Indian Journal of Agricultural Sciences **92** (9): 1162–1164, September 2022/Short Communication
https://doi.org/10.56093/ijas.v92i8.122537

Mobile-based wide area pest surveillance and advisory services for horticultural crops in Haryana

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Received: 25 March 2022; Accepted: 26 July 2022

Keywords: Horticultural crops, Mobile app, Pest reports, Pest advisory, Pest monitoring

Tomato, Cucurbits, Crucifers (Cabbage/Cauliflower) and Kinnow are important horticultural crops widely grown in the Haryana. Per cent of the area under horticultural crops has increased to 7.07% in the last two decades which was 3.08% during 2001–02 (Anonymous 2020). The pest scenario has also changed and the epidemic appearance and vast devastation of these crops by the pests are regular features causing significant yield losses. Pest monitoring or surveillance is the foundation of Integrated Pest Management (IPM) (Grant *et al.* 2006) as compared to calendar-based treatments. Through regular and wide area pest monitoring, epidemic situations can be avoided by detecting damage before establishing a higher pest population (Sharma *et al.* 2013). Pest monitoring provides field-specific information on pest pressure and crop injury leading to the appropriate selection and application of pest management procedures by pest management experts (ISPM 6, 1997). The boom in the use of mobile devices, including smartphones and tablets are forcing the provision of services by making full use of recent communication innovations (Karetsos *et al.* 2007, Antonopoulou *et al.* 2010). Therefore for effective management of pest epidemics, technical and administrative stakeholders of State and Central agencies designed and developed a mobile-based pest monitoring and advisory system which has been successfully implemented in selected horticultural crops i.e. Tomato, Cauliflower, Cabbage, Bottle gourd, Bitter gourd, Cucumber and Kinnow in the state. The use of Information and Communication Technology (ICT) helped speed up the process of providing timely and correct management advice to the farmers, based on scientifically observed pest activity/incidence information from their fields.

Execution plan of pest surveillance: Regular pest monitoring needs a proper plan of execution to record pest incidence from farmers' fields (Singh *et al.* 2012). It was very difficult to monitor all fields and plants, therefore appropriate plans and procedures for the selection of fields, pest sampling and methods of recording pest infestation were devised to get accurate data considering time and labour requirements (Fishel *et al.* 2009), representing the whole area under the selected crops in the state. Under the pest monitoring, quantitative information about the incidence of key pests was observed by pest scouts from farmers' fields belonging to the selected villages of the state as per the pest-specific sampling plan and data formats for each crop as scheduled. Selected farmer fields were regularly surveyed starting from crop establishment to harvest. District offices of the State Horticulture Department were responsible for coordination and execution of the pest monitoring activity. The area of monitoring in each district was demarcated and the required human resource was arranged and equipped with smartphones, connectivity etc.

Village and field selection: 452 villages belonging to 9 districts of the state, growing selected horticultural crops were chosen for pest monitoring during 2018–19 & 2019–20. The villages having a maximum area under the selected crops were chosen for pest monitoring. Four fixed and four random fields of around one-acre size from each of the selected villages were selected for regular pest monitoring. These fields were selected from different directions of the village to correctly represent the estimated pest situation of the whole village. However, if more than one crop was grown in a selected village, fixed and random fields were selected based on the proportionate crop area. If the crops grown were in the equal ratio in a village, an equal number of fixed and random fields were selected for each crop. If either of the crops covered an area of more than 90% of a village, all the fields were selected from that crop. In the process, it was ensured that the chosen village represents the cluster of villages growing the selected horticultural crops.

Pest infestation observations: Data formats were devised for pest monitoring in each crop in consultation

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with crop experts to record pest infestation in the fields. Location details of the field, insect pests & disease information were major components of these data formats which were incorporated into the mobile app for capturing pest data. Each field was assigned a unique ID and its geo-special coordinates were also recorded by the mobile app while capturing pest information from the field. Other information such as the owner of the field, variety, sowing date and seed rate could also be obtained. The sampling procedures and units for recording pest infestation varied with crops and pests. A weekly plan of recording pest infestation and dissemination of pest advisories to the farmers was scheduled. Pest scouts had to capture pest infestation from farmers' fields through a mobile app five days a week i.e. Monday to Friday. The app had the inbuilt capacity to synchronise captured data with the centralised database and when got into the internet connectivity zone. Subsequently, pest experts from State agencies viewed the pest reports generated through web-based reporting and advisory application on the same day and submitted the appropriate decisions of pest management as advisory into the system. These advisories were disseminated to the registered farmers immediately through SMS.

Mobile-based pest surveillance and advisory system: Considering the constraints of pest monitoring and network connectivity in remote areas of the state, three-tier architecture-based system was devised (Sharma *et al.* 2018), comprising three functional components, viz. mobile app for data recording, a centralised database and a web-based reporting and advisory application (Fig 1). Development of the system was accomplished in various phases, in consultation with the stakeholders and by incorporating their valuable suggestions.

Database: A centralised database is the core of this system. The scope of the database was finalized through an elaborate user requirement analysis done in consultation with domain experts, a review of literature, and pest management guides (Singh *et al.* 2018). Blueprint of the database was devised and thus moved to the physical design of the database by determination of storage, access methods and structures. The database was developed using SQL Server 2012 having 20 tables which comprised 170 data points of storage for user information, location details, pest infestation and other relevant information. The database also consisted of various stored procedures for data manipulation. Database security and user access management were duly emphasized during the process of its development, which was subsequently tested and refined. In the form of a database, a solid foundation was established for the system, powering its functionality and integration capabilities and efficiently supporting application workflows and data manipulation.

