Agrometeorological Crop forecasting proposal for Moldova

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Content

• Operational Crop yield forecasting techniques
• Present status of the Crop Yield Forecast in Moldova
• Potential improvements
  – Products improvements
  – Communication and dissemination improvements
• Conclusions
Operational crop yield forecasting techniques
Objectives of crop production and crop yield forecasting systems

- Pricing
- Market stability
- Food security
- Control of supply

} data in real time!

<table>
<thead>
<tr>
<th>Common wheat Barley Durum Maize Rye Sorghum Oats Triticale Others</th>
<th>(Mio t)</th>
<th>EUR 15</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Beginning stocks (01.07.2002)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market</td>
<td>12.7</td>
<td>7.3</td>
</tr>
<tr>
<td>Intervention</td>
<td>0.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Total</td>
<td>13.2</td>
<td>9.8</td>
</tr>
<tr>
<td><strong>Usable production</strong></td>
<td>93.9</td>
<td>47.7</td>
</tr>
<tr>
<td>Import</td>
<td>6.2</td>
<td>0.1</td>
</tr>
<tr>
<td><strong>TOTAL AVAILABILITIES</strong></td>
<td>113.2</td>
<td>57.6</td>
</tr>
<tr>
<td><strong>USE</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Human</td>
<td>33.0</td>
<td>0.0</td>
</tr>
<tr>
<td>- Seed</td>
<td>2.9</td>
<td>2.0</td>
</tr>
<tr>
<td>- Industrial</td>
<td>6.3</td>
<td>7.4</td>
</tr>
<tr>
<td>- Ultra peripheral islands</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>- Animal feed</td>
<td>41.6</td>
<td>31.8</td>
</tr>
<tr>
<td><strong>TOTAL USE</strong></td>
<td>84.1</td>
<td>41.4</td>
</tr>
<tr>
<td>Solde disponible</td>
<td>29.2</td>
<td>16.2</td>
</tr>
<tr>
<td>Export (1)</td>
<td>16.5</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>End stocks (30.06.2003)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market</td>
<td>12.7</td>
<td>6.7</td>
</tr>
<tr>
<td>Intervention</td>
<td>0.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Total</td>
<td>12.7</td>
<td>7.2</td>
</tr>
<tr>
<td>Change in stocks</td>
<td>-0.5</td>
<td>-2.6</td>
</tr>
<tr>
<td>Change in public stocks</td>
<td>-0.5</td>
<td>-2.0</td>
</tr>
</tbody>
</table>

(1) Grains equivalent. * Maize includes 1.8 mio. t processed products and animal feed

## Maximum W T O: 2002/2003

<table>
<thead>
<tr>
<th>Wheat incl. durum</th>
<th>14.438 mio t +0,5 mio t food aid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse grains</td>
<td>10.8432 mio t.(inclu. 0,4 mio t potato starch)</td>
</tr>
</tbody>
</table>

## ESTIMATED EXPORT QUANTITIES 2002/2003

<table>
<thead>
<tr>
<th>Wheat incl. durum</th>
<th>17.40 mio t (food aid included and refund-free)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse grains</td>
<td>13.50 mio t (inclu 1.8 mio t maize products, but excl. 0,4 mio t potato starch)</td>
</tr>
</tbody>
</table>
Basic relation

Production = Yield X Area
Yield assessment
Yield variability in cereals

Gommes, FAO, 2003
Yield factors of variability

In Gommes, FAO, 2003
Crop monitoring & Yield forecasting: General Flowchart

Estimates for each YEAR x REGION x CROP on:

- Yield = $f_{cal}(4 \text{ types of Indicators})$
  - Trend, Meteorology, Crop growth model, Remote Sensing
- Production = Yield x Area
Agricultural statistics

Yield district (Region)

NDVI or other gridded data

Water balance at station level

ETA /grid
Updated general methodology

**INPUTS**
- ETP
- Actual rainfall
- Spot-VEGETATION
- NOAA GAC
- Temperature, RR, RH,…
- Other: Fertilizer costs,…

**AGROMET SHELL** (AMS)

**METEO**

**Explanatory Variables**
- Initial Water Holding Content
- Soil Water Satisfaction Index
- Water excess, deficit
- Actual ETA
- …
- Starting date
- NDVI max
- Time peak
- …
- NDVI
- Cumulated actual rainfall
- Trend

**CROP YIELD DATA**
- Historical crop yield data at departmental level
- …

**OUTPUT**
- Yield prediction model at departmental level
- Yield aggregation at national level
- Yield prediction model at national level

**S T A T I S T I C A**

**M A T L A B**
Yield and forthcoming weather...
Present status of the Crop Yield Forecasting in Moldova
Information provided by Hydromet
• Field observations
• Meteorological data (3-hourly data and hourly data)
• Phenological data (every 2 days)
• Dekadal Soil moisture content in all agromet stations and posts (37)
• Dense agromet observation network (37 stations)

Crop yield forecasting for major crops
• Winter wheat, Corn, Sugar Beet, Sunflower
• Based on agromet models developed 20 years ago (input data = temperature, rainfall, development stage, crop status after winter)

No plant disease forecasting by Hydromet:
• Meteo data sent to the Plant Protection Dept of MAFI
• Information provided by Ministry of Agriculture and Food Industry (MAFI)
  – Done by Agriculture Regional Centers
    • February : post winter evaluation
    • June : Number of ears/m², grains/ear,…
  – Crop Yield Forecast based on expertise inside MAFI. Data provided by USDA…
Dissemination of Agrometeorological Data and Information

By mail or email to
- MAFI, Prime minister office, …
- Private companies

By Website, open information available
- In 2011, 7 messages: 2 for wheat yield, 1 for Sunflower yield, 1 for maize yield, 1 for soil moisture content, 1 for situation after winter for cereals and 1 for fruit trees and vineyards after winter time.

