INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

BENGALURU

EVALUATION OF RKVY PROJECTS

OF

UNIVERSITY OF AGRICULTURAL SCIENCES,

RAICHUR

"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"

INSTITUTION OF AGRICULTURAL TECHNOLOGISTS,

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CONTENTS

"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"

EXECUTIVE SUMMARY

Given the changing climatic conditions, and unreliable and erratic rainfall pattern that require adoption of new types of crops and farming skills. Farmers are mostly in desperate need of information on modern farming methods and practices that can increase the yields of their farms. The highly variable rainfall of 400 -6000 mm distributed across 40-100 rainy days besides the extreme weather events cause significant variability of crop yields. The low productivity of crops is also due to imbalanced input uses, gap in access to modern technologies and absence of technological break throughs post green revolution. In meeting the need and to improve agricultural productivity, mobile-based phone technology can be leveraged to provide farmers with timely, relevant and accurate agricultural technological information ranging from farm preparation to pre-harvest and post-harvest crop and farm produce management. Indeed, access to mobile-phone connectivity has empowered the consumers and is significantly driving economic growth as users can now access most essential services including market financial services and credit facilities, health and education services, and utilities through their mobile phones to ensure food security and to improve agricultural productivity, mobile-based phone technology has been exploited and leveraged to provide farmers with relevant, accurate, timely and consumable agricultural information ranging from farm preparation to pre-harvest and post-harvest crop and farm produce management.

This includes information on pest and disease control, precision farming and irrigation, market availability and produce pricing, access to credit facilities and extension services among others including livestock management.

Crop yield losses due to insect-pests, diseases, weeds, nematodes and rodents range from 15-25% in India, amounting to 0.9 to 1.4 lakh crore rupees annually. Although pesticide use per hectare (0.57 kg/ha) is lower in India and Maharashtra ranks third (0.73 kg/ha) after Andhra Pradesh and Punjab, pesticide residues in produce have been high mainly due to the indiscriminate use of chemical pesticides (Vennila et al, 2016). In addition, lack of awareness on the label claims and waiting periods before harvest aggravates the problems. Farmers are also unaware of the environment friendly bio-pesticides that constitute 4.2% of the India's total pesticide market. Surveillance of crops to detect early signs of buildup of pests and diseases is crucial for the success of IPM. For timely and effective intervention in the face of an emerging pest/ diseases situation, it is necessary for the surveillance data to be interpreted by technical experts and advisories

issued in real time. Delay in issuing an advisory could lead to a breach of the economic threshold level of the pest leading to loss in production and quality. Rashtriya Krishi Vikas Yojana (RKVY) launched by Government of India during XI Plan provided flexibility to choose innovative and pervasive use of Information and Communication Technology for reaching out to the farmers to assess the pest scenario in their fields, and for issue of real time pest management advisories through short message service (SMS).

A web-based decision support system called e-pest surveillance system (CROPSAP) was developed and implemented for effective and regular pest monitoring in soybean [*Glycine max* (L.) Merrill] and cotton (*Gossypium spp*) crops in Maharashtra. These systems are being implemented in different states like Odisha, Punjab, Madhya Pradesh and Haryana.

The success of CROPSAP in Maharashtra in field crops motivated the officials of Department of Horticulture of the Maharashtra State to adopt ICT-based pest surveillance for horticultural crops. ICAR-NCIPM with its expertise in ICT-based pest management solutions in collaboration with multiple institutions of Indian Council of Agricultural Research with State department officials of horticulture and farmers of target fruit crops are involved in programme implementation. Horticulture pest surveillance and advisory project (HortSAP) – Maharashtra, was initiated from 2011-12 initially for Mango, Pomegranate and Banana followed by the expansion to other fruit crops *viz.,* Sapota, Orange (Nagpur Mandarin) and Sweet Orange (Mosambi) since 2014-15.

"E-National Pest Reporting and Alert System" in pulse crops is a unique ICT based decision support system, which is very effective and easy to operate through a centralized server system at National Centre for Integrated Pest Management (NCIPM), New Delhi, connected with internet and mobile phones. This system has developed to cater to the needs of rural farmers of India, who grow pulse crops.

Keeping the above in view, the project, **"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"** was sanctioned under Rashtriya Krishi Vikas Yojane (RKVY) during 2014-15 and was taken up by University of Agricultural Sciences, Raichur. Dr. A. Prabhuraj, Professor of Entomolgy, College of Agriculture, Raichur was the Principal Investigator. Originally e-surveillance in Rice, Cotton and Soybean was taken up in Raichur, Bidar, Koppal, Yadagir and Ballari. The details of the project are as under:

1.	**Title of Project**	**:**	**"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"**
2.	**Nodal officer and Principal Investigator**	**:**	**Dr. A. Prabhuraj,** Professor of Entomology and Project Leader, College of Agriculture, University of Agricultural Sciences, Raichur
3.	**Implementing Institution (S) and other collaborating Institution (s)**	**:**	College of Agriculture, Raichur, ARS Bidar, Gangavathi, Koppal, Ballari and Yadgir
4.	**Date of commencement of Project**	**:**	2014-15
5.	**Approved date of completion**	**:**	2014-15
6.	**Actual date of completion**	**:**	2014-15
7.	**Project cost**	**:**	Rs. 81 lakhs

OBJECTIVES

The objectives of the project were as under:

1. To provide pest identification and latest pest management strategies to the farmers of the region for major crops
2. To generate pestilence data in the selected districts based on regular sampling.
3. To develop additional features that significantly enhance the functionalities of e-SAP.
4. To empower field staff of e-SAP of the selected districts of the region.

The focus of Evaluation is:

1. to understand the effectiveness of the e-SAP tool in identification, quantification and intensity based recommendation for management of pests.
2. To assess whether e-SAP tool is effective in sending advisories to farmers for management of all pests.
3. To examine whether farmers are in a position to understand the severity of pest problem and are able to take up management efforts for better control of pests and higher farm returns.
4. To examine whether e-SAP tool can be standardized to extend the services to farmers in management of pests in different crops.

5. To examine whether information generated by e-SAP tool can be effectively used to lay down policy guidelines in management of pests.

The intention of the project is

a. To evaluate the effectiveness of e-SAP in issuing advisories to farmers for management of pests.
b. To examine whether the tool can be further improved to cover more crops and
c. To evaluate whether e-SAP tool can be used to generate and analyse data on pest intensity overlaid with climatic variations so that effective prophylactic measures can be initiated for effective management of the pests.

FINDINGS AND DISCUSSION

Use of the tool of Information and Communication Technology (ICT) in survey of incidence of pests and diseases is a systematic and rigorous approach to pest surveillance and management. It speeds up the pace of IPM implementation on a wider area through adoption of pre-emptive actions of pest management which could mitigate the impending pest outbreaks, and could showcase the minimization of yield losses due to crop pests *vis a vis* success of IPM. e-pest surveillance using Electronic Solutions against Agricultural Pests (e-SAP) is a path-breaking ICT system dedicated for crop health management. The scientists at the University of Agricultural Sciences, Raichur have successfully developed the application. The application which was initially confined to few crops and districts has been extended to a total of 40 crops including horticultural crops and to the entire state.

The e-pest surveillance was initially confined to soybean crop in Bidar, paddy in Koppal and Ballari and cotton in Raichur and Yadgir districts. Encouraged by the positive response received from farmers and field functionaries, the surveillance was extended to a total of 40 crops including horticultural crops and was extended to the entire state. The application now acts as a connecting link among all stake holders (Farmer – Field Officer – Scientist – Administrator – Policy maker) in agriculture and horticulture on a single platform in real time in the field of crop health management.

Scientific survey protocol has been developed for identification, quantification of pests and for management solutions. Totally 17 experts in Agriculture and 17 experts in Horticulture have been enrolled for validation of the management strategies as advisories to cover over 40 crops and for content management.

Device management is being done by experts in the field. The software is upgraded to the latest Android version (6.1 and above) and made device independent.

More than 1,000 extension officers in the Departments of Agriculture and Horticulture have been trained is using the application. An important feature of e-SAP is

the ability to capture farmer-specific data in the field and build database of the activities of each farmer. All relevant details of each farmer and the crop raised, including acreage, images, etc., are captured on the field device and a database is created in the cloud, which is accessed through the web application. Every farmer is identified by a unique number with which a log of all his activities across time is created and made available for further use. Also, opportunities to capture any information on farm activity are made available.

Fields belonging to more than 32,000 farmers have been surveyed under e-pest surveillance and more than 1,00,000 advisories have been given. The application has been found to identify pest incidence with 90 to 95% accuracy.

While selling ineffective (and sometimes, spurious) substances has drastically come down and the quantity of pesticides applied has also been according to the prescription, which has reduced indiscriminate usage of pesticides, quantification of savings on use of pesticides is yet to be done.

Impact

A study on "*perception analysis of e-SAP by farmers in the districts of implementation of e-SAP*" conducted by the Extension Department has revealed highly positive response from the farmers (70% of the sample farmers gave positive response) regarding the power of the technology in all aspects of crop protection. e-SAP has helped farmers overcome a major difficulty - reliable identification of their crop pest problems. Further, e-SAP has effectively driven the concept of quantification of the pest problem and has introduced the concept of pest-intensity based management system. Today, many farmers are receiving printed prescriptions to carry to the retailers and demand the same chemicals to be given to them.

Scientists have discovered many new pest problems in their areas of operation through e-SAP. More important has been the fact that identification of the new problems and their pest management strategies can be disseminated to the field devices in just minutes, such that the field users can henceforth manage these problems by themselves. Certain area-wide decisions have been taken by managers on the basis of data made available in real-time through e-SAP system.

Use of “e-pest surveillance system” as a tool in pest management, benefited the farmers in terms of lesser pest incidence vis-à-vis conservation of beneficial insects by timely action with appropriate plant protection measures and popularisation of eco-friendly management practices. The programme also benefited in terms of employment generation, knowledge sharing among technocrats and efficient extension of pest management technologies. This technology applied 1st time for the purpose of pest management in India resulted in encouraging response from all the stakeholders.

Electronic Solutions against Agricultural Pests (e-SAP), a novel ICT application developed by Dr. Prabhuraj. A and his team of University of Agricultural Sciences, Raichur bagged the "**e- agriculture ICT initiative of the year 2014**" award at national level. This award was instituted by Associated Chambers of Commerce and Industries of India (ASSOCHAM). The award was conferred in the "*National Conference on Information Communication Technologies and awards*" held at Hotel Le Meridian, New Delhi on 4th March 2014. Dr. Prabhuraj A, Project Leader and Mr. Y. B. Srinivasa, Associated Leader of e-SAP received the award from Dr. R. Chandrashekhar, President, NASSCOM. The award was conferred to e-SAP in recognition to the innovative approach adopted for integrating all the stake holders in agriculture on a single platform.

Research paper on "e-SAP: a complete ICT Solutions for Agricultural Extension" was conferred with "Best paper award" at National Conference on VIIth National Extension Education Congress held during 8-11 Nov. 2014 at ICAR RC for NEHR, Umiam, Meghalaya. The award was conferred to e-SAP in recognition to the innovative approach to strengthen the Indian Agricultural Extension system.

REFLECTIONS AND CONCLUSIONS

1. Use of the tools of Information and Communication Technology (ICT) in survey of incidence of pests and diseases is a systematic and rigorous approach to pest surveillance and management and is a multi-disciplinary approach.
2. It speeds up the pace of IPM implementation on a wider area through adoption of pre-emptive actions of pest management which could mitigate the impending pest outbreaks, and could showcase the minimization of yield losses due to crop pests vis a vis success of IPM.
3. e-pest surveillance using Electronic Solutions against Agricultural Pests (e-SAP) is a path-breaking ICT system dedicated for crop health management. The scientists in the University of Agricultural Sciences, Raichur have successfully developed the application. The application which was initially confined to few crops and districts has been extended to a total of 40 crops including horticultural crops and to the entire state.
4. Scientific survey protocol has been developed for identification, quantification of pests and for management solutions. Totally 17 experts in Agriculture and 17 experts in Horticulture have been enrolled for validation of the management strategies as advisories to cover over 40 crops and for content management.
5. Device management is being done by experts in the field. The software is upgraded to the latest Android version (6.1 and above) and made device independent.
6. More than 1,000 extension officers in the Departments of Agriculture and Horticulture have been trained in use of the application.

