INFORMATION AND COMMUNICATION TECHNOLOGY BASED PEST SURVEILLANCE AND ADVISORY FOR IPM

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1. INTRODUCTION

Welfare of a nation and its citizens is dependent on thought processes led actions executed at policy and implementation levels. In an era driven by advancements in the field of information and communication technology (ICT) for livelihood and lifestyle privileges, vistas of its application are ubiquitous. Approach to use of ICT evolves from a specific vision of improvising the existing practices accounting the drawbacks associated with them. More often than not the advantageous features of ICT transform the structure and function of the organizations for their mandated services. Leveraging individual and integrated services of agriculture to the farmers ensuring their efficiency, transparency and reliability at affordable costs is possible through use of ICT. In agricultural research and development, the role of ICT is enormous from down to earth to the limit of the sky, and localized to global scales of space and time offering information with security along with the value addition of data preservation for a single to manifold components of any given subject.

Integrated pest management (IPM) like ICT has many components of crop protection. Levels of IPM could be for a given crop or for a cropping and production system. However, based on the status of harmful organisms (be it insect-pests, pathogens, nematodes, weeds, mites and rodents) that need a continuous watch kept over them. Realizing the scope of ICT in plant protection with multifold possibilities of centralization and decentralization, considering the roles and responsibilities of the stakeholders involved, the National Research Centre for Integrated Pest Management (NCIPM) with its mandate of eliciting national pest scenario across crops *vis-á-vis* dissemination of IPM practices to the growers revolutionized the ICT-driven pest surveillance, often referred as e-pest surveillance, and incorporated into various programmes operational across India.

2. PRE-REQUISITES FOR PEST SURVEILLANCE

An elaborate preparation is necessary for an effective and efficient pest surveillance. An organized sampling plan is needed based on the distribution of cropped area under the target crop for village and field selections. Scientifically-based sampling methodology including selection of spots/plants in a field and pests to be observed (incidence or the damage) need finalization. Information such as crop variety, date of sowing, other agronomic practices and pesticides applied add value when recorded. Regular schedule is must for recording pest observations during the cropping season. Guidelines for field selection, tools, global positioing system (GPS), traps and lures for insect-pests and data sheets (books) for recording field details and pest observations and training of personnel (pest scouts and monitors) on identification cum sampling of insect-pests and diseases of the target crops are the essential components. Additionally, infrastructure including computers, customized software and internet connectivity besides trained manpower (data entry operators) makes the best possible implementation of e-pest surveillance. There is need to be continuous co-ordination among the stakeholders right from programme formulation to field level implementation in terms of knowing the pests status, recommendation of pest management advisories and their dissemination to farmers.

3. PROGRAMMES OF ICT-BASED PEST SURVEILLANCE OF NCIPM AT A GLANCE

3.1. Crop Pest Surveillance and Advisory Project (CROPSAP) of Maharashtra

Severe pest attack on soybean during 2008-09 in Marathwada and Vidarbha regions of Maharashtra,

and the reasons for the outbreak implicating the lack of scientific and systematic pest monitoring and management led to the innovative use of ICT in the field of plant protection for implementation of IPM on an area-wide basis in India. It was strongly felt that pre-emptive actions are a must for averting pest outbreaks given the changing pest scenario associated with diversifying cropping systems, cultivation practices and the felt effects of high variability in seasonal weather. Considering the increased area under soybean on equivalent scale with cotton at Maharashtra, and the common pest status of *Spodoptera litura* on cotton as well as soybean, the program was initiated for both the crops followed by inclusion of pigeonpea and the *Rabi* crop of chickpea since 2009. Rice grown as *Kharif* crop was also included under the surveillance crop-based pest management advisory from 2011. Creation of awareness among farmers of Maharashtra across all target crops under pest surveillance was continuously aimed *vis-á-vis* issuing of real time pest management advisories through tools of ICT. The Department of Agriculture (DA), Maharashtra is the CROPSAP implementation authority with the funding through *Rashtriya Krishi Vikas Yojana (RKVY)* by Central Government till 2012 followed by Government of Maharashtra from 2013 till date.

3.1.1. Objectives

- Implementation ICT-based pest surveillance and advisory
- Awareness creation among farmers on IPM
- Integrated pest management by issuing appropriate advisories and ensuring timely availability of critical inputs

3.1.2. Stakeholders

State Agricultural Universities (SAU) of Maharashtra *viz.,* Mahatma Phule Krishi Vidyapeeth, Rahuri, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Marathwada Agricultural University, Parbhani, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and ICAR institutes *viz*., the National Research Centre for Integrated Pest Management, New Delhi, Directorate of Soybean Research, Indore, Madhya Pradesh, Central Institute for Cotton Research, Nagpur, Maharashtra, Directorate of Rice Research, Hyderabad, Telangana (2012 and 2013 seasons), National Rice Research Institute, Cuttack, Odisha (from 2013), Central Research Institute for Dryland Agriculture, Hyderabad, Telangana, Indian Institute of Pulses Research, Kanpur, Uttar Pradesh, National Institute of Plant Health Management, Hyderabad (from 2013) and the implementing authority of State Department of Agriculture, Maharashtra with its farmers constitute the participants.

3.1.3. Target crops and area of operation

Nearly 43000 villages across 348 talukas of 33 districts from among seven divisions of Maharashtra are being covered under the programme. The area under each crop fluctuates with seasons. Soybean among *Kharif* crops and chickpea of *Rabi* has shown marked increase in area under cultivation during 2014-15.

Area of cultivation (m ha) of the target crops in Maharashtra

Crop	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Soybean	30.19	27.29	30.10	30.64	32.18	39.17
Cotton	33.92	39.42	41.67	41.87	41.50	38.72
Rice	14.50	14.86	15.16	15.28	15.92	15.14
Pigeonpea	10.93	13.02	12.33	12.14	11.60	10.93

3.1.4. Framework of pest surveillance implementation

Establishment of pest monitoring units (PMU) covering blocks based on cropped area, manpower deployment in terms of pest scouts (covering around 8 villages/week), pest monitors (one for every 10 scouts), one data entry operator per PMU and server supporters across the State, and engagement of contractual staff such as research associates and computer operators at the ICAR and SAUs formed the platform for implementation of CROPSAP. The villages were clustered into 8000 ha of target crops and those having highest area under each target crop were selected for pest surveillance. For every 1000 ha under the target crop two fixed (observations recorded from start to end of crop season from same fields) and two random fields were selected for pest scouting.

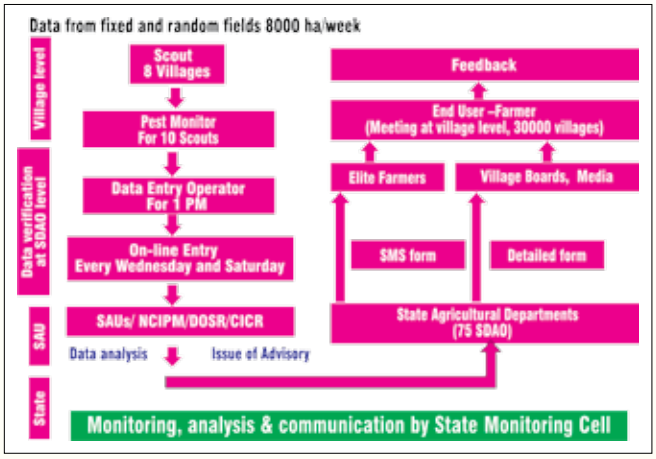
Fixed and random fields were selected from different directions of the village. During this process of field selection it was ensured that the selected villages represent the cluster of villages. In each block, the villages not covered for pest scouting were considered for roving surveys done twice a week by pest monitors wherein 10-15 fields spread across 10 villages were observed in a single day. The unit of field observations was 0.4 ha. In roving

survey, qualitative pest status was recorded from randomly selected fields of villages other than those selected for quantitative surveillance by pest monitors.