Mobile App: The mobile application was developed to capture pest infestation from farmers' fields and subsequently transfer them to a centralised database. The app can work in offline and online modes and sync with the database in real-time. The app started as a standalone by introducing itself and asking the data entry operator to log in. Once, the pest scout logged into the app, it loaded the area of monitoring from the database as assigned to the scout. App comprised four modules, viz. village registration, field registration, pest data entry and farmer's mobile number registration. At the outset, the user had to register the village selected for pest monitoring and subsequently registered fixed and random fields belonging to the village selected. The Pest data entry module of the app provided a format to enter pest infestation recorded by the scouts. Once data entry was done, the app compiles the data and transfers it into the centralised database as and when gets into the internet connectivity zone. A web service was developed for the exchange of information between the app and the centralised database.

Pest reporting and advisory application: Pest reports were designed to indicate the date(s) of the pest report, the status of the pest, their distribution and the nature of the immediate or potential danger (ISPM 17, 2002). The purpose of the pest reporting was to timely communicate the potential danger arising from the pest occurrence or outbreak. Hence, a web-based reporting and advisory application were developed as a user interface to generate reports of pest data captured from farmer fields and disseminate pest advisories to the farmers. The application consisted of three major modules: admin, pest reporting and pest advisory. Admin module facilitated database management; user creation; assignment of user access rights and area of pest monitoring while pest reporting generated pest reports i.e.

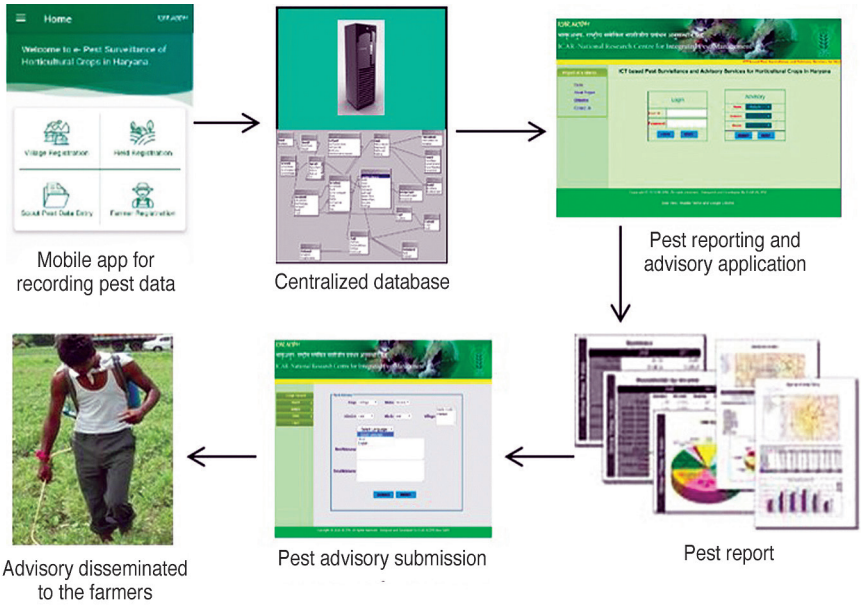

Fig 1 Structure of pest monitoring and advisory system.

Table 1 Data entries and advisories sent for pest management (2018–20)

Crop	Data entries	Advisories issued (Nos.)
Kinnow	8,570	794
Tomato	5,525	497
Cauliflower	3,460	340
Cabbage	144	9
Bitter Gourd	1,541	124
Bottle Gourd	1,456	201
Cucumber	58	6
Total	20,754	1,971

administrative reports, general pest reports and Economic Threshold Level (ETL) based pest reports. Administrative reports were designed to track the progress of various activities of the programme. The managers were able to track the progress of data entry and advisory by different monitoring units through these reports.

General pest reports provided current and temporal pest information of district/bock/village wise in tabular and graphical formats whereas ETL-based pest reports emphasised the locations having pest incidence above ETL. These reports facilitated the pest experts in taking appropriate pest management decisions to be advised to state agencies and farmers. Expert's decisions on pest management, based on the reported pest situation in farmers' fields were submitted to the system in the form of advisories, which were immediately disseminated to the registered farmers through SMS (Table 1).

SUMMARY

The development and implementation of ICT based pest monitoring and advisory system was an innovative idea to speed up the process of providing timely and correct pest management advice to the farmers. The system captured a total of 20,754 pest incidence, recorded through pest-specific scientific methods during 2018–20 and produced reports of pest status in farmer fields *vis-a-vis* pest ETL. Based on these pest reports, experts submitted 1,971 pest management advisories into the system which were disseminated to 7000 registered farmers of 9 districts of the state, through 4,49,465 SMSs during the years. The timely availability of correct pest management information greatly helped in minimising crop losses. The system also helped in the quick identification of pest hot spot areas and thus preparing the state agencies to effectively manage the pest problems in those areas. This also helped in the promotion and awareness of integrated pest management among the farmers. Implementation of appropriate pest management strategies by the farmers led to increasing in crop yield and avoidance of pest epidemics during the period. Besides, the system created a centralised pest data repository which could be utilised for drawing inferences in future. Such a database combined with a weather database could be a potential source for the development of forewarning models of insects and diseases.

ACKNOWLEDGEMENT

The authors are grateful to the Directorate of Horticulture, Government of Haryana for generous financial support to carry out the research.

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