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An ICT Based e-pest Mapping, Surveillance, Management Technique Versus Traditional System – a Comparative Study for Efficient Management of Crop-Agro Ecosystems

Surender Kumar Singh, V. K. Barnwal, Tapati Banerjee, A. K. Kanojia, Kanchan Sharma, Chirantan Chattopadhyay

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Abstract Modern pest management cannot operate without accurate estimates of pest and natural enemies population densities in the fields. To meet this requirement, an ecologically and economically sound strategy for pest management which was based upon e-pest mapping and e-pest surveillance technique was conceptualized, developed and studied. It was compared with traditional pest surveillance and management system as practiced in the developing countries like India. The e-pest mapping of paddy, cotton (using historical pest data) and soybean (current season pest data) were done. The temporal assessment of pest scenario can be depicted through the maps. The district wise index map of India was also prepared. When different parameters viz., information on pests' populations build up, quantification of plant protection inputs required, agro-ecosystem planning, pest advisories, plant protection inputs performance, various other parameters and impact analysis strategies were compared, the new Information and Communication Technology (ICT) based e-pest surveillance cum mapping was found far superior over the traditional pest surveillance and management system.

Keywords Traditional pest surveillance system, E-pest mapping, E-pest surveillance, GIS.

S. K. Singh*, A. K. Kanojia, K. Sharma
National Research Center for Integrated Pest Management, I.A.R.I., Pusa Campus, New Delhi 110012, India

V. K. Barnwal
Department of Plant Pathology, IARI, Pusa Campus, New Delhi 110012, India

T. Banerjee
Regional Station of NBSS & LUP (ICAR), Kolkata, WB, India

C. Chattopadhyay
Uttar Banga Krishi Vishwavidyalaya, Cooch Behar, Pundibari, West Bengal 736165, India
e-mail : sk_ncipm@yahoo.com
*Correspondence

Introduction

India is gifted with rich and beautiful flora and faunsadue to its diverse agro-climatic conditions. The epidemic of pests (insects, diseases, nematodes, weeds) and their intensity varies from one agro-ecosystem to another and from one season to another. These biotic stresses cause huge losses to the crop production. In the absence of availability of true picture of pest build up information during the crop season, the farmers are applying chemical pesticides on the crops in different agro-ecosystems just on time bound schedules mostly. The indiscriminate use of chemical pesticides pose certain problems like pest

Fig. 1. Index map of India showing districts.

resistance, environmental pollution, residues, harmful effects on biotic agents along with high cost of inputs. Therefore, and attempt was made to develop an economic GIS based e-pest mapping and e-pest surveillance technique and this was compared with the old traditional method of pest surveillance and management to determine and analysis the possible benefits and practical application of the new technology in managing pest epidemics intelligently.

Materials and Methods

E-pest distribution mapping of paddy and cotton had been done using the historical pest data of insect pests and diseases of these crops collected from the agencies responsible for doing pest surveillance work in India. The insect pests' surveillance data of soybean crop had been collected directly from the crop fields for the preparation of e-pest mapping. The computerized pest database was prepared for the specified years representing the major pests and diseases of these crops. An administrative map of India digitized in GIS with district as polygon and used as base map (Fig. 1). Similarly, agro-ecological region map of India collected from the institute of National Bureau of Soil Survey and Land Use Planning having 20 agro-ecological regions has been used for digitization to show pest distribution in different agro-ecological regions of the country. After the completion of digitization, different thematic layers were developed in GIS platform linking the primary fields of the maps with the database file. Over the period, the methodology was improved, studied and analyzed. The GPS (geo-positioning system) based current pests' infestation data information had also been collected by conducting pest surveillance in different districts of the state of Rajasthan, India. To analysis the practical application and benefits of this new technique, performance of different parameters in e-pest surveillance, mapping and management has been compared with the traditional pest surveillance cum management system.

