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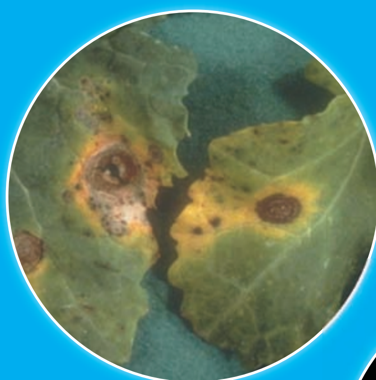
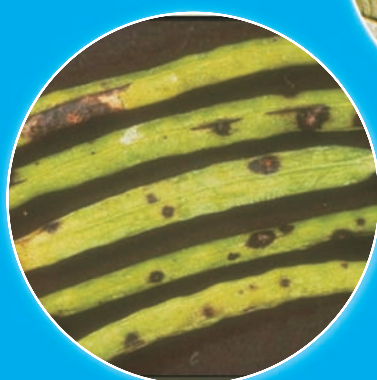
Climate and Crop Disease Risk Management : An International Initiative in the Asia-Pacific Region

APN

SCOPING WORKSHOP PROCEEDINGS





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Participating Institutions :

This APN project brings together 23 key researchers, with expertise in agronomy, agrometeorology, plant protection, epidemiology, plant physiology, and modelling, from a dozen institutions of seven countries viz. Australia, India, Bangladesh, Cambodia, the USA, Switzerland, and the Netherlands. The key collaborating institutions include: in Australia – University of Western Sydney (UWS), New South Wales Department of Primary Industries (NSWDPI)- Wagga Wagga; Queensland Department of Primary Industries and Fisheries (QDPIF) - Toowoomba; in India - Indian Council of Agricultural Research through Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad & National Research Centre for Rapeseed & Mustard (NRCRM); Department of Science and Technology, New Delhi; Tamil Nadu Agricultural University, Coimbatore; Bidhan Chandra Krishi Vishwavidyalaya, Calcutta; in USA- Columbia University-International Research Institute for Climate Prediction, National Soil Tilth Laboratory, Iowa and University of Florida, in Bangladesh - Bangladesh Science Foundation; and in Cambodia - Cambodian Agricultural Research and Development Institute and three international organisations viz. the World Meteorological Organisation (WMO), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT),

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Climate and Crop Disease Risk Management: An International Initiative in the Asia-Pacific Region

(A proceedings of the APN Scoping Workshop, 6-10 November 2006)

Editors

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PREFACE

Given the growing importance of climate change and climate variability scenarios, the aims of the project in developing a strategy to advance sustained operational support for better forewarning of crop disease occurrence, leading to reduced pesticide use, and alternate agricultural and land-use practices have been timely. The project draws on and integrates a diverse body of knowledge that includes seasonal climate prediction, downscaling of climate information, agroecosystem modeling, decision analysis, risk communication and farmer-participatory research.

The initiative taken by researchers in Australia to build on the past collaboration with institutions particularly in India and the USA to develop and strengthen network in the Asia-Pacific region supported by Asia-Pacific Network for Global Change Research (APN) has paid dividends by bringing together researchers of common interest on to a common platform. The team has efficiently used the vast data base generated by researchers from India through their earlier projects on "Development of weather based forewarning systems for insects/pests and diseases", and through All India Coordinated Research Project on Agrometeorology are used in this international effort for validating the models.

One of the major outcomes of this continued research is strengthening of an international network of researchers and a collaborative plan for advancing the objectives of the APN project. Review and future planning workshop will be held during 11-14 February 2008 in Dhaka, Bangladesh, in cooperation with the Bangladesh Science Foundation to share research findings and to explore future funding opportunities to ensure viability, and regionalisation of the project.

The publication arising form the APN funded activity including the workshop held at the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad during 6-10 November 2006 should be of benefit to researchers, extension workers, farmers, policy makers for improved agricultural and environmental decision-making in the Asia-Pacific region.

Editors

Executive Summary

Participants from major research laboratories of Australia, Asia, America, and Europe working on climate related aspects and crop diseases participated in the scoping and planning workshop “Climate and Crop Disease Risk Management: An International Initiative in the Asia-Pacific Region” at the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, India during 6 – 10 November 2006. The workshop was funded by the Asia-Pacific Network for Global Change Research (APN) and hosted by CRIDA as part of a project to enhance the understanding of the relationships between weather/climate, crop disease, and yield reduction, leading to the development of cost-effective and timely management interventions for growers.

The objectives of the workshop were:

- To network with government, community stakeholders and scientists in terms of achieving workshop aims
- To revise specific project plans in order to identify needed data
- To study available models and decide on the applicability of each.
- To identify way ahead, and determine a strategy for larger project funding so that the initiative could continue in the future.
- To take steps to ensure that the project was delivered in an efficient and accountable manner.

This project aims to integrate existing climate, crop and epidemiological research to develop a regionally predictive model for crop disease risk management. By engaging scientists already researching in relevant topics, scientific and policy-analysis linkages will be forged and duplication of research effort is reduced. The project targets three crops in participating countries (peanut, canola and mustard) that are at risk from climate-sensitive diseases. Late leaf spot (*Phaeoisariopsis personata*) inflicts damage to peanut crops around the world. Sclerotinia stem rot (*Sclerotinia sclerotiorum*) and Alternaria blight (*Alternaria brassicae*) are major concern for canola and mustard in many countries. Information on a broad scale is available regarding the influence of weather on disease development in these crops including some prediction models. However, they have not been validated on a large scale. At present, scheduled applications of fungicides help to reduce losses due to these diseases. However, often, the small and marginal farmers in developing countries cannot afford to use a scheduled spray cycle. Hence, a fine-tuned and validated forewarning system can reduce the number of sprays, increase the viability of other disease control options, and thus can help in improved sustainability and livelihoods of farmers.

The scoping workshop at CRIDA explored available research information on modelling and epidemiology of the three diseases. The participating researchers will collaborate and network with each other in follow up projects. Workshop participants represented a broad range of disciplines with interest in modelling of climate, crops and diseases and their applications in crop disease management. Participants were invited from Australia, India, Bangladesh, Cambodia, United States, and Netherlands covering two broad discipline groups viz. climate, crop modelling, risk communication and agrometeorological services (Huda, Ramakrishna, Khan, Jagannathan, Meinke, Hansen, Boote, Stigter, Rathore and Coughlan), and plant protection, epidemiology (Spooner-Hart, Derry, Thakur, Desai, Visarto, Hind-Lanoiselet, Chattopadhyay, Asaduzzaman and Alam). They also had overlapping expertise and interest across disciplines particularly in risk analysis and communication.

Days one to three of the workshop were a series of presentations, each followed by small group discussions to determine the future course of action. On the first day, the potential, suitability and readiness of several different crop, disease and climate-models were discussed. The second day looked at data requirements and availability to run these models in each participating country. There was also a session on grower requirements for a model and discussion on which model/s were to be selected for each crop. On the third day, future projects, funding opportunities and the roles and responsibilities (crop and country) for each participant were deliberated. On the fourth day, a study tour of the group to the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) was organized, while on the fifth day five specific crop and disease models were demonstrated, followed by a final summary meeting. The detailed workshop program can be found in the next section of this booklet, although it was fine-tuned throughout the workshop.

The outcomes from the workshop were:

- An enhanced understanding of the relationship among weather/climate, disease incidence, and yield reduction to develop suitable management interventions
- An appreciation of the need of a bottom up (“what do the users want”) rather than a top down (“what does the modeller want”) approach in developing a model
- Recognition of the need for a risk management model as the basis for decision making
- The need for this project, and in particular new projects to involve the user and include impact analysis of both economic and social outcomes
- A list of collaborators and their respective responsibilities for networking during the APN project
- Regional collaborations for capacity building
- A list of potential funding agencies for future funding, to build on the APN seed funds

The expected outputs from this project and planned future projects that can be targeted for collaboration are provided in the Outcomes of the scoping workshop.

Conclusion

With increasing concern about climate variability, this workshop has highlighted the need to incorporate climate forecasts into models that will enable stake holders within the agricultural sector to economically manage risk from diseases from season to season. The workshop increased the international standing of our projects and the participant’s international linkages; this is a process which should continue.

Background and Introduction to the workshop

This project entitled "Climate and Crop Disease Risk Management: An International Initiative in the Asia-Pacific Region" was initiated by Associate Professor Dr Samsul Huda from the University of Western Sydney. Dr Huda contacted Dr Gordon Murray (Principal Research Scientist NSW DPI) and Dr Tamrika Hind-Lanoiselet in 2005 about initiating a proposal for an Asia Pacific Network for Global Change Research (APN) application as APN funds capacity building and networking as well as planning and scoping workshops in areas where there are research gaps. With the help of this team, Dr Huda developed a proposal and presented at the pre-project workshop in Hyderabad, India during 2005 where other risk management research such as "Rustman" for stripe rust of wheat and climate models for Sclerotinia stem rot on canola were discussed.

This project aims to integrate existing climate-, crop-, and epidemiological-research to develop a 'regional predictive model' for agricultural risk management. The model will be validated through concurrent application to index crops in selected areas with a regular communication with local stakeholders during model development. By involving scientists already engaged in relevant research, scientific and policy-analysis linkages will be forged and also try to reduce duplication of research efforts. Management strategies relating to pesticide usage to meet climatic circumstances will be researched in the interests of safe- and strategic-food production.

The project targets three economically important annual crops (peanut, canola and mustard) that are at risk from climate-sensitive diseases. Peanut/groundnut is an important oil-seed crop in each collaborating county. In India it covers about 8 million ha producing 8.3 million tonnes of pod yield. Australia has a substantial production shortfall necessitating importation of 5 - 8 thousand tonnes p.a. from China, India and Argentina. The crop worldwide suffers from late leaf spot (*Phaeoisariopsis personata*), which coupled with rust (*Puccinia arachidis*), can cause yield losses of 15-50% in India (CRIDA 2001). In Australia, *P. personata* is the most important foliar disease causing up to 85% foliage loss, if untreated (Belgard and Ham, 2004). Weather-climate risk predictions and warnings are vital in leafspot control (Naab *et al.* 2004). This disease, along with early leaf spot and peanut rust, is currently managed with a scheduled fungicide application. Rapeseed-mustard is another important oil seed crop in India. In Australia, canola is an increasingly important crop (currently worth $680 million) that provides a rotational break crop for cereals (Nelson, *et al.* 2001). Both mustard and canola crops suffer from Alternaria blight (*Alternaria brassicae*) and Sclerotinia rot (*Sclerotinia sclerotiorum*) in the participating countries. Alternaria blight causes yield losses of 35% in Indian mustard crops (CRIDA 2001). In New South Wales (NSW), Australia, *S. sclerotiorum* has been known to cause AUD$47 million loss to canola production, when favourable weather prevails (Hind-Lanoiselet 2006). Prolonged humid (wet) conditions during flowering of canola favour disease development and yield losses as high as 24% in NSW (Best Bet Canola Project, Harden, Copy of Raw Data). At present, fungicide application at 20–50% flowering is the only effective means of control but the fungicides are expensive so growers only get an economic return when disease pressure is very high. Dr Hind-Lanoiselet has an extensive database on this disease, and climate data that could be used to devise a disease model. It is envisioned in this project that crop models will be coupled with disease models and tested/validated against climate data. This will provide better insights and information in the management of target pathogens in index crops in participating countries. CROPGRO-Peanut model (Jones *et al.* 1998) will be used, and the suitability of the coupled peanut crop-leafspot model will be tested against climate data. Similar process will be followed for Sclerotinia rot and Alternaria blight using off-season and crop-season data with interpolation to augment data gaps, building on the work of the Australian group.

