



EC/FAO Programme on Information Systems to Improve Food Security Decision-Making in the European Neighbourhood Policy (ENP) East Area

Introduction of Winter Wheat Disease Forecast and Prevention to improve crop-forecasting system in Armenia

Moussa El Jarroudi - International Consultant

ARMSTATEHYDROMET Service, Yerevan, Armenia
April 3 – 7 2012

CONSULTANCY REPORT

1. Background and objective

The objective of the consultancy was to develop capacity of Armstatehydromet and Ministry of Agriculture in predicting and preventing winter wheat crop diseases. The consultant was invited to deliver a four day training which was jointly organized by the ARMSTATEHYDROMET (hereinafter: Hydromet), MoA and FAO from 3 to 6 April 2012 under the “*EC/FAO Programme on Information Systems to Improve Food Security Decision-Making in the European Neighbourhood Policy (ENP) East Area*”. The Programme is financed by the European Commission and implemented by FAO. The mission was carried out under the Agro-meteorological Component of the Programme in Armenia. The objective of the Programme in Armenia is to support government’s priorities to reduce food insecurity and poverty by improving the quality and sharing of information across institutions and promoting evidence-based analyses and assessments.

The assignment contributed to improve long term agro-meteorological forecasting and the dissemination of information to Marz Support Centres. This is the fifth mission under this component¹. This mission was devoted to the introduction of a modelling system for the forecasting and prevention of winter wheat diseases by an expert in agrometeorology and crop yield forecasting. The mission was carried out by Moussa El Jarroudi, University of Liege, Belgium (ULg).

¹ The objective of the 1st mission was to review forecasting capacity in Armenia and prepare a workplan for future activities. One of the recommendations of the mission was to create a Working Group (WG) that would be responsible for preparing the Crop Yield Forecasts at National level. The WG was established in April, 2011 and includes representatives from Hydromet and the Ministry of Agriculture (MoA). The second mission was aimed at preparation and delivery of a two-week training on crop yield forecasting techniques and tools adapted to the Armenian context to the members of the Working Group as well as other national technicians from the National Statistical Service (NSS) and the Agrarian University of Yerevan. The third mission had an objective of following up the activities implemented by Hydromet under this component, in particular, development of the updated Agromet Bulletin. The fourth mission was aimed at development of capacity of Armstatehydromet and MoA in predicting and preventing potato diseases.

2. Programme of the consultancy

The consultancy included 12 days to be performed from 2 to 27 April 2012: 6 days in Armenia (Yerevan), 4 days to get prepared for training, 2 days for the development of a mission report.

Tasks and responsibilities of the Consultant are provided in Annex 1.

Day	Work
From beginning of March to 23 March	<ul style="list-style-type: none"> • Training sessions and PP Presentations preparation; • 4 home working days; • Sending of the presentations to EC/FAO Program office in Armenia for their translation in Armenian.
2 April	Travel to Armenia
3 April	<ul style="list-style-type: none"> • Meeting at the Armstatehydromet with Tapalstyan Mane, coordinator of the EC/FAO Program, Petrosyan Zara, head of the Hydrometeorological Operational Centre General and M. Odabashian Vahe, translator. General introduction to the EC/FAO program, discussion about the training planning; • Opening remarks by Zara Petrosyan; • Beginning of the training session; • Presentation on the Computer-based Decision Support System for Septoria leaf blotch control in Wheat: Its development and Implementation in Belgium and Grand-Duchy of Luxembourg; • Presentation on the Assessment of the night weather parameters and their use in a forecasting models of Leaf Rust; • Visit at wheat fields and weather stations with Petrosyan Zara and Tapalstyan Mane.
4 April	<ul style="list-style-type: none"> • Presentation on the Distrain software; • Presentation on the site-specific monitoring for diseases forecasting in winter wheat. Presentation of the life cycle of the most fungal diseases and the relation between the weather parameters and the development of the diseases. The simulation model proposed for each disease; • Training session on fungicides to be used for the control of Septoria leaf blotch, wheat leaf rust, wheat stripe rust, Stem rust, Smuts, wheat powdery mildew, wheat Tan spot, Fusarium head blight: types, mode of action, application; • Training session on the simulation model in winter wheat: Comparison between the weather station in Luxembourg, Belgium and Armenia. PROCULTURE Model in Armenia.
5 April	<ul style="list-style-type: none"> • Training session on the occurrence and distribution of the mycotoxin produced by Fusarium species isolated from winter wheat; • Training session on the spatial heterogeneity of leaf wetness duration in winter wheat canopy and its influence on plant disease epidemiology; • Training session on the modeling of fungal diseases impact: A case study with the Belgian crop growth monitoring system;

	<ul style="list-style-type: none"> • Evaluation on the training sessions by the participants through the Evaluation form; • Exercises on the calculation of the phyllochron (130 growing degree-day); • Handling several disease infection models and how to determine the optimum time of treatment.
6 April	<ul style="list-style-type: none"> • General discussion of various wheat fungal diseases and their relationship with environmental conditions (crop management, meteorological conditions, crop protection, etc.); • Information about the activities of Hydromet given by Zara Petrosyan; • Meeting with Petrosyan Zara about the building of warning system for winter wheat in Armenia; • Exercises on the prediction of Septoria leaf blotch using the PROCULTURE and Septor softwares; • Exercises on the prediction of leaf rust using the Septroui software; • Exercises on the prediction of Fusarium head blight using the FUSAR Software.
7 April	Travel to Belgium
20 and 21 April	Mission report

3. Training objective

The objective of the training was to develop capacity of Hydromet and Ministry of Agriculture in predicting and preventing winter wheat crop diseases.

The training provided both theoretical and practical knowledge and skills in winter wheat diseases identification and prevention. The training focused on the prediction of diseases in wheat crop based on the monitoring of climatic conditions (cycle, fungicides), an important winter disease in Armenia, and showed how it can be predicted by using software which has been developed and is currently used in Belgium and Luxembourg.

The Head of the Hydrometereological Operational Centre took the opportunity of the presence of the representatives of Agricultural Support Marz Centres in Yerevan to introduce the latest developments in crop forecasting.

4. Training participation

The training took place between 2 and 6 April at Hydromet building. The training was organized for the stakeholders of the Programme concerned with crop forecasting, including mainly staff from Hydromet (Agrometeorological and Climatology Unit, 8 people, 2 of them from the Crop Forecasting Working Group) and from the MoA (14 people) (Figure 1).

5. Evaluation of the training.

An evaluation of the quality of the training was organized among the participants through an evaluation-form at the end of the training.



Figure 1. Participants from Hydromet and from the MoA.

6. Training topics

The main topic was to train the participants the management of the winter wheat diseases with a specific focus on the Septoria leaf blotch (SLB) (*Septoria tritici*). SLB is an important disease in many parts of the world, including Armenia. It can cause considerable yield reduction if the flag and second leaves are severely affected before the grain-filling stage. The development of SLB in fields can be forecasted using software such as PROCULTURE that is based on the analysis of weather parameters (relative humidity, temperature, rainfall). The model considers infection to have occurred when, during a 2-h rainfall event, precipitation for the first hour is at least 0.1 mm, allowing the swelling of pycnidia, followed by a second hour with at least 0.5 mm of precipitation, leading to the release and splash dispersal of the conidia. In addition, after rainfall, relative humidity should be higher than 60% during the following 16 h and the temperature should remain above 4°C for 24°C for germination and infection.