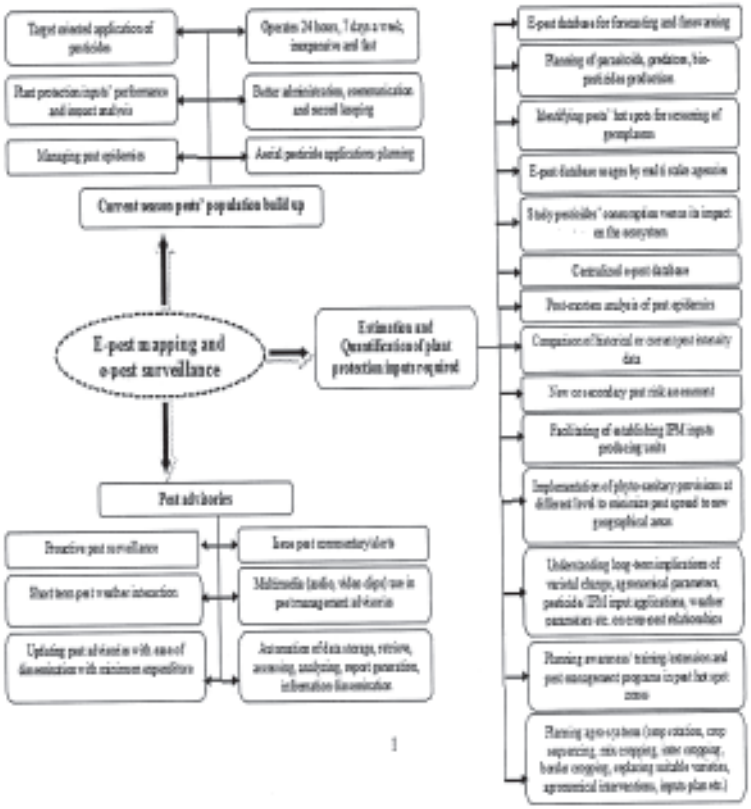

Fig. 2. Benefits of newly developed e-pest mapping and surveillance technique.

Results and Discussion

E-pest mapping of paddy, cotton and soybean crops had been done. In paddy crop, a total of 77 e-pest maps along with one index map of India and agro-ecological region map has been prepared. Similarly e-pest mapping of cotton and soybean crops have been done. By using this technique, one can easily find information about the intensity of a particular pest affecting different districts in a particular year or affecting a particular district in different years . The pest intensity attack in the form of severe, moderate, low and traces can be shown in different colored shades in the e-pest maps. The pests' attack in different agro-ecosystems can be easily studied by superimposing the agro-ecological region map over the e-pests' map. This pest database can also be updated regularly by adding the current data of the pests' infestation. E-mapping of pests' distribution and pests' hot spot areas of any crop can be done in the country by following this procedure.

By this technique, the scenario of pest infestation in a geographical region can be easily put up into a lucid map form. This e-pest mapping cum surveillance tool has numerous scope in designing and planning good pest management options for sustaining crop production with an eco-friendly way. When different key pest information and management parameters were categorized and analyzed (Fig. 2), the newly developed e-pest mapping, surveillance and management technique was found better over the traditional pest surveillance method. This tool gives users the opportunity to digitally capture data and manage it in

a dynamic, portable and safe manner and it can be easily shared and preserved. Additions of special features such as treatment details, pest infestation data entry, selective data export/import to standard GIS formats and background contextual layers including images are the additive advantages.

E-mapping of pests' distribution and pests' hot spot areas helps in understanding the pest build up easily in a larger geographical area in comparison to understand it from the bulk data as remains available in tabular form or in hard paper sheets in traditional pest surveillance system. In the traditional pest surveillance programs, the pest infestation data sheets reach to the headquarters when the crop season had already been over or the pest outbreak had already been taken place. Hardly any time left to give pest advisory to the farmers. Recent advancement of ICT along with high resolution satellite images and GPS has made the spatial distribution and analysis of pest infestation much easier with high level of accuracy from precision farming to national level. High resolution images of regular interval help to identify the pest infested area and spatial distribution, temporal assessment of pest infestation and also to monitor the result of pest management. The pest scouts, pest monitors, extension workers can collect pests' infestation and severity data during the crop season with GPS to geo--reference the infested area and can send directly e-pest database to the server along with photograph. This system can be utilized at participatory mode utilizing the farmers or stakeholders support and help. Accordingly, e-distribution maps of pests and pests' hot spot areas of an agro-ecological region can be created during the crop season itself. It will help in taking right pest management decision at right time and at right place with regular updating. Mapping of pests through this e-pest surveillance program can be supervised by the central or state plant protection personnel and they can release pest adversary/conmmentary/pest alerts/pest management information through SMS (short message service) or through mobile phones on the specific region during the crop season itself. This land to lab. and lab. to land approach can help to take timely action and facilitates prevent of pests' outbreak. By sound e-pest monitoring system, the farmers can save money and reduce the pesticide use, which at the end benefits the environment and human health.

