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An innovative electronic technique to manage biotic stresses of different crops timely

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ABSTRACT

To manage biotic stress of insect pests and diseases of field, vegetable and horticultural crops timely, an electronic technique was developed, studied and analyzed. Mapping geographical distribution of crop pests and current pest build-up scenario using Geographic Information System (GIS) Arc-info software techniques were analyzed. The bottleneck was identified. It became known that the recommended plant protection measures as recommended by local state agencies are not available at one single centralized platform. As a result, it becomes difficult to manage biotic stress (es) quickly. To solve this technical limitation, the present study was made and a centralized platform was developed wherein the electronic databases of the plant protection measures was incorporated to manage the biotic stress (es) of field, vegetables and horticultural crops. A network of pest mapping, e-pest surveillance during current crop season and facility to assess the recommendation of plant protection measures was developed to reach the farming community at large-scale.

Key words: An electronic technique, biotic stresses, recommended plant protection measures, IPM, databases.

Climatic variations, its uncertainty and losses caused by biotic stress (es) are major reasons for the low crop productivity of field, vegetable and horticultural crops in different agro-ecological zones. In vast agro-ecological areas, it becomes difficult to assess and analyze the intensity of biotic stress (es) in different crops. Crop failure may happen in case of serious outbreak of biotic stress(es) and cause around 20–30% of global agricultural losses each year (Karthikeyan *et al.,* 2020; Nayak and Solanki 2021). Indiscriminate calendar based applications of chemical pesticides to manage biotic stress are further exaggerating the situation. It cause harm to environment, including around 25% of worldwide soil deterioration and 30% of biodiversity loss in crop fields (Midler, 2022). These chemical pesticides put a wide range of acute and long-term health impacts in humans, including neurological impairment, reproductive issues, cancer, congenital anomalies, and immunological abnormalities (Upadhayay *et al.,* 2020). Nowadays, agro-ecosystems have become more demanding in order to fulfill the increasing market for food and fiber (Tang *et al.,* 2025). The average amount of chemical pesticides applied worldwide was 2.4 kg ha^{-1} in 2022 which is twice as was recorded in 1990 (Tang *et al*., 2025). Approximately 40% of nations surpassed this figure in 2022, while between 2008 and 2018, the use of chemical pesticides increased by about 150% in low-income countries (Shattuck *et al.,* 2023; FAO 2024). A spectrum of different pests are found in different agro-ecological regions and it required to be managed locally. Integrated pest management (IPM) is an important component of sustainable agriculture and is location specific. It is a pest management system that includes all suitable techniques, tools and methods in a compatible manner to keep pest populations below those causing economic injury, within the context of the associated environment and population dynamics of the

pest species. To implement it, consolidated information on pest management measures and quick asses to it, is the basic requirement. This information platform is lacking in the field of plant protection sciences. Therefore, the present study was done to fulfill the gap to manage biotic stress (es) timely.

Materials and Methods

An innovative electronic technique was developed to prevent and manage biotic stress (es) of different field, vegetable and horticultural crops. It was analyzed and up-scaled over a period of 1997-2023. This technique consists of three component pronged strategy (Fig. 1,2,3,4). The first component includes e-pest mapping technique to identify pest hot spot(s) based upon historical pest build-up data. The second component includes real time e-pest surveillance technique to capture and store current crop season's pest build-up status. The third component consists of e-databases of pest management recommendations for different field, vegetable and horticultural crops across different agro-ecosystems as recommended by different local State Govt. agencies. The technique developed earlier for mapping hot-spot(s) of paddy, cotton and other crops (Puri *et al*., 1998; Singh *et al.,* 2017) was used to analysis the practical applicability and the bottleneck in it. The first component where the historical pest data of insect pests and diseases of the crops were collected from the agencies responsible for doing pest surveillance work in India. Based upon these historical data, mapping of pest hot-spot(s) of insect pest and diseases of the different crops were made. The pest data of these crops were obtained from the Directorate of Plant Protection, Quarantine and Storage (DPPQ&S), Ministry of Agriculture, Govt. of India and All India Coordinated Research Project (AICRP) and Indian Council of Agricultural Research (ICAR). These data were the outcome of regular