To reach the aim of the training, different Power Point presentations were delivered to the participants:

“A computer based Decision Support System Septoria leaf blotch Control in wheat:

The model PROCULTURE has been developed to simulate the progress of the septoria leaf blotch disease on winter wheat during the cropping season. This model has been developed in order to guide field observations on different leaf layers and to find the optimum time of fungicide spray in fields. The model provides information which explains disease progression on the upper leaves. The relationship between disease control by fungicides and yield reduction varies from site-to-site and from season-to-season. A weekly PROCULTURE recalibration is routinely done using actual disease levels observed on site. On average, no spray of fungicides or only one application is required to efficiently control the septoria leaf blotch disease. The PROCULTURE forecasts have been validated to be correct in about 85 percent of all cases.



Figure 2. Young, oblong lesion with black spots (pycnidia) on a leaf with *Septoria tritici* blotch.

The treatment defined with the simulation model over 2003 to 2009 was recognized as the most effective one compared to the other treatments and resulted in increase of grain yield (by 80 percent). At Reuler (North of Luxembourg), over 2003 to 2009, treatments based on the *Septoria* risk simulation model were recommended only in 2007. The climatic conditions of this site tend to favour organic farming in this region where the evolution of the foliar disease is very weak.

“Assessment of the night weather parameters and their use in forecasting models Of Leaf rust”

The model was elaborated by the analysis of the night weather and leaf rust incidence. Statistical validation using regression analysis reports a strong correlation between the number of hours with specific meteorological conditions and the percentage leaf area covered by brown rust lesions for the two upper and youngest leaves, which are mostly responsible for photosynthesis activity and assimilates production filling the grains. In the past, the cereal disease management strategies were oriented towards the control of predominant and yield reducing diseases such as that caused by *Septoria tritici*.



Figure 3. Leaf rust symptoms

The succession of mild winters and warm springs over the last 5 years allowed the early occurrence and the fast development of the brown wheat leaf rust in the Grand-Duché of Luxembourg and Belgium; it is advisable to take this disease into account in fungicide application schemes. What about Armenia? Discussions with participants showed that leaf rust is a very popular disease in Armenia. This model could be a good platform for the simulation of leaf rust in this country.

“Distrain: A computer program for training people to estimate disease severity on cereal leaves”

The most common method of estimating disease severity is to compare the infected plant tissue to standards diagrams on which the diseases lesions are arrayed. The Distrain program was developed to train people to estimate disease severity on leaf. The program mimics eight common diseases of small grains: leaf rust, powdery mildew, septoria blotch, scald, spot blotch, net blotch, stripe rust, and stem rust. The estimate data entered by the user is compared to the actual “diseased” displayed on the computer monitor. By using the Distrain program, an inexperienced person could be trained to estimate disease severity and also could develop confidence because the program provides immediate evaluation.

“Site-specific monitoring for disease forecasting in winter wheat”

This session provided more precise details on the assessment and the use of weather parameters in disease forecasting model in order to teach participants the management tools for each disease and the method of simulation. The overall components of the life cycle of fungal diseases (i.e. Stripe rust, powdery mildew, fusarium head blight,) affecting winter wheat and depending on weather parameters for their development, were presented.

“The simulation model in winter wheat”

This presentation was delivered in order to perform a preliminary analysis of winter wheat disease forecasting. Different diseases models were presented. A case study of diseases forecasting based on weather data from Luxembourg and Armenia was developed. A first comparison of data of the 2002-2003 crop season showed that temperature, relative humidity and rainfall data were close to some sites studied in Luxemburg for this crop season. In Artashat for example, the number of days with the winter negative temperature in 2002-2003 was higher than that of Luxembourg sites. Rust (brown, yellow and stem) are very important in Armenia. Conditions of temperature and humidity are very favorable. We tested our models and it works very well. The originality of our model is based on the analysis of the night weather and leaf rust incidence.

“Occurrence and distribution of the mycotoxin producing *Fusarium* species isolated from winter wheat in the Grand-Duchy of Luxembourg”

Participants requested a lot of information about *Fusarium* species and their mycotoxins affecting yield quality. This presentation was given in order to answer those questions. The high occurrence of *Fusarium* Head Blight (FHB) on wheat is likely to be associated with the comparatively mild winter (1.9°C above average 2000-2007) and abundant rainfall during the flowering period. It is very important to determine the species of FHB that dominate. Maize was recognized as the previous crop which favoured a high occurrence of FHB (significant higher prevalence of FHB as opposed to other crops). Among the different species of FHB, only some of them produce mycotoxin, affecting the quality of grains. These are: *Fusarium graminearum*, *F. culmorum*, *F. poae* and *F. avenaceum*. *Microdochium nivale* are described as a non-typical *Fusarium* mycotoxin producer. The distribution of the *Fusarium* species varied strongly from location to location.

“Spatial heterogeneity of leaf wetness duration in winter wheat canopy and its influence on plant disease epidemiology”

The leaf wetness duration (LWD) is one of the most important factors influencing the occurrence of plant disease epidemiology. This session was devoted to the introduction of the methodology for measuring this parameter and informations on how LWD is distributed on wheat leaves according to the distance from a hedge. This presentation was based on a case study at Luxembourg. The diversity of meteorological situations in this country favours the occurrence of very local microclimate conditions that may initiate disease in specific locations of the plot and not in other.

A good knowledge of the distribution of this meteorological parameter could be useful in the pest and diseases management of other crops such potatoes, fruit trees.

“Modeling plant diseases impact with the Belgian crop growth monitoring system”

This presentation came in more precise details to the integration of fungal diseases in a crop yield forecasting system. The example of the Belgian crop yield forecasting system and the relevant documentation (El Jarroudi et al., Eur. J. Agron. 2012) were presented and discussed.

“Projections of video clips on fungal diseases of cereals”

Since the training was organised at the early stage of the crop season, thus only one field observation was carried out. These illustrations will illustrate to the participants material studied in textbooks by giving them a vivid visual demonstration of structures and functions. The interactions between fungi and plants come alive via the artistry of these clips. A copy of the compact disc with all presentations was distributed to each participant at the end of the session.

Exercises on the prediction of *Septoria* leaf blotch, rusts and *Fusarium* head blight using the PROCULTURE, the Septroui, and the FUSAR software, respectively.

These exercises provided more precise details (due to the participants' request) on the simulation of wheat diseases infection models, with a specific focus on four main fungal diseases: *septoria* leaf blotch, *Fusarium* head blight, leaf rust and yellow rust.

The training was deliberately practical because the participants were, for the majority of them, wheat field specialists with a very good knowledge of the winter wheat crop.

Hydromet staff was particularly satisfied with receiving the software which can help them achieve their objectives, in particular the forecasting of late blight appearance in the fields for a better control.