Trajectory for the Workshop

The project aims at a strategy to advance sustained operational support for better forewarning of crop disease occurrence, leading to reduced pesticide use, and alternate agricultural and land-use practices.

Existing university-government linkages through advisory programs will secure scientific-policy cross-cutting and linkage. This research contributes directly to uncertainties associated with global climate change by providing an analytical framework to integrate medium range weather forecasts along with seasonal climate forecasts to minimise crop losses and institutional mechanisms to anticipate and adapt to climate fluctuations. The project draws on and integrates a diverse body of knowledge that includes seasonal climate prediction, downscaling of climate information, agroecosystem modelling, decision analysis, risk communication and farmer-participatory research.

The Scoping Workshop

This scoping workshop at CRIDA, Hyderabad, India held during 6-8 November 2006 is part of the APN proposal and aimed to integrate existing climate, crop, and epidemiological research to develop a regionally predictive model for disease risk management. Weather/climate risk predictions and warnings are vital for effective control of many crop diseases. The workshop/project team brought together a broad spectrum of regional and international participants, with a wide range of complementary disciplinary interests and experience, with the common goal of analysing and modelling climate and crops in the interest of disease management and food security. Participants were invited from Australia, India, Bangladesh, Cambodia, United States, and Netherlands covering two broad discipline groups viz. climate, crop modelling, risk communication and agrometeorological services (Huda, Ramakrishna, Khan, Jagannathan, Meinke, Hansen, Boote, Stigter, Rathore and Coughlan), and plant protection, epidemiology (Spooner-Hart, Derry, Thakur, Desai, Visarto, Hind-Lanoiselet, Chattopadhyay, Asaduzzaman and Alam). These invitees also have overlapping expertise and interest by cross-cutting different disciplines particularly in risk analysis, communication, and policy analysis and advisory to governments. Participants in the workshop were able to discuss opportunities for integrating existing work and future effort to meet a common goal, and to explore common ground in existing modelling for a range of relevant parameters.

Objectives of the Workshop

The overall aim of the project is to develop a regional risk management approach for selected climate-sensitive crop diseases. The specific objectives are to:

- Develop and adapt predictive models for climate-sensitive diseases (late leaf spot in peanut, *Sclerotinia* rot and *Alternaria* blight in canola and mustard) of index crops and, integrating this with existing climate, crop and epidemiological knowledge
- Evaluate the predictive performance of crop growth and disease models, using existing data and generate additional datasets
- Identify and evaluate improved crop disease management strategies based on climate information and predictive models
- Assess information needs and propose communication strategies (e.g., climatic and disease risk, disease forecasts, and advisories) and
- Engage appropriate institutions and policy linkages that are in a position to provide support for climate-sensitive crop disease management in each target country

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Project Timeline for 2007/2008 from May 2007

Introduction and welcome to the delegates

Dr Ramakrishna welcomed the delegates of the workshop. In his address, he highlighted the need for focus on cost-effective management of insect-pests and diseases that are causing severe yield losses. For a meaningful integration of impact on weather on insect-pest and diseases, critical long term data is lacking and he stressed that by collating the small amounts of existing data models could be developed and validated. If the growers have to be convinced of reduced pesticide usage, they should be provided with reliable forewarning systems including simple, stand-alone models and ways to link existing forecasting tools/expert systems to disease models. CRIDA had worked on prediction models during 2001-2004 using six diseases with an approximately 60% success rate for climatic periods of 1-2 weeks. Apart from risk assessment, risk communication should also be given due importance using existing networks Dr Ramakrishna highlighted the need for regional- as well as international-collaborations while maintaining a harmony with farming communities for validation and refinement of technology.

In conclusion, he raised three issues viz.

- Can we use the existing modeling network for real time predictions?
- Can we strengthen international collaboration?
- Can we link new predictive models with existing models?

Prof. Robert Spooner-Hart introduced the University of Western Sydney and highlights of current research including response of plants to the greenhouse effect, particularly rising levels of atmospheric CO_2 and impact of climate and climate change on crop disease. He described the series of events/meetings that identified data shortfalls in crop models that led to the organisation and funding by APN for this particular 2-year project and workshop which has been able to network a worldwide team of expertise on crop modelling and disease modelling. So far the project has enabled a paper to be presented at the WMO (World Meteorological Organisation) workshop in Delhi in 2006, they have been able to make some progress in incorporating disease risk management into models by gaining interest and possible future funding from the National Bank for Agriculture and Rural Development in India.

Dr. Kep Coughlan, facilitator of the workshop, emphasized that the workshop has to be flexible so that its content can change if one area needs more inputs. He also emphasized that this pilot project should lead to the development of other projects and suggested to explore the usefulness of the workshop to the growers and what can the team develop/add to existing information.

Prof Huda from the University of Western Sydney (facilitating body) sketched the past involvement of some of the workshop participants in related fields. He described the ground work which had been covered in the International UWS workshop 26-28th May 2004, during which international collaboration on climate and crop disease had been established. Diseases which had been co-identified with help of ICAR had been Alternaria blight and Sclerotinia rot and the crops for consideration were peanut, rape and mustard and canola. The importance of modelling in management of the diseases had been emphasised.

A previous workshop in Hyderabad had identified some existing data but with shortfalls, and had explored funding leading to the successful application for an APN grant. Dr Samra's visit to Australia had been funded and networking meetings had taken place. New initiatives such as NABARD (National Bank Agricultural and Rural Development) Mumbai were reported to be active; a problem however was the need for a relatively large network using relatively small funding. Many members of the network were fortunately already engaged in meaningful research, including CRIDA, ICRISAT, WMO in India, relevant state departments in Bangladesh and Cambodia, UWS in Australia and the University of Florida, in the USA.

Rationale for Scoping Workshop

Prof Huda presented the rationale for the workshop with five objectives:

- To network with government, community stakeholders and scientists to achieve workshop aims
- To revise specific project plans in order to identify needed data
- To study available models and decide on the applicability of each.
- To identify way ahead, and determine a strategy for larger project funding so that the initiative could continue in the future and
- To take necessary steps to ensure that the project was delivered in an efficient and accountable manner.

To achieve these objectives, specific areas at the workshop such as the development of systems for improved climate, crop and disease information should be addressed. In this regard individual members of the collaborative team would need to identify their own roles and contributions in achieving an integrated network. To achieve predictions using existing models, local collection (field measurements) of climate and crop data might be required.

Prof Huda mentioned the social stress imposed by climate variability and climate change as summarised in his recent paper "Agrometeorological risk management: opportunities and challenges"; in Australia alone a farmer commits suicide every fourth day, which is double the incidence in the 1990s. The paper also highlighted the multifaceted nature of climatic information uses – so research may have range of spin-offs, reducing the effective cost of collection.

Salient points from papers presented, along with relevant comments comments and dicussio, are provided ont he following pages.

Potential for CROPGRO-Peanut Model: Predicting Production and Leafspot Disease Risk Relative to Weather and Management

K. J. Boote

The CROPGRO-peanut model was introduced and its use as a tool to evaluate peanut yield response to climatic conditions, crop management, and leafspot disease epidemic was described. This crop growth simulator has soil, water, and crop growth processes typical of other crop growth models, and requires typical Class A weather inputs to run, to include the need for relative humidity or dewpoint temperature to predict dew duration. There are several principles and requirements for coupling of pests to crop growth simulators. The linkage points of pests can be via crop processes such as photosynthesis or pests can directly affect (consume) state variables such as leaf area or plant organs. The CROPGRO-peanut model has two ways to link to pests: one via input of pest damage (such as percent defoliation or percent necrosis observed as scouting observations), and secondly, via direct linkage to a concurrent dynamic pest simulator, such as the leafspot disease simulator developed by G. Bourgeois. Examples of simulated peanut yield gap from foliar diseases were shown for Ghana, based on inputs (to the model) of pest damage inputs (percent defoliation, percent necrosis, or converted from ICRISAT disease score). Yield losses of 50 to 70% were predicted by this method, and were confirmed by subsequent split-plot fungicide trials in Ghana. The second pest coupling method is by a dynamic pest simulator, in this case by linkage of the LATESPOT disease simulator of Bourgeois to the peanut model. The leafspot disease simulator is based on infection, latent period, lesion expansion, and sporulation over time on successive leaf cohorts (as the leaves are produced by the crop model, they can become infected if weather conditions are favorable). The epidemic is polycyclic from spores produced in the crop, spores produced by initial crop residue in the soil, and low intensity source of spores in bulk air. Examples were presented for time course of leafspot disease (percent defoliation and percent necrosis) and time course of reduced crop growth and yield predicted by the linked PNUTGRO-LATESPOT model for four seasons of data in Florida. The LATESPOT model, while functional, still needs to be fully re-linked to the latest CROPGRO-peanut model (this work is in progress). New components such as cultivar resistance and fungicide efficacy needed to be developed in light of new more resistant cultivars and new fungicide chemistries. Improvements in weather effects on infection process may also be helpful if new information is available from micro-meterological and disease studies. Both the CROPGRO-Peanut and LATESPOT models are available for this project and the peanut model was previously tested against many growth analyses data sets in India.

Questions and discussion

These related mainly to the broad spectrum of parameters needed to drive the model, including biochemical, physiological, water balance, soil nitrogen balance, variety, plant spacing, weather input, etc. Ken explained that the coupling of factors would be explained as part of a CROPGRO workshop session to be held on the day following the workshop. The proactive nature of the model which does not require disease inputs to run was explained by Ken, as were strategies for running the model with limited data sets.

Session – I: Current scenario of crop-, climate- and disease- models

New coping strategies for agrometeorological risks and uncertainties in Integrated Pest Management

A.K.S. Huda T. Hind-Lanoiselet, C.W. Derry, G.M. Murray and R.N. Spooner-Hart

The paper outlines some approaches for coping with the agrometeorological risks and uncertainties associated with integrated pest management, based on the Australian experience with canola. The need to understand the linkage between climate and pest cycles is discussed, as is the need to include factors relating to local farming practice and farm economy in the risk assessment process. Areas for further study, such as the relationship between macro- and microclimate, and the timing of pesticide application, are outlined. A major focus of Australian research is the optimisation of natural controls relating to informed planting strategies, and the minimisation of pesticide application through the prediction of climatic influences, in the interests of sustainable and cost effective control of disease agents. Some epidemiological and risk-management perspectives for building capacity to support this concept are outlined.

Conclusions

- Location-specific knowledge is needed about the complex relationships between climate and pest cycles
- Need for collaborative activity between scientists, risk managers, government and local farmers to develop economically-sound and ecologically-sustainable world's best- practice for pest management
- Evaluation of useful practical findings of Sclerotinia rot management systems in Australian canola in other regions
- A major focus on optimisation of natural controls relating to informed planting strategies, and the minimisation of pesticide application through the prediction of climatic influences.
- Technology transfer is, however, a highly specialized area which has resulted in errors in the past, and which must therefore be treated with circumspection.
- The relationship between macro- and microclimate, and the effects on the cycles of disease agents, needs special attention.
- While improvements in meteorological and crop-pest monitoring and modelling will remain important, a sound understanding of local economic, ecological and social realities is essential to ensure the effectiveness and accountability of interventions.