surveys conducted by these organizations on insect pests and diseases in different crop growing areas of the country. After creating the database, the map of India was digitized with state as well as district boundaries using Geographic Information System (GIS) Arc-info software package. Each district was marked with a particular identification number. Topology was created after digitization of the base map to link all the polygons with district identity number. All the dbfs containing the pest data were converted into Polygon Attribute Table (PAT) for GIS usage. The different shades were selected to identify the severe, moderate, low and trace intensity area. A separate key file was also created for shading to show the pest intensity. Arc plot of GIS Arc info was used to plot the map on the screen as well as to get the print out.

Agro-ecological region map of the country was collected from National Bureau of Soil Survey and Land Use Planning (NBSS & LUP, ICAR) having 20 agro-ecological regions. An index map of India was also prepared indicating serial number against each district. India map with district boundaries prepared by National Atlas and Thematic Mapping Organization (NATMO) Calcutta (Govt. of India) has been used for digitization through GIS as a base map. The first component was studied and analyzed. The gap in the technique was identified. It was found that the pest hot-spot(s) were made based upon historical data only. This technical gap was overcome by putting the current season's pest build-up data. The current crop season's pest build up data of soybean crop (District Kota, Rajasthan, India) was collected through field observations from selected farmers' fields using the prescribed data collection formats to develop digital database and for the preparation of e-pest mapping for the current crop-season's pest build-up. Now, the need was arise to issue the pest prevention and management strategies to the concerned

farming community quickly and timely. The quick asses to the recommended plant protection measures as recommended by concerned local state authorities were not found available at a single centralized platform. To remove the bottleneck, under the third component, an effort was made to put together the scattered information on plant protection measures recommendations for field, vegetable and horticultural crops in different agro-ecological systems at one place for ready reference in the form of e-databases. The plant protection recommendations from different states of India *viz.,* Jammu and Kashmir, Himachal Pradash, Punjab, Haryana, Rajasthan, Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh, Gujarat, Maharashtra, Assam, Manipur, Karnataka, Andhra Pradesh, Kerala and Tamil Nadu have been included in it. The pest management recommendations of different states were arranged crop-wise. The pests were arranged in columns and these recommendations of each state were arranged in row for each pest so that it can be easily accessed.

The main focus of the study was to interlink the three components *i.e.,* mapping pest hot spot(s) based upon historical data, e-pest surveillance during current crop season and e-database of plant protection measures as recommended by local state agencies.

Results and Discussion

The networking ease of operation and the feasibility of the present technique were studied. The identification of pest hot-spot(s) of any crop based upon historical pest data can be mapped. The pest data of any set of years can be put into the technique and it can map the pest hot-spot(s) and its intensity level severe, moderate, low and trace. It can indicate the affected areas clearly by the biotic stress (es). It can facilitate

to find information about the intensity of the pest affecting different districts in a particular year or affecting a particular district in different years easily.

The technology facilitated to locate the pest hot-spot(s) across different agro-ecological zone(s) in a concise and understandable form which otherwise is difficult to visualize from the annual text reports which contains the information in written, tabular and figure based form(s) only. As the biotic stress(es) prevention and management measures has to be taken during the on-going cropping season; the mapping of pest build up status through e-pest surveillance during the current crop season's, solved the earlier gap where historical data was only used for pest hot-spot(s) mapping. Under this, the pest data from the targeted crop was collected from the farmers' fields during the on-going crop season itself.