For each of target crops *viz.,* soybean, cotton, rice, pigeonpea and chickpea, two types of data sheets were prepared *viz.,* proforma for use by scouts (to record the quantitative data for the pests of surveillance from fixed and random fields) and pest monitor proforma (to record the qualitative information on the target and additional pests of importance). Guidelines to record each of the information and data are provided in the data books for pest scouts and monitors.

ICT tools *viz.* laptop, internet modems and GPS devices formed essential part of the program under custody of the PMUs. Functionality of data entry, upload and online reporting software applications are maintained by ICAR-NCIPM, New Delhi.

3.1.5. Scheme of CROPSAP implementation process



3.1.6. Pests under surveillance

Crop	Quantitative	Qualitative surveillance
Soybean	*Spodoptera*, Semilooper (*Chrysodeixis acuta*), *Helicoverpa armigera*, Girdle beetle (*Obereopsis brevis*)	Hairy caterpillar, Stem fly *(Melanogromyza sojae)*, Whitefly *(Bemisia tabaci)* , Yellow mosaic virus, Rust *(Phakopsora pachyrhizi)* and Pod blight *(Colletorictum truncatum)*
Cotton	*Spodoptera*, Jassids (*Amrasca devestans*), Whiteflies (*Bemisia tabaci*), Thrips (*Thrips tabaci*), Mealybug (*Phenacoccus solenopsis*) and Leaf reddening	Aphids *(Aphis gossypii)*, *H. armigera*, *Earias* spp., Pink bollworm *(Pectinophora gossipiella)*, Grey mildew *(Ramularia areola)* and Parawilt
Rice	Yellow stem borer (*Scirpophaga incertulas*), Gall midge (*Orseolia oryzae*), Swarming caterpillar (*Spodoptera mauritia*), Leaf folder (*Cnaphalocrosis medinalis*), Plant hoppers – White blacked plant hopper (*Sogatella furcifera*) & Brown plant hopper (*Nilaparvata lugens*), Blue beetle (*Leptisma pygmaea*), Bacterial leaf blight (*Xanthomonas campestris pv oryzae*), Sheath blight (*Rhizoctonia solani*) and Blast – (*Pyricularia oryzae*)	Caseworm *(Nymphula depunctalis)*, Brown spot *(Helminthosporium oryzae)*, *Hispa*
Pigeonpea	Pod borer (*Helicoverpa armigera*), Pod fly *(Melanagromyza obtusa)*	Mealybug, Cowbug, Pod bugs, Termites, Stem weevil, Blister beetle and Sterility mosaic
Chickpea	*Helicoverpa armigera*, Wilt disease (*Fusarium*)	-

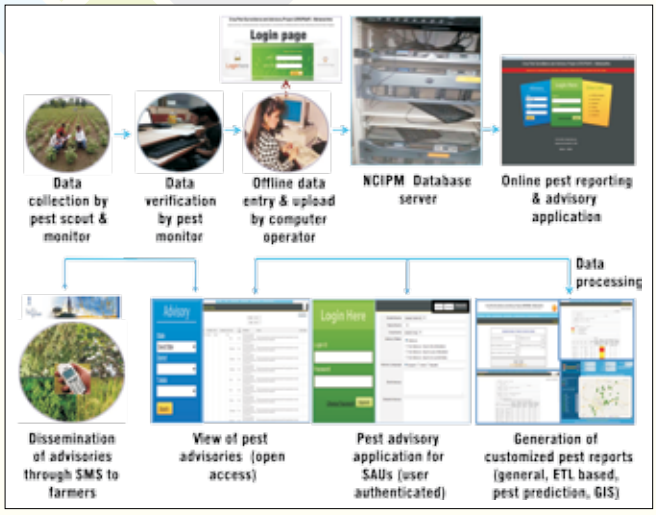
Quantitative surveillance are done by the pest scouts; Qualitative surveillance (Low/ Moderate/High) done by pest monitors

3.1.7. Schedule of pest surveillance and management advisories

Data collection	Data entry and uploads	Data analysis & issue of advisories (SAUs)	Dissemination of advisories by DA
Monday & Tuesday	Wednesday	Thursday	Thursday
Thursday & Friday	Saturday	Monday	Monday

3.1.8. Architecture of e-pest surveillance and advisory

The architecture is a three-tier system designed for pest surveillance that consists of offline data management facility, online pest reporting application and centralised database. Database having various tables for information storage were developed using SQL 2000. Offline data management and online pest reporting applications were developed using ASP.net 2.0 technology. XML format was used for data transfer from offline application to database.

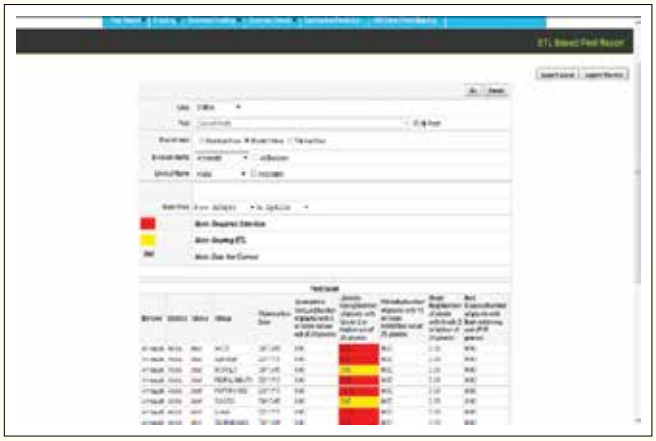


3.1.9. Features of off-line client application

Client application is user-authenticated for application by the pest monitoring units to enter and upload the collected data in respect of the fields from villages of selected talukas of districts of the State. The quantitative and qualitative data collected from fields by pest scouts and pest monitors, respectively in respect of crops (soybean, cotton, rice, pigeonpea and chickpea) could be entered offline and stored. While viewing and editing of field details data can be scrutinised for their correctness before uploads. The upload option compiles and synchronizes the data base and connects to the server through internet.