7. Fields belonging to more than 32,000 farmers have been surveyed under e-pest surveillance and more than 1,00,000 advisories have been given. The application has been found to identify pest incidence with 90 to 95% accuracy.
8. Scientists have discovered many new pest problems in their areas of operation through e-SAP. Notable has been the white-tip disease of paddy and banana skipper. e-SAP has a provision for flagging difficult to identify problems in the field, which has resulted in these discoveries. More important has been the fact that identification of the new problems and their pest management strategies can be disseminated to the field devices in just minutes.
9. Procurement of ineffective (and sometimes, spurious) substances has drastically come down and the quantity of pesticides applied has also been according to the prescription/ package of practices, which has reduced the indiscriminate usage of pesticides. However, quantification of savings on use of pesticides is yet to be done.
10. Use of "e-pest surveillance system" as a tool in pest management, benefited the farmers in terms of lesser pest incidence vis-à-vis conservation of beneficial insects by timely action with appropriate plant protection measures and popularisation of eco-friendly management practices. The programme also benefited in terms of employment generation, knowledge sharing among technocrats and efficient extension of pest management technologies. This technology applied 1st time for the purpose of pest management in India has yielded encouraging response from all the stakeholders.
11. The application now acts as a connecting link among all stake holders (Farmer – Field Officer – Scientist – Administrator – Policy maker) in agriculture and horticulture on a single platform on real time basis in the field of crop health management and harvest.

ACTION POINTS

1. While the University of Agricultural Sciences, Raichur has made commendable efforts in developing the ICT based e-SAP for pest surveillance in over 40 crops and more than 1,00,000 advisories have been sent to the farmers, the impact of these advisories on pest management needs to be studied in detail. Procurement of ineffective (and sometimes, spurious) substances has been reported to have drastically come down and the quantity of pesticides applied has also been according to the prescription/ Package of practices, which has reduced indiscriminate usage of pesticides. However, quantification of savings on use of pesticides is yet to be done.
2. The application now has a data base of more than 1,00,000 farmers. This data base and the information generated through e-pest surveillance can be effectively analysed and converted into policy initiatives for integrated pest management measures.

3. Pest distribution map of some insects overlaid with climate data has been developed using the application. However, this has not been effectively used for contingent planning for pest management as also for future prediction of pest incidence. This should be urgently developed to enable the farmers to take up preventive measures. Besides, integration and convergence of disciplines is needed.
4. There is need to analyse the data generated in e-pest surveillance to assess:

i. Whether the e-pest surveillance device developed is being optimally used by field functionaries and management solutions to pest incidence given to farmers?

ii. Information on effective use of advisories can be obtained through "Follow Up" feature integrated in e-Sap app. Whether such analyses have been made to evaluate whether the farmers are making effective use of the advisories in management of pests in their farm?

iii. Whether e-solutions provided are complete in all respects or there are areas which need to be developed further? This is reflected by the number of UDMs generated and resolved. It is understood that only a few UDMs have been generated showing the usefulness of the e-solutions provided. However, there is need to analyse the same.

iv. The impact of use of e-pest surveillance device in management of pests and resultant impact of crop production.

v. The nature of recommendations given as the indicators of level of understanding of the pests to be managed and corresponding research lacunae identified.

vi. The impact of e-SAP use on the economics of crop production needs to be worked out.

vii. Whether any policy initiatives are required in management of pests based on e-pest surveillance data generated?

5. The process of ICT protocol developed by scientists may be patented.
6. There is need for capacity building on e-SAP both at implementation level as well as farmers level in addition to the line departments. It is understood that four state level workshops were conducted in all Agril. Universities involving scientists, department officials, public and private sector agri entrepreneurs, progressive farmers, NGOs, FPOs and SHGs. And several department level master's trainees trainings were conducted at different places of Karnataka in a capacity building programme. The details are, however, not available.
7. There is need for ground truthing of data base on its reliability and acceptability and impact.
8. The operational details and economics of dissemination of the technology needs to be worked out and it should be user friendly.
9. Strategies for sustaining the e-SAP technology for its maintenance needs to be worked out.

10. The impact of e-SAP technology needs to be worked on pests and diseases and IPM activities besides economics.
11. The evaluation methodology and sampling size and techniques need to be standardized.
12. A mechanism to include every farmer and every crop grown in the state may be developed, so that a systematic registry of all farmers and the crops grown by them can be generated, such that the same can be used by the government agencies to develop policy decisions, for disbursement of subsidy, compensation, *etc.*
13. Listing of critical criteria for each technological intervention needs to be documented for dissemination of technology.
14. Integration of indigenous technology knowledges (ITKs) needs to be relooked into.

RESEARCHABLE ISSUES

1. Development/ standardization of protocols for surveillance of pests and diseases, constant watch on the population/ spread dynamics of pests and diseases, their incidence and damage on each crop at fixed intervals to forewarn the farmers to take up timely crop protection measures.
2. There is need for documentation of level of incidence of pests species, loss caused by the incidence and the economic benefits their control will provide.
3. Convergence of remote sensing with special reference to satellite and air borne remote sensing data compiled with geographic information systems are potentially powerful tools for monitoring pest incidence.
4. There is need to develop Standard Operation Procedures (SOPs) for IPM, IPDM and INM for successful implementation of e-pest surveillance in addition to capacity building of farmers and workers on the above subject.
5. Formation of Steering Committee for all stake holders for convergence and co-ordination in decision support system.
6. Formation of University level Pests and Diseases Monitoring Unit.
7. Strengthening of research on e-pest surveillance and digital delivery of Pests and Diseases Management Advisories.
8. Development of future prediction models of pests and diseases outbreak in relation to climate change.

"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"

INTRODUCTION

Given the changing climatic conditions, and unreliable and erratic raining patterns that require adoption of new types of crops and new farming skills, farmers are mostly in desperate need of information on modern farming methods and practices that can increase the yields of their farms. The highly variable rainfall of 400 -6000 mm distributed across 40-100 rainy days besides the extreme weather events cause significant variability of crop yields. The low productivity of crops are also due to imbalanced input uses, gap in access to modern technologies and absence of technological breakthroughs post green revolution. In meeting the need and to improve agricultural productivity, mobile-based phone technology can be leveraged to provide farmers with timely, relevant and accurate agricultural information ranging from farm preparation to pre-harvest and post-harvest crop and farm produce management. Access to mobile-phone connectivity has empowered the consumers and is significantly driving economic growth as users can now access most essential services including financial services and credit facilities, health and education services, and utilities through their mobile phones. There are massive opportunities to deliver personalized and context-aware mobile-based services to these mobile users. Thus, to ensure food security and to improve agricultural productivity, mobile-based phone technology has been exploited and leveraged to provide farmers with relevant, accurate, timely and consumable agricultural information ranging from farm preparation to pre-harvest and post-harvest crop and farm produce management.

This includes information on pest and disease control, precision farming and irrigation, market availability and produce pricing, access to credit facilities and extension services among others services including livestock management.

Crop yield losses due to insect-pests, diseases, weeds, nematodes and rodents range from 15-25% in India, amounting to 0.9 to 1.4 lakh crore rupees annually. Although pesticide use per hectare (0.57 kg/ha) is lower in India and Maharashtra ranks third (0.73 kg/ha) after Andhra Pradesh and Punjab, pesticide residues in produce have been high mainly due to the indiscriminate use of chemical pesticides. In addition, lack of awareness on the label claims and waiting periods before harvest aggravates the problems. Farmers are also unaware of the environment friendly bio-pesticides that constitute 4.2% of the India's total pesticide market (Vennila et al, 2017). Surveillance of crops to detect early signs of buildup of pests and diseases is crucial for the success of IPM. For timely and effective intervention in the face of an emerging pest/ diseases situation, it is necessary for the surveillance data to be interpreted by technical experts and advisories issued in

real time. Delay in issuing an advisory could lead to a breach of the economic threshold level of the pest leading to loss in production and quality. Rashtriya Krishi Vikas Yojana (RKVY) launched by Government of India during XI Plan provided flexibility to choose innovative and pervasive use of Information and Communication Technology for reaching out to the farmers to assess the pest scenario in their fields, and for issue of real time pest management advisories through short message service (SMS).

In recent years, there has been a significant increase in mobile phone penetration in rural India. Rural India saw higher increases in both 'penetration' & 'tele-density' (as compared to urban India) with 218.9 million rural versus 188.4 million urban mobile subscriptions. According to market research agency Kantar IMRB, India's internet users are expected to register a 11% growth to reach 627 million in 2019, driven by rapid internet growth in rural areas. In its ICUBE 2018 report that tracks digital adoption and usage trends in India, it noted that the number of internet users in India has registered an annual growth of 18 percent and is estimated at 566 million as of December 2018, a 40 percent overall internet penetration, driven by rural internet growth and usage. It projected a 11% growth for 2019 and estimates that the number of internet users will reach 627 million by the end of this year.

Crop health management is a complex subject. It majorly encompasses problems caused by and solutions for various pestiferous species of insects, viruses, fungi, bacteria, nematodes and weeds, and nutritional deficiencies that decrease crop production and impact farmers' welfare. There are numerous species of pests that affect each crop, and not all impact in equal propensities at any given space and time. Pests have always plagued agriculture; the numbers of challenges having multiplied following green revolution. After water, they are perhaps the most worrisome to a farmer in India, and, post sowing, take a major chunk of his finances. Total crop losses, even suicides by farmers, have been attributed to pests. Crop yield losses due to insect-pests, diseases, weeds, nematodes and rodents range from 15-25% in India, amounting to 0.9 to 1.4 lakh crore rupees annually (Vennila et al, 2017). Modern agriculture has witnessed the rise of many locally unknown pests, or those that once had a "minor pest" tag on them. Invasive pests, pest resurgence and pest resistance have complicated the issues.

On the other hand, pest management options are equally complex. There are many microbial, botanical, chemical, cultural, mechanical and biological methods, and there are many techniques and tools for administering these methods to affect pest populations. Some of them are ecologically sensitive, while some others are part of the humble natural world; some are economical, while some others are expensive; some methods suit intensively managed agriculture, while some others suit extensive farming systems, and a mismatch could have dire consequences on the society, like large-scale ecosystem poisoning. Selection of pest management strategies depends on the intensity of the pest

problem at a given space/time. However, assessment strategies to decide on pest intensity vary with crops, pests and physiographical features; taking it to the ground level is a difficult task. At most times, one method of management, or one strategy, would not suffice to lower a pest population; it is a combination of strategies that has been proven to be effective in most cases. This can be complicated because some methods are compatible with some others and incompatible with certain others; some methods are applicable only at a particular time of the day and some others at particular positions above/below the ground. Further, it is often observed that farmer preferences play a significant role in selection of management strategies.

Some look for organic methods, some for inorganic, some prefer cultural and biological, while some others are open to any effective management action. All such variations should be taken into consideration while suggesting remedial actions. Moreover, there is a constant influx of new pest management tools and molecules into the market. These too need to be used appropriately so that farmers and the Nation obtain the maximum benefit. Therefore, pest management is an extremely challenging and complicated section of agriculture.

Adding to the challenges posed by the diversities of pests and their management strategies is the delivery mechanism of pest management solutions to farmers. The social fabric of our farming community, the economic position of our farmers, their level of education, the infrastructure at their disposal and their sheer numbers have erected tall hurdles along the routes of the delivery channels. Of course! This is additional to the complexities of pests themselves and their management strategies. Therefore, there has been little notable success obtained in the field of crop health management, unlike other subjects of agriculture, where there has been measurable amounts of achievements made since the 1970s. Success stories in the field of crop health management are sporadic at most; a national revolution has been a distant dream. Pest dynamics, and the number of variables that influence them, easily surpass market dynamics. And, when it has been difficult to regulate market dynamics surrounding agriculture, it is undoubtedly a bigger challenge to manage pest dynamics.

Recent improvement in farm research brought considerable change in the cropping system and allowed farmer to grow several crops throughout the year, which were very seasonal in the past. Needs of farmer in pest management revolves around pest diagnostics, surveillance, forecasting and dissemination of expert information in short time. For successful management of pests, surveillance of crops to detect early signs of buildup of pests and diseases is crucial. Monitoring of pests for their onset and intensity during the crop season is of utmost importance for an effective pest management. Integrated Pest Management (IPM) being holistic and knowledge intensive requires timely processing of temporal and spatial information gathered out of crop-pest surveillance for

quicker need based management actions to be disseminated by the extension functionaries for adoption by farmers (Vennila et al, 2016). For timely and effective intervention in the face of an emerging pest/ diseases situation, it is necessary for the surveillance data to be interpreted by technical experts and advisories issued in real time. Delay in issuing an advisory could lead to a breach of the economic threshold level of the pest leading to loss in production and quality.

National Plant Protection Organisation (NPPO) and other regulatory agencies conduct different types of survey programmes to fulfil diverse purposes of surveillance. In addition, these Plant Protection agencies often rely on outreach to passively surveil partners who report pest detections. However, the success of plant protection programmes depends on the ability to detect pests. To conduct a survey, a large number of associated tools and technologies are required. Some of the tools/technologies include statistics, GIS, data management and risk mapping (Rao, 2012). In our country, there are limited options in terms of effective surveillance tools and technologies are concerned (Sankaran et al., 2010). For instance, when no effective insect trap or lure is available, the officials must have to rely on visual surveys. Detecting plant diseases and pests often present an even greater challenge. The combination of high costs and inadequate technology leads to survey programmes that are less than optimal. As a result, pests frequently are introduced and become established before timely detection. With delay in discovery of invasive pests, the likelihood of eradication decreases while the cost of control/management/eradication increases dramatically.