It facilitated to earmark the pest intensity areas into severe, moderate, low and trace. Now it needs quick asses to the specific plant protection measure(s) as recommended by concerned local state agencies. As this requisite information was not available in consolidated form in single central platform. The third component of the technology developed under this innovative electronic technique *i.e.,* e-databases of plant protection measures for field, vegetables and horticultural crops assisted to play its role to fill this gap. As it being the electronic databases, therefore, it is easy to assess the information or the concerned area-specific plant protection measures of the targeted crop of the zone. The timely pest management action can lead to minimize the upsurge of the biotic stress (es) on a wider area basis. The community level pest management strategies can also be initiated to manage the biotic stress in the concerned agro-ecological area(s) by applying this technique. Some of the biotic stress can only be managed affectively by motivating

and creating awareness at right time. Sometime, community mobilization is also required to act in cohesively to prevent the pest build-up and its spread. Timely information of pest build-up during the on-going season can also facilitate to implement alternative pest management strategies to replace the calendar based chemical pesticide application(s). The e-pest surveillance data of insect pests of soybean crop from district Kota, Rajasthan, India was collected and it followed the pest management advisories dissemination based upon the plant protection measures recommended.

The plant protection measures recommendations can be quickly disseminated through different social media (WhatsApp, SMS and Instagram etc.) among the farming community, policy makers, plant protection functionary etc. in different agro-eco zones so that the timely action can be taken. All the three components are interlinked and work in a networking to implement the integrated pest management programme. This technique can be applied to any crop *i.e,* field, vegetable and horticultural crops. It can be implemented for any country or any region(s) to manage the biotic stress (es) timely. The resources can be judiciously used and it may lead to save environment and to produce safe food.

Global scenario of pest distribution maps, pest modeling, pest forewarning using GIS had also been studied in many countries such as United Kingdom, Uganda, Finland and Australia (Kanojia *et al.,* 2002) and found an effective technique.

Good Pest management practices are essential to minimize the losses caused by pests. Spectrums of different pests are found in different agro-ecological regions and they need to be tackled locally. Since IPM is an important component of sustainable agriculture and is location specific, consolidated information on different key pests attacking major crops in different agro-ecological regions and their management is of paramount

importance.

In India, diverse agro-climatic conditions of the country permit growing of several field, vegetable and horticultural crops around the year. The comprehensive information on recommended plant protection measures is not available at a single central platform generally leading to non-judicious and indiscriminate use of chemical pesticides on the crops. Quick access to recommended plant protection measures is one of the pre-requisites for integrated pest management (IPM).

Though the researches on various aspects of pest management were intensified in many parts of the system(s), the information on plant protection measures recommended by different National Research institutes, Plant Protection Centres and State Agricultural Universities was scattered and was non cohesive. The present technique having electronic pest databases of field, vegetables and horticultural crops solved this gap. As the information has been arranged crop-wise, therefore, it can be easily accessed. Crop-specific pest management advisories can be disseminated during the crop season itself.

It can be concluded that this innovative electronic technique which consists of pest mapping, monitoring and management option at one central platform will solve the indiscriminate application of chemical pesticides on different crops. This will serve as an important technique in biotic stress (es) management timely and precisely. The technology can be replicated for any other crop and can be implementing in any other country to manage the biotic stress (es). It will also be useful for researchers, policy makers and extension workers for planning the plant protection strategies.

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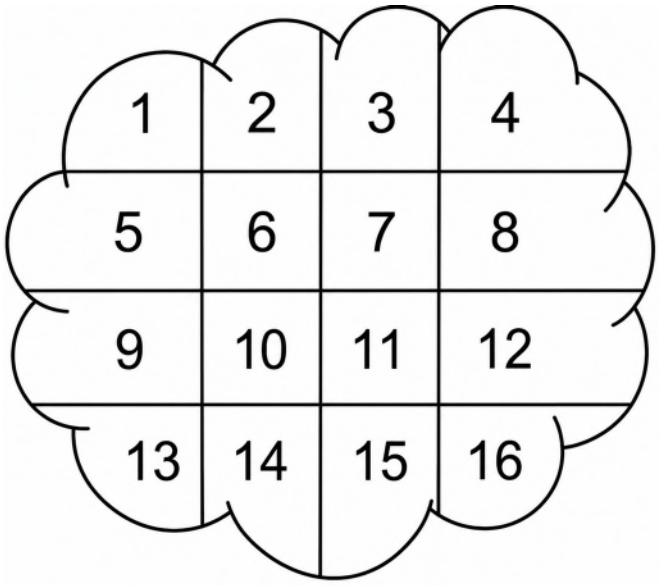