7. Conclusions and recommendations

The training was successful in meeting its objectives. At the end of the training:

- Trainees are knowledgeable about the methods to predict and prevent the occurrence of diseases triggered by climatic conditions.
- Trainees are able to understand the life cycle of most fungal diseases and the relation between the weather parameters and the development of the diseases.
- Trainees are able to use the PROCULTURE Model in order to estimate the development of the five youngest wheat leaves, as well as the Septoria tritici inoculum available to infect those leaves. The software was tested with the Hydromet staff and with the MoA Extension Services agents who now know how to run the software with Armenian agrometeorological data.
- Trainees are able to handle wheat disease infection forecasting such as Septor, Septroui and FUSAR.
- Trainees are able to predict the daily infections of the main fungal diseases.

Recommendations to the participants:

The following recommendations and comments are provided to national institutions in Armenia for a good implementation of the forecasting and prevention system of winter wheat diseases in Armenia:

- A decision-support system (DSS) has been developed in Belgium to help farmers and advisers to manage *Mycosphaerella graminicola* in winter wheat during stem elongation. The system calculates in real time the interactions between winter wheat and *M. graminicola* development to simulate disease progression in the canopy in order to guide field observations on different leaf layers and determine the risks for the crop. It has been structured to run with individual field input and local hourly meteorological data. It is more a “Decision Support System” (DSS) than an “Expert System”. Complementary information has also to be taken into account to decide on fungicide application, mainly phenological stages, sowing date, cultivar susceptibility, previous crops, and which leaf is emerging. Crop development stage and fungicides characteristics must be taken into consideration to decide on final fungicide application. This information must be provided by experts who are close to the fields conditions.

This system was proposed for the wheat diseases monitoring in Armenia because of its easy implementation. With the introduction of leaf rust and septoria infection models, the farmer will be better assisted in crop management. During the field visit (3 April), the winter wheat (Figure 4) was at tiller growth stage in Armenia. This system could be calibrated and used later in the cropping season.



Figure 4. Winter wheat field 30 km from Yerevan, Ararat Marz

- These considerations mean that there must be a good cooperation between those in charge of monitoring the weather parameters and running the software (Hydromet) and those who know the fields’ practical conditions (MoA Extension Services).
- From the discussion with the participants, it came out that Stripe Rust is very important in northern Armenia, but low disease severity is observed in the South where local varieties are sown. According to the participants, in the North, many cultivars are imported from North America. This is probably due the breakdown of the Yr17 resistance gene to wheat Stripe Rust detected in many cultivars in North America.
- For an efficient early warning system in Armenia, a network of automatic weather station is necessary.



Figure 5. Automatic weather station in Ararat

The first step could be the detection of the topoclimatology variation through meteorological parameters measurements (Figure 5) (mainly rainfall, relative humidity, air temperature) through a mobile weather station. These measurements could provide the basis for a comparison to existing synoptic stations and help determine the location of future stations (the final aim of this strengthening of the weather network being the establishment of the early warning system). Priority should be given to rain due to its influence in the pathogen development and the fungal disease infection.

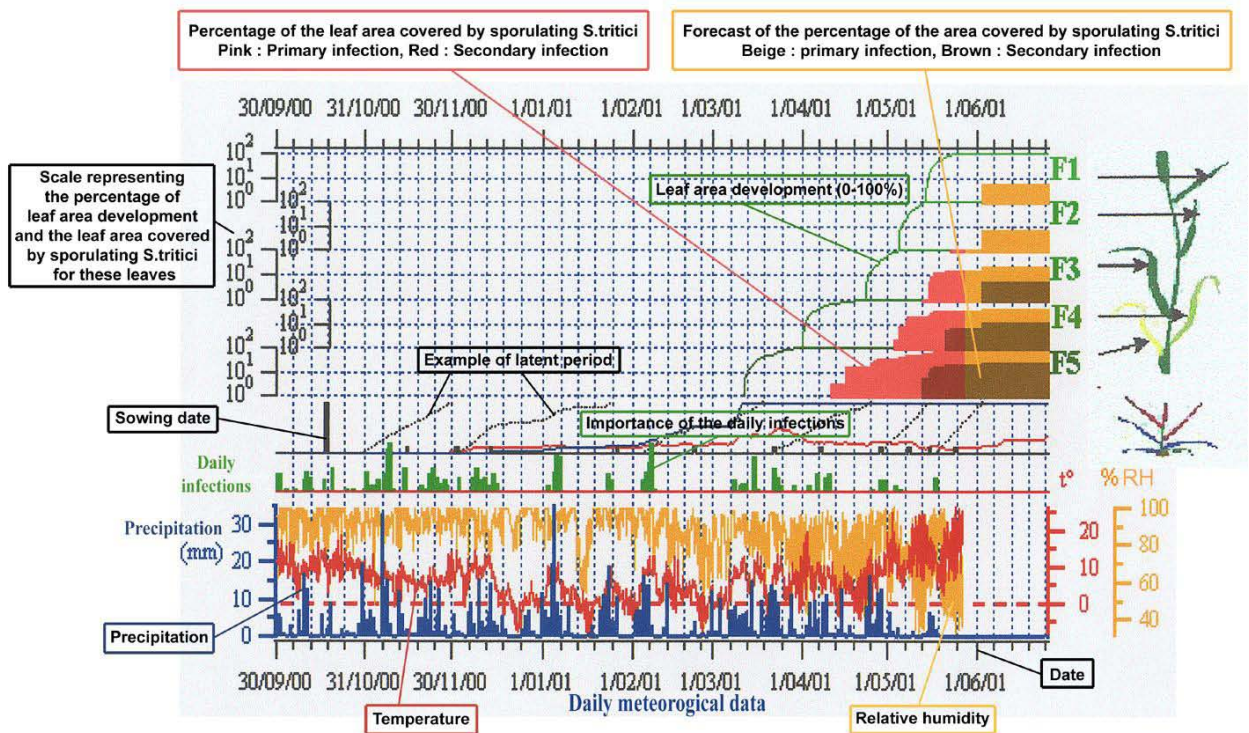
Overestimation or underestimation of the risk could often be traced back to differences in rain events captured by the tipping-bucket rain gauges at the weather station compared with the rainfall to which a particular field was actually exposed. Rainfall data could be interpolated between weather stations but precipitation between fields is characterized by high spatial and temporal variability, making the interpolation unreliable.

- It is recommended for a good implementation of the system in Armenia:
 - To check first the reliability of the information provided by the software under Armenian field practical conditions: the software was validated in West Europe and has to be checked, in particular the length of the latency period. That can be done by observing the appearance of the symptoms after the detection of a potential infection by the software: the period between this detection and the potential fructification also detected by the software has to coincide with the symptoms appearance in the fields. This work must be carried out through a close collaboration between Hydromet and the Extension Services of MoA and/or with the help of scientists of Agricultural Universities.
 - Armstatehydromet is the right Institution to take responsibility for the weather data collection and their analysis through the software. The results of this analysis, in other words the graph which shows when the potential infection, latence for each disease (septoria leaf blotch, leaf rust, stripe rust, fusarium head blight), can be put on

the specific webpage of Hydromet for its visualisation by the MoA extension agents. The fungicide application decision will be the MoA extension agents' responsibility since they are closer to the fields practical situations. But, as they have to combine the information delivered by the software with fields observations in order to take the final decision, it will take some time for a good control of all the system. The best is to practice and to check a posteriori if the decisions have been the right ones or if anything can be improved. That means that some tests are needed before applying the system in a practical way (advices to growers).