To make India digitally smart, programmes like National e-Governance plan (2006) and Digital India project (2014) were launched to disseminate knowledge and technological products and processes on large scale for integral development of our country. For a successful IPM programme, timely processing of temporal and spatial information gathered out of crop-pest surveillance for quicker need-based management actions has to be disseminated by the extension functionaries for adoption by farmers. In this direction, the tool of Information and Communication Technology (ICT) not only allows assimilation of database on pests over time and space but also quickly processes data to facilitate a decision on pest management using the available knowledge base and critical inputs that can be mobilized and adopted for plant protection on an area wide basis. This systematic and rigorous approach to pest surveillance using ICT, is referred as e-pest surveillance. It speeds up the pace of IPM implementation on a wider area through adoption of pre-emptive actions of pest management which could mitigate the impending pest outbreaks, and could showcase the minimization of yield losses due to crop pests *vis a vis* success of IPM.

A web-based decision support system called e-pest surveillance system (CROPSAP) was developed and implemented for effective and regular pest monitoring in soybean

[*Glycine max* (L.) Merrill] and cotton (*Gossypium spp*) crops in Maharashtra (Niranjan Singh *et al*, 2012). These systems are being implemented in different states like Odisha, Punjab, Madhya Pradesh and Haryana (Niranjan Singh *et al*, 2019).

The success of CROPSAP at Maharashtra in field crops motivated the officials of Department of Horticulture of the Maharashtra State to adopt ICT-based pest surveillance for horticultural crops. ICAR-NCIPM with its expertise in ICT-based pest management solutions in collaboration with multiple institutions of Indian Council of Agricultural Research *viz.,* Central Citrus Research Institute, Nagpur, National Research Centre for Pomegranate at Solapur and National Research Centre for Banana at Trichi, and State Agricultural Universities viz., Mahatma Phule Krishi Vidyapeeth, Rahuri, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani with State department officials of horticulture and farmers of target fruit crops are involved in programme implementation. Horticulture pest surveillance and advisory project (HortSAP) - Maharashtra was initiated from 2011-12 initially for Mango, Pomegranate and Banana followed by the expansion to other fruit crops *viz.,* Sapota, Orange (Nagpur Mandarin) and Sweet Orange (Mosambi) since 2014-15. The districts selected are Jalgaon for banana, Thane, Raigad, Ratnagiri and Sindhudurg for mango and Ahmednagar, Nashik, Solapur and Sangli for pomegranate covering 44032 ha, 101840 ha and 38771 ha, respectively. At present the programme spreads over five districts for banana (Jalgaon, Solapur, Hingoli, Nanded, Akola), two districts for sweet orange (Aurangabad and Jalna), seven districts for mango (Palghar, Raigarh, Ratnagiri, Sindhudurg, Osmanabad, Aurangabad, Beed), five districts for Nagpur mandarin (Akola, Amravati, Buldhana, Wardha and Nagpur), eight districts for pomegranate (Ahmednagar, Solapur, Sangli, Satara, Nashik, Dhule, Aurangabad and Pune) and one district for sapota (Palghar) (Vennila et al, 2017).

“E-National Pest Reporting and Alert System” in pulse crops is a unique ICT based decision support system, which is very effective and easy to operate through a centralized server system at National Centre for Integrated Pest Management, New Delhi, connected with internet and mobile phones. This system was developed to cater to the needs of rural farmers of India, who grow pulse crops (Sharma *et al*, 2013).

Keeping the above in view, the project, **"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP”** was sanctioned under Rashtriya Krishi Vikas Yojane (RKVY) during 2014-15 and was taken up by University of Agricultural Sciences, Raichur. Dr. A. Prabhuraj, Professor of Entomolgy, College of Agriculture, Raichur was the Principal Investigator. Originally e-surveillance in Rice, Cotton and Soybean was taken up in Raichur, Bidar, Koppal, Yadgiri and Ballari. Later the e-pest surveillance was extended to 40 crops in the entire state to cover pests, diseases and weed problems. The details of the project are as under:

1.	**Title of Project**	**:**	**"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"**
2.	**Nodal officer and Principal Investigator**	**:**	**Dr. A. Prabhuraj,** Professor of Entomology and Project Leader, College of Agriculture, University of Agricultural Sciences, Raichur
3.	**Implementing Institution (S) and other collaborating Institution (s)**	**:**	College of Agriculture, Raichur, ARS Bidar, Gangavathi, Koppal, Ballari and Yadgir
4.	**Date of commencement of Project**	**:**	2014-15
5.	**Approved date of completion**	**:**	2014-15
6.	**Actual date of completion**	**:**	2014-15
7.	**Project cost**	**:**	Rs. 83 lakhs

OBJECTIVES

The objectives of the project were as under:

a. To provide pest identification and latest pest management strategies to the farmers of the region for major crops
b. To generate pestilence data in the selected districts based on regular sampling.
c. To develop additional features that significantly enhance the functionalities of e-SAP.
d. To empower field staff of e-SAP of the selected districts of the region.

HYPOTHESIS

The context of evaluation arises from the following facts:

1. Crop health management encompasses problems caused by and solutions for various pestiferous species of insects, viruses, fungi, bacteria, nematodes and weeds, and nutritional deficiencies that decrease crop production and impact farmers' welfare.
2. Crop yield losses due to insect-pests, diseases, weeds, nematodes and rodents range from 15-25% in India, amounting to 0.9 to 1.4 lakh crore rupees annually.
3. Modern agriculture has witnessed the rise of many locally unknown pests, or those that once had a "minor pest" tag on them. Invasive pests, pest resurgence and pest resistance have complicated the issues.
4. Pest management options are equally complex. There are many microbial, botanical, chemical, cultural, mechanical and biological methods, and there are many techniques and tools for administering these methods to affect pest populations.

5. Adding to the challenges posed by the diversities of pests and their management strategies is the delivery mechanism of pest management solutions to farmers. The social fabric of our farming community, the economic position of our farmers, their level of education, the infrastructure at their disposal and their sheer numbers have erected tall hurdles along the routes of the delivery channels.
6. Needs of farmer in pest management revolves around pest diagnostics, surveillance, forecasting and dissemination of expert information in short time. For successful management of pests, surveillance of crops to detect early signs of buildup of pests and diseases is crucial. Monitoring of pests for their onset and intensity during the crop season is of utmost importance for an effective pest management. Integrated Pest Management (IPM) being holistic and knowledge intensive requires timely processing of temporal and spatial information gathered out of crop-pest surveillance for quicker need based management actions to be disseminated by the extension functionaries for adoption by farmers.
7. In our country, there are limited options in terms of effective surveillance tools and technologies are concerned.
8. The tool of Information and Communication Technology (ICT) not only allows assimilation of database on pests over time and space but also quickly processes data to facilitate a decision on pest management using the available knowledge base and critical inputs that can be mobilized and adopted for plant protection on an area wide basis.
9. Use of ICT tool for e-pest surveillance and for educating the farmers to take effective measures to manage the pests has been made possible by a significant increase in mobile phone penetration in rural India in the recent years.
10. The effectiveness of this tool in crop health management needs to be evaluated for wider application.

OBJECTIVES AND ISSUES FOR EVALUATION

The scope of evaluation is to study the impact of scheme, **"e-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEMS THROUGH e-SAP"** sanctioned under Rashtriya Krishi Vikas Yojane and been taken up by University of Agricultural Sciences, Raichur at College of Agriculture, Raichur. The project was implemented during 2014-15 under the Principal Investigator, Dr. A. Prabhuraj, Professor of Entomology and Project Leader, College of Agriculture, University of Agricultural Sciences, Raichur. The total cost of the project was Rs. 83 lakhs.

1. Stake Holders

a) University of Agricultural Sciences, Raichur – Sponsorer
b) Rashtriya Krishi Vikas Yojane – as Monitoring Authority
c) Institution of Agriculture Technologists – as Consultant
d) Farmers / beneficiaries as target group of evaluation

2. Purpose of Evaluation

Evaluation Framework

The focus of Evaluation is:

a. to understand the effectiveness of the e-SAP tool in identification, quantification and intensity based recommendation for management of pests.
b. To assess whether e-SAP tool is effective in sending advisories to farmers for management of all pests.
c. To examine whether farmers are in a position to understand the severity of pest problem and are able to take up management efforts for better control of pests and higher farm returns.
d. To examine whether e-SAP tool can be standardized to extend the services to farmers in management of pests in different crops.
e. To examine whether information generated by e-SAP tool can be effectively used to lay down policy guidelines in management of pests.

LOG FRAME

The intention of the project is

a. to evaluate the effectiveness of e-SAP in issuing advisories to farmers for management of pests.
b. To examine whether the tool can be further improved to cover more crops and
c. To evaluate whether e-SAP tool can be used to generate and analyse data on pest intensity overlaid with climatic variations so that effective prophylactic measures can be initiated for effective management of the pests.

Evaluation Subject

1. How many, Year-wise, crop-wise and district-wise advisories were given under eSAP?
2. How many. Year-wise, crop-wise UDMs were identified, resolved and advisories given"?
3. What was the impact of advisories on Crop-wise follow up results?
4. Is it possible to prepare Pest distribution overlaid with climate data representation maps?

EVALUATION DESIGN

Evaluation design has a rationale of requirement of field level data (primary) that is required to study evaluation objective with respect to beneficiary farmers on one part and the projects taken up for study per se on the other part. The evaluation requires analysis of administration obligations under the two heads and hence a secondary data analysis becomes important and accordingly formats were designed to procure secondary data. The third obligation under evaluation is opinion of stake holders with respect to improvement

of the schemes, which require group discussions and exchange of views both in the form of a format, as well as group discussions with the stake holders. The entire evaluation process required a central administration of all activities.

A core team of experts at the Institution level considered three methods to bring a meaningful evaluation of the subject, keeping in mind the scope, evaluation questions and sub-questions duly keeping its focus on the purpose of evaluation. The three methods are:

a. Accessing and analysis of secondary data from the implementing department.
b. Interaction with Principal Investigator and his team.
c. Actual visit to the project site to study and obtain necessary information to elicit answers to the evaluation questions.

DATA COLLECTION AND ANALYSIS

PROGRESS REVIEW

In each of the five districts, five field staff were recruited to scout data regarding pests in the three major crops. A total of 31,919 ha was surveyed in 2097 villages of 34 taluks to record pests in a total of 16 agricultural and horticultural crops in addition to the three crops selected. The crops included pigeon pea, chick pea, chilli, maize, jowar, ground nut, sunflower, sugarcane, pomegranate, citrus, bhendi, brinjal, tomato, mango, lemon, orange, banana and coconut. The details of district-wise advisories sent in different crops are given in Annexure.

In pigeon pea, among various pests surveyed, highest incidence of leaf webber (47%) was noticed in all seven pigeon pea growing districts. This was followed by *Helicoverpa* to the extent of 32%. In paddy, thrips were the major insect noticed in the nursery (15%) followed by leaf folder (37%) and *Hispa* (12%) in the main field. In jowar, incidence of stem borer (43%) was highest followed by army worm (25%). In cotton, incidence of jassid was wide spread (42%) followed by leaf miner (16%). In groundnut, incidence of leaf miner was wide spread (25%) followed by jassid (19%), *Spodoptera* (18%), gram caterpillar (13%) and RHHC (12%). In chick pea, *Helicoverpa* was the major pest followed by *Spodoptera exigua*. In sunflower, defoliaters like semilooper (54%) followed by thrips (19%), in vegetables like tomato, leaf miner incidence (50%) followed by fruit

Table 1. Surveillance of agricultural and horticultural crops of North Karnataka through e-SAP during 2014-15

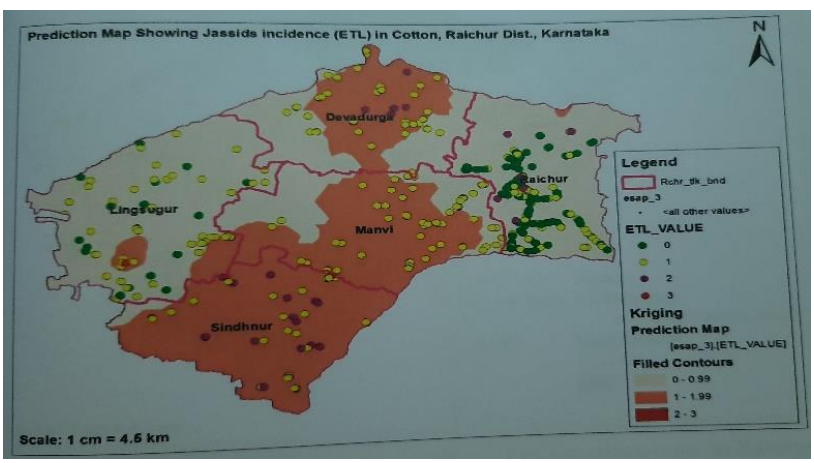
Sl. No.	Name of the district	No. of talukas covered	Toal no. of villages covered	Total area surveyed (in ha)
1	Gulbarga	07	538	9638
2	Bidar	05	530	6905
3	Raichur	03	139	3479
4	Yadgir	04	79	1159
5	Bijapur	06	249	4693
6	Bellary	04	251	3810
7	Koppal	05	311	2235
TOTAL		**34**	**2097**	**31919**

borer (19%), in Mango, leaf hopper incidence (33%) followed by leaf gall midge (29%), in citrus, leaf miner and citrus butterfly (26%) were the predominant pests.