3.1.10. Features of online reporting application

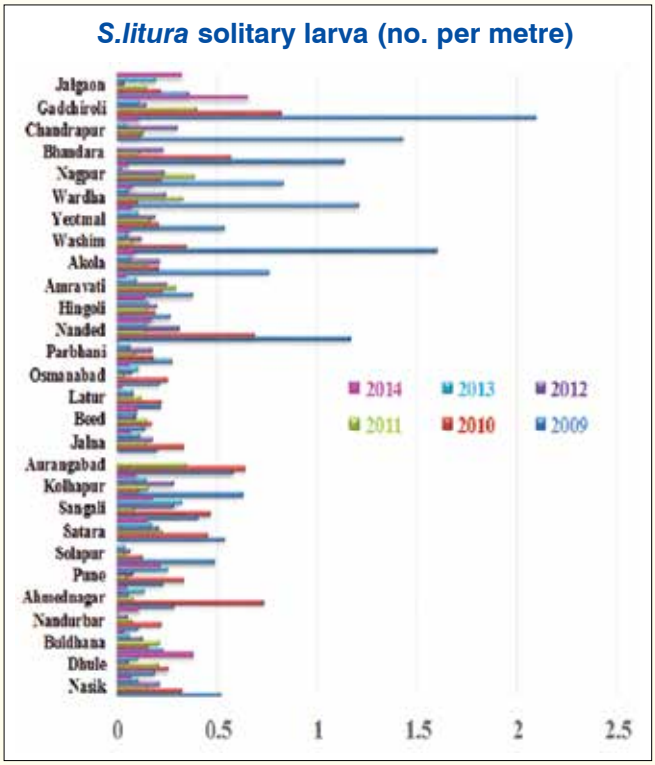
The technical inputs *viz.,* the economic threshold levels (ETL) and the pest management advisories formulated in detailed and brief formats for the selected pests of target crops by the SAUs and ICAR institutes formed the basis for developing reporting applications. The online reporting and analysis application accessible for authenticated users were assigned to the stakeholders through *http://www.ncipm.org.in/cropsap2015/login.aspx* that produces general and ETL based pest reports with additional options for tracking pest scout, monitor and advisory



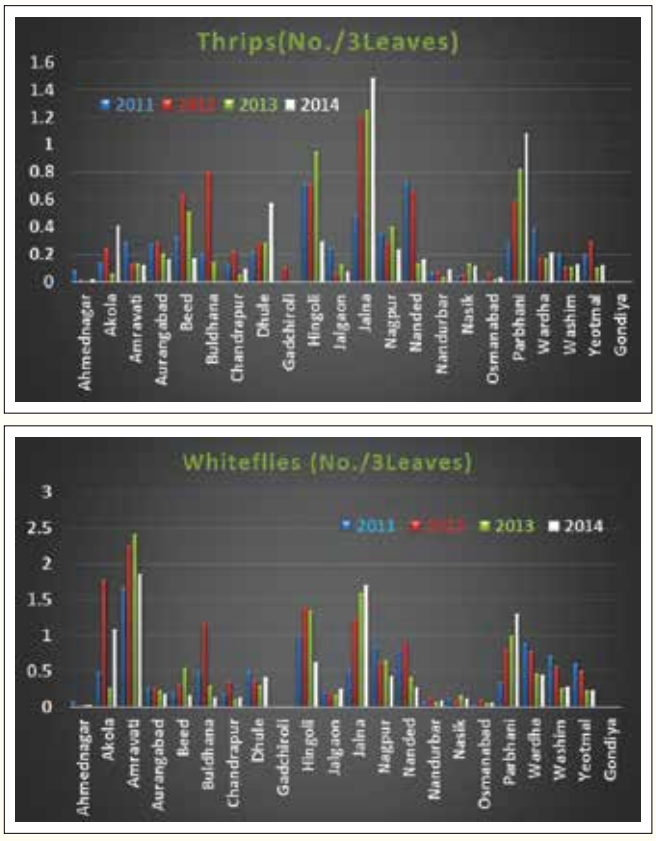
uploads, besides geographic information system (GIS) mapping indicating the hotspots of any pest of the target crop across the State. Prediction of *Spodoptera litura* severity on soybean, data reporting for different combinations based on user selections and data display in the form of tables that can also be exported to MS Excel for further analysis are the additional features. The advisories in brief and detailed forms relevant to the crop(s) pertaining to the current period are also accessible to any user at taluk level through *http://www.ncipm.org.in/cropsap2015/login.aspx.*

3.1.11.1. Pest status

Soybean: The semilooper, *Chrysodeixis acuta* and *Spodoptera litura* had been relatively lower across all districts during 2014 over the past five years of soybean cultivation. During 2014-15 *S. litura* assumed pest status often at Gadchiroli followed by Jalgaon, Jalna and Chandrapur districts. Semilooper *C. acuta* incidence too was low during 2014 throughout Maharashtra with above ETL population only in the districts of Jalna, Satara, Sangli and Amravati. Girdle Beetle (*Oberea brevis*) damage was greater than ETL (3%) only at Agekhed village of Patur taluka. Neipingah of Chandur bazar, and Amdapur of Varud taluk of Amravati, Sunegaon and Navki of Parbhani district of Latur division besides Kelzar village of Satana (Baglan) taluka of Nasik.

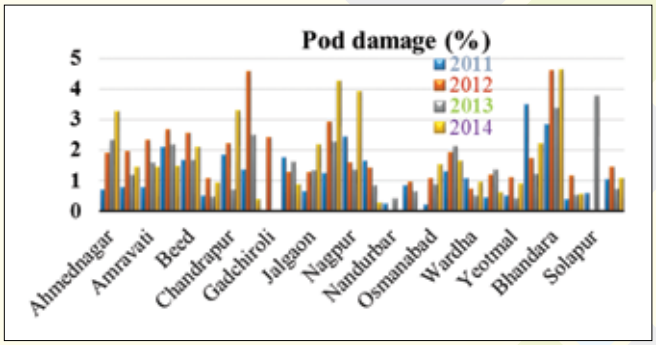


Cotton: The importance of sap feeders was Jassids (*A. devastans*) > Whiteflies (*B. tabaci*) >Thrips (*T. tabaci*). Increasing whiteflies at Jalna and Parbhani, and thirps at Akola, Dhule, Jalna and Parbhani in 2014 over 2011-2013 seasons was obvious.



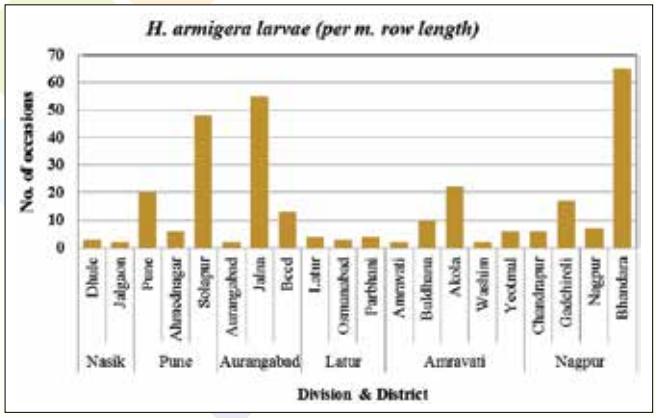
Pigeonpea: Pod damage due to the pod borer complex was higher at Jalna, Nagpur and Nandurbar, and moderate at Chandrapur, Nanded, Gondiya and Aurangabad districts. Pune, Parbhani, Buldhana and Washim had *Helicoverpa armigera* as well as pod damage above ETL, however on a lesser number of occasions. Increasing pod damage due to pod borer complex was observed during 2014 at Ahmednagar,

Comparative scenario of pod damage across districts of Maharashtra

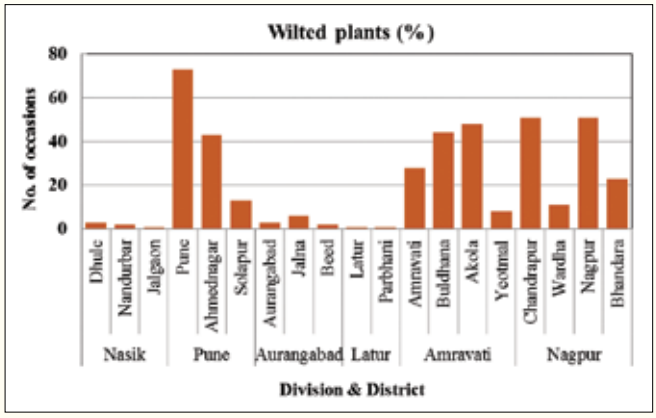


Chandrapur, Jalna, Nagpur, Wardha and Bhandara districts over the previous three seasons. Reduced pod damage was noticed at Dhule and Hingoli during 2014.