Acknowledgements

Support from the World Meteorological Organization (WMO), Asia-Pacific Network (APN), Australia-India Council, University of Western Sydney and New South Wales Department of Primary Industries (NSW DPI) in carrying out this research is appreciated.

Questions and discussion

Tamarika added comments relating to problems identified during time trend modelling relating to climate and disease as illustrated in the paper. Economic modelling was needed to indicate when benefit-cost did not warrant certain strategies, such as early spraying. General discussion on other problems associated with modelling followed, including the need to account for the unpredictability of climate change when setting variance limits in relevant models.

WhopperCropper - A Tool for Scenario Building

H..B. Meinke

Dr. Holger Meinke demonstrated the WhopperCropper model developed as a discussion support tool to explore alternative management options for cropping in Australia. It is a tool well suited to explore climate impacts and to conduct climate risk assessments across environments and management options.

Whopper Cropper – what is it?

It is a database of pre-run APSIM simulations run for long periods using historical climate data. Often these historical daily climate records exceed 100 years. This provides the capability to assess impact of historical climate variability on management.. The user can pick **one or more** VERY SPECIFIC combination of conditions. When multiple selection is made a **virtual trial** is created.

For each 'district' all combinations of:

- 8 crop types of Northern region
- 5 soil types or water-holding capacities
- 3 starting soil water amounts
- 3 starting soil nitrogen amounts
- 6 nitrogen fertiliser rates at sowing
- 3 in-crop N fertiliser application rates of Southern regions
- 3 crop maturities
- 5 sowing dates (fortnightly)
- 3 row configurations (sorghum and cotton)
- 5 plant populations
- SOI phases
- Gross margin analysis

Comments

1. WhopperCropper allows probabilistic *in silico* assessments of all of these factors. For example the effect of the range of sowing dates may want to be examined or the effect of N fertiliser rates on yield OR gross margin can be demonstrated. The gross margin is important because it is of vital interest to farmers.
2. There are a selection of graph types available to suit the preference of the program user or the farmer (these will be discussed later)

Outputs

There are over 50 in total. A few important ones are

- Grain yield, protein
- Biomass
- Rainfall planting to flowering
- Water use, WUE
- Available NO_3 and water at flowering/harvest
- Low temperatures around flowering/podding
- Phenological events
- $ return, costs, gross margins

All these runs assume no losses from weeds, disease, waterlogging (some crops) and the default is No Till (and effectively controlled traffic) i.e. the biological optimum.

Whopper Cropper aims to draw out strategic rather than technical thinking. It generates knowledge that could otherwise not be obtained – clearly it is unrealistic to experiment on the whole system for eg. 100 years. In such cases virtual crop growths conveniently replaces experimentation on the real biological system.

Benefits

- Cheap and easy (30min)
- Portable
- Many inputs & outputs
- Flexible presentation and analysis
- "To be roughly right rather than precisely wrong"
- Marketability indicates usage
- Most variables have a climate component (not disease to keep it proactive)
- Based on huge data base
- Probabilistic to identify/assess key drivers of variability
- Farmer has to decide what type of season he wants to plan for based on model

Setting the scene

- Farmers make many critical management decisions at the start of each cropping season
- Soil conditions and future climate will affect the outcome of these decisions
- The result will be a range of potential yields
- Decisions are sometimes made with less than optimum regard to risk and probability of risk

Comments

1. Farmers are making decisions at the start of every cropping season. On what expectation will they base their decision of level of inputs. Even older farmers will not have experienced the full range of potential seasons. Farmers and advisors have a good concept of the 'average' yield and may be tempted to base decisions on that value
2. but; we all know that seasons (rainfall events) are very variable. If a farmer knew what the coming season was going to be like then the decisions would be a lot easier. BUT can't know what the season will bring. All we can look at is what would have happened in the past range of seasons. The advantage of WhopperCropper is that is displays this range with its inherent variability.
3. Variable rainfall, variable soil water at sowing and every other input level brings about a range in the potential outcomes. The outcomes also interact in ways that are difficult to comprehend
4. Risk is about a negative outcome from a combination of events but there is also the opportunity to increase returns under some conditions

Purpose of Whoppercropper

- Strategic thinking vs tactical thinking
- Target an attitude to risk
- Range of outcomes driven by rainfall
- Range of outcomes driven by rainfall and stored soil water
- Other agronomic factors
- 2- way and 3-way interactions

- SOI effects
- Gross margin analysis

Comments

1. Farmers have to prepare for the coming season (tactical decision) and this is one area where WhopperCropper is useful. It does this by using the yield range generated from a **long period** of rainfall events and learning a bit more about how inputs interact in a very **variable** environment. This assumes that the future climate range will be similar to the past. Even with climate change the variability is going to far outweigh the change (will look at more detail later)
2. Using WhopperCropper allows farmers and advisors to think about and target their **attitude to risk.** This facilitates moves away from the concept of 'average yield' and more into a more specific outcome area.
3. In all non-irrigated environments the yield is driven by rainfall and this is the main driver of the yield variability in WhopperCropper
4. In Northern grain regions, the yield is also very influenced by stored soil water at sowing. Southern environments are increasingly recognizing the importance of stored soil water
5. Other agronomic factors create shifts in the yield outcomes and interact with the water inputs. Sometimes the other inputs can be varied to increase yields or reduce costs
6. WhopperCropper can generate 2-way and 3-way interactions in graphical format that would otherwise be very difficult to demonstrate from other sources or from experience
7. The SOI phase system is currently included as another tool to separate climate effects and possibly vary input levels
8. Expressing results in dollar terms can be very convincing and WhopperCropper easily allows this to be done

Questions and discussion

Participants agreed that this had been a very thorough exposition of an Australian model. It appeared to be user-friendly and robust but would possibly have to be run by an expert. It had, however, capacity to account for climatic vagaries driven by the Southern Oscillation Index (SOI) and could generate particularly relevant data for farmers at local level.

The principle behind Whopper Cropper is generic. The purpose for its demonstration was to highlight to workshop participates the usefulness of agricultural simulations models for scenario planning, particularly in relation to climate risk assessment. The database in the current Whopper Cropper program could easily be replaced by any other time series (not necessarily arising from simulation models). Likewise, the ENSO analyses, which are currently based on the 5-phase SOI system (Stone et al., 1996) could be replaced by other indices. The point is: we need such tools in order to become more quantitative in our environmental (climatic) risk assessments.

Pest Management in Canola

J. L. Hatfield

Canola has been grown for two years in central Iowa and has been incorporated into a crop rotation with corn, soybean, and wheat. These studies include measurements of the agronomic parameters, e.g., phenology, biomass, leaf area, and yield, and canopy microclimate, e.g., air temperature, relative humidity, net radiation, and windspeed. These data have been assembled to quantify the change in the microclimatic parameters during the growth cycle of canola. In addition, there have been reflectance measurements made on a weekly basis with the eight-band radiometer in order to develop vegetative indices that can be used to characterize canola growth and then use these vegetative indices to detect crop stress. These experiments will continue for the next three years to complete the first cycle of the rotation.

A literature review is being conducted to determine which insects and diseases are prevalent on canola and to determine the response of these pests to various microclimate parameters. These observations and relationships will be used to estimate the potential for insect or disease development in canola canopies.

Efforts are underway to extend the plot scale measurements to field scale variation studies of the factors that affect microclimate within canopies. Observations across fields coupled with reflectance, topographic, and soil type distribution are being assembled into a method to estimate the variation in temperature, relative humidity, and potentially leaf wetness. This type of spatial model has not been developed to assess potential insect and disease pressures on canopies. This will be one of the primary goals for this year and has potential for helping quantify risk for pest damage across different landscapes.

Development of weather based forewarning systems for brassica crop pests and diseases

P.S.N. Sastry

Rape and mustard are the most important oilseed crops of West Bengal which covers maximum acreage among all the oilseed crops. The productivity of mustard is low due to short and mild winter in comparison to north India and also for biotic stresses. Aphid is the most important pest of mustard. The optimum condition for crop growth is also favourable for disease and pests development.

The disease scenario in rape and mustard is changing rapidly. Among the diseases, Alternaria blight is one of the most important diseases in new alluvial agro-climatic zone in southern parts of West Bengal. In acid soils club root of crucifers caused by *Plasmodiophora brasicae* is a major disease particularly in red and laterite regions and also in Terai regions of North Bengal. Kalyani was one of the centers of the mission mode multi location National Agricultural Technology Project (NATP) for "**Development of weather based forewarning systems for brassica crop pests and diseases".**

The major objectives of the NATP (National Agricultural Technology Project) sponsored by ICAR are:

- To develop data base on climate, major pests and diseases affecting production of rape seed and mustard in the specific agro-climatic regions of India.
- To identify key weather factors conducive for incidence, intensification and spread of pest and diseases for establishing crop-pest weather relationship.
- To develop crop production strategies to ensure management of mustard pests and diseases.
- Experimental layout and data recording

Two varieties of Indian mustard were used viz. Varuna (*B. juncea*) and Yellow sarson (*B. campestris*). Data were recorded on weather, soil moisture status, crop phenological status, yield, alternaria blight incidence and severity. The onset of all the observed diseases and their peak period of intensity was recorded in different date of sowing. From the disease data, percent disease index and area under disease progress curve were worked out.

Leaf blight incited by *Alternaria brassicae* and *A.brassicaecola* caused maximum damage during 1st flowering to maturity stages of the crop. Siliqua infection caused more crop loss than leaf infection. Relationship between maximum temperature, minimum temperature and minimum relative humidity has significant role to play. The forewarning system has been developed using multiple regression based on recorded weather parameters and historical data of this region.

For Yellow sarson Variety B-9

Y= 42.11 + 0.048 max.tmp x tmp* rainfall+1.14Z rainfall * ssh- 0.19Zmaxtmp * ssh

For Varuna Y= 42.11 + 0.048 maxtmp x rainfall+ 1.14Zrainfall xssh-0.19Z maxtmp x ssh

With multiple regression equation developed with weather variables and crop phonological data, the crop sown during last week of October yielded the maximum seed yield.

An analysis of weather-disease relationship showed that incidence of seed borne Black rot (*Xanthomonas campestris p.v campestris*) reached highest levels in December(73%) followed by January(26%)and February(1%) on yellow sarson variety(B-9). Downy mildew (*Peronospora brassicae)* incidence recorded maximum on yellow sarson variety (Binoy/B-9) during January(63%) followed by December(25%) and February(10%). The early sown crops were affected mostly by Downy mildew, but could not cause much damage, as the floral deformation/head stage symptom of downy mildew has not been observed in this agroclimatic region. Onset of Alternaria blight appeared on yellow sarson variety (B-9) during 1st to 2nd week of December. Pod infection by Alternaria was very severe in late sown yellow sarson variety B-9.