- For a good implementation of the system it is proposed that another visit (preferentially in May) is organized to help Armstatehydromet test the different models and to define the optimum time of treatment.
- Hydromet staff is welcome to keep in touch with the University of Liège if additional recommendations or advices are needed.

Example of inputs and outputs of Septoria leaf blotch risk assessment model PROCULTURE in winter wheat fields.



Report on the training session and its results are provided in Annex 2.



FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Terms of Reference for Consultant/PSA

Job	
Title	International Consultant (Utilization of agromet data to predict wheat diseases)
Division/Department	
Programme/Project G C P	/GLO/275/EC
Location	ARMSTATEHYDROMET and Ministry of Agriculture, Yerevan, Armenia
12 working days (WAE): 2 days	
Expected Start	Duration Before the mission, 7 days of mission to Armenia and 3 days for reporting)
	30 March 2012
Date of Assignment	
Reports Name:	Title: Programme Coordinator
	Francoise Trine

GENERAL DESCRIPTION OF TASK(S) AND OBJECTIVES TO BE ACHIEVED

The objective of the consultancy is to develop capacity of Armstatehydromet and Ministry of Agriculture in predicting and preventing the main wheat crop diseases. The Consultant will work under the general supervision of the Programme Coordinator. He/she will work in close consultation with government institutions and the Country Coordinator.

The consultant will conduct three day training, including field work, for about 20 national staff. The training will focus on four main points:

1. Prediction of diseases in wheat crop based on the monitoring of climatic conditions. The consultant will:
 - present the cycles for main wheat diseases and explain the relations between the weather parameters and the development of the diseases;
 - explain how to predict the occurrence of the diseases by monitoring and analyzing the weather parameters (temperature, relative humidity, rainfall), using a model which has been developed in Belgium and Luxemburg;
 - train the participants in using specific software.
2. Prevention of wheat crop diseases which are caused by climatic conditions. The consultant will:
 - Present the main active substances commonly used against the development of wheat diseases: type, mode of action, application
3. Recognition of main wheat diseases. The consultant will:
 - present the main wheat diseases: recognition, pathogen involved, epidemiology, methods to eliminate them

Training results:

- Trainees are knowledgeable about the methods to predict and prevent the occurrence of diseases triggered by climatic conditions;

KEY PERFORMANCE INDICATORS

A/ All PowerPoint presentations and guidelines to use the prediction software sent for translation in Armenian as soon as possible

B/ Mission report summarizing the achievements, the problems met and the results (maximum 10 pages + annexes if needed).

C/ Inputs to the website posting (under the responsibility of the Country Coordinator)

Required Completion Date: April 27th

REQUIRED COMPETENCIES

- Agricultural meteorologist with at least five years experience prediction and prevention of crop diseases using meteorological data
- Previous experience in delivering training
- Excellent oral presentation skills
- Excellent writing, editing, and oral communication skills in English
- Previous experience in countries in transition is an asset

Technical Competencies and Experience Requirements



EC/FAO Programme on Information Systems to Improve Food Security Decision-Making in the European Neighbourhood Policy (ENP) East Area

Training on introduction of Wheat Disease Forecast and Prevention to improve crop-forecasting system in Armenia

ARMSTATEHYDROMET Service, Yerevan, Armenia
3 - 6 April 2012

- REPORT -

8. Background

A four day training was jointly organized by the ARMSTATEHYDROMET (hereinafter: Hydromet), MoA and FAO under the “*EC/FAO Programme on Information Systems to Improve Food Security Decision-Making in the European Neighbourhood Policy (ENP) East Area*” from 3 - 6 April 2012. The Programme is financed by the European Commission and implemented by FAO. The Programme aims at improving food security by enhancing the national capacity to generate, analyse, communicate and mainstream more relevant and reliable information into policies and programmes. The training took place at Hydromet.

9. Training objective

The objective of the training was to develop capacity of Hydromet and Ministry of Agriculture in predicting and preventing winter wheat crop diseases. Besides, Head of Hydrometereological Operational Centre introduced the latest developments in crop forecasting and agrometereological data to the representatives of Agricultural Support Marz centres.

The training provided both theoretical and practical knowledge and skills in winter wheat diseases identification and prevention. The knowledge and skills acquired will be immediately applied for the improvement of crop forecasting system and will be incorporated in Agromet Bulletin as winter wheat was identified by the Crop Forecasting Working Group as one of the three crops for real forecast. The training was conducted by Moussa El Jarroudi, University of Liege, Belgium (ULg).

10. Participation

The training was attended by 22 participants from Hydromet and MoA.

The training was organised for the stakeholders of the Programme concerned with crop forecasting, including mainly staff from Hydromet (Agrometeorological and Climatology Units, 8), Ministry of Agriculture (Plant Protection Centre, 1 participant; Agricultural Support Marz Centres, 13 participants). The training was also attended by 2 members of the Crop Forecasting Working Group. The objective of the Crop Forecasting Working group is to improve crop forecasting system in Armenia by providing decision-makers with reliable agrometeorological information.

The list of participants is provided in Appendix 1a.

Training sessions and group picture



11. Process

Introductory speeches

The participants were welcomed by Zara Petrosyan, Head of Hydrometeorological Operational Centre. Zara Petrosyan noted that improvement of crop forecasting system in Armenia requires new approaches and application of new technologies. The new experience for different components of crop forecasting is being actively introduced to different levels of national institutions by involving different structures.

The training itself was very practical. A total of 5 presentations were delivered by the international consultant. All of them were translated into Armenian before the training and distributed to each participant on CDs along with the certificates.

Main topics of the training were:

- “A computer based Decision Support System Septoria leaf blotch Control in wheat: Its development and Implementation in Belgium and Grand-Duchy of Luxembourg”
- “The Late Blight Cycle and relations to the weather parameters
- “Assessment of the night weather parameters and their use in forecasting models of Leaf rust”
- “Distrain: A computer program for training people to estimate disease severity on cereal leaves”
- “Site-Specific Monitoring for Disease forecasting in winter wheat”
- “The simulation model in winter wheat”
- “Occurrence and distribution of the mycotoxin producing Fusarium species isolated from winter wheat in the Grand-Duchy of Luxembourg”
- “Spatial heterogeneity of leaf wetness duration in winter wheat canopy and its influence on plant disease epidemiology”
- “Modelling plant diseases impact with the Belgian crop growth monitoring System”

In particular:

The main topic was to train the participants in the management of the winter wheat diseases with a specific focus on the Septoria leaf blotch (SLB) (*Septoria tritici*). SLB is an important disease in many parts of the world, including Armenia. It can cause considerable yield reduction if the flag and second leaves are severely affected before the grain-filling stage. The development of SLB in fields can be forecasted using software such as PROCULTURE that is based on the analysis of weather parameters (relative humidity, temperature, rainfall). The model considers infection to have occurred when, during a 2-h rainfall event, precipitation for the first hour is at least 0.1 mm, allowing the swelling of pycnidia, followed by a second hour with at least 0.5 mm of precipitation, leading to the release and splash dispersal of the conidia. In addition, after rainfall, relative humidity should be higher than 60% during the following 16 h and the temperature should remain above 4 °C for 24 °C for germination and infection.