Based on the survey of pests, prediction maps showing incidence of various pests were developed.

Table 3 : Major pests/diseases/deficiency along with the level of incidence in redgram during survey period in Northern Karnataka through e-SAP during 2014-15

Sl. No.	Districts	Major pests and disease	No. of reports indicating level of Incidence					
			Incidence	Low	< ETL	ETL	>ETL	Total
1	Gulbarga	Leaf Webber	44	00	583	627	11	**1265**
		Helicoverpa	08	00	416	302	32	**758**
		Flower Webber	01	00	31	80	00	**112**
		Pod Bug	01	00	03	66	07	**77**
		Plume Moth	00	00	04	62	02	**68**
2	Bidar	Leaf webber	14	00	191	02	00	**207**
		Helicoverpa	00	00	177	16	04	**197**
		Pod Borer	00	00	54	01	00	**55**
		Blister Beetle	00	00	14	04	02	**20**
		Bud weevil	01	00	07	03	01	**12**
3	Raichur	*Helicoverpa*	01	00	40	03	00	**44**
		Pod Borer	01	00	27	02	00	**30**
		Leaf webber	06	00	18	01	00	**25**
		Flea Beetle	03	00	10	00	00	**13**
		Bud Weevil	00	00	06	00	00	**06**
4	Koppal	*Helicoverpa*	01	00	46	01	00	**48**
		Leaf webber	01	00	42	01	00	**44**
		Flea beetle	00	00	16	00	00	**16**
		Pod Borer	00	00	13	00	00	**13**
		Pod Fly	00	00	05	00	00	**05**
5	Yadagiri	Leaf webber	06	00	85	02	00	**93**



ELECTRONIC SOLUTIONS AGAINST AGRICULTURAL PESTS (eSAP)

eSAP (Electronic Solutions against Agricultural Pests) is a path-breaking ICT system dedicated for crop health management. Insect pests, microbial diseases, nutritional deficiencies and weed problems are covered in the current version of eSAP. Further, it enables enumeration of different species of natural enemies, which has gained importance during recent times. There is also provision to capture the history of plant protection measures that have previously been adopted by the farmer while raising the current crop.

The potential of eSAP is such that any new agricultural technology can be communicated in an extremely effective manner, in real-time to the field; and, field situations across space and time are instantaneously made known to the managers/ policymakers/researchers. For instance, if a new pest management strategy has to be disseminated to many field workers spread across a vast geography, a press of a button in some remote location would ensure instantaneous delivery to all of them. The platform can disseminate information built in various forms like videos, animations, images, text and audio. On the other hand, if a pest attack is noted in a cotton field in Raichur district, the managers/ researchers will know it, and will be able to view the field in real-time in their respective offices/ laboratories anywhere in the world. Further, spatial coordinates of the field are instantaneously reflected on a GIS map along with the extent of severity of the problem. Additionally, such data are presented in automatically updated graphs and tables that enable real-time monitoring of field situations. Inbuilt intelligence aids the process of decision-making, so that biases are minimised and decisions are based on authentic, verifiable field data. Concurrently, this system will ensure seamless integration of different players in the agricultural ecosystem – field users, subject experts, managers, policymakers, and so on. This application has been successfully tested and put to practice for the first time in India by the University of Agricultural Sciences (UAS), Raichur. The features can be briefly summarised as follows. e-SAP is an application built on a platform that opens a gateway for two-way dissemination of information in real time. Central to the platform is a handheld medium that:

i) provides field users with all the relevant information in their hands;
ii) information can be accessed offline;
iii) information is intelligently metamorphosed into a form that can be easily understood and put to use by illiterate users transcending language barriers;
iv) it has substantial in-built intelligence for on-field decision support;
v) it has protocols for intelligent surveys and data collection;
vi) specific information on any/all devices can be updated remotely that makes real time dissemination possible;
vii) there is real time expert connect to handle emergencies and unknown field situations; and,
viii) all forms of data, including multimedia, can be disseminated in both directions in real time. The platform enables policy makers, researchers and users at the

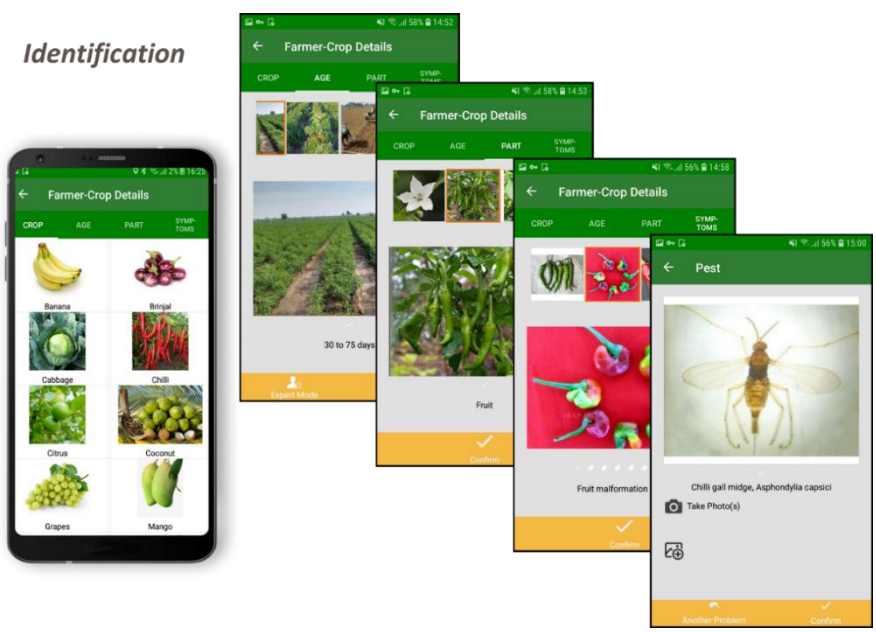
other end of the spectrum obtain field information in real time. Field data that streams-in is viewed over GIS platform. There are automatically updated graphs and tables along with decision support intelligence. It is multidirectional, flexible and scalable.

eSAP Features

e-SAP is an application built on a platform that opens a gateway for two-way dissemination of information in real time. The application has been built on android platform. The application can be accessed offline also.

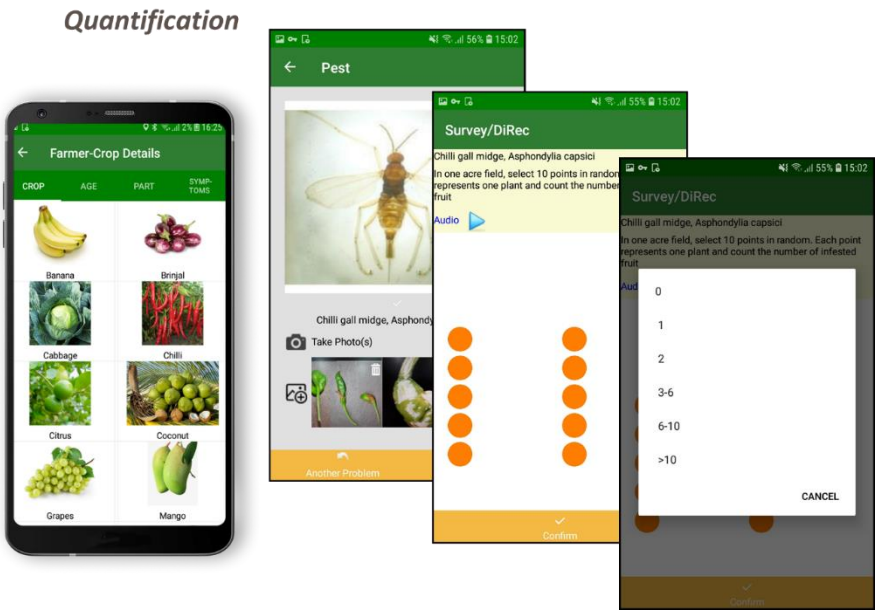
Pest identification:

This is one of the most highlighted features of e-SAP. The architecture for pest identification follows a unique image-based branching model. High-quality images that characterize pests and their symptoms are built on the platform to intuitively guide users in identifying the pest. The images have been collected from reliable sources such as Agricultural Universities, Research laboratories and other institutions and approved to be built on the platform by an Expert Committee of scientists drawn from different Agricultural Universities in the State. Audio assistance in local language is provided at every step; the user need not be literate. The user merely needs to touch a relevant image at each of the steps to identify the problem-causing organism. The content aims at covering all known pests, so that users are able to identify all pest-related problems in the field itself; dependency on external help is minimal. As the content can be accessed offline, it can be used anywhere, anytime. The user has to identify the farmer and crop details first and based on the pest observed on the crop, identify the same from the characteristics built on the platform.



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. For this purpose, there are intuitively built pest-specific survey forms to quantify damage caused by various pests. Data are automatically analysed based on the survey and the pre-determined economic threshold values for each pest. Results and respective suggestions are instantaneously visible on the field device. Depending on this, the user can decide on adopting management strategies or might simply watch for further buildup of the pest. Survey can be conducted offline too and results can be obtained straight away.



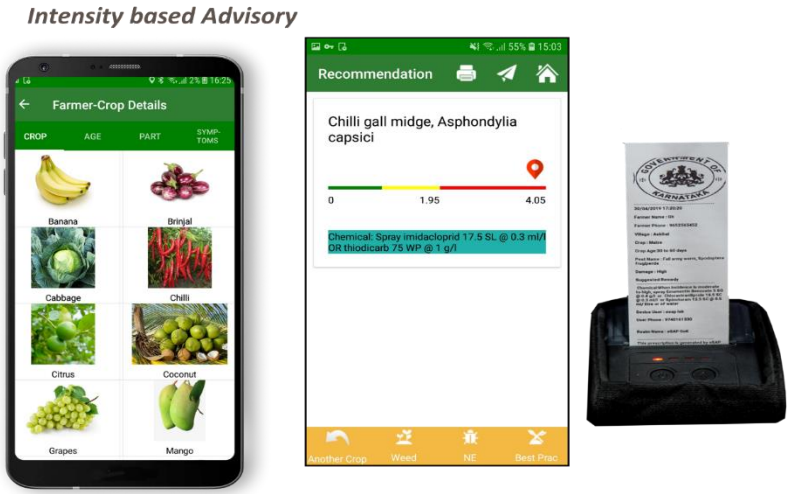
As surveillance entails multiple image capture by the field device, a set of close-ups and field images along with data on crop, crop age, pest damage and geo-coordinates of the field are transmitted to the cloud for further use by researchers/policymakers. Data transfer occurs instantly on the availability of telecommunication signals. This is done by an authorized user of the application such as the field functionaries of Agriculture and Horticulture departments.

Once the pest has been identified and pest damage is quantified, depending on the damage, pre-recommended management measures are automatically developed in the instrument screen and can be either printed by the user if printing options are available or can be shared with the farmers on his mobile through Whatsapp.

Pest management:

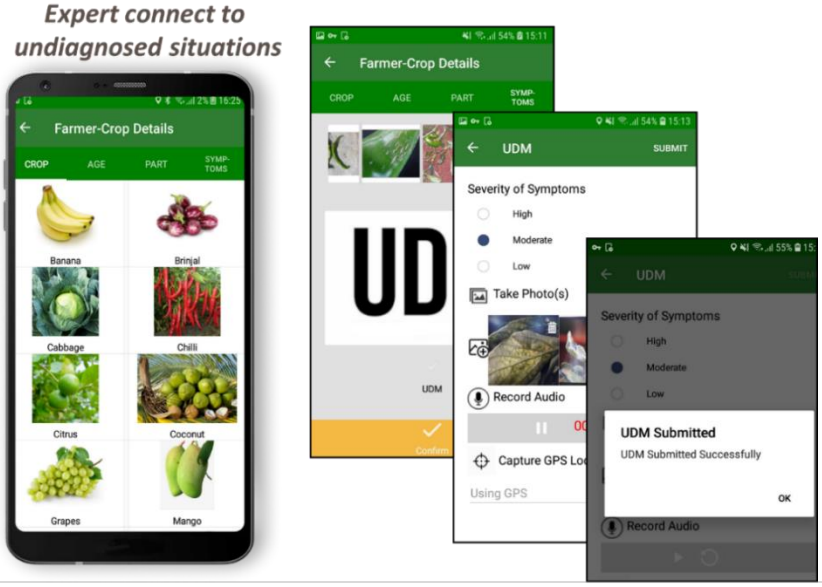
A schedule of recommended management strategies is made available against each pest after determining the extent of damage. The strategy takes into account the

crop, crop age and crop part affected. The user may adopt strategies depending on the automated suggestion made on the basis of the survey conducted. Management strategies



are also available offline. Any new strategy, or pest management technology, can be remotely made available on the availability of telecommunication signals.