Questions and discussion

Though it was initially thought that CROPGRO could be suitably modified for Indian mustard also, it was agreed that running the Brassica Model may be more relevant as it has been developed for Indian mustard. It was said that a wide range of models had been assessed when the model was developed in India, and most had been found to offer potential but have limitations. Some of these included MACROS, SUCROS and WTGROS. Since the Brassica Model had been developed after consulting other models such as SOYGRO, MACROS, SUCROS, WTGROS, to include some major parameters of importance, including nitrogen, water, pests, growth, yield, greenhouse gases, etc, it may be appropriate to try this model for Indian mustard.

Using InfoCrop – A user friendly crop simulation model -for mustard

A.V. M. Subba Rao, P.K. Aggarwal, A. K. S. Huda, C.Chattopadhyay

Crop models can accelerate inter-disciplinary knowledge utilization in agricultural research and development. These models present an opportunity for assessing potential production in a region and facilitate analysis of the sustainability options for agricultural development including planning of resource allocation. The greater application of crop models in agricultural research and developments, however, requires a simple, user-friendly modeling framework, whose inputs are easily available/ measurable. In addition, the framework should provide a structure that can be easily adapted by the application developers. Most of the existing models are too complex with large input data requirement, cannot be easily integrated in the application, and are not very user-friendly.

InfoCrop is a crop growth model that was developed by the Indian Agricultural Research Institute in New Delhi, India. It is a decision support system based on crop models that was developed by a network of scientists to provide a platform to scientists and extension workers to build their applications around it and to meet the goals of stakeholders' need for information. These models are designed to simulate the effects of weather, soils, agronomic management, nitrogen, water and major pests on crop growth and yield, water and nitrogen management, and greenhouse gases emission. Its general structure is based on a large number of earlier models and the expertise of the scientists involved.

The INFOCROP model is developed after consulting on MACROS, SUCROS, and WTGROWS models. InfoCrop is user-friendly, targeted to increase applications of crop models in research and development, and has simple and easily available input requirements. The crop models have been developed by the specialists in those crops and have been validated in major crop specific environments of India. The decision support system also includes databases of typical Indian soils, weather and varieties for applications. Models for rice, wheat, maize, sorghum, pearl millet, potato, sugarcane, cotton, pigeonpea, chickpea, groundnut, mustard and soybean are available in InfoCrop. The major application modules available in the InfoCrop model are Masters, Project, Results, Validation, and Weather Conversion.

The *Masters* contains all the data available for selection in the Project screen while carrying out a simulation, such as a database for Indian crops, varieties, soils and weather, pest and organic matter with a facility for user-defined data. A simulation can be run only with a complete dataset in *Masters*.

The *Project* is the main menu with sub menus (to be provided as input for simulation) consisting of simulation control options, treatment selection matrix; execution and validation of the simulation. Some aspects on climate change study options for temperature and CO_2 are also available.

The *Results* menu displays the detailed results generated and the default value of this has been set as 1 day for simulation projects involving less than 50 treatments and up to 10 days if the treatments are more.

Weather conversion is a utility for converting daily weather data from different formats to the one that can be read by the InfoCrop.

InfoCrop has a built-in mustard module. This may be validated for the selected locations for yield simulation. The module does not have any datasets for the disease/ pest module which need to be generated. Incorporation of this dataset in relation to crop growth and development routine would help to adapt this model for the APN project.

Group Discussion

Meinke suggested that the workshop needed to address whether climate and crop diseases be addressed separately (“break the dynamics”). However it was also necessary to discuss dynamics. The model needed to be useable at farm level in a short period of time while simultaneously addressing scientific objectives.

Derry asked how models would operate with incomplete data, challenging the concept that a complex model was better than a simple one when “fudge factors” had to be loaded for a large number of fields.

Boote responded that it was important to know lead weather forecast observation time, as accuracy depended largely on that.

Desai suggested that this might be 3 – 7 days and asked if models had capacity.

Spooner Hart said that there may be more important pests and crops which were not being considered because of the data problem. Chattopadhay said that Sclerotinia does not strike every year, but is a problem when it does.

Thakur said the effective forecast area (regional diameter) had to be known. Modelling was problematic for the small farms in the area. Boote said that CROPGRO could cope with diameters down to 3km. Meinke said that he felt it depended mainly on the parameters being forecast. Boote said activity was likely to be mixed with some models working on short term prediction, others longer. Coughlan said a needs assessment was needed or the model wouldn’t be widely accepted. Spooner-Hart supported the need to consider the practicalities of intervention. Derry explained that in terms of the cyclic management mode suggested for the project activity must involve risk communication with stakeholders but could start at any point of the cycle. Huda felt that the discussion had produced a diversity of points but was useful. He felt major points from the papers and discussion to be addressed were:

- Readiness of any model for use
- The prospects for major and minor models operating in unison.
- The data needs of different models.

Meinke made a final point that whatever approaches are used, a sound validation system needs to be established.

Crop Disease Models

T.. Hind-Lanoiselet

Crop disease models are patterned on the epidemiology of a plant pathogen. The presence and severity of a crop disease is determined by the dynamic interaction of a susceptible crop (host), a causal agent (pathogen), and favourable environmental conditions. The models can be driven by cultural practices, such as cropping history or plant variety; weather, including temperature, humidity and precipitation and forecasted weather conditions. A model can be presented as a formula, equation, rule, graph, table or algorithm with an output that can be a numerical index of disease risk, predicted disease incidence or severity, and/or predicted inoculum development. A simple empirical or regression model may be sufficient for a polycyclic disease such as stripe rust of wheat but a monocyclic disease such as Sclerotinia stem rot of canola may require a mechanistic or stochastic model.

Plant disease models can be developed from existing epidemiological data. However, there are usually gaps in the available data or knowledge. The aim is to predict the risk of disease and/or development of inoculum, based on monitoring key environmental, host, and pathogen variables. Based on management options and goals, action thresholds can be incorporated into the model to provide advice on management decisions. Models must be validated across a variety of microclimates over a number of years and refined based on on-farm results.

Disease prediction models

A wide variety of disease models exist. This includes models for pathogen or disease incidence and severity, onset of spore maturity, progression and termination of spore maturity, geographical spread of spores and economic models. Some of the models are explained below.

Rustman is an excel spreadsheet program that can be used as a decision support tool to estimate disease incidence, yield effect of stripe rust on wheat and potential economic benefits from spraying. It is based on monthly average temperatures during spring.

Blackleg Sporacle is a simple model that estimates the onset of pseudothecia maturity and seasonal ascospore showers for blackleg on canola. The model considers a combination of two weather factors, daily mean temperature and daily total rainfall, to drive progress of maturity of pseudothecia on the infested canola stubble left from past crops. Each day is categorized as suitable or not suitable for progress of the maturation process. The onset of pseudothecia maturity occurs when approximately 43 suitable days have occurred. Following the onset of maturity, ascospore showers are triggered when daily rainfall exceeds a threshold.

Blackspot Manager forecasts the onset and progression of blackspot spore dispersal from infected field pea stubble, and the incidence and frequency of ascospores during the growing season. The model estimates the probability of a blackspot infection occurring and takes into account the proximity to the previous season's field pea stubble, rainfall, wind speed and wind direction.

Sclerotinia risk model for North Dakota and Minnesota is a decision support tool to guide growers on their regional risk of getting Sclerotinia on canola. The maps show regions of North Dakota and Minnesota where the environmental conditions are favourable for the development of apothecia and release of ascospores. It is based on ground moisture for a four week period. However, is not a field-specific recommendation as other factors such as local weather conditions, seeding date, previous cropping history, and yield potential also need to be taken into consideration before applying fungicides.

Sclerotinia stem rot model for canola in Australia was developed by using 5 years of field survey data. In canola prolonged humid or wet conditions during flowering favour disease development. Due to the sporadic nature of this disease, it is important to determine the economic feasibility of any fungicide application. The best timing for protection is during flowering when the petals have just begun to senesce. Currently those fungicides registered for Sclerotinia stem rot control in Australian canola are applied at between 20 and 50% flowering. However, these recommendations are based on results overseas where flowering times are much shorter than in Australia. The relationship between petal infestation and stem rot incidence was examined first. This was followed by correlation, multiple regression and two sided t-tests on weather parameters (temperature and rainfall) and farming practices that may influence disease development. An equation for stem rot incidence was then calculated by combining weather data and farming practices using multiple regression analysis with groups.

Preliminary model for percent petal infestation (PPI)

When the weather parameters and farming practices were combined the following model for PPI was significant:

$$Y = -12.37 + 0.4024 (X_1) + 9.84 (X_2) + 36.96 (X_3) + 6.35 (X_4)$$

n = 102, P = < 0.001, Variance accounted for = 79.1%, Standard error of observations = 16

where: Y = petal infestation (%); X_1 = total rainfall in weeks negative 6 through to negative 1 (approximately 5 weeks before flowering through to the first week of flowering); X_2 = days with > 2 mm rainfall in week negative 17 (Just after sowing); X_3 = 1 when soil surface is visibly wet at petal collection (20 to 30% flowering) or 0 when soil surface is dry; and X_4 = 1 when a susceptible crop was grown in an adjacent field last year or 0 when no susceptible crop was grown in an adjacent field last year.

Preliminary model for disease incidence

The model predicted that Sclerotinia stem rot is unlikely to occur when petal infestation is d•10%. When the petal infestation data d•10% was omitted from the analysis the following combination of weather parameters and farming practices gave a significant model for stem rot incidence:

$$(Y)^{0.5} = -0.687 + 0.01567 (X_1) + 0.1761 (X_2) + 0.4784 (X_3) + -0.570 (X_4)$$

n = 101, P = < 0.001, Variance accounted for = 53.6%, Standard error of observations = 1.08

where: Y = stem rot incidence (%); X_1 = total rainfall in weeks 5 through to 7 (end to after flowering); X_2 = mean minimum temperature in weeks 3 to 4 (end of flowering); X_3 = days with > 2 mm rainfall in week negative 3 (week before flowering or very start of flowering); and X_4 = 1 when a group C herbicide was used or 0 when no group C herbicide used.

Conclusion

With increasing concern about climate variability this workshop has highlighted the need to incorporate climate forecasts into models to enable stake holders within the agricultural sector to economically manage risk from diseases from season to season. In addition a quick and efficient method for coupling weather data with models would allow easier updating and direct transfer of data into models so that real time information can be obtained.

Questions and Discussion

Discussion centred on the different models, the appropriate data needs, and the ability for adapting the models to meet the regional and crop needs in the Asia Pacific Region. Some were simple but did not take into account essential variables, others might be too complex. Direct data transfer from existing collection systems would be a major advantage. The importance of data validation because of inter-area differences was emphasised.

Predicting Crop Response to Climate

J.W. Hansen

"Climate" is the statistics of weather, integrated over time and space. Because the atmosphere is chaotic, knowing the current state of the atmosphere allows us to forecast weather no more than about 10-14 days in advance. Yet prediction at a seasonal lead time is possible because the atmosphere responds to the more slowly-evolving underlying ocean and land surfaces. The El Nino-Southern Oscillation (ENSO), based in the tropical Pacific, is a particularly important source of predictability in many regions. In contrast to weather forecasts, seasonal climate forecasts are inherently probabilistic, and not universal but only skilful in some regions and seasons.