To reach the aim of the training, different Power Point presentations were delivered to the participants:

A Computer-based Decision Support System for Septoria leaf blotch Control in Wheat: It is developed and applied in Belgium and Grand-Duche of Luxemburg.

“A computer based Decision Support System Septoria leaf blotch Control in wheat:

The model PROCULTURE has been developed to simulate the progress of the septoria leaf blotch disease on winter wheat during the cropping season. This model has been developed in order to guide field observations on different leaf layers and to find the optimum time of fungicide spray in fields. The model provides information which explains disease progression on the upper leaves. The relationship between disease control by fungicides and yield reduction varies from site-to-site and from season-to-season. A weekly PROCULTURE recalibration is routinely done using actual disease levels observed on site. On average, no spray of fungicides or only one application is required to efficiently control the septoria leaf blotch disease. The PROCULTURE forecasts have been validated to be correct in about 85% of all cases.

The treatment defined with the simulation model over 2003 to 2009 was recognized as the most effective one compared to the other treatments and resulted in increase of grain yield (by 80%). At Reuler (North of Luxembourg), over 2003 to 2009, treatments based on the Septoria risk simulation model were recommended only in 2007. The climatic conditions of this site tend to favour organic farming in this region where the evolution of the foliar disease is very weak.

“Assessment of the night weather parameters and their use in forecasting models of leaf rust”

The model was elaborated by the analysis of the night weather and leaf rust incidence. Statistical validation using regression analysis reports a strong correlation between the number of hours with specific meteorological conditions and the percentage leaf area covered by brown rust lesions for the two upper and youngest leaves, which are mostly responsible for photosynthesis activity and assimilates production filling the grains. In the past, the cereal disease management strategies were oriented towards the control of predominant and yield reducing diseases such as that caused by *Septoria tritici*.

The succession of mild winters and warm springs over the last 5 years allowed the early occurrence and the fast development of the brown wheat leaf rust in the Grand-Duche of Luxembourg and Belgium; it is advisable to take this disease into account in fungicide application schemes. What about Armenia? Discussions with participants showed that leaf rust is a very popular disease in Armenia. This model could be a good platform for the simulation of leaf rust in this country.

“Distrain: A computer program for training people to estimate disease severity on cereal leaves”

The most common method for estimating disease severity is to compare the infected plant tissue to standards diagrams on which the diseases lesions are arrayed. The Distrain program was developed to train people to estimate disease severity on leaf. The program mimics eight common diseases of small grains: leaf rust, powdery mildew, septoria blotch, scald, spot blotch, net blotch, stripe rust, and stem rust. The estimate data entered by the user is compared to the actual “diseased” displayed on the computer monitor. By using the Distrain program, an inexperienced person could be trained to estimate disease severity and also could develop confidence because the program provides immediate evaluation.

“Site-Specific Monitoring for Disease forecasting in winter wheat”

This session provided more precise details on the assessment and the use of weather parameters in disease forecasting model in order to teach participants the management tools for each disease and the method of simulation. The overall components of the life cycle of fungal diseases (i.e. Stripe rust, powdery mildew, fusarium head blight,) affecting winter wheat and depending on weather parameters for their development, were presented.

“The simulation model in winter wheat”

This presentation was delivered in order to perform a preliminary analysis of winter wheat disease forecasting. Different diseases models were presented. A case study of diseases forecasting based on weather data from Luxembourg and Armenia was developed. A first comparison of data of the 2002-2003 crop season showed that temperature, relative humidity and rainfall data were close to some sites studied in Luxemburg for this crop season. In Artashat for example, the number of days with the winter negative temperature in 2002-2003 was higher than that of Luxembourg sites. Rust (brown, yellow and stem) are very important in Armenia. Conditions of temperature and humidity are very favorable. We tested our models and it works very well. The originality of our model is based on the analysis of the night weather and leaf rust incidence.

“Occurrence and distribution of the mycotoxin producing Fusarium species isolated from winter wheat in the Grand-Duchy of Luxembourg”

Participants requested a lot of information about Fusarium species and their mycotoxins affecting yield quality. This presentation was given in order to answer those questions. The high occurrence of Fusarium Head Blight (FHB) on wheat is likely to be associated with the comparatively mild winter (1.9 °C above average 2000-2007) and abundant rainfall during the flowering period. It is very important to determine the species of FHB that dominate. Maize was recognized as the previous crop which favoured a high occurrence of FHB (significant higher prevalence of FHB as opposed to other crops). Among the different species of FHB, only some of them produce mycotoxin, affecting the quality of grains. These are: *Fusarium graminearum*, *F. culmorum*, *F. poae* and *F. avenaceum*. *Microdochium nivale* are described as a non-typical Fusarium mycotoxin producer. The distribution of the Fusarium species varied strongly from location to location.

“Spatial heterogeneity of leaf wetness duration in winter wheat canopy and its influence on plant disease epidemiology”

The leaf wetness duration (LWD) is one of the most important factors influencing the occurrence of plant disease epidemiology. This session was devoted to the introduction of the methodology for measuring this parameter and informations on how LWD is distributed on wheat leaves according to the distance from a hedge. This presentation was based on a case study at Luxembourg. The diversity of meteorological situations in this country favours the occurrence of very local microclimate conditions that may initiate disease in specific

locations of the plot and not in other.

A good knowledge of the distribution of this meteorological parameter could be useful in the pest and diseases management of other crops such potatoes, fruit trees.

“Modelling plant diseases impact with the Belgian crop growth monitoring system” This presentation came in more precise details to the integration of fungal diseases in a crop yield forecasting system. The example of the Belgian crop yield forecasting system and the relevant documentation (El Jarroudi et al., Eur. J. Agron. 2012) were presented and discussed.

“Projections of Video Clips on Fungal diseases of cereals”

Since the training was organised at the early stage of the crop season, thus only one field observation was carried out. These illustrations will illustrate to the participants material studied in textbooks by giving them a vivid visual demonstration of structures and functions. The interactions between fungi and plants come alive via the artistry of these clips. A copy of the compact disc with all presentations was distributed to each participant at the end of the session.

Exercises on the prediction of Septoria leaf blotch, rusts and Fusarium head blight using the PROCULTURE, the Septroui, and the FUSAR software, respectively

These exercises provide more precise details (due to the participants' request) on the simulation of wheat diseases infection models, with a specific focus on four main fungal diseases: septoria leaf blotch, Fusarium head blight, leaf rust and yellow rust.

The training was deliberately practical because the participants were, for the majority of them, wheat field specialists with a very good knowledge of the winter wheat crop.

Hydromet staff was particularly satisfied with receiving the software which can help them achieve their objectives, in particular the forecasting of late blight appearance in the fields for a better control.