Chickpea: *Helicoverpa armigera* on chickpea attained pest status to a higher frequency at



Pest status of *Helicoverpa armigera*



Status of *Fusarium* wilt

Bhandara>Jalna>Solapur>Akola>Pune. Most other districts had lower level of *H. armigera* incidence. Wilt due to *Fusarium* was greater at Pune division followed by Amravati and Nagpur. Nasik, Aurangabad and Latur divisions had the lowest wilt incidence.

3.1.11.2. Yield levels

Considering 2008-09 as the problematic year in terms of two dry spells of two weeks in June-July that had delayed the crop sowing followed by three weeks of dry spell in August resulting in severe pest infestation on Soybean, the observed productivity was less in soybean, cotton and pigeonpea crops. Although seasons of 2009-10 to 2011-12 witnessed 2-3 dry spells, despite timely onset of monsoon, and pest incidences were there after dry spells they were detected in time and corrective measures were taken appropriately through supply of critical pest management inputs. Since 2010-11, productivity of crops never declined to the level of (pest outbreak season) 2008-09 due to continuous vigil kept through e-pest surveillance.

3.1.11.3. ICT-based dissemination of pest management advisories

The participatory response of farmers for short message services (SMSs) enrolment, advisories issued by SAUs, sent by DA demonstrates the growing subscribers, and awareness on pest management generated under the programme during *Kharif* and *Rabi* seasons across five crops.

Area and productivity of target crops of pest surveillance during project period

Crop	Particulars	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Soybean	A	30.63	30.19	27.29	25.3	30.64	39.17	38.01
	P	601	728	1581	1312	1531	1302	499
Cotton	A	31.46	33.91	39.42	43.5	41.87	38.72	41.92
	P	257	256	322	280	276	343	163
Rice	A	14.99	14.5	14.86	15	15.28	15.13	15.00
	P	1496	1474	1766	1816	1964	1799	1875
Pigeonpea	A	10.08	10.93	13.02	12	12.17	10.96	10.37
	P	600	841	750	704	829	874	313
Chickpea	A	11.43	12.91	14.23	10.51	11.35	13.2	13.48
	P	677	863	914	775	826	932	615

(A=Area in 1 x 10^5 ha, P=Productivity in kg/ha)

Dissemination of pest management advisories through SMSs across the crops of soybean, cotton, rice, pigeonpea and chickpea based on ETLs of different pests since the inception of CROPSAP indicate the need-based and effective functioning of plant protection extension across the state of Maharashtra.

ICT-based pest management advisory dissemination

Year	No. of subscribers (lakhs)	No. of SMSs sent (lakhs)
2009-10	1.63	31.93
2010-11	2.40	112.00
2011-12	3.11	199.06
2012-13	3.40	360.83
2013-14	3.90	265.80
2014-15	15.00	550.27

Number of advisories issued

Season	Soy-bean	Cotton	Rice	Pigeon-pea	Chick-pea	Total
2014-15	9310	14171	15193	8097	10594	57365
2013-14	15170	24846	20959	13364	10759	85098
2012-13	10043	17177	13720	13120	16017	70077
2011-12	11935	16668	15528	11502	8537	64170
2010-11	12077	17289	**	15768	10996	56130
2009-10	2583	2212	**	3061	5661	13517

*** Rice crop was included for pest surveillance from 2012 season*

Since the inception of CROPSAP till date there has been no outbreak of any major pest on the targeted crops due to the consistent pest monitoring, timely guidance received by farmers through SMSs and adoption of appropriate pest management strategies.

On the side-lines of CROPSAP considered as one of the path-breaking initiatives with the possibility and success of the programme demonstrated, many other ICT initiatives have been brought into operation in plant protection. The highlights of the programmes are furnished in brief.

3.2. National information System for Pest Management (NISPM-*Bt* cotton) and On-line Pest Monitoring and Advisory Services (OPMAS) (cotton)

Introduction of *Bt* cotton in India from 2002 for the management of bollworms resulted in changing pest scenario with the sap feeders (mirids, mealybugs, aphids, thrips and whiteflies) acquiring the status of major pests in addition to emergence of grey mildew, leaf spot and rust diseases and the disorder of leaf reddening. There was an urgent need to monitor the insect-pests and diseases regularly for issue of advisories to take up remedial measures before epidemic situations arise. Department of Agriculture and Cooperation, Ministry of Agriculture operated the National Information System of Pest Management (NISPM) in *Bt* cotton under Technology Mission on Cotton Mini Mission II between 2008 and 2013. From 2014, programme has been renamed as "On-line Pest Monitoring and Advisory Services (OPMAS)" and covered under the National Food Security Mission (NFSM) - Commercial Crops with the aim to expand the web-based pest monitoring and advisory services across the country in major cotton growing districts with ICAR-NCIPM as a coordinating centre. While NISPM covered 1120 fields spread over 280 villages in 14 intensive cotton growing districts of nine states, presently OPMAS is being implemented in ten major cotton growing States with the help of 16 cooperating centres of SAUs, ICAR and *Krishi Vigyan Kendras* to cover 21000 farmers of 26 districts. OPMAS has been implemented in 23134 ha of cotton involving 19956 farmers of 216 villages during 2014-15.

3.2.1. Implementing centers of OPMAS

State	Participating centre	Implementing district	No. of farmers
1. Haryana	1. ICAR-Central Institute for Cotton Research, Sirsa	1. Sirsa	750
		2. Fatehabad	750
2. Punjab	2. Regional Research Station, Faridkot	3. Faridkot	1000
		4. Shri Muktsar Saheb	1000
3. Rajasthan	3. Agricultural Research Station, Banswara	5. Banswara	750
		6. Pratapgarh	750
4. Gujarat	4. Anand Agricultural University, Anand	7. Varodara	750
		8. Kheda	750
5. Madhya Pradesh	5. Cotton Research Station, Khandwa	9. Khandwa	1000
		10. Khargone	1000
6. Maharashtra	6. Cotton Section, Akola	11. Akola	1000
		12. Buldana	1000
	7. *KVK*, Kharpudi, Jalna	13. Jalna	1000
		14. Parbhani	1000
	8. *KVK*, Ahmednagar	15. Ahmednagar	1000
		16. Aurangabad	1000
7. Telangana	9. *KVK*, Jamnikunta, Karimnagar	17. Karimnagar	625
		18. Warangal	625
8. Andhra Pradesh	10. Regional Research Station, Guntur	19. Guntur	625
		20. Prakasam	625
9. Karnataka	11. *KVK*, Tukaratti, Belgaum	21. Belgaum	625
		22. Dharwad	625
	12. *KVK*, Mysore	23. Mysore	625
		24. Chamarajanagar	625
10. Tamil Nadu	13. *KVK*, Perambalur	25. Perambalaur	750
		26. Salem	750

Additionally, ICAR-Central Research Institute for Dryland Agricultural, Hyderabad and ICAR-Indian Agricultural Research Institute are serving as specialised centres involved in pest-weather correlation studies and hot spot identification.