Several climate Centres, including the IRI, issue seasonal forecasts based on general circulation models (GCMs), which model the physical processes and dynamic interactions within the global atmosphere in response to ocean and sometimes land surface conditions. Routine seasonal forecasts are typically averaged over 3-month periods, aggregated in space, and expressed as probability shifts of climatological tercile categories. Post-processing methods that often improve forecast skill include weighted averaging of multiple GCMs and multivariate statistical transformations. The Climate Predictability Tool, developed by the IRI, supports statistical correction and model skill evaluation methods.

Climate variability and model (including input) error are the major sources of uncertainty in yield forecasting. One way to characterize the uncertainty associated with climate variability is to simulate yields with antecedent weather up to a given forecast date within the season for a current or hindcast year, and sample weather for remainder of season from all other years. The resulting distribution approximates the climatic component of uncertainty. The proportion of total uncertainty that is due to climate, rather than model error, decreases through the growing season as an increasing proportion of weather is observed rather than predicted or sampled.

Long-lead yield forecasting based on seasonal climate prediction is complicated by the nonlinear, dynamic nature of crop response to rainfall, and a mismatch between the scale of dynamic climate models and crop simulation models. Crop response is generally nonlinear and often non-monotonic over a range of environmental variability. Crops respond not to mean precipitation but to dynamic interactions, particularly between soil water balance and phenological stage. Although GCMs simulate the atmosphere on a sub-daily time step, their coarse spatial resolution distorts the day-to-day variability of rainfall outputs in a manner that adversely affects simulated crop response. Seasonal rainfall forecasts that are skilful at a regional scale can sometimes be downscaled to a single station with only moderate loss of skill. Downscaling in time to shorter time periods is more difficult. However, there may be potential to predict some statistics of rainfall occurrence.

Methods that have been advanced for using seasonal climate forecasts with crop simulation models include: (a) crop simulation with daily climate model output, (b) use of synthetic daily weather conditioned on climate forecasts, (c) statistical prediction of crop response simulated with historic weather, and (d) classification and analog methods. Several of these methods could, in principle, be applied to weather-sensitive crop disease models.

Questions and discussion

Discussion centred on the possible coupling of seasonal climate forecast models with crop simulation models. Jim gave some valuable insights into concepts of prediction versus certainty, the need for probabilism in models leading to increased complexity, multi-model limitations and predictability value and outlined some of the software types which could drive data collection and analysis.

Current Pest / Disease Models

Y.G. Prasad

Forecasts are models that use past and future weather for predicting the likelihood of pest outbreaks. Models require access to weather and climate data, in addition to pest and crop data and can range from strictly empirical to most complex and sophisticated descriptive models. Many models that have been developed use temperature data to forecast insect activity as the rates at which insects complete their life cycles depend mainly on temperature, so that the times of activity of a given pest insect can vary greatly both from region to region and from year to year. Empirical approaches use pest-monitoring data; levels of incidence and intensity of infestation collected through experimentation and surveys and establish relationships with prevailing weather and/or past weather. Stochastic models simulate growth and development and aim at predicting future behaviour. MORPH suite of simulation models developed using HIPPO model building software at HRI, UK provide an easy way to run scientific models for pest forecasts in vegetable and fruit crops and manage weather data. Even the simplest model must be tested and validated over a wide range of conditions. In India, a significant percentage of research effort related to pest forecasting has been directed towards studies on monitoring the seasonal occurrence and studies that establish crop pest weather relationships. In cotton, currently developed models worldwide comprise of simple rule based models, degree-day models, empirical models correlating broods, simulation models for oviposition and migration (eg., Moth ZV, HEAPS, COTTON LOGIC etc). A combined model for simulation of rice leaf-blast epidemics and yield loss (CERES-Rice and BLASTSIM) was developed in the Philippines. Decision support systems for wheat, sunflower, tomato, cucumber and pears disease control advisories are in use in Israel.

Under the National Agricultural Technology Project (NATP), a mission mode project on “Development of weather based forewarning systems for crop pests and diseases” was launched at CRIDA in 2001. The Project brought together 6 crop lead centres (Cotton, Rice, Groundnut, Sugarcane, Pigeonpea and Mustard) with support from 14 cooperating centres, 3 satellite centres and 4 cooperating institutions (NCIPM, IASRI, IISc, NCMRWF) and aimed at a) development of a centralized database on climate, crop pests and diseases; b) identification of significant crop-pest-weather relationships to be used in c) development of forewarning models and d) their validation.

Under the project, a relational database management system (RDBMS) for historical database on climate, crop pests and diseases covering 6 crops and 75 locations in the country was developed. The data collected by all the cooperating centers was subjected to quality check, creation of interlinked data tables for all the 14 target insect pests and 12 target diseases in 6 crops. A total of 72 parameters were included to accommodate diverse data types for pests, diseases and natural enemies.

Crop-pest-disease weather relationships were developed for all the 14 target insect pests and 12 diseases in six crops. Simple weather based thumb rules/prediction rules for forewarning of 6 pests/diseases on rice, cotton, groundnut and pigeonpea were developed and validated.

Linear and non-linear statistical forecast models were developed using available historical data for all the target pests and diseases of 6 crops. Notable are models for yellow stem borer and leaf blast in rice; bollworms (*Helicoverpa* and *Pectinophora*), whitefly, jassid, *Alternaria* leaf spot and bacterial leaf blight in cotton; leaf miner and leaf spot in groundnut; early shoot borer, *Pyrilla* and top shoot borer in sugarcane; pod borer, pod fly, Phytophthora and sterility mosaic in pigeonpea; aphid, Alternaria blight, white rust and powdery mildew in mustard. In addition, a decision support model for groundnut leaf spot, day-degree model for mustard aphid and model for yellow stem borer and *Helicoverpa armigera* on cotton using data mining techniques were also developed. Forewarning models developed from analysis of historical database in all the six target crops were validated with the experimental data generated during the project period.

Questions and discussion

At this stage Spooner-Hart called on the participants who might not be in a position to carry out modelling but who might be playing a very important role in application, governance and community linkage in dryland agriculture to comment. The responses indicated that in terms of the Bangladesh system modelling was still relatively new and that local prediction by farmers was the norm. There were, however, three locations under study where data was being collected to determine the potential for modelling. In Cambodia modelling was still in preliminary stages with a need to test the viability of data collection. Here Spooner-Hart emphasised the value of networking and suggested different major network players attach themselves to different areas to spread expertise.

First day general discussion

The discussion debated on:

- Keeping models combined or separate. It was decided to leave this for the second day.
- The need to include the disease element more intensely than had been the case on the first day.
- The need for relative simplicity in disease modeling as the main need is for proactive research in anticipation of crop disease. Spooner-Hart warned against "a lot of research that will not produce a result in 3 years when this is just a 2 year project".
- The limitation of predictive weather models which only give reliable data for 3 to 7 days in the future.
- The need to consider secondary diseases (Thakur) when one disease is controlled by breeding, the relative importance of other diseases can increase. Therefore, on farm spraying to control the crop disease problem is not necessarily reduced.

Session – 2: Data requirements

Risk assessment, communication and management

C.W. Derry

The first day of the workshop has identified three broad challenges which need to be addressed. The first challenge concerns the identification of a model with a capacity to use the existing data in each of the project countries, in order to guide efficient and locally-accountable interventions. While we have heard of a range of existing models, including CROPGRO, WhopperCropper, Brassica, and Infocrop a challenge to each of these models is likely to be mismatch between the existing data and the data input requirement of the model itself.

While complex models such as CROPGRO are likely to generate precision outputs, the quality of these remain only as good as the data inputs. Working of data to meet input needs is therefore likely to remain a specialist function of those who have developed, and are used to working with, each model. This suggests the need for close collaboration between participant countries where research is to be carried out and the custodians of such models. All models, however, are likely to present some challenge in the area of matching available data to data need, and this is part of what we will be exploring through today's discussion.

Types of intervention available to member countries will also determine the types of modelling outcomes which are acceptable in a local context. An important area which has been identified is the precision timing and application of pesticide so as to avoid excessive dilution and runoff. This brings to mind that the workshop is not only about modelling, but about far-reaching effects in terms of ecological impact, when excessive or poorly-timed pesticide application results in runoff into watercourses, compromising ecological health and human safety. Economic losses to those who inadvertently over-apply pesticide in an attempt to compensate for the vagaries of climate are also an important consideration. Discussion on Day 1 has shown that this sort of prediction will require the incorporation of medium to short term climate data, and in this regard data availability and matching on analogous time scales again requires careful consideration.

Ultimately the right climate data carefully matched to crop disease occurrence can be a powerful tool in proactive intervention to limit damage to plants and hence the reduction of defences, which opens the way for the ingress of disease causing spores and aggravating insect damage. Data to be considered relate, therefore, not only to physiological plant disease factors but to the complex interplay of host, agent, environment and time factors which give rise to the characteristic epidemiology or endemicity of plant disease.

While discussion of data availability has been planned as the driving force, intrinsic performance of models based on assumptions and algorithm limitations is likely to surface, and this is likely to drive discussion on the third day and during the hands-on workshop sessions which modellers have kindly made available, to give a logical conclusion to the workshop sessions.

The second of the three challenges which I mentioned at the start of this summary concerns the selection dilemma relating to the appropriateness of each of the models for the needs of the APN program. The debate so far shows that there are three potential policies applicable to modelling in terms of the project, each of which require investigation and debate before a final choice can be made. I have added a short summary of advantages and disadvantages associated with each which came to light during discussion:

1. To select a simple yet robust model which suits the location offering the minimal data set, and apply this to all the study regions consistency. While this makes modelling available to most settings it nevertheless does not give scope for more complex modelling where data makes this possible.
2. Select a refined model with capacity for highly sensitive modelling using a wide range of accurate inputs, and resort to data interpolation to fill the data gaps. While this opens the way for advanced

modelling, a policy which will amount to the use of "fudge factors" has to be treated with great circumspection.

3. Run all the models in each setting and then select the most appropriate in terms of empirical reliability and usefulness of the outcomes generated. This suggests that time be committed to a complex trial (or trials) in which research and community interests will have to be carefully balanced. In this regard attention needs to be given at this workshop towards developing a modelling policy which is not quite the same as a modelling strategy, as is presently under discussion. This is needed to ensure that the entire exercise remain accountable to a project of regional relevance.

As discussion at workshops progresses, it is often found that more than the allocated time is needed to fully explore the way ahead, and the current workshop is no exception to this. To ensure that we reach constructive conclusions by the end of the workshop in terms of the intended timeline, we need to not only debate the issues but keep in mind the need for consensus rather than reaching conclusions which suit the need of any one party.

It is likely that data availability, to be explored today, will prove to be the limiting factor in determining the type of modelling used and regional interactions to take place, making today's deliberations of particular importance. In this regard we must be careful to heed what the representatives from the less agro-industrially developed areas have to say as their available data is likely to play an important part in determining the final design to be applied.

This leads into the third challenge, which concerns the process to be adopted to ensure that the project maintains a truly international relevance while reaching the communities concerned. This is a very challenging area and we will have to draw on the expertise of both those who represent the agricultural sector of member states, as well as those who have sewn together strategies for regional collaboration in the past. An important part of this process to be continued outside the workshop will be the gathering of qualitative information from the communities concerned as primary stakeholders in the regional initiative.