7. Conclusions and recommendations

The training was successful in meeting its objectives. At the end of the training:

- Trainees are knowledgeable about the methods to predict and prevent the occurrence of diseases triggered by climatic conditions.
- Trainees are able to understand the life cycle of most fungal diseases and the relation between the weather parameters and the development of the diseases.
- Trainees are able to use the PROCULTURE Model in order to estimate the development of the five youngest wheat leaves, as well as the Septoria tritici inoculum available to infect those leaves. The software was tested with the Hydromet staff and with the MoA Extension Services agents who now know how to run the software with Armenian agrometeorological data.
- Trainees are able to handle wheat disease infection forecasting such as Septor, Septroui and FUSAR.
- Trainees are able to predict the daily infections of the main fungal diseases.

The discussions during this training once more demonstrated that there is strong interest from the national institutions in improving crop forecasting in Armenia. The training was successful in gathering both users and producers of information. It is worthwhile noting that the Ministry of Agriculture (MoA) is both producer of information (providing operational data) and

direct user of agromet information for policy-making. The agrometeorological data is provided every 10 days to Agricultural Support Marz centres. There was excellent collaboration between the institutions involved in crop forecasting, in particular Hydromet and MoA. Participants have acknowledged that for the last year due to the Programme the collaboration between MoA and Hydromet have been strengthened. The training clearly demonstrates that this collaboration is indispensable for improving crop forecasting and will need to be institutionalized for sustainable results.

Participants were distributed hard copies of Armenian version of the Food Security and Agriculture Highlights (October – December 2011). The training was concluded with distribution of certificates of participation and workshop materials in electronic format.

The training agenda is provided in Appendix 2a.

13. Evaluation of the training

Participants were asked to assess the relevance and effectiveness of the training at the end of the training. The evaluation forms and the results of the surveys are presented in **Annex 3**. Participants were distributed hard copies of Armenian version of the Food Security and Agriculture Highlights (October – December 2011).

Appendix 1a. List of participants for wheat disease training (Hydromet, MoA, and Agricultural Marz Support centres)

1. L. Grigoryan Agrometeorological forecast Unit, Head armstate@meteo.am
2. N. Arakelyan Agrometeorological forecast Unit, First category specialist armstate@meteo.am, nelliarakel@gmail.com
3. A. Sahakayn Agrometeorological forecast Unit, Leading specialist armstate@meteo.am
4. R. Ghmboyan Agrometeorological forecast Unit, Second category specialist armstate@meteo.am
5. S. Shindyan Climate survey Unit, Leading specialist armstate@meteo.am
6. L. Simonyan Agrometeorological Survey Unit, Head armstate@meteo.am
7. V. Badalyan Agrometeorological Survey Unit, Chief specialist, armstate@meteo.am
8. M. Mkhitaryan Agrometeorological Survey Unit, Leading specialist armstate@meteo.am
9. A. Grigoryan MoA, Plant Protection Centre, Chief Researcher

13 representatives from Agriculture support Marz centres (7 Marzes)

Note: Preference was given to those Marzes where wheat is one of the main crops (based on MoA Deputy Minister's letter No. AP/05.2/1509-12 from March 23, 2012)

	Name	Institution	Passport details	E-
1	Armenak Melkonyan	Agriculture support Marz centre (Aragatsotn)	AB 0645308/029	aggamk@rambler.ru
2	Sos Haroyan	Agriculture support Marz centre (Aragatsotn)	AE 0563084/054	aggamk@rambler.ru
3	Leva Aleksanyan	Agriculture support Marz centre (Armarvir)	AC 03563135/054	armavir-gamk@inbox.ru
4	Tigran Skhoyan	Agriculture support Marz centre (Gegharkounik)	AE 0312860/040	metaksik@rambler.ru
5	Rafik Aleksanyan	Agriculture support Marz centre (Gegharkounik)	AG 0649663/043	metaksik@rambler.ru
6	Arman Dilbaryan	Agriculture support Marz centre (Lori)	AC 0619438/052	lgamk@mail.ru
7	Fahrad Manoukyan	Agriculture support Marz centre (Lori)	AM 0423283/052	lgamk@mail.ru
8	Gnel Avetisyan	Agriculture support Marz centre (Kotayk)	AF 06628885/019	kotaykgamk@rambler.ru
9	Khachik Hovhanisyan	Agriculture support Marz centre (Kotayk)	AC 06038786/049	kotaykgamk@rambler.ru
10	Jivan Aslanyan	Agriculture support Marz centre (Shirak)	AM 0428484/028	shasc@rambler.ru
11	Vaspurakan Melikyan	Agriculture support Marz centre (Shirak)	AF 0316543/030	90habet90@mail.ru
12	Artashes Manvelyan	Agriculture support Marz centre (Sjunik)	AF 0561439/032	sugamk2003@yahoo.com
13	Armik Bakunts	Agriculture support Marz centre (Sjunik)	AM 0481198/032	sugamk2003@yahoo.com

Appendix 2a. Training agenda

EC/FAO Food Security Information Systems to improve decision-making TRAINING TOPIC: Winter Wheat Disease Forecast and Prevention

Instructor: Moussa El Jarroudi

E-mail: meljarroudi@ulg.ac.be

Training objective

The objective of the consultancy is to develop capacity of Armstatehydromet and Ministry of Agriculture in predicting and preventing winter wheat crop diseases.

Target group

8 staff of Hydromet and 14 staff of Ministry of Agriculture (centralized and decentralized levels).

The candidates for participation to the training were provided by Hydromet and MoA.

Venue and resources

Training took place in ARMSTATEHYDROMET Service. The room was furnished with tables, 2 computers and overhead projector. All this was provided by ARMSTATEHYDROMET Service **free of charge**. Some other technical stuff, e.g. stationery, CDs with the presentations of the training, certificates was provided by the Programme.

Training outline

Session 1 (April 3): The main fungal disease affecting winter wheat.

For the main fungal diseases affecting winter wheat to provide information on symptoms, Causal organism, epidemiology and control tools. A Computer-based Decision Support System for Septoria leaf blotch Control in Wheat: Its development and Implementation in Belgium and Grand-Duchy of Luxemburg.

Session 2, 3 (April 4):

- **Distrain: A computer program for training people to estimate disease severity on cereal leaves.**

The most common method of estimating disease severity is to compare the diseased plant tissue to standards diagrams on which the silhouettes of diseases lesions are arrayed. Distrain program was developed to train people to estimate disease severity. The program mimics eight common diseases of small grains: leaf rust, powdery mildew, septoria blotch, scald, spot blotch, net blotch, stripe rust, and stem rust. The estimate entered by the user is compared to the actual "diseased" displayed on the computer monitor. By using the distrain program, an inexperienced person could be trained to estimate disease severity and also could develop confidence because the program provides immediate evaluation.