In case, the available content in the field device is insufficient or the user faces difficulty in using it correctly, the user can capture multiple images of the pest and record his/ her opinion and these can be transferred along with relevant details like geo-coordinates, crop and farmers details to the cloud in real time. Designated experts will receive an alert regarding the same and can access the information sent by the field device and resolve the undiagnosed malady. A total of 1076 UDMs were received out of which 845 UDMs have been resolved. Eight UDMs are pending evaluation and 231 UDMs were rejected. Highest UDMs were received in cotton crop (Total: 443, Resolved: 356, Rejected: 87) followed by pigeon pea (Total: 237, Resolved: 162, Rejected: 75), paddy (Total: 89, Resolved: 60, Rejected: 29).

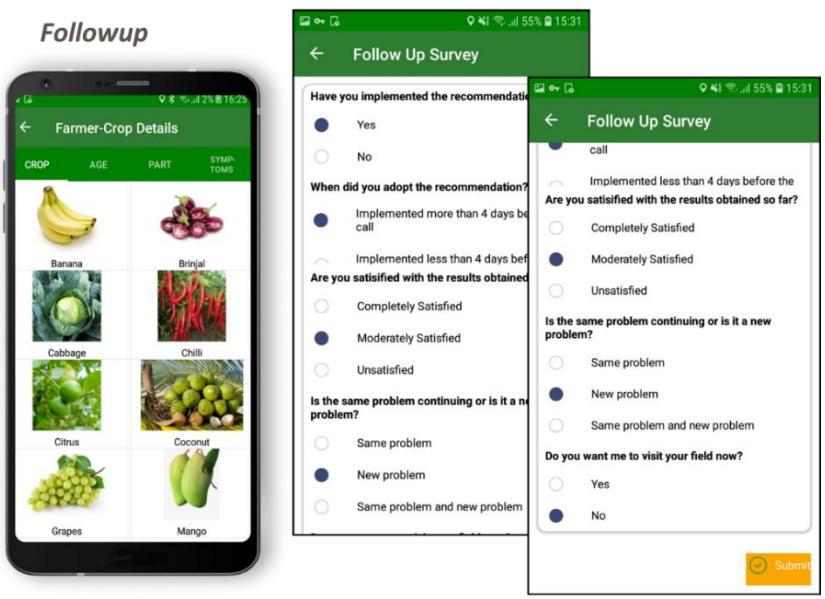


Pest information:

To supplement the knowledge of the users, details of each pest are made available on the field device, which is available offline. The information is updated by the experts on line from time to time.

Follow up:

The device automatically generates a follow up advisory 15 days after the advisory has been sent to the farmer with a view to evaluating the effectiveness of the advisory. The message sent to the farmer's device is in the form of simple questions to elicit information about the follow up taken by the farmer on the first advisory sent for management of the pest. The follow up survey indicates whether the farmer has followed the advice given and his level of satisfaction. If needed, a follow up visit of the expert is planned to the farmer's field if the problem is not solved.



Expert connect under extraordinary cases, when the available content in the field device is insufficient or the user faces difficulty in using it correctly, expert connect is made available on the device. Here, the application not only enables capture of multiple images of the crop, but also makes it possible for the user to record his opinion as he speaks. These images and audio files along with other relevant details like geo-coordinates, crop and farmer details are transferred to the cloud in real time. Designated experts receive an alert regarding the same, and can access information using e-SAP's web application. The application also allows inter-expert exchange of information before posting their suggestions to the field device. Normally, this process takes less than ten minutes when telecommunication networks are available to all the users.

Fig: Discussions on Technical inputs to e-SAP by experts

Features that assist policymakers/researchers

Farmer database:

An important feature of e-SAP is the ability to capture farmer-specific data in the field and build database of the activities of each farmer. All relevant details of each farmer and the crop raised, including acreage, images, etc., are captured on the field device and a database is created in the cloud, which is accessed through the web application. Every farmer is identified by a unique number with which a log of all his activities across time is created and made available for further use. Also, opportunities to capture any information on farm activity are made available.

Data analyses:

Data captured from various field devices are fed into several databases in the cloud, which are then made available for viewing over the GIS across any defined time and any chosen set of parameters. Users can access automated graphs over e-SAP‟s web application. Points over GIS maps and continuously updated graphs/tables allow real-time monitoring of pest situations across any defined space.

Decision support system:

Micro-level decision support system is provided on the field device for taking decisions on adopting pest management strategies. e-SAP also makes provision for macro-level decision support in the web application. Based on the data generated across space and time, and built-in analyses, alerts for various scenarios can be customised by each web-

user, which would warn in several ways – on mobile phones, emails, etc. for taking immediate actions on a larger scale.

Feedbacks:

As with respect to adoption of technologies and assessment of technologies by field users, provision is made to capture feedbacks in the form of multimedia content, like audio and images, and intuitive grading.

Content management:

e-SAP allows for real-time dissemination of pest management technologies and other information to all/designated field devices. Information on new pests or new information on existing pests, new/modified pest identification routes, additional/new symptoms, new survey plans, and new management strategies can be remotely updated on the field devices over existing telecommunication networks.

The additional features such as multiple image option, weed identification with survey protocol was added to the content management system.

Device management:

The device part of the platform exploits emerging technologies with capabilities to generate/ provide data in a format that an illiterate user can generate/use easy-to-understand multimedia content. Today, telecommunication networks reach a wide spectrum of geographies. However, in the absence of such networks, the device utilises offline storage and delivers content on network availability.

Large scale deployment:

e-SAP has reached over 1,00,000 farmers covering 26 crops in all 6 districts of Karnataka.

Rural Employment:

More than 50 extension workers recruited under various projects have received employment opportunities.

Effective use of pesticides:

The opportunities for selling ineffective (and sometimes, spurious) substances has drastically come down. The quantity of pesticides applied has also been according to the prescription, which has reduced indiscriminate usage of pesticides.

Scientific pest management:

e-SAP has helped farmers overcome a major difficulty - reliable identification of their crop pest problems. Further, e-SAP has effectively driven the concept of

quantification of the pest problem and has introduced the concept of pest-intensity based management system. Today, many farmers receiving printed prescriptions carry it to the retailers and demand the same to be given to them. It has had a significant impact on the interactions between the pesticide retailers and farmers. Their confidence levels for tackling pest problems have increased. This is largely because of the fact that they are completely involved in the identification and quantification process by the extension functionary.

FINDINGS AND DISCUSSION

The e-pest surveillance was initially confined to soybean crop in Bidar, paddy in Koppal and Ballari and cotton in Raichur and Yadgir districts. Encouraged by the positive response received from farmers and field functionaries, the surveillance was extended to a total of 40 crops including horticultural crops and was extended to the entire state. The application now acts as a connecting link among all stake holders (Farmer – Field Officer – Scientist – Administrator – Policy maker) in agriculture and horticulture on a single platform in real time in the field of crop health management.

Scientific survey protocol has been developed for identification, quantification of pests and for management solutions. Totally 17 experts in Agriculture and 17 experts in Horticulture have been enrolled for validation of the management strategies as advisories to cover over 40 crops and for content management.

Device management is being done by experts in the field. The software is upgraded to the latest Android version (6.1 and above) and made device independent.

More than 1,000 extension officers in the Departments of Agriculture and Horticulture have adopted the application. An important feature of e-SAP is the ability to capture farmer-specific data in the field and build database of the activities of each farmer. All relevant details of each farmer and the crop raised, including acreage, images, etc., are captured on the field device and a database is created in the cloud, which is accessed through the web application. Every farmer is identified by a unique number with which a log of all his activities across time is created and made available for further use. Also, opportunities to capture any information on farm activity are made available.

Fields belonging to more than 32,000 farmers have been surveyed under e-pest surveillance and more than 1,00,000 advisories have been given. The application has been found to identify pest incidence with 90 to 95% accuracy.

While selling ineffective (and sometimes, spurious) substances has drastically come down and the quantity of pesticides applied has also been according to the prescription, which has reduced indiscriminate usage of pesticides, quantification of savings on use of pesticides is yet to be done.

Impact

A study on "*perception analysis of e-SAP by farmers in the districts of implementation of e-SAP*" conducted by the Extension Department has revealed highly positive response from the farmers (70% of the sample farmers gave positive response) regarding the power of the technology in all aspects of crop protection. e-SAP has helped

farmers overcome a major difficulty - reliable identification of their crop pest problems. Further, e-SAP has effectively driven the concept of quantification of the pest problem and has introduced the concept of pest-intensity based management system. Today, many farmers receiving printed prescriptions carry it to the retailers and demand the same to be given to them. It has had a significant impact on the interactions between the pesticide retailers and farmers. Their confidence levels for tackling pest problems have increased. This is largely because of the fact that they are completely involved in the identification and quantification process by the extension functionary.

Three more fellow agricultural universities in Karnataka have adopted e-SAP. Together, there are more than 1,00,000 farms in Karnataka who have benefitted from e-SAP till date. More than 100 extension workers recruited under various projects have received employment opportunities.

Scientists have discovered many new pest problems in their areas of operation through e-SAP. Notable has been the white-tip disease of paddy and banana skipper. e-SAP has a provision for flagging difficult to identify problems in the field, which has resulted in these discoveries. More important has been the fact that identification of the new problems and their pest management strategies can be disseminated to the field devices in just minutes, such that the field users can henceforth manage these problems by themselves. Certain area-wide decisions have been taken by managers on the basis of data made available in real-time through e-SAP system. Notable example has been management of cotton leafhopper resistance in Raichur area. Real-time data showed that the pest population was not declining in the area despite adoption of management strategies. Soon, the expert team found that the population had developed resistance to the pesticide. Administrators, with the help of researchers, decided on changing the strategy. The new strategy was made available on the field devices in real-time, which resulted in successfully managing the pest population before it got escalated to serious levels. Such has been the impact of e-SAP.

Use of “e-pest surveillance system” as a tool in pest management, benefited the farmers in terms of lesser pest incidence vis-à-vis conservation of beneficial insects by timely action with appropriate plant protection measures and popularisation of eco-friendly management practices. The programme also benefited in terms of employment generation, knowledge sharing among technocrats and efficient extension of pest management technologies. This technology applied 1st time for the purpose of pest management in India resulted in encouraging response from all the stakeholders.

e-SAP bagged the “e-agriculture ICT initiative of the year 2014” award

Electronic Solutions against Agricultural Pests (e-SAP), a novel ICT application developed by Dr. Prabhuraj. A and his team of University of Agricultural Sciences, Raichur

bagged the "**e- agriculture ICT initiative of the year 2014**" award at national level. This award was instituted by Associated Chambers of Commerce and Industries of India (ASSOCHAM). The award was conferred in the "*National Conference on Information Communication Technologies and awards*" held at Hotel Le Meridian, New Delhi on 4th March 2014. Dr. Prabhuraj A, Project Leader and Mr. Y. B. Srinivasa, Associated Leader of e-SAP received the award from Dr. R. Chandrashekhar, President, NASSCOM. The award was conferred to e-SAP in recognition to the innovative approach adopted for integrating all the stake holders in agriculture on a single platform.

e-SAP bagged the "Best paper presentation award at national level Conference"

Research paper on "e-SAP: a complete ICT Solutions for Agricultural Extension" was conferred with "Best paper award" at National Conference on VIIth National Extension Education Congress held during 8-11 Nov. 2014 at ICAR RC for NEHR, Umiam, Meghalaya. The award was conferred to e-SAP in recognition to the innovative approach to strengthen the Indian Agricultural Extension system.