E-pest mapping and surveillance facilitates in knowing pest hot spot areas, pest free areas and current scenario of pest build up in an area. Accordingly, this information can be utilized in planning and designing good pest management strategies. E-pest mapping and surveillance information database can be used in estimation and quantification of plant protection inputs required i.e., planning of parasitoids, predators, bio-pesticides production, identifying pests' hot spots for screening of germ-plasms, study pesticides' consumption versus its impact on the ecosystem, post-mortem analysis of pest epidemics, comparison of historical or current pest intensity data, new or secondary pest risk assessment, facilitating of establishing integrated pest management (IPM) inputs producing units, implementation of phyto-sanitary provisions at different level to minimize pest spread to new geographical areas, understanding long-term implications of varietal change, agronomical parameters, pesticide/IPM input applications, weather parameters on crop-pest relationships, planning awareness/training/extension and pest management programs in pest hot spot zones. It can also help in planning agro-ecosystems i.e. crop rotation, crop sequencing, mix cropping, inter cropping, border cropping, replacing suitable varieties, agronomical interventions, inputs plan. The pest advisories viz., proactive pest surveillance, issue pest commentary/ alerts, short term pest weather interaction, updating pest advisories with ease of dissemination with minimum expenditure, multimedia (audio, video clips) use in pest management advisories, automation of data storage, retrieve, accessing, analyzing, report generation, information dissemination can be easily managed. The current season pests' population build up i.e., target oriented application of pesticides, plant protection inputs' performance and impact analysis, managing pest epidemics, operates 24 hours, 7 days a week, inexpensive and fast, better administration, communication and record keeping, aerial pesticide applications planning can also be easily done in a economical and efficient way.

Global scenario of pest distribution maps, pest modeling, and pest forewarning using GIS had already been studied in many countries like U.K., Uganda,

Finland and Australia. Quantitative alternatives to multi-criteria/weighted-average approaches for combining multiple spatial data layers into a single map of species risk had already been explored [1]. Attempts had also been made to determine optimum sample size as well as the distribution of survey hexes/points in order to stipulate freedom from a particular insect or disease based on a risk map for the pest [2]. For the prediction of the geographical extent of future damage from pests, the distributions of these pests had also been mapped in Eastern United States [3]. To improve decision-making and the assessment of government investment programs, the national mapping of the abundance of established, new and emerging pest animals had also been attempted [4].

India, being a large country, it is difficult to visualize the pest intensity in different crop growing regions at a glance. In India, the climatic variations especially the uncertainty of rainfall along with the increase of temperature and evaporation invites pests' incidence which are the major reasons for low crop productivity. In the area of plant protection, e-pest distribution maps prepared on the basis of this information offer such capabilities which at present is lacking in agricultural systems particularly in the developing countries. In addressing the farming community, which drives the economic growth of the developing countries, e-mapping of pests' distribution during the current crop seasons through e-pest surveillance programs will be of vital importance. In the long run, the database would be used for understanding long-term implications of climate change and such other phenomenon on crop-pest relationships in a particular agro- ecosystem. Finally, it can be concluded that e-mapping of pest and pest surveillance will be very useful for the country to plan good pest management tactics and policies. It will help in designing and planning the cropping systems/sequence for a particular agro-ecosystem in an economic manner.

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