Fig 1 **: A symbolic index map of any place/ region/agro-ecosystem/country**

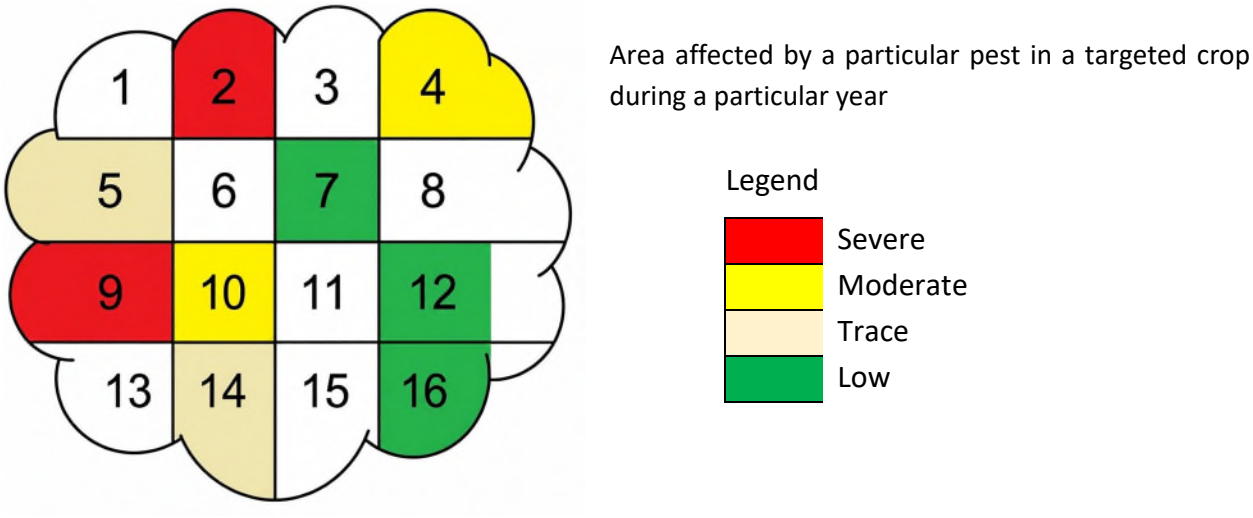


Fig 2. A symbolic pest severity in a crop in different parts of any place/ region/agro-ecosystem/country