REFLECTIONS AND CONCLUSIONS

1. Use of the tools of Information and Communication Technology (ICT) in survey of incidence of pests and diseases is a systematic and rigorous approach to pest surveillance and management and is a multi-disciplinary approach.
2. It speeds up the pace of IPM implementation on a wider area through adoption of pre-emptive actions of pest management which could mitigate the impending pest outbreaks, and could showcase the minimization of yield losses due to crop pests vis a vis success of IPM.
3. e-pest surveillance using Electronic Solutions against Agricultural Pests (e-SAP) is a path-breaking ICT system dedicated for crop health management. The scientists in the University of Agricultural Sciences, Raichur have successfully developed the application. The application which was initially confined to few crops and districts has been extended to a total of 40 crops including horticultural crops and to the entire state.
4. Scientific survey protocol has been developed for identification, quantification of pests and for management solutions. Totally 17 experts in Agriculture and 17 experts in Horticulture have been enrolled for validation of the management strategies as advisories to cover over 40 crops and for content management.
5. Device management is being done by experts in the field. The software is upgraded to the latest Android version (6.1 and above) and made device independent.
6. More than 1,000 extension officers in the Departments of Agriculture and Horticulture have been trained in use of the application.
7. Fields belonging to more than 32,000 farmers have been surveyed under e-pest surveillance and more than 1,00,000 advisories have been given. The application has been found to identify pest incidence with 90 to 95% accuracy.
8. Scientists have discovered many new pest problems in their areas of operation through e-SAP. Notable has been the white-tip disease of paddy and banana skipper. e-SAP has a provision for flagging difficult to identify problems in the field, which has resulted in these discoveries. More important has been the fact that identification of the new problems and their pest management strategies can be disseminated to the field devices in just minutes.
9. Procurement of ineffective (and sometimes, spurious) substances has drastically come down and the quantity of pesticides applied has also been according to the prescription/ package of practices, which has reduced the indiscriminate usage of pesticides. However, quantification of savings on use of pesticides is yet to be done.
10. Use of “e-pest surveillance system” as a tool in pest management, benefited the farmers in terms of lesser pest incidence vis-à-vis conservation of beneficial insects by timely action with appropriate plant protection measures and popularisation of eco-friendly management practices. The programme also benefited in terms of employment generation, knowledge sharing among technocrats and efficient extension of pest management technologies. This technology applied 1st time for

the purpose of pest management in India has yielded encouraging response from all the stakeholders.

11. The application now acts as a connecting link among all stake holders (Farmer – Field Officer – Scientist – Administrator – Policy maker) in agriculture and horticulture on a single platform on real time basis in the field of crop health management and harvest.

ACTION POINTS

1. While the University of Agricultural Sciences, Raichur has made commendable efforts in developing the ICT based e-SAP for pest surveillance in over 40 crops and more than 1,00,000 advisories have been sent to the farmers, the impact of these advisories on pest management needs to be studied in detail. Procurement of ineffective (and sometimes, spurious) substances has been reported to have drastically come down and the quantity of pesticides applied has also been according to the prescription/ Package of practices, which has reduced indiscriminate usage of pesticides. However, quantification of savings on use of pesticides is yet to be done.
2. The application now has a data base of more than 1,00,000 farmers. This data base and the information generated through e-pest surveillance can be effectively analysed and converted into policy initiatives for integrated pest management measures.
3. Pest distribution map of some insects overlaid with climate data has been developed using the application. However, this has not been effectively used for contingent planning for pest management as also for future prediction of pest incidence. This should be urgently developed to enable the farmers to take up preventive measures. Besides, integration and convergence of disciplines is needed.
4. There is need to analyse the data generated in e-pest surveillance to assess:

j. Whether the e-pest surveillance device developed is being optimally used by field functionaries and management solutions to pest incidence given to farmers?

viii. Information on effective use of advisories can be obtained through “Follow Up” feature integrated in e-Sap app. Whether such analyses have been made to evaluate whether the farmers are making effective use of the advisories in management of pests in their farm?

ix. Whether e-solutions provided are complete in all respects or there are areas which need to be developed further? This is reflected by the number of UDMs generated and resolved. It is understood that only a few UDMs have been generated showing the usefulness of the e-solutions provided. However, there is need to analyse the same.

x. The impact of use of e-pest surveillance device in management of pests and resultant impact of crop production.

xi. The nature of recommendations given as the indicators of level of understanding of the pests to be managed and corresponding research lacunae identified.

xii. The impact of e-SAP use on the economics of crop production needs to be worked out.

xiii. Whether any policy initiatives are required in management of pests based on e-pest surveillance data generated?

5. The process of ICT protocol developed by scientists may be patented.
6. There is need for capacity building on e-SAP both at implementation level as well as farmers level in addition to the line departments. It is understood that four state level workshops were conducted in all Agril. Universities involving scientists, department officials, public and private sector agri entrepreneurs, progressive farmers, NGOs, FPOs and SHGs. And several department level master's trainees trainings were conducted at different places of Karnataka in a capacity building programme. The details are, however, not available.
7. There is need for ground truthing of data base on its reliability and acceptability and impact.
8. The operational details and economics of dissemination of the technology needs to be worked out and it should be user friendly.
9. Strategies for sustaining the e-SAP technology for its maintenance needs to be worked out.
10. The impact of e-SAP technology needs to be worked on pests and diseases and IPM activities besides economics.
11. The evaluation methodology and sampling size and techniques need to be standardized.
12. A mechanism to include every farmer and every crop grown in the state may be developed, so that a systematic registry of all farmers and the crops grown by them can be generated, such that the same can be used by the government agencies to develop policy decisions, for disbursement of subsidy, compensation, *etc.*
13. Listing of critical criteria for each technological intervention needs to be documented for dissemination of technology.
14. Integration of indigenous technology knowledges (ITKs) needs to be relooked into.

RESEARCHABLE ISSUES

1. Development/ standardization of protocols for surveillance of pests and diseases, constant watch on the population/ spread dynamics of pests and diseases, their incidence and damage on each crop at fixed intervals to forewarn the farmers to take up timely crop protection measures.
2. There is need for documentation of level of incidence of pests species, loss caused by the incidence and the economic benefits their control will provide.
3. Convergence of remote sensing with special reference to satellite and air borne remote sensing data compiled with geographic information systems are potentially powerful tools for monitoring pest incidence.
4. There is need to develop Standard Operation Procedures (SOPs) for IPM, IPDM and INM for successful implementation of e-pest surveillance in addition to capacity building of farmers and workers on the above subject.
5. Formation of Steering Committee for all stake holders for convergence and co-ordination in decision support system.
6. Formation of University level Pests and Diseases Monitoring Unit.
7. Strengthening of research on e-pest surveillance and digital delivery of Pests and Diseases Management Advisories.
8. Development of future prediction models of pests and diseases outbreak in relation to climate change.

RESEARCHABLE ISSUES AND RECOMMENDATIONS

A. There is a need to evaluate the recommendations given for each of the pests and then to check whether the recommendations can be improved in terms of ease of management.

B. Proportional representation of non-chemical recommendations (biopesticides) may be increased to move towards reducing chemical load for pest management.

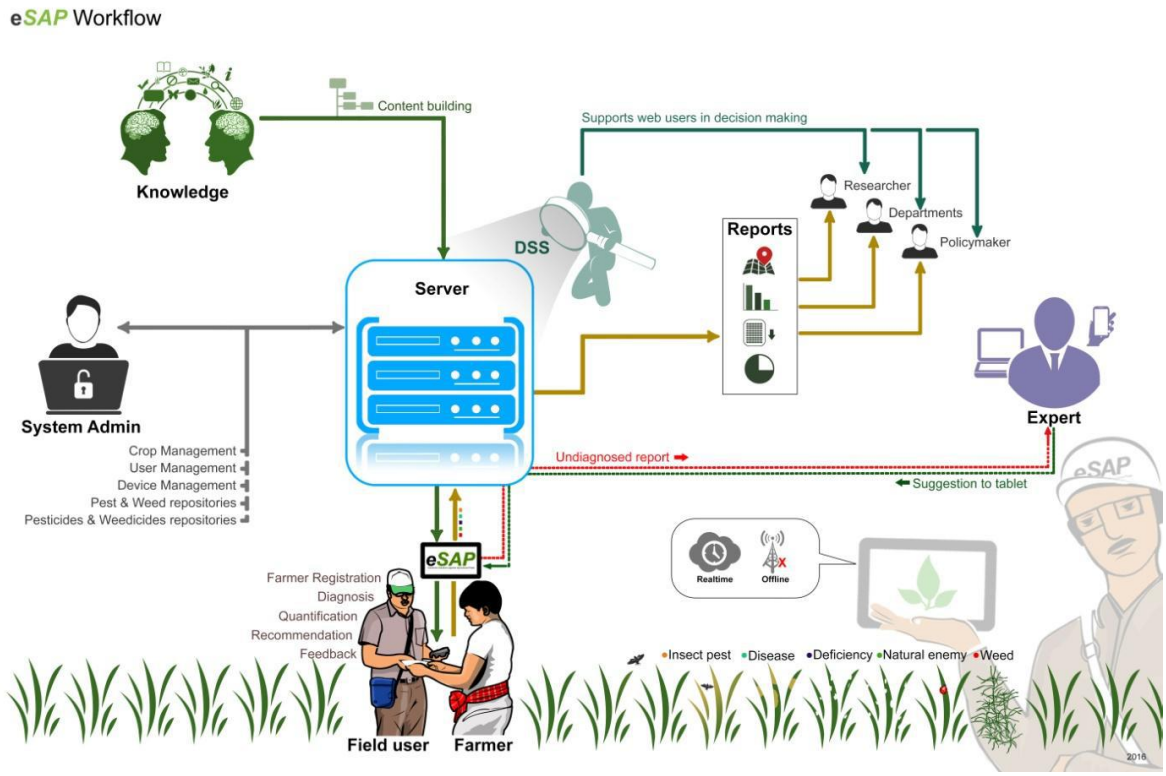
C. Geographic data collated on a state-wide basis may be evaluated for widespread pests to check whether climatic data can be used to make predictions on the pest outbreaks. In order to achieve this, abundance maps may be overlaid with weather data to check how the weather factors are influencing the pest situations.

D. Once a recommendation is given, it was observed that 70 % of the farmers are happy with the results. The question of why the other 30 % are not positive needs to be appreciated. This would help understand the limitations on the part of the farmer to implement the given recommendations. This would help develop more easily adoptable recommendations or alternatively mechanisms of implementation of the given recommendations such that the overall adoption rates are improved.

E. Voluminous data generated may be made available in public domain for interested researchers to explore the data. This will help in the long run in many different

ways in understanding the pest biology, population dynamics, development of alternative management options, etc.

F. Extension of the eSAP system to all farmers and all fields cultivated right across the state would in many different ways will help manage socio-economic and policy issues. That would also help in employment generation apart from bringing the entire farming lot of the state into an accessible and meaningful documentation of the farming activity.



USE OF e-SAP APPLICATION BY FIELD FUNCTIONARIES FOR PEST IDENTIFICATION

Fig: Extension worker assessing pest incidence using e-SAP app

Capacity building of Extension Officers of the department of horticulture regarding handling eSAP device and web application

Sample format of a pest, disease and nutrition disorder

Crop name : **Brinjal**
Crop age : Vegetative stage, Reproductive stage
Affected part : shoot
Pest : Shoot and fruit borer, *Leucinodes orbonalis*
Pest incidence quantification: This may be done through defined survey methodology or visual observation which is based on type of pest/damage/available information.
Defined survey methodology

Area: 1acre

Point	No. of points :	
Row	No. of rows:	No. of points in a row:……..
		No. of segments: Length of each segment:
Block	No. of blocks: 04 Block dimension: 10 sq.m.	Points within a block: Entire block: yes

Observation method: In one acre field, choose four blocks each of 10 sq.m. in random (approximately 13 plants) . From each block observe 20 shoots and record the number of infested shoots.
Scale: count
Grades (including visual assessment):

Grades	No. of infested shoots
I	0
II	1
III	2-3
IV	4-6
V	7-10
VI	>10

ETL:4+/- 25%
Value Beyond Recovery: 15

Recommendation:

Severity	Management plan	Remark
Less than ETL / Low	**Mechanical control:** ➢ Collection and destruction of infested shoots along with larvae ➢ Shoot clipping at weekly interval ➢ Install pheromone trap @ 8/acre (Note: change the lure once in two months) **Bio pesticide/Botanical :** *Bacillus thuringiensis* @ 2 g/l or azadirachtin 10000 ppm @ 2ml/l **Biological control :**Release of *Trichogramma chilonis* @ 20,000/acre at weekly interval for 5 times	
Equal to ETL / Moderate	**Mechanical control:** ➢ Collection and destruction of infested shoots along with larvae ➢ Install pheromone trap @ 8/acre (Note: change the lure once in two months) **Chemical Management:** spray any one of the above chemical First spray - spinosad 45 SC @ 0.3ml/l or emamectin benzoate 5 SG@ 0.2 g/l Second spray - chlorantraniliprole 18.5EC @ 0.3 ml/l (15 days after first spray)	
More than ETL / High	**Chemical Management:** First spray - spinosad 45 SC @ 0.3ml/l Second spray - chlorantraniliprole 18.5EC @ 0.3 ml/l (15 days after first spray)	

BORON DEFICIENCY

Crop name : **Citrus**
Crop age : 1-5 years and >5 years
Affected part : Upper Canopy and Whole plant
Nutrient deficiency quantification: This may be done through visual observation which is based on specific of nutrient deficiency symptoms.
Defined survey methodology: Visual observation/DiRec
Recommendation

