Numerical Maps of Profit Probability for Maize Production in Poland

EFITA/99
27-30.09.1999 University of Bonn

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Objective

To work out a method for presenting how the profit from production of various utilisation modes of maize depends on variations in climatic conditions
Background (I)

- maize production in Poland always involves some risk

- the magnitude of risk depends on:
  - thermal conditions of the region
  - utility type of maize: the biggest risk is characteristic of grain utility types
  - earliness of hybrid: it is higher for maize with bigger FAO number
Background (II)

- production strategy: maximising profit
- even if the probability of profit or loss is known, it is not obvious if it will pay to produce the given crop
- to solve this incertitude, the concept of mathematical expectation can be used
Assumptions

1. Three utilization types of maize were analysed:
   - maize for CCM
   - maize for silage
   - maize for grain

2. One type of earliness (FAO 270) was analysed

3. The area under crop was 20 hectares
Procedures and tools:

1. Calculating profit
   - Program for modelling farm production activities
2. Calculating expected profit
3. Calculating probability
   - Model of agroclimate
The model of agroclimate

- the data
- a program that computes phenological periods of maize
  (date of sowing, date of ripening, probability of ripening)
The data for the model of agroclimate

The base point cover
Attributes: $\phi, \lambda, h$

Points with three co-ordinates: latitude, longitude and height above sea level, spaced over the area of Poland in a mesh 2 km by 2 km.

A number of tables containing various attributes can be related to this base point cover.
The algorithm for calculating phenological periods (I)

- The algorithm for calculating phenological periods is based on the algorithm for calculating normal temperature.

- The latter describes spatial distribution of temperature as a function of geographic coordinates ($\varphi$, $\lambda$, $h$) and time ($t$), making it possible to determine normal temperature at arbitrary locations and in arbitrary periods, not necessarily identical with the calendar months.
The algorithm for calculating phenological periods (II)

The algorithm for calculating phenological periods calculates sums of effective temperatures (degree-days above 6°) based on $\varphi$, $\lambda$, $h$ from the day when normal temperature reaches 11°C till the day when it drops below 10 °C.

Exact values of probability of ripening are obtained from the normal distribution function after relating the sum of effective temperatures needed for ripening to the sum of effective temperatures reached at a given spot calculated from normal temperatures.
Calculation of the sum of effective temperatures (degree-days) from normal temperatures
Calculating probability of ripening

The higher the sum of effective temperatures reached at a given spot, the higher the probability of maize ripening:

If $A_{tp} < A_{tn}$ then $P > 0.5$;
If $A_{tp} > A_{tn}$ then $P < 0.5$;

where:

- $A_{tp}$ - sum of effective temperatures, needed for ripening, corrected for the effect of precipitation and photoperiod
- $A_{tn}$ - sum of effective temperatures reached at a given spot
- $P$ - probability of maize ripening
Program that computes phenological periods (as used to calculate probability of maize ripening)

**PROGRAM**

(uses the algorithms for effects of temperature, precipitation and photoperiod, then compares the result with the sum of effective temperatures calculated on the basis of normal temperatures)

**DATA**

<table>
<thead>
<tr>
<th>φ</th>
<th>λ</th>
<th>h</th>
</tr>
</thead>
<tbody>
<tr>
<td>52.9</td>
<td>23.0</td>
<td>128</td>
</tr>
<tr>
<td>49.8</td>
<td>19.0</td>
<td>302</td>
</tr>
</tbody>
</table>

**Probability of ripening**

<table>
<thead>
<tr>
<th></th>
<th>Silage</th>
<th>CCM</th>
<th>Grain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.36</td>
<td>0.25</td>
<td>0.16</td>
</tr>
<tr>
<td></td>
<td>0.83</td>
<td>0.72</td>
<td>0.54</td>
</tr>
</tbody>
</table>

**Relation**
Output from the model of agroclimate

<table>
<thead>
<tr>
<th>Probability of ripening</th>
<th>Silage</th>
<th>CCM</th>
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<td></td>
</tr>
</tbody>
</table>

APPLICATION

Point output cover

Polygon output cover
Normal temperature

Mean yearly temperature of the air
Precipitation

Sum of precipitation in the year
Probability of maize ripening

Probability of ripening FAO 270 for grain

T. Górski, M. Słodka
A. Zalewski, E. Wróblewska
(IUNG Puławy 1998 r.)
Program for modelling farm production activities

Prices and exploitation data database → Cropping plan → Operation sheets

Results of calculations
Program for modelling farm production activities
Results from the program for modelling farm production activities
The idea behind expected profit calculation

- **P(S)** - probability of success,
- **P(F)** - probability of failure

<table>
<thead>
<tr>
<th>Decision</th>
<th>Probability</th>
<th>Earning and loss [zł]</th>
<th>Expected value [zł]</th>
<th>Expected profit [zł]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Silage</strong></td>
<td><strong>P(S)=0.9</strong></td>
<td>$139,394 \times 0.9 = 125,455$</td>
<td></td>
<td><strong>117,395</strong></td>
</tr>
<tr>
<td></td>
<td><strong>P(F)=0.1</strong></td>
<td>$-80,606 \times 0.1 = -8,060$</td>
<td></td>
<td><strong>-833</strong></td>
</tr>
<tr>
<td><strong>CCM</strong></td>
<td><strong>P(S)=0.6</strong></td>
<td>$48,367 \times 0.6 = 29,020$</td>
<td></td>
<td><strong>-833</strong></td>
</tr>
<tr>
<td></td>
<td><strong>P(F)=0.4</strong></td>
<td>$-74,633 \times 0.4 = -29,853$</td>
<td></td>
<td><strong>-833</strong></td>
</tr>
</tbody>
</table>
Program for computing expected profit

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit from SEED</td>
<td>3210</td>
</tr>
<tr>
<td>Loss from SEED</td>
<td>-86790</td>
</tr>
<tr>
<td>Profit from CCM</td>
<td>48367</td>
</tr>
<tr>
<td>Loss from CCM</td>
<td>-74632</td>
</tr>
<tr>
<td>Profit from SILAGE</td>
<td>139394</td>
</tr>
<tr>
<td>Loss from SILAGE</td>
<td>-80606</td>
</tr>
<tr>
<td>Limit of profit</td>
<td>4000</td>
</tr>
</tbody>
</table>

- Replace for Silage
- Do Not Replace

[Compute] [Cancel] [Help]
Expected profit from maize grown for CCM
Expected profit from maize grown for silage
Conclusions

• by using the model of agroclimate together with economic data it was possible to obtain valid information on spatial distribution of expected profit from production of three utility types of maize

• the method can be used successfully to present spatial differentiation of various economic aspects of farm activities caused by climatic conditions

• the method can be implemented in a DSS for support of decision making also at the farm scale