By Radio and TV Channels
Potential improvements
Products improvements

1. Use a second Crop Yield Forecasting system:
   - Adopt the Crop Yield Forecasting (CYF) general methodology applied in many countries by adapting it to the Moldovan context
   - Integrate remote sensing data into the Moldovan CYF and Drought Monitoring Systems
   - Improve spatial interpolation through adapted interpolation techniques, especially for crop development stages
   - Yield forecast at Regional level in addition to the National level
Products improvements

- Define Other factors or explanatory variable to be put into the CYFS
  - Fertilizers increase/decrease in time
  - Crop diseases increase/decrease in time
  - Extreme factors (frost during flowering, frost kill, Insects, hail,...) damaging crop yield
  - Technological trend
  - Other models…
  - …

- Produce monthly forecast from 3 to 4 months before harvest
- Reach less than 10% error (>15% currently)
Example for Moldova
Detailed Crop Yield Forecasting Methodology
(Source: Global Monitoring for Food Security (GMFS) project)

1. **INPUTS**
   - ETP
   - Actual rainfall
   - NDVI
   - Temperature, RR, RH,…
   - Other: Fertilizer costs,…

2. **INDEPENDENT VARIABLES**
   - Initial Water Holding Content
   - Soil Water Satisfaction Index
   - Water excess, deficit
   - Actual ETA
   - Starting date
   - NDVI max
   - Time peak
   - …
   - NDVI
   - Cumulated actual rainfall
   - Trend

3. **OUTPUT**
   - Yield prediction model at departmental level
   - Yield aggregation at national level
   - Yield prediction model at national level

**CROP YIELD DATA**
- Historical crop yield data at departmental level

**STATISTICA**

**MATLAB**
First trial for Wheat

• Simplification:
  – 11 years of data (meteo, RS, agricultural statistics)
  – 17 stations
  – 1 single model for the whole country
  – Agrometeo and Remote sensing explanatory variables only

• 30 potential explanatory variables
  • 4 variables retained after statistical analyses:
    – WDEFF, Horz, ETAt and Frost Kill index
Wheat Yield Forecast
Model Cross Validation Results

First Trial with the new approach
Wheat Yield Forecast
Model Validation Results

First Trial with the FAO CYF System

Quadratic error = 16.7%

Current Model

Quadratic error = 16.8%
Products improvements

2. Evolve to a Drought Monitoring Center
   – Combine model and observations (ETa, Water stress indices per crop, satellite data…). Show maps and images!
   – Use Remote sensing data for Drought Monitoring and Warning
   – Warning codes per sub-regions with 10-daily or weekly updates
   – Link with hydrologic activities of Hydromet
Chisinau

Agroclimatology

Temperature
(Max, Min, Average)
In NewLocClim
Maps of Rainfall

June 2010 dek 1 Rain
Water stress indices

Water stress (ETA/PET)
Wheat 2007
Agromet explanatory variables: Chisinau Water Balance

2008

2007
SPOT-VEGETATION IMAGERY (Average 10-daily data) Available at FAO

2007 – Bad for wheat

NDVI Profile 2007

Dekade
NDVI CN
Calarasi
Vulcanesti
Drochia

2008 – Good for wheat

NDVI Profile 2008

Dekade
NDVI CN
Calarasi
Vulcanesti
Drochia
Products improvements

3. Use plant diseases models for plant protection activities that are also crucial for crop yield forecasting
- Valorization of hourly data provided by automatic weather stations
- Benefit from the weather radar for rainfall occurrence assessment
Crop diseases model
Case of W. Wheat (Septoriosis) – Proculture model

Sensitive variety

Infections journalières
Pluie (mm)

Meteo hourly data
Septoria LB forecast with PROCULTURE Model

* The treatment recommended by PROCULTURE
nw: Treatment not recommended
M: Mildew
Reuler

Net return in €/ha

2003 2004 2005 2006 2007 2008 2009

Control GS32 GS37 GS45 GS59 GS31+GS59

nw

M

M
Phytophthora Infestans (Mildew) on Potato

**Dispersion:**
- Wind
- Rain

**Sporulation**
- Opt T°: 18 to 22 °C
- Min 8h with RH > 90%

**Incubation**
- Opt T°: 17 to 20°C
- Min 5°C

**Infection**
- Free water
- Opt T°: 12 to 16°C
- Min 5°C

**Guntz-Divoux curves**

- No infection
- Light infection
- Moderate infection
- High infection
- Very high infection

**Average Temp with RH>90%**

**Time in hour**

- 4 – 10 days
The use of radar could be a promising alternative for site-specific SLB risk assessment.
Communication and dissemination improvements

Observations

• A lot of high quality agromet data available in Hydromet but not sufficiently known and used.
• Crop yield forecasts sent to MAFI but no feedback

Need for an exchange/discussion between MAFI and Hydromet.

– Utility of Hydromet Products, MAFI needs ?
– Data product quality ?
– Usefulness of phenological observations and post winter observations : why these duplications?
Communication and dissemination improvements

Proposal

• To set up an annual meeting between Hydromet and MAFI in order to discuss the crop campaign and the different hydromet products for the crop campaign monitoring and forecasting

• Website development
  – Disseminate intermediate information (factors responsible of yield reduction like dought, heavy rains,...) and final information (crop yield) through an improved layout : more maps, more figures, more tables (see EU Bulletins)
  – Monthly update, more in case of disaster monitoring
Communication and dissemination improvements

Proposal

• Collaboration with the World Bank project
  – Agromet information (including localized drought, extreme weather event and plant diseases states) to farmers with mobile phones