Severity	Management plan	Reference	Remark
Low	**Foliar spray:** citrus special @ 5g/l before and after flowering (twice at each stage of spraying **(citrus special Preparation** : mix citrus special @ 75g + 1 lemon + 1 shampoo sachet in 15 litre of water) Note : it will take care of secondary nutrient (Ca, Mg and s) and micro nutrient (Zn, B, Fe, Cu, Mn, Mo and Cl)	IIHR, Bengaluru	
Medium	Soil application of Borax salt @ 20-30g per/plant/ year. **or** Foliar spray : Solubor @ 0.1 (1g/L) at 15 days interval **or** Citrus special @ 5g/l before and after flowering (twice at each stage of spraying) **(citrus special Preparation** : mix citrus special @ 75g + 1 lemon + 1 shampoo sachet in 15 litre of water) Note : it will take care of secondary nutrient (Ca, Mg and s) and micro nutrient (Zn, B, Fe, Cu, Mn, Mo and Cl)	NRC, State expert team and IIHR, Bengaluru	
High	Soil application of Borax salt @ 20-30g per/plant/ year. **or** Foliar spray of Solubor @ 0.1 (1g/L) at 15 days interval **or** Foliar spray citrus special @ 5g/l before and after flowering (twice at each stage of spraying **(citrus special Preparation** : mix citrus special @ 75g + 1 lemon + 1 shampoo sachet in 15 litre of water) Note : it will take care of secondary nutrient (Ca, Mg and s) and micro nutrient (Zn, B, Fe, Cu, Mn, Mo and Cl).	NRC, State expert team and IIHR, Bengaluru	

Pomegranate

Disease : Wilt
Crop age : 1-3 years and >3 years
Affected part : Leaf and Whole plant

Disease incidence quantification: This may be done through defined survey methodology or

Visual observation which is based on type of pest/damage/available information.

Defined survey methodology

Area: 1 acre

Point	**No. of points :**	
Row	No. of rows:……	No. of points in a row:……..
		No. of segments:……..
		Length of each segment:…….
Block	No. of blocks: 02	Points within a block:
	Block dimension: 400sq m	Entire block: yes

Observation method: In one acre field, choose 02 block each of 400 sq m. In each block (approximately 20 plants) record the number of wilted plants.
Scale: Count
Grades (including visual assessment):

Scale	Number of wilted plants
0	0
1	1-5
2	6-10
3	11-25
4	>25

ETL: 3 +/- 67

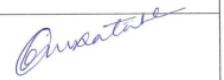
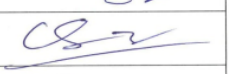
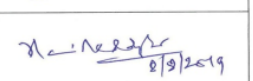
Value Beyond Recovery: 20

Recommendation

Type of recommendation: Conventional/ **Chemicals** / Biocontrol / Biological / **Cultural** / Mechanical / **Organic**

Severity	Management	Reference	Remarks
Less than ETL / Low	**Cultural control:** • The planting material (sapling as well as soil in which it is planted) should be freefrom all wilt organisms. • Before planting solarize the soil or sterilization with formalin (50 ml/l). • Follow recommended spacing of 4.5 m × 3.0 m in the orchard in sandy loam soil with proper drainage	Pests of fruits E pest Surveillance and pest management Advisory NCIPM New delhi. NRC on Pomegranate, POP Solapur	
Equal to ETL / Moderate	**Chemical control:** • Soil drenching with chlorpyriphos 20EC @ 2.5-4.0ml/l + carbendazim50 WP@ 2.0g/l or propiconazole 25EC @ 2ml/l (To control fungal pathogens andshot hole borer)	NRC on Pomegranate, POP Solapur	
More than ETL / High	**Chemical control:** • Soil drenching with chlorpyriphos 20EC @ 2.5-4.0ml/l + carbendazim50 WP@ 2.0g/l or propiconazole 25EC @ 2ml/l (To control fungal pathogens and shot hole borer) • For shot hole borer management : 10 litres preparation containing mix 4 kg red soil + Chlorpyriphos 20EC @20ml+ Copper oxychloride WP @25 g needs to be applied on plant base up to 1-2 ft. from second year onwards.	NRC on Pomegranate, POP Solapur Pests of fruits E pest Surveillance and pest management Advisory NCIPM New delhi	

Validation and certification of insect and mite pest management in Cabbage

Sl. No.	Name and Designation	University	Signature
1	Dr.Arunkumar Hosamani, Professor and Head (Biocontrol), MARS ,UAS, Raichur -584104	UAS, Raichur	
2	Dr.Venakteshalu, Professor and Head, Dept of Entomology, CoH, Bagalkot.	UHS, Bagalkot	
3	Dr. Sharanabasappa Deshmukh, Assistant professor(Entomology), CoA, Navile, Shivamogga-577204	UAHS, Shivamogga	
4	Dr. Murali Mohan. K, Associate Professor (Agricultural Entomology), CoA, GKVK, Bengaluru.	UAS, GKVK, Bangaluru	
5	Dr. Shivanna, Assistant professor, Dept. of Entomology, COA, GKVK, Bengaluru.	UAS, GKVK, Bengaluru	
6	Dr. P. V .R. Reddy, Pricipal Scientist (Entomology), IIHR Hesaraghatta, Bengaluru.	IIHR, Bengaluru	

DISTRICT-WISE SURVEYS CONDUCTED AND ADVISORIES GIVEN IN DIFFERENT CROPS

PADDY				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Koppal**	04	108	1194
2	**Raichur**	04	182	1105
3	**Bellary**	05	64	584
4	**Yadgir**	03	12	82
5	**Bidar**	02	04	04
6	**Bijapur**	01	01	01
7	**Gulbarga**	01	01	03
Total		20	372	2973

COTTON				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Koppal**	07	274	1779
2	**Raichur**	05	272	4526
3	**Bellary**	03	107	1367
4	**Yadgir**	03	60	619
5	**Bidar**	06	150	1011
6	**Bijapur**	04	117	468
7	**Gulbarga**	01	02	03
	Total	**29**	**982**	**9773**

JOWAR				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	07	257	2009
2	**Bellary**	06	35	172
3	**Koppal**	**04**	**56**	**175**
4	**Bidar**	05	88	262
5	**Raichur**	05	59	182
6	**Yadgir**	03	12	38
7	**Bijapur**	02	02	02
Total		**32**	**509**	**2840**

GROUNDNUT				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	Bellary	06	127	1065
2	Yadgiri	03	63	1549
3	Koppal	04	109	549
4	Raichur	05	75	321
5	Bidar	04	11	21
6	Gulbarga	06	41	156
7	Bijapur	01	03	34
Total		29	429	3695

CHILLI				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Raichur**	05	55	426
2	**Bellary**	06	89	561
3	**Gulbarga**	07	45	141
4	**Bidar**	05	26	34
5	**Koppal**	04	87	185
6	**Yadgir**	02	10	46
7	**Bijapur**	01	34	380
TOTAL		30	346	1773

SUNFLOWER				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	Raichur	03	06	24
2	Bellary	05	30	218
3	Gulbarga	07	57	130
4	Bidar	02	03	09
5	Koppal	04	68	205
6	Yadgir	03	04	10
7	Bijapur	00	00	00
TOTAL		**24**	**168**	**596**

SUGARCANE				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Raichur**	03	06	11
2	**Bellary**	04	30	155
3	**Gulbarga**	06	114	625
4	**Bidar**	05	225	950
5	**Koppal**	04	26	47
6	**Yadgir**	01	03	07
7	**Bijapur**	01	23	38
TOTAL		**24**	**427**	**1833**

BHINDI				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	05	14	56
2	**Raichur**	03	07	12
3	**Yadgiri**	02	04	11
4	**Bijapur**	01	02	02
5	**Bellary**	03	04	13
6	**Koppal**	03	15	23
7	**Bidar**	04	07	09
TOTAL		**21**	**53**	**126**

TOMATO				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	05	26	97
2	**Bellary**	06	32	103
3	**Koppal**	04	50	96
4	**Bidar**	03	12	24
5	**Raichur**	05	15	42
6	**Yadgir**	01	04	11
7	**Bijapur**	03	12	24
Total		**27**	**151**	**397**

POMEGRANATE				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	04	07	39
2	**Bellary**	02	05	10
3	**Koppal**	00	00	00
4	**Bidar**	00	00	00
5	**Raichur**	03	07	26
6	**Yadgir**	03	06	07
7	**Bidar**	01	02	02
Total		**13**	**27**	**84**

MANGO				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	06	40	460
2	**Bellary**	04	05	09
3	**Koppal**	**03**	**18**	**30**
4	**Bidar**	03	10	13
5	**Raichur**	03	06	07
6	**Yadgir**	03	04	81
7	**Bijapur**	00	00	00
Total		**22**	**83**	**600**

LEMON				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	06	24	230
2	**Bellary**	01	01	03
3	**Koppal**	03	04	04
4	**Bidar**	03	04	04
5	**Raichur**	01	01	04
6	**Yadgir**	01	05	25
7	**Bijapur**	01	19	28
Total		16	58	298

MAIZE				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	5	30	75
2	**Bellary**	6	72	519
3	**Koppal**	4	117	380
4	**Bidar**	3	4	14
5	**Raichur**	4	5	5
6	**Yadgir**	1	1	2
7	**Bijapur**	1	9	11
Total		24	238	1006

COCONUT				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	03	03	04
2	**Bellary**	03	04	35
3	**Koppal**	01	01	02
4	**Bidar**	01	04	05
5	**Raichur**	00	00	00
6	**Yadgir**	00	00	00
7	**Bijapur**	00	00	00
Total		**08**	**12**	**46**

BANANA				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	01	19	128
2	**Bellary**	02	04	31
3	**Koppal**	01	17	78
4	**Bidar**	02	02	03
5	**Raichur**	00	02	02
6	**Yadgir**	00	00	00
7	**Bijapur**	00	00	00
Total		06	44	242

BENGAL GRAM				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	07	90	306
2	**Bellary**	04	10	21
3	**Koppal**	04	45	144
4	**Bidar**	04	68	167
5	**Raichur**	04	07	12
6	**Yadgir**	00	00	00
7	**Bijapur**	00	00	00
Total		23	220	650
BRINJAL				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	06	31	130
2	**Bellary**	05	21	52
3	**Koppal**	04	31	55
4	**Bidar**	00	00	00
5	**Raichur**	05	26	79
6	**Yadgir**	02	08	26
7	**Bijapur**	01	06	06
Total		23	123	348

ORANGE				
Sl. No.	**Name of the district**	**No. of talukas covered**	**Total no. of villages covered**	**Total advisories**
1	**Gulbarga**	03	11	104
2	**Bellary**	00	00	00
3	**Koppal**	02	03	03
4	**Bidar**	02	04	09
5	**Raichur**	01	01	01
6	**Yadgir**	01	01	02
7	**Bijapur**	00	00	00
Total		09	20	119

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TERMS OF REFERENCE

FOR EVALUATION OF PROJECT ENTITLED "E-PEST SURVEILLANCE IN SELECTED CROP ECOSYSTEM THROUGH ESAP" IMPLEMENTED DURING THE PERIOD 2014-15 BY UNIVERSITY OF AGRICULTURAL SCIENCES, RAICHUR AT THE COLLEGE OF AGRICULTURE, RAICHUR

1. Title of the study: **E-Pest surveillance in selected crop ecosystem through eSAP**
2. Department/ Agency implementing the scheme: Department of Entomology, AC, Raichur
3. Project approval number:
4. Year of Start: 2014
   Year of Conclusion: 2015
5. Total budget of the project : 0.81 crore

4. Background and context:

One of the prominent measures to enhance production is to overcome losses caused by insects and diseases. Although drastically varying, estimates show that average losses by pests can exceed 30% of the total production. From the perspective of agricultural extension, a two-pronged approach would be needed to drive an initiative to combat pests. First, timely delivery of the latest pest management technology for the affected farmers, and second, real time analysis of pest situations across space and time for various crops to take decisions for the future. The first situation would entail instantaneous identification of the pest followed by quantification of the problem in the field itself. Simultaneously, the latest pest management strategies should be available. Second, field situations should be captured, synthesized and tabled in real time to experts, pest managers and policymakers to facilitate instant decisions based on real field data.