3.2.2. Surveillance plan under NISPM and OPMAS

Formulation of data sheets along with guidelines for recording the pest observations formed the basic step of pest surveillance. Collection of pest data was done by pest scouts from two fixed and two random fields per village at weekly intervals following the prescribed method of sampling using the developed data sheets.

3.2.3. Pests under surveillance

Pest category	Insect/Disease/Beneficial/Disorder
Sap feeders	Jassids *(A. devastans)*
	Aphids *(A. gossypil)*
	Whiteflies *(B. tabaci)*
	Thrips *(T. tabaci)*
	Mirid bugs *(Creontiodes biseratense)*
	Mealy bugs *(Phenacocus solenopsis)*
Bollworms	American bollworm (egg larvae) *(H. armigera)*
	Spotted bollworm (larvae) *(Earias spp)*
	Pink bollworm (larvae)
	Spodoptera (Egg mass & larvae)
	Fruiting structures (Squares and green bolls)
	Bollworm damage-(Square bolls)
Beneficials	Coccinellids *(Coccinella, Scynmus)*
	Chrysoperla eggs
	Spiders
Diseases	Cotton Leaf Curl Disease
	Grey mildew *(Ramularia aureola)*
	Para wilt
Disorder	Leaf reddening

3.2.4. Features of the ICT in OPMAS

Both NISPM and OPMAS involve the online data feeding and uploads by the cooperating centres. Exclusive launching of home page has been made at NCIPM website. While erstwhile NISPM operated on the URL of *www.ncipm.org.in/NISPM* between 2008 and 2014, the present web-based system under OPMAS was re-designed and hosted on *www.ncipm.org.in/OPMAS/2015/* for cotton pest monitoring and issuing pest management advisories to the farmers through SMS. OPMAS involving ICT was developed using SQL server 2008 and asp. net 4.0 technologies. Other than pest data entry and reporting, OPMAS web-based application has additional salient features such as farmer registration for receiving pest advisories, pest image library and news section. While images of pests are helping the project workers in pest identification, news section provides recent happenings across areas of cotton pest management. Pest image library has both static as well as video recorded images.

3.2.5. Highlights of NISPM & OPMAS

3.2.5.1. Pest status on Bt cotton (NISPM): 2009-2013

Sucking pests, especially jassids, thrips and whiteflies showed increasing trend up to 2011-12 with a decline in the following two seasons. Jassids>thrips>whiteflies was the order of importance at the national level. Leaf reddening emerged as a serious physiological disorder in *Bt* among 14 districts during 2010-11 with its decline in the later years due to effective management interventions.

ETL-based pest scenario on *Bt* cotton under NISPM

Pest	No. of districts (No. of occasions above ETL)				
	2009-10	2010-11	2011-12	2012-13	2013-14
Jassid	8 (109)	8 (210)	12 (582)	9 (112)	12 (218)
Whiteflies	6 (61)	-	7 (282)	8 (61)	10 (57)
Thrips	6 (68)	1 (1)	8 (131)	7 (116)	10 (59)
Mealybugs	5 (12)	3 (178)	8 (445)	5 (25)	6(42)
Mirid bug	2 (5)	3 (21)	2 (31)	1 (41)	2 (7)
American bollworm	1 (4)	3 (4)	6	-	-
Spotted boll-worm	1 (5)	-	-	-	-
Spodoptera	3 (8)	-	-	2 (5)	2 (7)
CLCuD	1 (2)	1 (2)	-	-	1 (6)
Wilt	2 (13)	12 (290)	5 (22)	-	5 (22)
Leaf reddening	-	14 (1964)	10 (349)	5 (193)	11 (266)

Experiments undertaken at selected centres of NISPM *viz*., Akola, Patur, Kanheri Saraf and Bhaurad on the management of leaf reddening brought out spray of $MgSO_4$ @ 1% (w/v) to be significantly better along with other recommended practices for *Bt* cotton.

3.2.5.2. Extension of pest management advisories

The capabilities of farmers on pest management strategies in *Bt* cotton were enhanced through village level group meetings and trainings at NISPM

Awareness creation and extension of IPM (NISPM)

Activity		2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Village group meetings	No. during season	48	740	801	1030	553	356
	No. of farmers	1051	10100	10630	13106	10758	8796
Farmer trainings	No. during season	27	60	86	80	95	72
	No. of farmers	1189	2779	2984	3453	3480	2159
Newspaper coverage	No. during season	12	176	95	87	93	127
Radio talks		NA	17	31	42	34	38

centres. Further awareness through mass media (newspapers and radio talks) was created regularly as and when situations warranted. Extension folders and technical bulletins in local vernacular languages were published by different centres to bring awareness on the emerging insect-pests and diseases besides their management using IPM.

The numbers of advisories and news items on cotton pest management issued in respect of OPMAS centres, and of farmers to whom the advisories were disseminated during 2014-15 indicate the user details of the ICT-based technology.

Extension of IPM (OPMAS): 2014-15

Centre	No. of advisories issued	No. of news items uploaded	No. of farmers involved
Sirsa	7	2	0783
Faridkot	4	3	0276
Banswara	20	11	1038
Anand	20	16	1500
Khandwa	5	2	1811
Akola	6	11	-
Jalna	12	4	1789
Ahmednagar	11	10	1795
Karimnagar	4	1	1240
Guntur	20	9	2031
Belgaum	19	9	1509
Mysore	18	10	2619
Perambalur	11	10	-
Total	*157*	*98*	*16391*

3.2.6. Impact of IPM through NISPM

The regular monitoring and dissemination of advisory helped in reducing the number of chemical pesticide sprays in fields of IPM trained farmers as compared to farmer practices (FP). The seed cotton yield recorded was also higher in IPM as compared to FP.

Pesticide use and yield levels of IPM *versus* FP

Year	Number of pesticide sprays		Cost of pesticide sprays/ha (in ₹)		Seed cotton yield (kg/ha)	
	IPM	FP	IPM	FP	IPM	FP
2008-09	4.2	6.3	2071	2924	2043	1850
2009-10	4.1	6.5	2234	3193	2040	1775
2010-11	3.9	6.0	2475	4246	2138	1841
2011-12	3.7	6.1	2685	4510	2107	1850
2012-13	4.04	6.37	2900	4725	2195	1865
2013-14	4.27	7.34	42168*	45944*	2248	1885
2014-15	3.85	5.94	34513*	37567*	2628	2356

** cost of cultivation*

Centre-wise economic analysis made in 2014 in respect of centres based on ICT-based IPM implementation across seasons of 2008-2013 through NISPM indicated reduced application of chemical pesticides in all the locations.