- **Assessment of the night weather parameters and their use in forecasting models of Leaf Rust.**

The model was elaborated by the analysis of the night weather and leaf rust incidence. Statistical validation using regression analysis reports a strong correlation between the number of hours with specific meteorological conditions and the percentage leaf area covered by brown rust lesions for the two upper and youngest leaves, which are mostly responsible for photosynthesis activity and assimilates production filling the grains. In the past, the cereal disease management strategies were oriented towards the control of predominant and yield reducing diseases such as that caused by *Septoria tritici*. Because the succession of mild winters and warm springs over the last 5 years allowed the early occurrence and the fast development of the brown wheat leaf rust in

the Grand-Duchy of Luxembourg and Bulgaria, it is advisable to take this disease into Account in fungicide application schemes what's about Armenia?

Session 4, 5 (April 5):

Site-Specific Monitoring For Diseases Forecasting in Winter Wheat

The typology of the main fungal diseases affecting winter wheat is very important when we decide to apply fungicide. It also important step for the spatial risk of diseases which could include the regional effect of each disease.

The simulation of septoria tritici in winter wheat. Introduction on the software: contents, how it runs, practical exercises on the usage of the system.

Session 6 (April 6)

The simulation Model in winter wheat. practical exercises on the usage of the system by using meteorological station.

Support for the future an interactive decision-support system in winter wheat in Armenia

In the conditions of the Republic of Armenia, taking into account the economic blockade of the country, cereal crops (wheat, barley, emmer wheat) are of strategic significance as the prior source of food security. At present they occupy a major part of the areas sown by agricultural crops. Winter wheat is the most widespread cereal crop, as it ensures more sustainable and higher yields comparing to other cereal crops (spring wheat, winter and spring barley, emmer wheat) <http://www.fao.org/docrep/013/i1500e/Armenia.pdf>.

A winter wheat field visit was made on 03 April 2012 (Figure 1a). During the mission, the necessity to develop in Armenia an interactive field-specific, decision-support system based on the mechanistic modelling of the development of the last five leaf layers of the crop and of SLB development on these layers was observed.



Figure 1a. Winter wheat field 40 km from Yerevan, Ararat Marz

The mission visited also automatic meteorological station (Figure 2a). Meteorological data are crucial for crop monitoring. There are 3 automatic stations for the whole country. Having seen the number of fields, their structure related to topography levels and if potato crop and fruit trees are included, it is important to at least increase the number of rain gauges.



Figure 2a. Automatic weather station Ararat

Further activities to improve crop forecasting system and to strengthen data distribution:

- Training on prevention of fruit trees diseases
- Publication of 1st updated Agromet Bulletin, including agricultural conditions for crops
- Trial on first real crop forecasting

Appendix 3. Evaluation results

Evaluation Form

At the end of the training a survey was carried out among the participants to find out their opinion about the training to develop the capacity of Armstatehydromet and Ministry of Agriculture on predicting and preventing winter wheat diseases. A questionnaire has been developed for this survey which is shown here below.

Training Programme on Wheat (April 3 to 6, 2012)

1. What is, according to you, the level of concordance between the training programme and the objective which is to develop the capacity of Armstatehydromet and Ministry of Agriculture on forecast and prevention of winter wheat diseases?

Overall

excellent very good good middle bad

In particular

The software Distrain

excellent very good good middle bad

The main fungal diseases

excellent very good good middle bad

The Cycle for main wheat diseases and relations to the weather parameters

excellent very good good middle bad

The Proculture Model

excellent very good good middle bad

Wheat rust simulation

excellent very good good middle bad

Site specific simulation

excellent very good good middle bad

Give your comments:

.....

2. Do you estimate that your training will be beneficial to the activities of your Service or Institution?

yes no

3. Estimate how this training programme will serve in your activities in your country?

.....

.....

4. Evaluate the level of this training according to your own instruction level and your experience.

appropriate level too high level too low

If the level did not suit you, give explanations:

.....

5. Do you estimate that the length of your training was sufficient?

yes no

If no, what is according to you, the length that is the more suitable?

.....

6. How was the training programme organization?

excellent very good good medocre bad

Comments:

.....

7. Please indicate any comments that appear important and relevant on any non-didactical

aspects that was not mentioned above.

.....
.....

8. Do you have some recommendation for FAO and EC for the improvement of such kind of training session?

.....
.....

9. Estimate the quality of translation during the training

excellent very good good mediocre bad

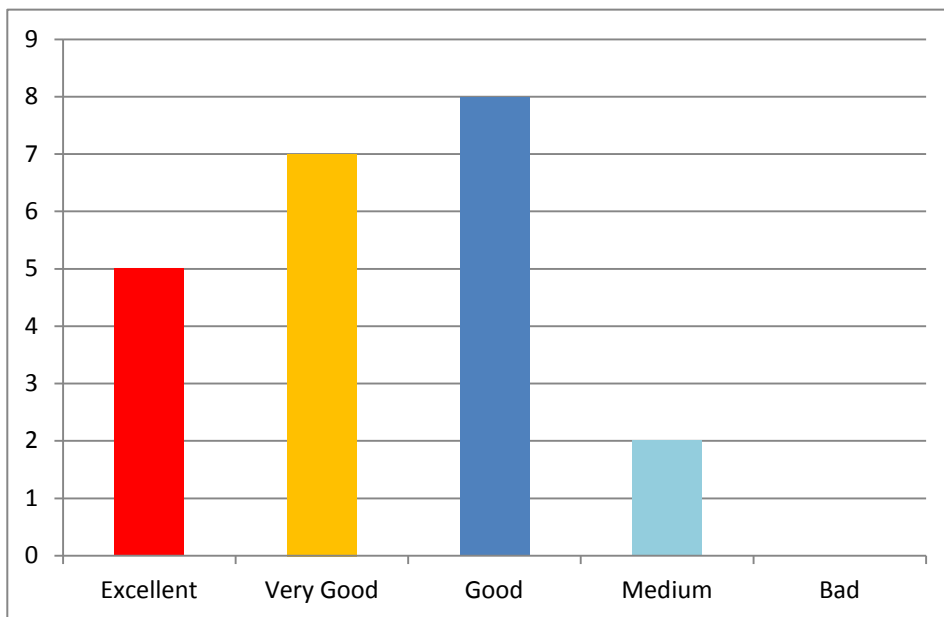
Comments:

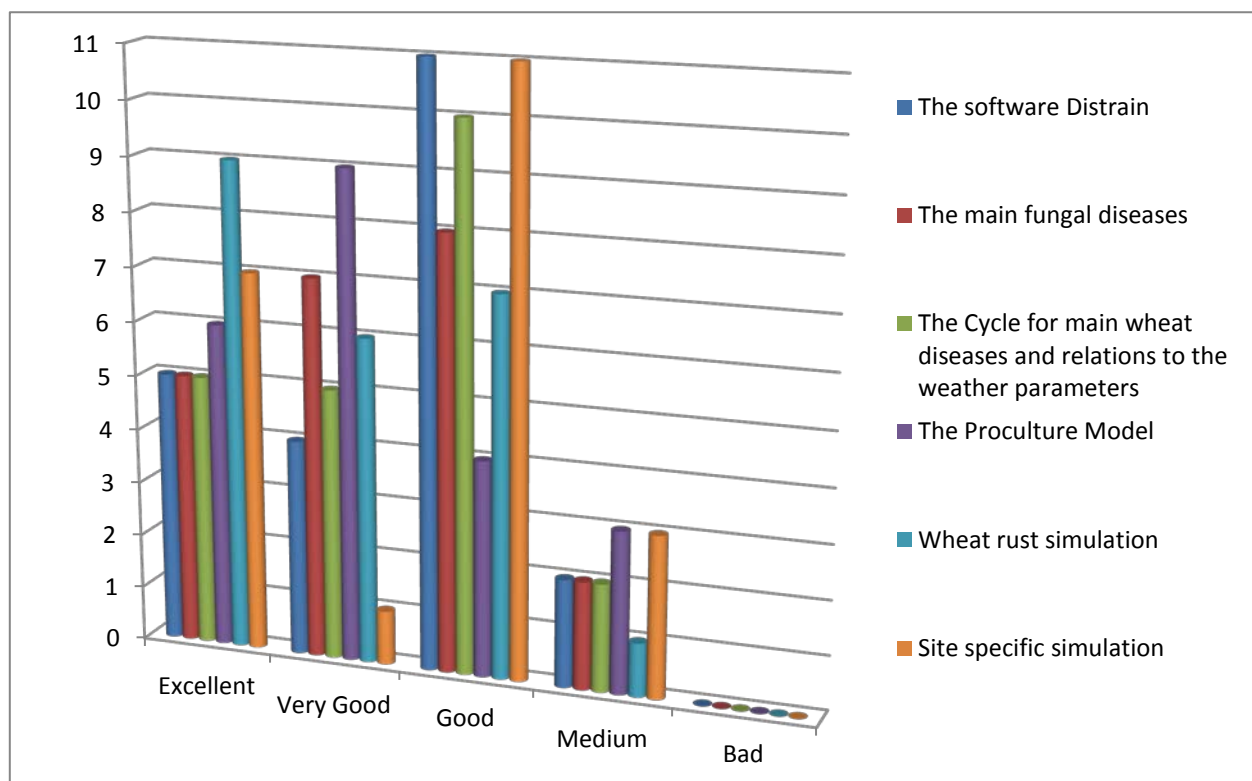
Date:

Survey Results

The survey questionnaire was filled out by 22 participants of the workshop. The results of the survey based on the answers of these respondents are presented below.

The participants were asked to evaluate the overall training, as well as its each separate component, and to provide comments/feedback.





Level of concordance to the objective of developing the capacity of Armstatehydromet and Ministry of Agriculture on predicting and preventing winter wheat diseases

More than half of the respondents (12) acknowledged that the training overall corresponded excellently or very well to the objective of developing winter wheat diseases forecast and prevention capacity. At the same time eight respondents indicated a good level of correspondence, and two respondents considered it medium.

The training component “Wheat rust simulation” fared the best with 9 “Excellent” and just a single “Medium” evaluations. Of the 22 surveyed participants, between 5 and 9 respondents (23-40%) evaluated the various parts of the training as “Excellent”. No respondents evaluated any of the components as “Bad”, with the lowest evaluation being “Medium” given to every training component by at least one and maximum three participants. The most popular answer in appraising the level of concordance for the various parts of the training was “Good”, which constituted total 51 answers by number of respondents varying between 4 and 11. The results of evaluation for the level of concordance to the programme objectives are presented in the graphs above.

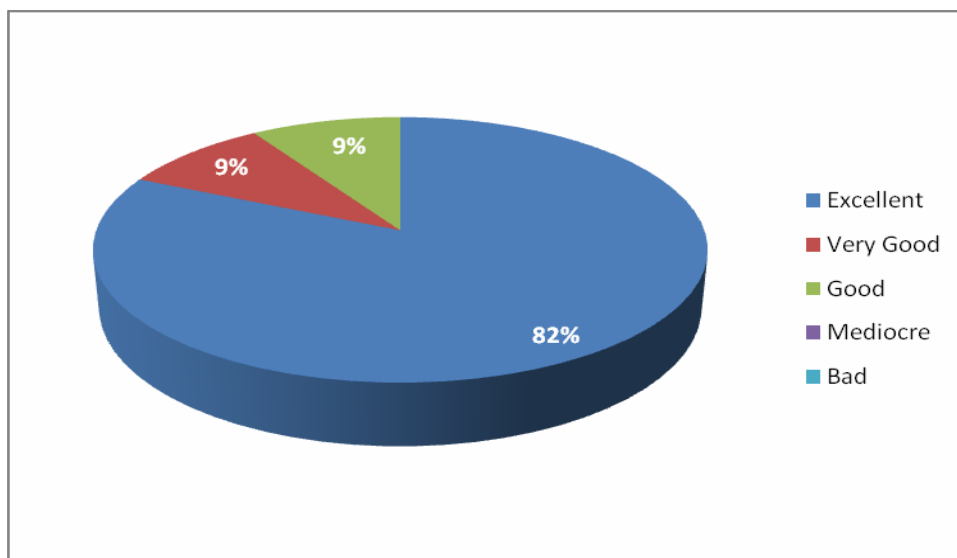
It has to be noted that most comments/feedbacks provided by the participants with regards to correspondence between the training and programme objectives were positive and encouraging, exemplified by the following phrases:

“The presented methods/programme was novelty”; “Such trainings need to be organized more frequently”; “Promising”; etc.

There were also some other comments, such as: “Adopting the training to the local needs would bring better results” and “Could have been done better”.

It is quite important that one hundred percent of the respondents gave an affirmative answer to the question whether the training was beneficial to the activities of their Service or Institution. Similarly, every single participant thought that the length of the training was adequate.

The respondents were not as unanimous in evaluating the level of the training according to their own instruction level and experience. One participant indicated that it was too easy and another thought it was too difficult, whereas the rest (i.e. 20 respondents or 91%) considered it appropriate.



Organization of the training

It has to be noted that the organizational aspect of the training program was appraised very positively. As shown in the figure above, not a single respondent appraised it as mediocre or bad, whereas 82% of respondents thought it was excellent. This shows a continuous and significant progress in this aspect of the trainings, as the organization of every next workshop achieved higher evaluation results in the eyes of the participants compared to the previous one (“Excellent” assessment constituted 50% for Crop Yield Forecasting and 76% for Winter Diseases Forecast and Prevention)

The high professionalism in translating the materials and interpreting between the trainer and participants was especially noted by the respondents. 18 out of the 22 respondents rated it “excellent”, 3 as “very good” and only one as “good”.

As the survey included some open-ended questions to enable the participants express their own opinions, it is worth mentioning some of the most frequent and interesting thoughts:

1. In future it would be good to do training in field conditions / in Marzes / at extension services in Marzes and focus on locally widespread cultures/...at least one session.
2. It is desirable to have trainings on prevention of adverse effects of chemicals.
3. There was no much talk about actual disease combating. It would be better if we were given advice on how to control each of the diseases.
4. I believe that when considering wheat, the overall behavior of the plant should be studied, and not just the plant leaves.
5. I will use the knowledge gained during the workshop in consulting the farmers.
6. Training could be organized abroad so that we see on the spot the methods and actual work on disease control.
7. It would be beneficial to organize this type of trainings also for grapes and fruits / vegetables / other crops.