There is always the danger that the project will become an academic modelling exercise and this has to be carefully guarded against as there is a difference between achieving a generic modelling program and a collaborative regional intervention initiative. In this regard I would like to remind participants of the risk management model which was sent out as the proposed model for this project. The model clearly shows that risk communication between all project participants, including governments, agricultural stakeholders and scientists, lies at the centre of the management hub, and without such communication it is unlikely that a truly integrated climate and crop disease risk management initiative can be achieved.

The first day the workshop showed encouraging signs of being a sound communication hub between the various stakeholders, which augurs well for reaching sensible conclusions within the limitations of time and information, which provide the realistic framework for the workshop.

Questions and Discussion

Meinke reminded the workshop that many would like to look at the questions the end user will be asking and not to forget end users that are not farmers, including agribusiness. Robert Spooner-Hart outlined that in crop models there may be problems with using a 1-9 scale used in disease assessments. Boote preferred leaf area or photosynthetic area reduced by disease to be included in a disease model and the way it reduces crop yield. Thakur said that in India they may have enough data for groundnut to support Infocrop and made a statement of support for the model. Boote was also interested in economic yield response at different fungicide application times. Desai intimated that in India some models have been successful in reducing spray volumes. Hansen reminded everyone that we need to focus our efforts and with the constraints of this project address the imperative of setting up a framework for future work.

Agrometeorological services in the context of climatic aspects of coping with crop disease risk

K. Stigter

We consider all agrometeorological and agroclimatological information belonging to agrometeorological services "that can be directly applied to try to improve/protect the livelihood of farmers in agricultural production", as well as quality and quantity of the yield, while safeguarding the agricultural resource base from degradation. Various examples may be found and in extensive protocol forms with background information on farmer target group involvements in Stigter.

The idea was developed and applied in Africa and China that agrometeorological services can be established with farmers from farmer experience and/or information products that are offered by meteorological services, research institutes and universities.

Five basic issues that have to be addressed in pilot projects are

- Priority problem selection and determination of needs
- Target group differentiation and fine tuning of problem definition and information needs assessment
- Product selection, improvement and focusing (client friendliness)
- Development and establishment of agrometeorological services (risk communications leading to preparedness and mitigations) from those products by applied scientists, government extension intermediaries and farmers
- Upscaling from pilot projects through training exercises.

Priority problem selection and determination of needs

- The priority problem selection has been made: climate-sensitive diseases in peanut, canola, mustard: late leaf spot, *Alternaria* blight, *Sclerotina* rot and their yield repercussions;

- Overall needs are improved climate related disease early warning and related weather and climate forecasting; with spraying advices for reduction of pesticide use in crop protection and related improved agricultural and land use practices expressed as predicted higher crop yields; lower yields should be connected with health impacts; higher yields with risk appreciation, preparedness and management modelling as the basis for decision making;

It is unclear whether this choice was made by farmers, extension, scientists, and in the latter cases whether the choice was farmer supported as a priority problem related to their priority needs.

Target group differentiation and fine tuning of problem definition and information needs assessment

- Differentiation has to take place first after country: Australia, India, Bangladesh, Cambodia, sometimes also after region in the country; then after crop and crop disease and farming system concerned (including production/income levels and levels of education of farmers concerned and ways in which agrometeorological information is presently reaching each of the target groups, if any), in each country; this is a priority task to be performed.
- For each target group so distinguished, the previously defined problems should be fine tuned with the specific information needs as the farmers see them and the channels of communication existing (if any) and preferred. Questionnaires with farmers are needed to these ends and have to take place at the start of the project.

Product selection, improvement and focusing (client friendliness)

- It should be realized that forecasts, predictions, models, decision analyses, communication methods (including participative research) are tools that only become (information) products when they can be operationally used by others down the line towards farmers for better preparedness and mitigation decisions;

From the project proposal the following explicitly wanted products can be read and on these products the earlier defined differentiation has to be applied. Further, to be effective at the farm level, these three products have to be applied collectively.

- Application of predictive capacity in terms of climate, weather, disease and production capacity in combination;
- Model framework application in farm and policy decision making;
- Management strategies/practices relating to pesticide usage to meet climatic circumstances and minimize crop losses.

Development and establishment of agrometeorological services

The question was where and how to focus to bring products operationally to problems (still with the differentiations applied).

- collect existing agrometeorological services of the kind related to the products identified in the proposal, if any; determine the communication channels;
- determine which (information) products need to be focused on which priority problems and which applied scientists (from which institutions), extension intermediaries and farmers should be involved in making these products into services along which communication channels; and
- organize the establishment of such agrometeorological services in risk communication along the right channels.

Upscaling from pilot projects through training exercises

- Any agrometeorological service so detected or established with a target group of farmers through certain communication channels (from products operationally used to solve priority problems) in pilot projects should be considered for upscaling, through the development of training modules for extension intermediaries (working at the institutions concerned or along the communication channels established) to be used in farmer field classes;
- In first instance these will be farmers in the same category of differentiation, because for other groups the best approaches could be different.

For the APN project the pertinent questions would be,

What can we recognize in the proposal on the five issues just distinguished?

What is unclear or missing?

Where to focus for organizing actual risk communications to government and farmers as agrometeorological services for better preparedness and mitigations?

Quesions and discussion

Derry said that this was a seminal paper in that without risk communication to communities it would be very unlikely that the project would bring any of the modelling findings and products to fruition. Boote asked if there were agromet advisor in India who might take the initiative forward on the ground and Ramakrishna confirmed that this would shortly be the case.

Present status of research on Alternaria leaf blight in Bangladesh

Golam Ali Fakir, M. Asaduzzaman and S.N. Alam

Mustard the principal oil seed crop of Bangladesh occupies about 66% of the total oil seed area producing 61 % of the total oil seed grown in the country. There is an acute shortage of edible oil and oil seeds in Bangladesh. The country has to import huge quantity of edible oil and oil seeds every year spending valuable foreign exchange. So, there is no alternative but to increase the production of oil seeds. In this context mustard can play an important role. The total land under mustard cultivation in the country is 3,52,000 ha and the total annual production is 334000 Metric Tons. The average yield is 900 Kg/ha. As mustard has to compete with many winter crops, there is little scope for expansion of cultivation area of the crop. However, short duration high yielding varieties may fit between the two rice crops early Aman and Boro. In low lying areas prior to Boro cultivation short duration high yielding mustard varieties may also be suitable. So, production of mustard can be increased substantially by proper management.

Mustard (*Brassica* sp.) suffers from 14 different diseases. Of these, Alternaria leaf blight caused by *A. brassiceae* is the most devastating disease in Bangladesh. The disease occurs on all the known varieties grown in all mustard growing areas of the country. Under favorable condition the disease can break out in epidemic form resulting more than 70 % yield losses. In average, 25% yield can be reduced by the disease. The pathogens can attack all parts of the plant- leaves, stem, siliqua as well as the seeds. The pathogen, *A. brassiceae* is seed borne and seed transmitted. Seed borne infection ranges from 0.5-40%, the average being 3% depending on the variety, agro ecological zones and weather conditions. The disease is weather dependent. High temperature, foggy weather and high relative humidity (if there is rain during the growing season) favours the disease development. Also aphid attack in the late growing season results more spread of the disease causing more yield loss in the crop. There is no effective method has yet been developed for controlling the disease. So far, no variety has been found resistant to the disease. Seed treatment with Redomil MZ-72 (0.25%) has been found useful in controlling seed borne infections. Spraying with selective fungicide can control the disease partially.

Limited work has been done on the epidemiology in relation to disease prevalence under varied environmental conditions. Attempt has been made to control the disease through environment friendly management practices by the Bangladesh Agricultural University, Mymensingh and Bangladesh Agricultural Research Institute, Gazipur. Adjustment of sowing time and use of plant extract has been found promising in controlling the disease.

Research work is in progress and development of the disease in relation to weather viz, temperature, relative humidity, rainfall and day length need to be undertaken as a prelude to a disease modeling.

National Facility of Agromet Databank at CRIDA

V.U.M. Rao and G.G.S.N. Rao

A databank facility was created at Central Research Institute for Dryland Agriculture to pool historical data on weather, crop morphology, phenology, yield and yield characters, soil data, and insect-pest and disease data from centres of AICRPAM, AICRPDA, other ICAR institutes and SAUs. Data from special projects such as Mission mode project on Development of weather based forewarning systems for crop pests and diseases from National Agricultural Technology Project, and National Network Project on Climate Change operated at All India Coordinated Research Project on Agricultural Meteorology units have been appended to this database. Collected data was scrutinised, quality-checked computerised and catalogued. This process is continuous. Visual basic programmes were developed for derived weather parameters viz. PET and water balance components, conversion of weather data into weekly, monthly and seasonal basis. Mode for collection and retrieval of crop data have also been developed.

The databank consists of daily rainfall data from 38 stations in Vidarbha, 58 stations in Marathwada regions of Maharastra and 1100 mandals of Andhra Pradesh. Monthly rainfall data of 1400 stations spread across the rainfed districts in India since 1970 has been collected. Hourly weather data for 45 stations located in AP, Maharastra, Karnataka and Rajasthan was collected from private entrepreneurs and added to databank. Creation of Spatial Database on Agrometeorology and preparation of thematic maps for different derived climatic parameters using GIS were undertaken. Trend in annual rainfall was analyzed using spectral techniques for the 1100 stations located in different rainfed districts in the country.

The databank maintains a dynamic website 'Crop weather outlook.org' with a facility for regular uploading data from participating centres to strengthen the agro-advisory services at national level. Regular uploading of the data by all 127 AMF units spread across the country can make this website more useful in developing meaningful agro-advisories. The website provides compiled crop data formatted in web pages for different states and for different crops separately, The parameters considered are crop variety, soil type, pest, disease, contents, program, treatment, season and year of the experimentation. The website also provides region-wise contingency crop planning at weekly interval and critical analysis of weather data. An intranet website was designed and developed for easy retrieval of information including derived parameters. This website will be made operational on Internet after finalizing the 'Data Policy Issues' with the approval of ICAR. As part of service, agromet data was supplied to users from ICAR, SAUs, NCMRWF, DST and other institutions through ARIS network of the ICAR.

This database could be effectively used for development, validation and refinement of weather based forewarning systems, and validate the decision support systems developed from time to time.

Questions and discussion

Discussion centred largely around accessibility to the data and the use of the data in modelling.

Peanut pest risk management in Cambodia

P. Visarto

Agricultural diversification and household food security are severely limited in Cambodia by low yields of most agricultural products, particularly in the upland crops; peanut is one of them, which farmers can harvest only up to 800kg/ha. By contrast, there have been significant gains in other countries in the Pacific region (Australia, Bangladesh & India). Improve cropping practices and pest risk management has the potential to push average yields to 2 tons/hectare. To reach this potential yield level we need to minimize losses due to the crop constrains especially leaf spot disease. The aspects of disease management which can modify the development of diseases such as host plant resistance and rotation will need to be monitored and to incorporated into the model development. The project will therefore address the diseases of peanut by examining data from both off-season (to address the pathogen presence and dissemination) and crop-season (to address disease progress). Pest risk management can be managed by understanding the nature of disease and relevant factors for disease development. New field data from this project such as microclimate, crop performance and disease development combined with sharing data from other countries in the Pacific region (Australia, Bangladesh and India) will help relate microclimate values, validate international models on estimation of leaf wetness, and link with disease progress estimation. This will be validated through concurrent application to index crops in selected areas, enabling development in the important area of risk communication through engagement with local stakeholders. By engaging eminent scientific and policy specialists, analytical linkages will be addressed and duplication of research-effort reduced. Environmentally friendly management strategies relating to possible pesticide usage when climatic considerations deem this necessary in the interests of strategic food production, will contribute to sustainability in agricultural production.