The use bio-pesticides including botanicals was to an extent of 23.5% of total pesticidal sprays in IPM as against 6.78 in non-IPM fields. Higher net returns as well as benefit cost ratio in IPM over non-IPM was obtained across all centres.

3.3. e-National Pest Reporting and Alert System for Pulses

The domestic demand and increasing import of pulses resulting in an urgent need to increase the pulse production in the country by reducing yield losses due to pest attack led to the development of "Accelerated Pulses Production Programme (A3P)"

under the National Food Security Mission (NFSM) of the Department of Agriculture & Cooperation (DAC), Government of India. Development of web-based tool towards reporting of pest situation from fields through periodical monitoring, and issuing of appropriate pest management advisories to the farmers were built in the programme. The broader objectives of A3P initiative were:

1. To detect pest build-up and monitor their progress through web-based query interface at village/taluk/district level
2. Facilitate the electronic transfer of appropriate information from National Research Centre for Integrated Pest Management (NCIPM) to State Agricultural Departments for initiating timely action.
3. To forewarn farmers through SMSs to ready themselves with preventive as well as curative pest management tools

The purpose of web-based approach was to report the real time pest infestation in the fields and to advise the farmers for applying the appropriate pest management practice so that epidemic situations can be avoided by detecting damage prior to establishment of a higher pest population. The web-based tool 'e-National Pest Reporting and Alert System for Pulses' for the crops of Pigeonpea and Chickpea was implemented initially in five states since 2009, and was extended to Jharkhand from 2010 to 2014.

Number of villages and farmers covered under e-National Pest Surveillance

State (Districts)	Pigeonpea		Chickpea	
	Villag-es	Farm-ers	Villag-es	Farm-ers
Karnataka (Gulbarga)	34	3301	23	1529
Maharashtra (Badnapur, Parbhani, Osmanabad, Nanded)	26	5017	20	3587
Andhra Pradesh (Anantapur)	25	482	12	1000
Madhya Pradesh (Chindwara & Narsimpur)	316	2967	55	1708
Uttar Pradesh (Hamirpur & Banda)	69	3000	12	557
Total	470	14767	122	8381

3.3.1. Features of e-national pest reporting & alert system

The "e-National pest reporting & alert system" for pulses could be accessed at *http://www.ncipm.org.in/A3P/UI/HOME/Login.aspx.* Its platform was independent and could be accessed from any computer connected to the internet. The only requirement at the client side is a web browser and authorization following online registration at NCIPM home page. The system was developed using three tier architecture with online data entry, reporting and advisory to farmers through SMSs in respective languages of the States. Javascript, ASP.Net 3.5 and SQL server 2005 technologies were used in the development of the application. The GIS has been used for pest reporting on map for spatial data management to facilitate easy understanding and visual interpretation.

Home page of "e-National pest reporting & alert system".

Pest reporting through Google maps

Temporal reports (graphical horizontal bars & tabular), and map-based report using Google maps depicting pest incidence and affected areas in different colors representing severity of incidence

are possible. The purpose of this pest reporting through Google maps is to communicate immediate or potential danger arising from the occurrence, outbreak or spread of a pest as well as identifying the pest hotspots so as to advise the State machinery and farmers to take appropriate and timely action for pest management to minimize losses due to pest incidence. This application represents the pest population through an icon in Red, Yellow and Green colours for easy inference regarding different levels of pest intensity. These pest reports allowed them to adjust for necessary pest management requirements and actions to take into account. Pest reports also provided useful current and weekly information for operation of ongoing pest management programme in the States. e-Pest alert system also featured (a) sending SMS to single mobile phone (web2mobile), (b) broadcasting SMS to a group of mobile phones (web2mobiles). However modification was done to include forwarding of single SMS from a mobile phone to a group of mobile phones (mobile2mobiles). More specifically, the pest expert logs in the system and selects the SMS recipient(s). Then a pop-up window emerges where the SMS is written. The SMS could be written in English as well as regional languages (Hindi, Marathi, Kannada and Telugu). 'Translate' tool of Google has been used to convert messages from English into regional languages.

Options (view and send) of pest management advisories

3.3.2. Impact of A3P

Near 25000 farmers were registered for receiving SMS advisories. Total SMSs sent during 2010 were 9530. Currently, potential beneficiary of the system are 25000 farmers who were selected by NCIPM as well as 90% of the farmers that own a mobile phone.

State based A3P co-operators (UP, MP, AP, Maharashtra and Karnataka) conveyed their pest management advisories across 592 villages covering 36000 ha to 3545 and 4650 farmers through 9530 and 13245 SMSs during 2009-10 and 2010-11, respectively.

Implementation of this application not only helped in identifying the hot spots but also geared up the staff to manage the crisis situations through creation of popularity and awareness.

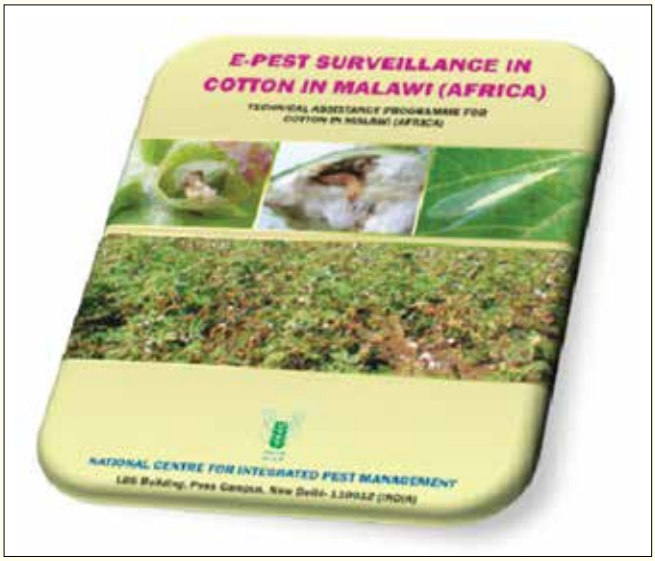
Yield could be increased from 10 to 12 q/ha over 2009-10 by minimizing losses caused by pests. Pest advisories sent to the farmers through SMS on the basis of pest reporting led to the reduction in number of chemical pesticide sprays from 6 to 3 in Gulbarga district. This has also proved very successful and led to 3 million tonnes additional production of pulses in comparison to previous years, despite failures in Anantapur (AP) as well as Chindwara and Narsingpur (MP).

The system has also enabled identify the potential areas wherein yield can be increased by minimizing losses caused by proliferating pests (*Maruca* and *Melanagromyza obtusa*) as well as identification of endemic areas (sterility mosaic virus & leaf spot *Cercospora*) diseases.

