Journal of Applied and Natural Science 10(1): 262 - 265 (2018)

A smart precision plant protection technique based upon information and communication technologies for field crops in India for wide-area implementation

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Received: September 13, 2017; Revised received: September 28, 2017; Accepted: January 31, 2018

Abstract: A smart and modern technique based upon information and communication technology (ICT) was conceptualized and developed. It facilitates pests' information collection timely, its fast processing and planning with quickly implementable options - to manage biotic stresses on field crops on large-scale area basis. The pest mapping in field crops (paddy, cotton) in different agro-ecosystems of India was done based on using Geographic Information System (GIS) Arc-info package. To fast track the decision-making, its mass communication to farming community, an exhaustive e-database of plant protection measures as recommended by different agencies in the country for different field crops *viz.,* cereal crops, oilseed crops, pulses, fibre crops, sugar crops, fodder crops etc. - had also been prepared and digitized. The outcome and benefits of this technique had been analyzed and findings - that demonstrate the benefits of using the proposed architecture are also detailed.

Keywords: Cotton, Database, Field crops, GIS, ICT, IPM, Paddy, Pesticides

INTRODUCTION

India is blessed with diverse flora and fauna. Pest build -up and their outbreak intensity vary from one agro-ecosystem to another and from one crop season to another. These biotic stresses cause enormous economical losses to the crop production in the country time to time. In the lack of actual picture of pest-build-up information timely in different agro-ecosystems, the agrarian community has to apply chemical pesticides on the crops at calendar –based schedules. Industrialization of agricultural sector has further increased the chemical burden in the different agro-ecosystems. Indiscriminate application of agrochemical lead to widespread its toxic residues in the environment, causing significant contamination of terrestrial ecosystems and poisoning human foods (Carson, 1962). It also lead to the problems of pest resistance, environmental pollution and harmful effects on beneficial biotic fauna along with high cost of inputs (Goulson, 2014; Pimentel *et al*., 2014 Chourasiya *et al.*, 2015; and Pirsaheb *et al.,* 2015). Therefore, there is an urgent need of innovative ideas and techniques to tackle the indiscriminate applications of chemical pesticides on agro-ecosystems. Hence, the present study was conceptualized and done to digitize and map the pest build-up information in the different agro-ecosystems of the country as well as digitization of pest management recommendations to fast track the decision-making process and its implementation through electronic mode of mass-communication.

MATERIALS AND METHODS

The precision plant protection technique for field crops in India was conceptualized, developed and studied using information and communication technologies ICT during the period of 1998-2015.

An electronically-operated smart and modern mode of system of pest mapping and issuing pest-management recommendations on large-scale net-working basis was developed and studied to tackle the short-comings of traditional manual pest surveillance, reporting and pest management programmes prevailing in the country. To begin with, strengthening of pest-management information-base was done by collecting the plant protection measures as recommended by different State Agricultural Universities of India. The plant protection measures as recommended in the package of practices of *kharif* and *rabi* crops by different state agencies of India *viz.,* Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar, Odisha, Assam, Karnataka, Kerala, Tamilnadu, Gujarat, Maharashtra, Andhra Pradesh, Madhya Pradesh, West Bengal and others were collected and digitized to bring all information at one place. This information-base included plant protection recommendations for different

ISSN : 0974-9411 (Print), 2231-5209 (Online) | journals.ansfoundation.org

agricultural field crops *viz.*, cereal crops, oilseed crops, pulses, fibre crops, sugar crops, fodder crops etc. The plant protection recommendations had been arranged crop wise so that they can be easily accessed. The pests were arranged in columns and these recommendations of each state were arranged in row for each pest (Puri *et al.,* 1999).

To know the pest build-up scenario in different agro-ecosystems of the country and to identify the pest hot spot areas in different agro-ecosystems, an innovative technique for the preparation of e-pest distribution maps based on Geographic Information System (GIS) Arc-info package had been used and studied. An administrative map of India digitized in GIS with district as polygon was used as a base map (Fig.1) (Puri *et al.*, 1998). E -pest distribution mapping of cotton (Fig.2) and paddy (based upon historical pest data as collected from the agencies responsible for doing pest surveillance work in India) and soybean crop (based upon current season data from soybean growing belt of Rajasthan state, India) had been prepared with the help of multi-disciplinary teams and agencies to initiate the programme. 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 had been used for digitization to show pest distribution pattern in different agro-ecological regions of the country.

RESULTS AND DISCUSSION

The newly developed ICT based precision plant protection technique was found effective and unique as compared to the traditional manual pest surveillance and management system. The information-base provided consolidated information on different key pests attacking major crops in different agro-ecological regions and their management recommendations at one place which had paramount importance. In traditional system, information was not readily available on the pest status and management options for plant protection in different agro- ecosystems. Due to this vital technical and information gap, correct pest-management decision making was difficult. Spectrums of different pests are found in different agro-ecological regions and they need to be tackled locally. Pest management decision-tools are important components of sustainable agriculture and these are dynamic and location specific in nature. Earlier the information was scattered, non-cohesive and it was difficult to locate the right information on various aspects of plant protection. As the plant protection recommendations had been arranged crop-wise, hence, these can be easily accessed from this information-base. The digitization of pest management information helped in analyzing and quick retrieval of information for fast decision-making. It will work as ready-reference for policy-makers and plant protection specialists.