The peanut pest risk management project objective is to enable higher yield with better quality of peanut crop by improving cropping practice and pest management in the upland and the Mekong delta soil type with a better understanding of pest management, so that yield losses due to insects and diseases can be minimized and higher profit can be improved.

The production in farmer fields will be compared with that at the research station on grain yields, profits margins, the incidence and severity of diseases & insect pests and crop loss. The research activities will be done on research station and nearby farmers' fields.

The research activities will be conducted in two research stations (CARDI's and ChamKar Leu Station) and in two villages; one in Kampong Cham province and the other in Kandal province. In Kandal province (Saang district), the research activities will be conducted at the end of the wet season (November-March) while in Kampong Cham province farmer's field and station trials will be conducted at the early wet season (May-August). At CARDI's, we will conduct the experiments in both seasons. Fungicide treatment at different peanut leaf spot disease levels will be conducted at all research study sites to compare the effectiveness of fungicide treatment and farming input cost.

Comparisons between fungicide-treated and untreated plots will be used to assess crop loss, while comparisons between provinces (soil type and planting dates) will be used measure the impact of micro-climates (soil moisture, maximum & minimum temperatures and rainfall) on peanut disease incidence and severity and consequently on grain quality and yields.

The research activities and outputs of this project will help form closer working relationships among the various technical experts of CARDI. The Peanut Pest Risk Management Project will link and strengthen the research network in Asia Pacific region which Australia, Bangladesh, Cambodia and India are working on peanut and other oil crops.

Questions and discussion

This largely centred on technicalities in making the data accessible for the CROPGRO model.

Relevance of epidemiological data and establishing relationship between Metlab and canopy weather data for better predictability of diseases

S. Desai and Y.S. Ramakrishna

Disease is a product of the interaction between host and pathogen in a favourable environment over time. Even though susceptible host and aggressive pathogen are present, absence of congenial weather at the canopy level, generally referred to as microclimate, restricts the disease development. However, recording canopy weather is tedious, expensive and time-consuming. Hence, majority of the disease forewarning systems take into account the weather recorded at the nearest metrological station (Metlab), which often results in accounting for only 50-60% variability. Hence, determining a relationship between Metlab and canopy weather data will be helpful in deriving microclimate data that could be used for forewarning systems with improved accuracy.

Field trials were laid out during the three monsoon seasons of 2004-2006 to establish a relationship between Metlab and groundnut canopy weather to establish relationship for effective forewarning of late leaf spot of groundnut caused by *Phaeoisariopsis personata*. While the maximum and minimum temperatures showed a logistic relationship, maximum and minimum relative humidity showed an exponential relationship. Efforts are being made to incorporate these results into a decision support system that has been developed for late leaf spot forewarning and check for the precision levels. For establishing such relationships, field trials should be conducted for test crops sown at different spacings so that meaningful relationships could be established.

Similarly, the disease intensity depends on the multiplication rate of the pathogen expressed as apparent infection rate ‘r’. Since, ‘r’ is a product interaction between available susceptible host and congenial environment, this parameter should also be considered in developing forewarning systems. In India, late leaf spot development varies across different groundnut production systems. When the data sets from various centres across Tamil Nadu over years were critically analysed, the disease progress varied across centres and over years. Hence, considering the ‘r’ factor in decision support systems would help in understanding the disease dynamics and thus increasing the precision of the forewarning system.

Incorporation of these details into the crop growth models such as PNUTGRO and INFOCROP will help in better prediction of the disease and development of a disease risk management strategy.

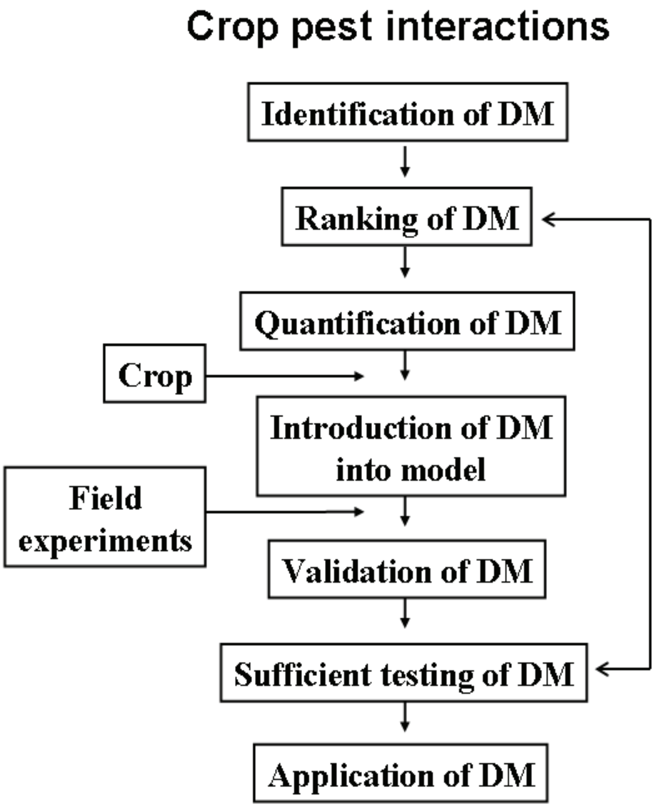
Questions and discussion

There was consensus that there would need to be an in-depth examination of epidemiological aspects of disease implications at local level before quality control could be applied to any of the models. This could be an advanced issue and the paper by Desai and Ramakrishna had given some direction to the way forward.

Data needs on use of climate information to develop and apply decision making tools to manage disease risks for improved crop production

R.P. Thakur

There is a need for conducting precise experiments for obtaining reliable data for developing models or validating the existing models for groundnut-late leaf spot and mustard-blight systems. The main aspects covered were: bench mark locations for conducting experiments; using highly susceptible commercial cultivars; precise experimental planning having proper plot size, plant density, planting time, replications, and agronomic practices; disease induction-creating adequate disease pressure and recording the disease data at the progressive crop growth stages; within crop weather data – from the automatic weather station to include rainfall, temperature (min and max), leaf wetness, radiation, soil moisture on hourly basis; daily weather data from the nearby Met Station; and the seasonal climate forecast data from the nearby source.



Need to collect data on crop phenology and disease progress at 1-9 standard scale at weekly interval (PNUTGRO model) was further emphasised to include extent of defoliation and role of other foliar diseases and insects in defoliation, crop biomass and finally pod yield.

Understanding the relationship between crop microclimate data, Met station data and seasonal climate forecast data is critical to further relate this to disease severity data for developing a model for disease forecasting.

These data sets thus collected and their relationship understood could be used to validate some of the existing models for the crop-disease systems or developing a new system advisory tool that would be cost effective at the farm level.

The experimental details for conducting such experiments should take into consideration the crop phenophase, disease record, recording of weather data and ancillary data. A detailed module was presented for generating the datasets that are essential for this project.

Questions and discussion

General discussion suggested that the workshop had come a step closer to understanding the available data and its limitations. However, there was still a feeling that none of the models discussed would be precluded by the limitations.

Climate, Crop and Disease data availability in Australia

T. Hind-Lanoiselet

Climate data availability

There is a vast network of weather stations that collect rainfall and climate data across Australia. The data from these stations is sometimes collected by hand. However, many of the stations are moving towards automation. Climate data can be accessed and purchased from a vast array of sites depending on the type of data required. A summary of some of these is provided on the Queensland government web site http://www2.dpi.qld.gov.au/climate/9193.html and include the Commonwealth of Australia Bureau of Meteorology site http://www.bom.gov.au, which provides a comprehensive daily forecasts, maps, satellite images, historical records, warnings, educational information, climate outlooks, averages (temp, rainfall) for different locations. The length of time a station has been operating and the type of climate data the station collects can also be accessed from the Bureau of Meteorology site.

However for disease modelling the data obtained from these sites can be incomplete with missing data points. In these cases sites such as SILO (http://silo) provide a Patched Point Dataset and Data Drill, which provide continuous daily runs of climate data for use with simulation models. For example, the Patched Point Dataset combines original Bureau of Meteorology measurements for a particular meteorological station with interpolated data to infill any gaps in the record.

Crop

In Australia the majority of crop information has been collected on wheat followed by canola and other pulses. Crop models include Agricultural Production Systems Simulator APSIM (http://www.apsim.info/apsim/) and Oz-Wheat derived from APSIM (http://www2.dpi.qld.gov.au/extra/pdf/climate/Oz-Wheat/Oz-WheatReport-Abstract&Intro.pdf).

Disease

A variety of disease models exist in Australia. These include Rustman, Blackspot management, Blackleg Sporacle, Anthracnose of Lupin forecasting, Cereal barley yellow dwarf virus (BYDV) risk and Lupin cucumber mosaic virus (CMV) risk. Most of the disease models have been developed in Western Australia, largely because this state has a modeller dedicated to disease models (http://www.agric.wa.gov.au/servlet/page?_pageid=449&_dad=portal30&_schema=PORTAL30).

There is also epidemiological data available that is currently suitable to put into models including Sclerotinia stem rot of canola.

Limitations

Very little disease modelling work is being conducted in Australia as this type of work is costly in terms of time and effort to collect the appropriate epidemiological data to put into the model and in model development. There are few people employed in this area possibly because there is little understanding in the industry and by the farmers on the limitations and benefits of using these models and also a lack of modelling information that they can access.

Small Workshops: Afternoon Day 2

The plenary session separated into two groups along plant lines (Peanut/Groundnut or Mustard/Canola) to:

- decide on and recommend models for both crops.
- discuss useful outputs from the model that would be useful
- discuss evaluation strategies and usefulness of the research.
- determine some strategies for risk communication.

Also discussed at this time:

- Epidemiological aspects *vs* forecasting
- Risk management ability
- Analysis of frequency of occurrence of diseases in various regions

Workshop outcomes

There was brief discussion which indicated the feeling that there were two distinct camps emerging; those that favoured the CROPGRO model and those that favoured Infocrop. As there could be extrinsic problems potentially affecting each and that data availability had to be ground-truthed, there was no reason why both should not be applied. It was felt by some members of the Indian agricultural services that because of work already in hand and because of geographical similarities, India would be in a position to best support Bangladesh in terms of the Infocrop model which had been well designed to address regional issues. Cambodia could perhaps lend itself to the more exploratory application of the CROPGRO model and there would be interest in the findings of the parallel workshop which would address the Bangladesh modelling needs. There was some concern that not all representation relevant to Bangladesh could attend that meeting.

It was felt that some of the strategies relating to evaluation strategies and risk communication could not be finalised at the workshop and would require working in conjunction with the communities concerned following the workshop. In this regard problems associated with representation of a broad spectrum of stakeholders in planning processes were briefly discussed.