3.4. Implementation of ICT-based Pest Surveillance in Malawi-Technical Assistance Progamme (TAP), Africa

Expertise of ICT-based pest surveillance and advisory carried out by NCIPM under National Information System for Pest Management (*Bt* cotton) in addition to the operational success of programmes like CROPSAP and A3P facilitated the pilot scale implementation of ICT-based pest surveillance in Malawi (Africa) in cotton. ICAR-NCIPM in collaboration with Ministry of Agriculture and Food Security, Malawi and Infrastructure Leasing & Financial Services of Clusters Private Ltd. (IL&FS) took up the initiative of demonstrating the potential of ICT in agriculture for cotton pest surveillance and issuing of pest management advisories to extension personnel and farmers of Malawi. As a pre-requisite to the implementation of e-pest surveillance, the baseline information was collected on insect-pests and diseases though a visit by NCIPM scientists for finalizing the data formats for pest observations and customized software development. Software

for data entry, and advisory dissemination were customized as per the infrastructure available at Malawi. ICT-based application was hosted vide. *http://www.ncipm.org.in/ICTMalawi/.* A manual on e-pest surveillance for cotton in Malawi (Africa) was also prepared. Training and workshop were conducted by NCIPM team at Balaka and Machinga districts of Malawi for extension personnel on the identification of cotton pests and implementation of the e-pest surveillance. About 500 farmers from both the districts were registered to receive the pest management advisories through SMSs. ICT-based pest surveillance was launched in Malawi in December 2014. The software has the provision to cover the entire country (28 districts) although only two districts have been covered on a pilot scale presently. Scope of the continued implementation of ICT-based pest surveillance in those two districts and further expansion to other districts of Malawi depends on further funding for deployment of man power and additional infrastructure development.



3.5. Implementation of e-Pest Surveillance and Pest Management Advisory for Fruit Crops (Maharashtra)

The thrust for rising fruit productivity through reduction of yield losses due to pests through action

threshold-based application of pesticides constitute an essential part of integrated pest management. The success of CROPSAP at Maharashtra in field crops motivated the officials of Department of Horticulture of the 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). The implementation profile of e-pest surveillance across fruit crops is exhaustive as given below.

Area of operation under e-pest surveillance of fruit crops

Crop	Districts	Talukas	Villages	Area covered (ha.)
Banana	4	13	462	53,881
Mango	7	45	3670	1,07,182
Pomegranate	8	32	1121	64,928
Orange/Nagpur Mandarin	6	25	944	73,381
Sweet Orange/ Mosambi	4	23	574	56,859
Sapota	1	4	42	5,416
Total	23	142	6813	3,61,647

Key insect-pests and diseases of the six fruit crops considered for surveillance are:

Insect pests and diseases of surveillance

Crop	Pests of surveillance
Santra and Sweet Orange	Bark eating caterpillar, Blackfly, *Psylla*, Fruit sucking moth, Leaf miner, Mites, *Phytophthora*, Thrips, Whitefly
Sapota	Bud Borer, *Phytophthora*, Seed borer
Banana	Leaf Spot, Thrips
Mango	Anthracnose, Hopper, Powdery mildew, Thrips, Trap catch of fruit flies
Pomegranate	Bacterial blight severity for leaf/ Stem/Fruit, Fruit borer, Fruit damage due to thrips, Thrips damage to twigs, Wilt

3.5.1. Features of HortSAP ICT application

HortSAP application also consists of data capture, pest reporting and advisory modules. The system is access rights based that only authorize users to log into the application. The application has provisions to capture information such as location, agronomic, pest details and other relevant information as envisaged in data recording formats. Reporting module generates location-specific current and temporal ETL-based pest reports. (http://www.ncipm.org.in/Horticulture15-16/Default.aspx). Wherever pest population has either reached near or crossed ETL, pest experts issue advisories using the system to the farmers of that area. One of the important feature of the system is that user can easily add crop and pest into it. This also has provision to generate tracking of reports for user activities.

3.5.2. Impact of HortSAP

Implementation of the project in the state has helped the progressive farmers in creating awareness for the correct identification of the pests, timely and ETL-based application of the IPM technologies without time lag between the occurrence of the pests and their management as envisaged from the final estimate of productivity of fruits of Maharashtra presented by National Board of Horticulture. The productivity (mt/ha) of mango, banana, pomegranate, citrus and sapota was 2.5, 58.2, 10.5, 6.4 and 6.5 during post project implementation period of 2013-14 and was higher over 2011-12 (1.0, 52.6, 5.8, 4.4 and 4.1), the startup season of e-pest surveillance and advisory, respectively.

Advisories and SMS issued to farmers

Crop	2011-12		2012-13		2013-14		2014-15	
	Advisories	SMS	Advisories	SMS	Advisories	SMS**	Advisories	SMS
Banana	3	2382	223	67923	452	-	329	78,385
Mango	772	3,63,710	1024	4,52,990	156	-	1425	4,14,611
Pomegranate	692	74,254	1444	10,90,883	452	-	857	25,43426
Sapota*	-	-	-	-	-	-	19	1,42,482
Orange* (Nagpur Mandarin)	-	-	-	-	-	-	445	5,18384
Sweet Orange* (Mosambi)	-	-	-	-	-	-	1692	4,47,263
Total	1467	4,40,346	2691	1,61,1796	2095	28,30,222	4767	41,44,551

** Orange and Sweet orange crops were added for e- pest surveillance and advisory from 2014-15, ** data not available*

3.6. ICT as a Tool for Data Base Development through Electronic Networking and Pest Forecasting

Pest risks associated with climate change requires comprehensive and long term data of crop-pest-weather over space and time, and ICT serves as a translational tool to assimilate them effectively and efficiently. National Innovations on Climate Resilient Agriculture (NICRA) provides a research platform to ICAR-National Research Centre for Integrated Pest Management (NCIPM) for studying the changes in the pest scenarios in response to climatic change across crops of rice, pigeonpea, groundnut and tomato that are important for food and livelihood security of India. Assessment of the changing pest scenarios, mapping of vulnerable regions of pest risks, and evolving curative and preventive pest management strategies towards climatic stress have been emphasized. Twenty five locations from 12 States representing 10 agro-climatic zones (3, 4, 6-13) and 12 agro-ecological regions (R2-8 & R10-11, R15 & R18) of the country were identified for study on real time pest dynamics (RTPD). The centres of project implementation across crops are: Rice: Aduthurai (TN), Mandya (KA), Raipur (CG), Ludhiana (PB), Chinsurah (WB), Karjat (MH) and Hyderabad (TS); Pigeonpea: Gulbarga (KA), Dantiwada (GJ), Warangal (TS), Vamban (TN), Jabalpur (MP), and Anantapur (AP); Tomato: Varanasi (UP), Ludhiana (PB), Rahuri (MH), Hyderabad (TS), Kalyani (WB), Raipur (CG) and Bengaluru (KA); Groundnut: Junagadh (GJ), Jalgaon (MH), Virudhachalam (TN), Anantapur (AP) and Dharwad (KA). Pest surveillance plan for experimental stations and farmer's fields was devised and the list of pests along with their sampling method and weather variables and GPS coordinates to be collected were used to design data recording formats through consultative group meetings involving experts of target crops (*http://www.ncipm.org.in/nicra/DataSheets_Manuals_Guidelines.aspxhttp://www.ncipm.org.in/nicra/index.aspx).* A web-based system consisting of four major components *viz.,* centralized database, offline client data capture, admin panel, and data reporting and analysis was designed. System consisting centralized database, offline data capture and online pest reporting cum analysis facility was developed using SQL Server 2005, ASP.net 3.5 and XML technologies, respectively. Setup files for client software installation by RTPD centres are generated using admin panel configuring software applicable for the target RTPD centre. Reporting application consisting admin panel is functional and available on website: *http://www.ncipm.org.in/nicra/.* The reporting system operates through the start page: *http://www.ncipm.org.in/nicra/NICRAAdminPanelNew/rvLogin.aspx* to log in. Staff exclusively for pest surveillance, training and involvement of subject matter team with their active participation in RTPD centres improves the ICT process and project efficiency. Data base developed through this project is accessible to all stakeholders and serves to bring out location-specific as well as national pest scenario for the present and future climatic scenarios. A web-enabled weather-based forewarning module (available at: *http://www.ncipm.org.in/nicra/ForewarningSystem/PestPrediction.aspx; http://www.ncipm.org.in/nicra/ForewarningSystem/PestPredictionEmpirical.aspx)* for *(a)* Rice yellow stem borer for five locations for *Kharif (b)* Rice leaf folder for *Kharif* (two locations) and for *Rabi* season (one location) (c) *Spodoptera litura* on groundnut for three locations has also been developed and integrated into the system. While field level impacts of climate change on pests are serving