Mapping of pest build-up information during the current crop-season in different agro-ecosystems can facilitate in taking precision plant protection decisions in the targeted hot spot areas timely. The advance plan-

Fig. 1. *Index map of India showing districts.*

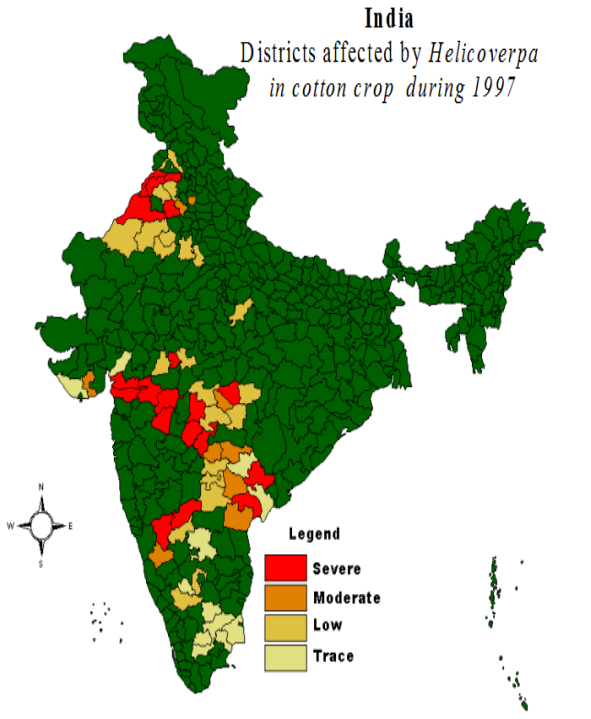

Fig 2. *Helicoverpa* severity in cotton crop in different districts of India.

ning can also be made to manage the up-rising pest-build-up population. Using this technique, mapping of *Helicoverpa armigera* severity in cotton crop in different districts of India had been prepared and depicted in Fig. 2. The severe, moderate, low and traces population of the pest had been easily shown with help of different colour shades in the country map. Following this technique, pest mapping in different agro-ecosystems of the country can be easily done utilizing either the historical pest data or current pest build-up data. The pest information-database can easily be up-scaled as and when required. Pest mapping of the current crop-season can be done by employing the pest scouts who can take the responsibility of collection of the pest-build-up data information and send it to the central data processing unit through on-line means. Need-based modifications as per the requirement of a particular crop and its associated pest complex can be made to achieve the desired outcome. With the help of the technique, it becomes easy to find out the information about the intensity of a particular pest affecting different districts in a particular year or affecting a particular district in different years etc. Pest build-up information through maps in different agro-ecosystems can be easily visualized and understood in comparison to the tabular form of pest data as remained available in the old traditional plant protection system. Pest build-up in different agro-ecosystems can be understood by superimposing the agro-ecological region map over the e-pests' map. This e-pest mapping technique along with strong database of plant protection recommendations of different agro-ecosystems has numerous scopes in designing and planning smart pest management options for sustaining higher crop yield. Some related studies on mapping of zones for plant introduction and pest mapping had also been done by a few research workers (Bacon *et al.,* 2014, Bebber *et al.,* 2014, Peter, 2011 and Sutherst, 2014) and results were found encouraging. E-pest mapping can be supervised by the experts and policy makers. They can issue e-pest adversary/ commentary/ pest alerts/ pest management information timely through SMS (short message service) or through mobile phones for the specific agro-ecosystem(s) during the crop season itself. The plant protection alters and advisories based upon the real picture of pest build-up and targeted in the pest hot spot areas just at the initiation of pest build-up situation may save the ecosystems, resources and helps in conservation of beneficial fauna and also minimise the inputs costs.This technique may help in the establishment of a national pest information platform for extension, education and policy making on a very large canvas if implemented on a national level in future. For the prediction of the geographical extent of future damage from pests, the distributions of these pests can also be mapped. This unique technique will afford and enhance outreach to different agro-ecosystems in a fast and quick manner. This technique has features of pest build-up assessments, mapping, easily available digitized pest management information-base that had been built from the assumption that plant protection specialist alone cannot individually interact with each farmer at that scale. Governments all over the world are also trying to adopt Information and Communication Technology (ICT) based solutions for improving internal productivity as well as strengthening of interfaces with citizens. India, being a large country having diverse agro-ecosystems, it is difficult to assess and visualize the pest build-up scenario at a glance through the pest data in tabular form as remained available in old traditional system. This technology can help in early detection programs and assist in resource planning and prevention activities. This innovative technique was found effective in visualizing the pest build-up in a lucid and concise way in the different agro-ecosystems facilitating in taking precision plant protection decisions.

Conclusion

An economically viable and ecological sound precision plant protection technique based upon ICT technology was developed, studied and up-scaled to fast track the decision-making process and its execution in field crops on large-scale area in India. The technique will facilitate timely to know the pest build-up scenario in different agro-ecosystems of the country which will lead to fast and quick decision-making. Timely pest management implementation will certainly manage the biotic stress in field crops and minimize the crop losses. Easily available digital location-specific pest-management recommendations will further facilitate in issuing alters and providing pest-advisories communication to the farming community on mass-scale in targeted locations. Need-based modifications as per the requirement of a particular field crop and its associated pest complex and along- with management options can also be updated easily to achieve the desired outcome. This innovative technique facilitates in visualizing the pest build-up in the different agro-ecosystems of the country in a lucid and concise way and also helps in taking precision plant protection decisions and their electronic communication on mass-scale

ACKNOWLEDGEMENTS

The author is thankful to all the colleagues for their help and support. He is also thankful to Director, NCIPM, New Delhi for all the encouragement and providing the facilities for this work.

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