Although the meeting ran out of time to take the issues further it was felt that the determination of the model to be used and the identification of an India-Australia-Bangladesh sub-network within the main umbrella of the project was a sound starting point to move the program ahead.

Session III- The Way Forward

Project Implementation and Monitoring

R. N. Spooner-Hart and A.K.S. Huda

After a brief workshop summary by Spooner Hart, discussion leading to the assignment of activities followed:

General project activities and coordination

- Participants to identify their individual roles and responsibilities in the project **(everyone)**
- Participants to contribute to workshop proceedings **(Huda to coordinate)**
- Identify and produce papers, publications emanating from the project (one option is a special issue of Aust J Exp Agriculture) **(Huda to coordinate, Spooner-Hart)**
- Communication during the project (email list, website, updates)
- On-going coordination and communication in task groups. Identification of funding support for additional identified activities (eg visits, capacity building Bangladesh, Cambodia) **(Huda)**
- Prepare project progress report for APN **(Huda to coordinate)**
- Prepare workshop in Bangladesh **(Alam, Asaduzzaman, Huda)**
- Prepare final report **(Huda to coordinate)**
- Identify new funding sources **(Huda, Coughlan, Spooner-Hart)** and develop new project(s) **(Huda)**

Model validation/improvement

1. Mustard/canola Sclerotinia (+Alternaria)

- Validate/Improve Sclerotinia model
  - i. Yield data from India (various) further data from Australia
  - ii. ENSO, average temp and high temp

  (Hind-Lanoiselet, Chirantan, Chattapadhyay, Hansen, Huda)
- Validate/Improve INFOGRO model for Mustard

  (Aggarwao, Subba Rao, Chirantan, Huda)
- Investigate the inclusion of Sclerotinia disease model in INFOCROP **(Aggarwal, Hind-Lanoiselet, Huda, Chirantan)**
- Evaluate simple models for Alternaria (rule of thumb) and Sclerotinia model in Bangladesh, India **(Chirantan)**
- Investigate forecast models for Alternaria.

2. Peanut/Groundnut (Late leaf spot (+rust))

- Improve parameters and relationships in late leafspot model, complete linkage with CROPGROmodel **(Boote, Desai, Jagannathan, Thakur, Huda)**
- Test predictions, validate and improve CROPGRO using available data in India, new data from Cambodia, India. Particularly predictions between disease progression and impact on yield **(Boote, Desai, Jagannathan, Desai, Huda)**
- Improve decision support systems **(Desai, Jagannathan, Thakur, Huda, Boote)**

3. Both Crops

- Identify most urgent primary users of products of models, identify selection of farming systems, advisory services and other users. Identify via questionnaire what these representative user groups want. Overall coordination by Stitger, but nominated persons in each country to collect surveys and assist in interpretation of data **(Stigter, Huda & one from each country)**
- Develop simple sets of rules for disease forecasting
- Link simple rules with specific data for region-specific applications.
- Investigate relevance of incorporation of seasonal climate forecasts for strategic decision making with predictability based on ENSO. If influence present, evaluate predictability using past data and, if positive, provide training and tools to assist in implementation **(Hansen, Desai, Rathore, Huda, Derry)**
- Develop economic and risk elements of combined modelling system **(Hansen, Derry, Huda).**

Field investigations

1. Mustard/canola

- West Bengal (2 locations) Alternaria, and other key diseases **(Bhattacharya)**
- Bangladesh (3 locations) x 2 years to generate field data with determined agreed protocols, and parameters measured. Support and capacity building with India and others (visit) **(Alam, Asaduzzaman, Blattacherya, Chirantan, Spooner-Hart).**

2. Peanut/groundnut

- Cambodia (2 locations) to identify and monitor peanut diseases, with agroclimate and crop development data, with agreed protocols and parameters measured. Also monitoring of disease in farmer fields. Support and capacity building with India and other (visit) **(Visarto, Coughlan, Desai, Huda, Derry, Spooner-Hart)**
- Tamil Nadu (1 location) requires funding support **(Jagannathan).**

Other issues

- Emphasis to date on risk assessment: need more consideration of risk management (eg communication with stakeholders, planning advice) **(Derry, Huda, Stigter)**

How we could proceed

- Identification of additional participants in nominated project activities
- Formation of activity or task groups, to develop activity plans in more detail: roles and responsibilities
- What resource implications are there for these activities?
- Compare identified activities and stated project objectives/activities: are we missing something?
- Are there any other issues/concerns about where we have got to in the workshop regarding the project? There needs to be ownership by project participants.
- The most positive outcome of the wqorkshop was that the network members did not seek funding for their own work, but preferred to use funds and their own resources for capacity building within the membership.

Outcomes of the Scoping Workshop

K. Coughlan

- An enhanced understanding of the relationships between weather/climate, disease incidence, and reduction in crop yield, leading to the development of management interventions (leverage points)
- An appreciation of the need to survey the decision making needs of various users. This requires some general analysis of the farming system, and of the major leverage points, rather than "leading" questions. We can consider those to do with weather/climate services, such as in ***early disease warnings and related climate/weather forecasting***. However, we must also be careful not to take a top-down approach ("we are good modellers, and that is what you will get")
- The need for a ***risk appreciation, preparedness and management model*** as the basis for decision making in this area. This project, and in particular the new project, must involve the farmer interface and an impact analysis of economic and social outcomes
- A list of potential funding agencies for future funding, to build on APN seed funds
- A list of collaborators and their respective responsibilities for networking during the APN project

Outputs of the APN project

1. Network of researchers able to collaborate in follow-on project; a springboard to effective project operation
2. Results from a set of pilot projects-Field trials and parameter development in Bangladesh and Cambodia. Communication systems are well developed in India. What is the pilot project in India? (A farmer survey of use and economic impact of advisory service?)
3. Theoretical (from modelling) and actual (farmer survey) economic analysis of impact of improved decision-making.
4. Quantification of yield impact of diseases
5. Regional collaborations for capacity building

Future activities

1. Incorporate policy issues of food security and food safety, environmental issues of reduced chemical usage, ability to assess impact of climate change (beyond the scope of this project). Crop disease and pest forewarning is a priority of the Indian Government.
2. Framework for extension of Indian methodologies and modeling expertise to other Asian collaborators (capacity building)
3. Aggregation of benefits from farm to district level-benefits to players other than farmers (assuming that farmers remain our main users for the project services)
4. Extension of activities to fruit and vegetables, where (particularly pesticide) residues are an issue and the potential benefits are high with high-value crops. Need to look at availability of crop growth models!

Possible future projects that can be targeted for collaboration include:

- Development of an ability to assess impacts of climate change on crop diseases and pests
- Development of a crop disease/pest forewarning system for growers and extension personnel
- Development of a framework for capacity building in some of the Asian collaborators countries
- Identification of and model development for users other than growers and agricultural extension officers. For example: insurance industry
- Extension of activities to fruit and vegetables
- Incorporation of policy issues of food security/safety and environmental issues of reduced chemical usage into models

Annexure 1

Workshop Program

Scoping Workshop of "Climate and Crop Disease Risk Management: An International Initiative in the Asia-Pacific Region"

(November 6-8, 2006)

Workshop facilitators: Kep Coughlan and Y.S. Ramakrishna

Objectives:

- To identify appropriate models, modelling framework and data needs to incorporate relevant climate risk factors for managing selected diseases/crops within the region
- To develop systems to improve access of existing climate, crop and disease information
- To determine strategies for value-adding to climate and crop data through local collection (field measurements)
- To identify the specific needs, interests and strengths of this interdisciplinary multilateral project team, and to explore opportunities for increased collaboration.

06.11.2006 (Monday):

Rapporteurs: C. Derry, S. Desai, P. Visarto

0930-1000	Welcome: Ramakrishna, Spooner-Hart, Thakur, Coughlan
1000-1030	Project aims/objectives with a short presentation on the progress and future plans in integrating climate, crop, disease and management models (Huda)
1030-1100	Potential for CROPGRO model for peanut modeling in the APN project (Boote)
1100-1130	Tea
1130-1200	Potential for WhopperCropper for mustard/canola modeling in the APN project (Meinke)
1200-1230	Brassica model (Sastry)
1230-1300	Infocrop (Huda & Subba Rao)
1300-1345	Group discussion: Applicability of different models Group lead: Ramakrishna • Readiness of models for use • Major or minor modifications needed • Data needs of models Seeking information from each modeler (10 min each)
1345-1430	Lunch
1430-1500	Crop diseases models(Lanoiselet)
1500-1530	Climate models(Hansen)
1530-1600	Current status on Pest/Disease modules (YG Prasad)
1600-1615	Tea
1615-1700	Small group discussion (3 groups)Group lead: Lanoiselet, Chattopadhay, and Spooner-Hart
1700-1730	Report back in plenary with summary – Rapporteurs
1900-	Conference Dinner

07.11.2006 (Tuesday):

Rapporteurs: Chris Derry, YG Prasad, SN Alam

0900-0930	Summary presentation on applicability of models (Desai)
0930-1000	Data needs (Thakur)
1000-1030	Farmers' needs for Agromet service and models (Stigter)
1030-1130	Small group discussion (3 groups)Group lead: Boote (Peanut models), Huda (Mustard/ canola model), Simple DSS models (Meinke)
1130-1200	Tea
1200-1230	Report back in plenary with summary - Rapporteurs
1230-1245	**Data availability (climate, crop, disease) for country specific crops:** India (GGSN Rao)

1245-1300	Bangladesh (Alam)
1300-1315	Australia (Derry, Lanoiselet)
1315-1330	Cambodia (Visarto)
1330-1430	Lunch
1430-1530	Small group discussion (3 groups) – on database Group lead: Jagannathan • Collection, compilation and generation of new datasets for testing Group lead: Rathore • Generation of user-friendly Decision support systems/ Operational agro-advisory models Group lead: Hansen • Linking SCF, pest models and DSS for improving agro-advisory systems
1530-1600	Tea
1600-1630	Report back in plenary with summary - Rapporteurs
1630-1730	Discussion – issues on • Model selection and modifications • Generation of DSS for use in region-specific agro-advisory systems • Roles and responsibilities
2000-	Dinner

08.11.2006 (Wednesday):
Rapporteurs: Chris Derry, Chatopadhyay, Asaduzzaman

0900-1015	***The way ahead- Time line for current program and development of new project proposal*** • Spooner-Hart – Overview and future scoping • Rathore – SCF, MRF, Agromet service linkage • Coughlan – Future funding opportunities
1015-1115	Small group discussion (3 groups) • Group Lead: Spooner-Hart, Rathore, Coughlan (One rapporteur would join each group)
1115-1130	Tea
1130-1200	Report back in plenary with summary - rapporteurs
1200-1400	Developing a plan for the data collection and validation during the current year as well as for the second year for formulation of a mega project proposal • Roles and responsibilities (crop-wise and country-wise) • Model selection, generation, testing and validation • Funding and other resource needs • Inputs for final workshop
1400-1500	Lunch
1500 onwards	Modeling Session:Ken Boote Demonstrates Models

09.11.2006 (Thursday): Free for APN participants (eg Visit to ICRISAT); Modelling sessions: Optional

10.11.2006 (Friday): Modelling sessions: Optional for APN project participants

Annexure 2

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