At this juncture, a path-breaking shift in agricultural extension happened with the development of e-SAP©, or *e-Solutions against Agricultural Pests*. This application has been successfully tested and put to practice for the first time in India by the University of Agricultural Sciences (UAS), Raichur. e-SAP is an application built on a platform that opens a gateway for two-way dissemination of information in real time. Central to the platform is a handheld medium that i) provides field users with all the relevant information in their hands; ii) information can be accessed offline; iii) information is intelligently metamorphosed into a form that can be easily understood and put to use by illiterate users transcending language barriers; iv) it has substantial in-built intelligence for on-field decision support; v) it has protocols for intelligent surveys and data collection; vi) specific information on any/all devices can be updated remotely that makes real time dissemination possible; vii) there is real time expert connect to handle emergencies and unknown field situations; and, viii) all forms of data, including multimedia, can be disseminated in both directions in real time. The platform enables policy makers,

researchers and users at the other end of the spectrum obtain field information in real time. Field data that streams-in is viewed over GIS platform. There are automatically updated graphs and tables along with decision support intelligence. It is multidirectional, flexible and scalable.

e-SAP targets one of the critical requirements of a crop cycle, i.e., pest management. Pests, basically herbivorous insects and microbial diseases, have always plagued agriculture; the numbers of challenges having multiplied following green revolution. Total crop losses, even suicides by farmers, have been attributed to pests. Modern agriculture has witnessed the rise of many locally unknown pests, or those that once had a 'minor pest' tag on them. Invasive pests, pest resurgence and pest resistance have complicated the issues. Academia, like the Universities and research institutions, private enterprises and traditional knowledge, have all been continually responding to resolve pest crises. But, linking Ps and Ss has remained a major issue. It is in this regard that e-SAP has been built. It contains features that can be categorized into those that assist field workers and those that assist policymakers/researchers.

5. Objectives:

1. To provide pest identification and latest pest management strategies to the farmers of the region for major crops
2. To generate pestilence data in the selected districts based on regular sampling.
3. To develop additional features that significantly enhance the functionalities of e-SAP
4. To empower field staff of e-SAP of the selected districts of the region

6. The present status of the project:

At present the eSAP (Electronic Solutions against Agricultural Pests) application developed during this period is now scaled up to the entire Karnataka state and being implemented through Karnataka State Department of Agriculture and Karnataka State Horticulture Department.

The software is upgraded to the latest Android version (6.1 and above) and made device independent. The advisory content related to over 40 crops have been validated and certified. The application is now acts a connecting link between all the stake holders (Farmer-Field officer- Scientist-Administrator- policy maker) in agriculture on a single platform in real time in the field of crop health management.

The officers of KSDA and KSHD are empowered with the use of eSAP application and installed in their mobiles. Advisories are generated now being generated based on eSAP application.

eSAP technology is being implemented in association with other agricultural and horticultural Universities of Karnataka state as well as ICAR-IIHR

7. Out come of the project :

OBJECTIVE 1:

Objective 1 & 2

A total of 31919 ha was surveyed in 2097 villages of 34 talukas in seven districts of UAS, Raichur to record the pests of 19 agricultural and horticultural crops (Paddy, Cotton, Pigeonpea, Chickpea, Chilli, Maize, Jowar, Groundnut, Sunflower, Sugarcane, Pomegranate, citrus, Bhendi, Brinjal, Tomato, Mango, Lemon, Orange, Banana, Coconut, etc.) during 2014-15 (Table 1 and Fig.1).

In pigeonpea, among the various pests surveyed, highest incidence of leaf webber (47%) was noticed in all the seven districts. This was followed by *Helicoverpa* to the extent of 32 %. Other pod borers occupied 5%. The flower webber was recorded to the extent of 4% in major red gram growing districts. In paddy, thrips was the major insect noticed in the nursery (15 %) followed by leaf folder (37%) and Hispa (12%) in the main field. In Jowar, incidence of Stem borer (43 %) was highest followed by army worm (25%).

Out of 9773 ha surveyed in cotton, incidence of jassid was wide spread (42%) in all the cotton growing areas followed by Leaf Miner (16%) mainly in Raichur, Gulbarga and Yadgiri districts. Thrips was noticed to the extent of 7 % in the early period of the crop. Ash weevil was mainly noticed in Raichur district to the extent of 6%.

In groundnut, incidence of leaf miner was wide spread (25%) followed by Jassid (19%) , Spodoptera (18%), Gram Caterpillar (13%), RHHC (12%) and Thrips (9%). In chickpea, *Helicoverpa* was the major pest recorded followed by *Spodoptera exigua* in traces. Of the 1773 ha surveyed in chilli, thrips (37%) occupied major area followed by midge complex (22%) especially in Bellary and Raichur districts. Incidence of Spodoptera (18%) was also noticed along with mites. (13%)

In sunflower, defoliators like semilooper (54%) followed by Thrips(19%), *Helicoverpa* (8%) and Jassid (8%). In sugarcane, Early shoot borer was wide spread (48%) followed by wooly aphid (20%) and Leaf hopper (13%).

In vegetables like tomato, leaf miner incidence was wide spread (50%) followed by fruit borer (19%) and recently Tomato Leaf Miner or fruit borer (Pin worm) has recorded 11 % incidence. In mango, leaf hopper incidence was wide spread (33%) followed by leaf gall midge (29%), whereas, in pomegranate, Leaf eating caterpillar (32%) followed by thrips (29%) and aphid (18%) were wide spread. In citrus, leaf miner and citrus butterfly (26 %) were predominant pests noticed.

3) To develop additional features that significantly enhance the functionalities of e-SAP

In total 1076 UDMs were received out of which 845 UDMs resolved, 231 rejected and eight UDMs are pending. Among 19 crops, highest UDMs were found in cotton crop (Total: 443; Resolved: 356; Rejected: 87) followed by redgram crop (Total: 237; Resolved: 162; Rejected: 75), paddy (Total: 89; Resolved: 60; Rejected: 29). In remaining crops the UDMs were minimal

Objective 3

The additional features such as multiple image option (Figure 5), weed identification with survey protocol was added to the content management system which was similar to that of IDD(Fig 5).

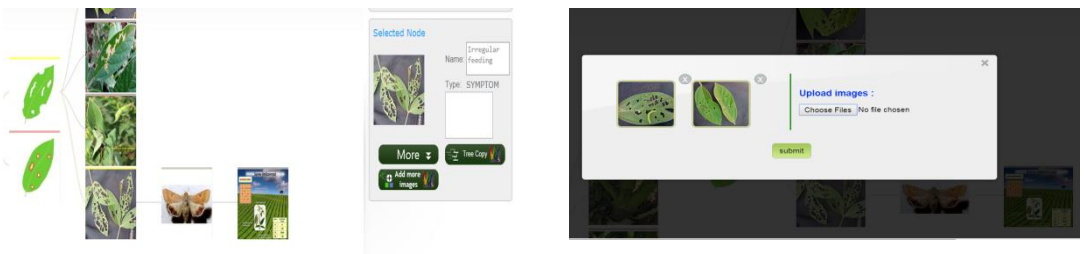

Fig 5: Screenshot of multiple image adding option

In tab the weed survey option includes

Fig 6: Screenshot of weed survey methodology

CAPACITY BUILDING

1. Conducted hands on training on "**Using e-SAP tablet**'' to field scouts on 30, July, 2014 (Plate 1).
2. Project leader participated and presented the paper entitled " e-SAP: A Complete ICT Solutions for Agricultural Extension" in 7th National Extension Education Congress-2014 on "Translation Research-Extension for Sustainable Small Farm Development"

during 8-11,November,2014 organized by Society of Extension Education, Agra in collaboration with ICAR Research Complex for NEH Region, Umiam, Meghalaya.

3. Participated in exhibition on technologies for enhancing oilseeds production through NMOOP conducted by DOR on 18-19, January, 2015.
4. Created awareness about "e-SAP technology and use to farmers'' to school students of Raichur during their educational visit to UAS, Raichur (Plate 2).

8. Assets : Include building, eqipments - all the assets purchased under the project.

9. Where the project is undertaken : In six districts (Bidar, Kalaburgi, Yadgir, Raichur, Bellary and Koppal) of North East Karnataka
Places to visit to evaluate the project : eSAP Unit, UAS, Raichur

10. Evaluation questions and minimum expectations:
a. Whether the eSAP unit is established in terms of infrastructure facility?
b. Whether the pest surveillance as per the target is achieved through eSAP
c. Whether the e-pest surveillance in designated crops are conducted through eSAP?
d. Whether the eSAP platform was added with new features?
e. Whether the capacity building on eSAP has beed done

11. Evaluation methodology and sampling
1. By interaction with Project Leader
2. Visiting the eSAP unit to witness the eSAP technology
3. To go through the eSAP annual report submitted to RKVY

12. Deliverables
A detailed report of e-Pest surveillance in selected crop ecosystem was submitted to RKVY

13. Duration and time schedule of the study
Within three months

14. Quality expected from the evaluation report:
a. The number of farmers' field covered in the e-pest surveillance programme
b. Features developed during the development of eSAP platform/ application
c. Capacity building on eSAP

15. Recommendation
Specific recommendation leading to policy changes towards sustenance of eSAP technology in Karnataka and grants for its maintenance has to be highlighted

16. Cost and schedule of budget

1. Release of grants towards maintenance of eSAP platform, training to officers of the line departments, support to technical staff in compilation and validation of existing and new crops in the field of crop health management .

17. Contact person:

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EVALUATION TEAM MEMBERS

Sl. No.	Name	Designation
1	Dr. B. C. Suryanarayana	Principal Investigator
2	Dr. M. A. Shankar	Associate Investigator
3	Sri. Siddaraju	Associate Investigator
4	Dr. A. R. V. Kumar	Subject Matter Specialist

Dr.Suryanarayana, B.C. is a doctorate in Agriculture with specialization in Agronomy and is a Certified Associate of Indian Institute of Banking (CAIIB), Fellow of Indian Institute of Valuers. He worked in State Bank of India from the year 1981 to 2014 as a Technical Officer and retired as Asst. General Manager (Rural Development). He is a practicing consultant in the field of Agriculture, Horticulture, poultry, dairy, fisheries and plant tissue culture and covered cultivation. He has about 35 years of experience in the field and has prepared several project reports for financial institution, written books in vanilla cultivation, anthurium, medicinal and aromatic crops, minor irrigation, poultry and dairy farming. He has appraised more than 6,000 proposals in agriculture and related fields for funding by the Bank and has also been involved in many studies relating to development of Agriculture and allied activities. He has served as a General Manager in a bio-fertilizer, bio-pesticides and organic manures manufacturing company and is also a Technical Director in a company involved in manufacture of agricultural implements and equipment.

Dr. M. A. Shankar is a doctorate in Agriculture with specialization in Agronomy. He is former Director of Research, University of Agricultural Sciences, Bengaluru and presently the Executive Member of Institution of Agricultural Technologists, Bengaluru and Co-Chairman of Agribusiness Consultancy Subcommittee. He has implemented 51 research projects for the University funded by International organizations, Central and State governments, Private firms. He has guided 6 Ph. D. students and 15 M. Sc., (Agri) students. As Dean of College of Agriculture, Hassan, he has, with his administrative skills, streamlined accounting, financial, academic and administrative issues. He has been involved in review and evaluation of Technical Reports of 32 All India Co-ordinated Research Projects (AICRP) spread all over India. He has also evaluated 11 operational research projects for the technical feasibility and implementation. He has published 173 peer reviewed research papers. He has also penned 54 booklets and books for the University. He has vast experience in evaluation studies of projects.

Sri. Siddaraju is a Graduate in Agriculture with more than 35 experience in the field of Agriculture. He has served in the Karnataka State Department of Agriculture (KSDA) as Asst. Agricultural Officer in Farmers' Training and Education Centre, Soil Testing laboratory and as Subject Matter Specialist. He was Deputy Director of Agriculture (Commercial Crops) for 6 years, District Watershed Development Officer for 2 years. He has also been Joint Director of Agriculture (Inputs) for 5 years. He was involved in preparation of Annual Programme Planning booklets pertaining to Agricultural Inputs in Department of Agriculture. After retirement, he is serving as Chairman, Agriculture Consultancy Subcommittee, Institution of Agricultural Technologists, Bengaluru and has been actively involved in evaluation studies of projects.

Dr. A.R.V. Kumar, is a doctorate in Agriculture with specialization in Agricultural Entomolgy from University of Agricultural Sciences, Bangalore. He served in the University in various capacities and retired as University Head of Entomology Department, Professor of Entomology. He has worked on aspects of Pest management in different cropping systems and for an extended period on the management of White grubs in different cropping systems. He has built up a collection of over 50,000 white grub specimens of India at the department. He has also worked on the use of neem in pest management and Insect Tolerant Transgenic Crops. He has guided both masters and Ph.D. students on various aspects of Pest Management and Insect Taxonomy. He has taught Insect Morphology, Principles of IPM, Insect Ecology and Insect Taxonomy at the University. He took special interest in the development of infrastructure at the Department of Entomology, set up a molecular biology lab and to set up the First Butterfly Park at the Banneraghatta National Park, Bengaluru. He has 95 research articles and Two edited books to his credit. Two of his publications are being extensively used in teaching Community Ecology. Currently he is working on the development of mass multiplication techniques for several insects as sources of animal protein.