to develop resilient pest management technologies (through further adaptive research), the pest forewarning feature of the project is directly applied at the regional (district) level to minimize the yield losses caused by the insect-pests and diseases. While the ICT accelerated data base development is leading to faster research outputs and forms repository for long-term research, the forewarning component aids in judicious and timely use of pesticides at farm level thus accruing economic and environmental benefits to the crop growers.

3.6.1. Highlights of pest dynamics in relation to climatic variability

- Twenty five real time pest dynamic (RTPD) centers from 11 states, across 11 agro-climatic zones covering 12 agro-ecological regions are being implemented with e-pest surveillance for the four target crops (rice, pigeonpea, groundnut & tomato) during *Kharif* 2011-2015. Comparative analysis of pest scenario *vis-a-vis* weather variables from climatic variability perspective was made considering the data base over three *Kharif* (2011-2013) and *Rabi* (2011-12 – 2013-14) seasons for seven, six, five and seven real time pest dynamic (RTPD) locations in respect of 34, 23, 27 and 30 parameters (including insect-pests, diseases, beneficial, light and pheromone trap catches) corresponding to Rice, Pigeonpea, Groundnut and Tomato crops.
- While outbreak of rice black bug, *Scoutinophara lurida* was seen at Aduthurai (TN) due to greater and unusual rains during 33 standard meteorological week (SMW), Ludhiana (PB) has witnessed reduced rice BPH, *Nilaparvata lugens* due to absence of rainfall and associated reduced humidity levels during the 33 and 34 SMWs.
- Heavy incidence of jassids (*Empoasca kerri*) during 2014 and 2015 as against trace population in the past years was observed at Gulbarga (KA) following higher minimum temperature of 2-5°C over normal throughout the pre- and post-monsoon periods (mid-March – September) followed by torrential rains (195 mm in 35 SMW) coupled with dry spells and intermittent rains (>10mm). Pigeonpea *Phytophthora* blight is on the rise at Gulbarga (KA) in response to the increased rainfall over normal during the late crop growth stage. *Helicoverpa armigera*, *Grapholita critica*, *Adisura atkinsoni* and *Exelastis atomosa* were at their lowest during 2014 at S.K. Nagar (GJ) when the rainfall amount during the season (June - December) had been lower over previous three seasons.
- Higher temperature during pre-monsoon period coupled with delayed rains and late sowing of Groundnut at Dharwad (KA) followed by continuous rains till October during *Kharif* 2014 saw moderate to high (40-50% leaf defoliation) damage due to *Spodoptera litura* and late leaf spot (Grade 5) with leaf miner at its low. Early and late season dry spells and comparatively high rainfall events amidst crop season during 2014 at Jalgaon (MS) had the increasing population levels of jassids *Empoasca kerri*, thrips *Scirtothrips dorsalis* and leaf miner *Aproaerema modicella*. The rare occurrence of thrips damage at maturity period of groundnut at Junagadh (GJ) in 2014 was due to the prevalence of high temperature in day time and absence of rains.
- South American tomato leaf miner, *Tuta absoluta* was documented as a new invasive pest from India during *Rabi* 2014 at Bengaluru (KA). Heavy rains of August (149 mm in 35 SMW as against normal of 21 mm) in 2014 led to *Phytophthora* rot of fruits (40-50%) at Rajendranagar (Telangana) besides early blight and *Fusarium* wilt. Rabi tomato had 40-50% severity of late blight in the 3rd week of March (12th SMW) at Patiala (PB). Increasing target leaf spot incidence with increasing maximum temperature and decreasing relative humidity of December, and decreasing early blight with increasing minimum temperature and morning relative humidity of February were noted at Kalyani (WB).
- Prediction rules based on weather criteria and pest severity levels were developed for brown plant hopper *Nilaparvata lugens* at Raipur (CG), Ludhiana (PB) and Aduthurai (TN), and for early leaf blight at Bengaluru (KA). Web-enabled weather-based predictions for four rice pests (yellow stem borer, gall midge, case worm and green leaf hopper), and *S. litura* on groundnut at weekly and fortnightly basis predicting maximum severity of *S. litura* forewarned low severity in 100% of the occasions during *Kharif* 2014.

4. WAY FORWARD

Use of ICT in plant protection has obviated the drawback of non-availability of complete data sets on pests at one or a few places that make the spatial and temporal pest scenario compilations and exchanges highly difficult for the crop. Considering that large amount of research data that gets lost in the note books of the persons who recorded the data, carefully designed ICT-based pest surveillance not only brings convergence in measuring pests essential for comparison purposes but also fastened the pest scenario known on real time basis for instant recommendations of need-based pest management through advisory notifications. It is also well known that changes in technology are continuous and the sophistication levels of surveillance/ reporting tools are dynamic. Electronic gadgets and networking make pest surveillance and monitoring a commercial enterprise however with the continuous trainings and skill development made available. ICT would continue to play a greater role in effective use of data gathered over time and space in understanding changing pest scenario, effects and efficacy of pest management methods, effects of weather/climate change on crop-pest interactions and in development of forecasts and policies of plant protection. Evolving instant feedback mechanisms from farmers for aiding alternate pest/ crop management planning is required to be attempted hereafter.

PRIME MINISTER'S AWARD FOR EXCELLENCE IN PUBLIC ADMINISTRATION 2012-13

Crop Pest Surveillance and Advisory Project (CROPSAP) - for pest management in major crops in Maharashtra was awarded 'Prime Minister's Award for Excellence in Public Administration' for the year 2012–13. Shri Prabhakar Deshmukh, then Commissioner of Agriculture, Maharashtra received the award on the Ninth Civil Services Day held on 21 Apr 2015 organized by the Department of Administrative Reforms and Public Grievances.

E GOVERNANCE GOLD MEDAL

Crop Pest Surveillance and Advisory Project (CROPSAP) – Maharashtra was an award winner for exemplary use of ICT-based solutions at the 15th National Conference on e-Governance held during 9-10 Feb 2012 at Bhubaneshwar, Odisha.

.... the cup of joy is full only when the findings find practical applications

– Louis Pasteur