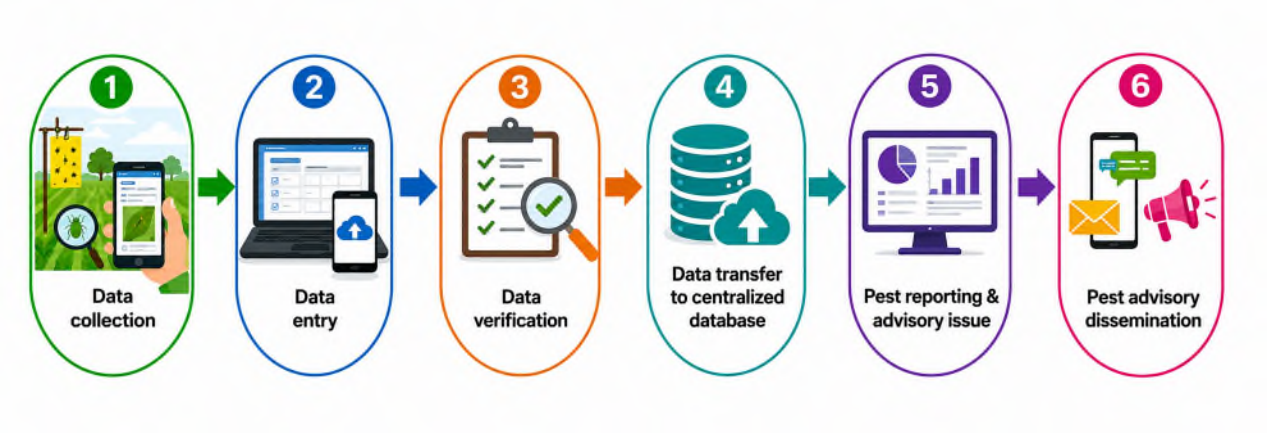


Fig 3**: Current –season e-pest surveillance plan**

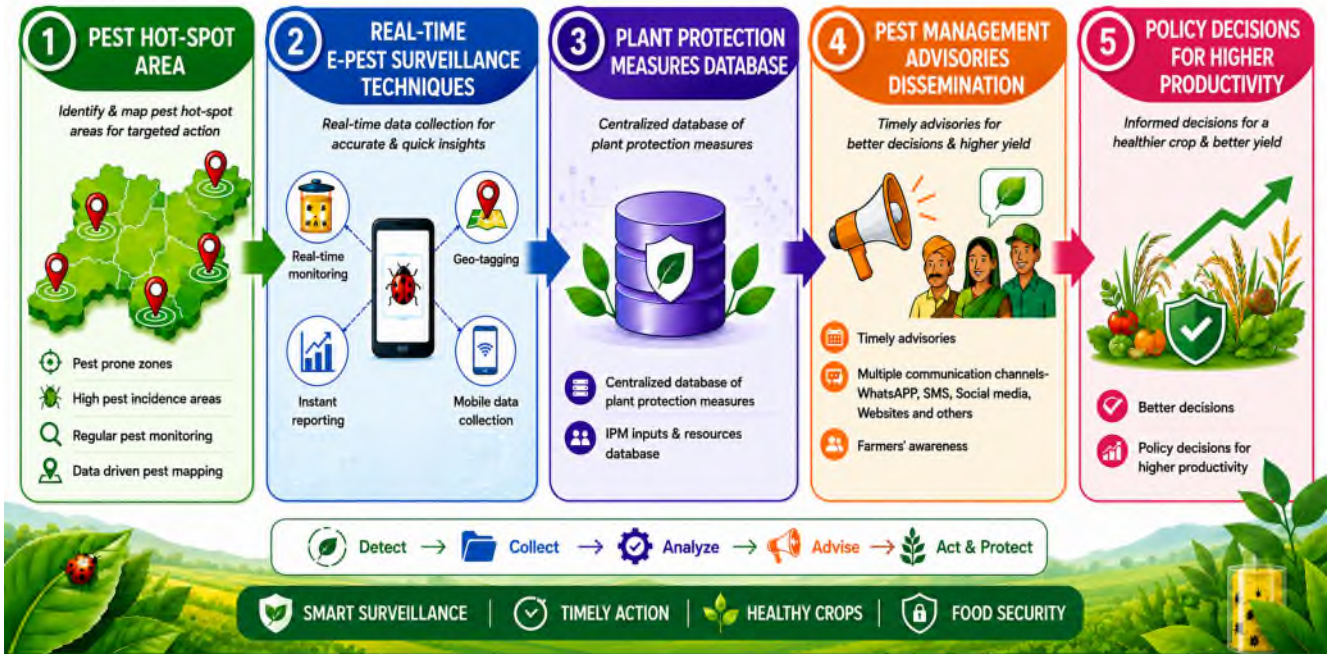


Fig 4 : Net-working of this innovative technology