitute to chemical pesticides such as bio-pesticides is also made available. Users may also create their own customized reports.

e-pest surveillance system: In 2009, NCIPM and Odisha State Agriculture Department united hands to develop and implement ICT-based pest surveillance and advisory system, also called e-pest surveillance system for cotton and soybeans crops in the state. This surveillance system is basically an internet-based system of capturing pest information from fields and producing instant and customised pest reports to the plant protection experts to advise the state agriculture agencies who further advise concerned farmers and the same information is available

for agricultural policy planners. Keeping in view the size of data and internet connectivity in remote areas, the system was designed as having offline data entry and online pest reporting and advisory.

Challenges in adoption

Despite the increasing availability of ICT-based decision support systems for IPM in India, several challenges limit their effective adoption among farmers. One of the major constraints is low digital literacy, particularly among small and marginal farmers, who often face difficulties in operating smartphone applications and interpreting advisory messages. Inadequate rural infrastructure, such as poor internet connectivity, irregular electricity supply, and limited access to smartphones, further restricts the use of these technologies in remote areas. In addition, lack of standardised and real-time pest surveillance data affects the accuracy and reliability of

National Pest Surveillance System

Launched on 15th August 2024 to enhance the surveillance and management of pest diseases across the country. The system utilises latest digital technologies such as Artificial Intelligence and Machine Learning (AI and ML) to provide quick and instant solution regarding pest attacks, crop diseases, crop damages, etc. by issuing real time crop protection advisory to the farmers. It includes a user-friendly mobile app and a portal for identification of pests and disease mitigation through integrated pest management.

