Numerical Maps of Profit Probability for Maize Production in Poland

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Abstract

The paper presents a method for calculating expected profit for three utilisation modes of maize, grown for grain, silage and CCM. The method combines results from two modelling tools: model of agroclimate and program for modelling farm production activities. The economic analysis has shown that the highest net income is from silage and the lowest from grain. Spatial distribution of expected profit for silage has been shown in a map against the assumed threshold of productivity.

Keywords: maize, GIS, expected profit

Introduction

Climatic conditions in Poland are rather diversified and there are many regions not suited for maize growing, as it requires rather high sums of degree-days (Nawrocki St., Kozakiewicz J. 1975). Although in certain regions there are good thermal conditions for growing maize, there is always some risk involved: the later a variety matures, the bigger the risk. Varieties grown for grain are the most susceptible because their climatic requirements are the highest. The risk depends also to some extent on the flexibility of the farmer to change the strategy while it is still time, but neither to overestimate nor to underestimate the situation. Technically, change in strategy is not always feasible. Thus, if maize grown for grain does not ripen, theoretically it could be harvested for silage. Nevertheless, things are not so simple, as this presupposes existence of demand for such produce; only on farms that keep livestock some of the silage would be used. This is so because silage only rarely becomes object of trade. On those farms where maize is grown for CCM switching production to silage would also be only conceivable if livestock is kept, as CCM is fed to pigs. In consequence the farmer may want to know not only what yields and profits associated with the type of production are to be expected but also the magnitude of risk of each choice.

Materials and procedures

In the current paper a method of calculating expected profit from production of three utilisation modes of FAO 270 maize: grown for grain, silage and CCM is demonstrated. The method combines results from two independent modelling tools, developed at the IUNG (Institute of Soil Science and Plant Cultivation) in Puławy: a model of agroclimate and a program for modelling farm production activities.
Agroclimate Model

Modelling of climate is not a new concept (Duguay and Walker, 1996, Hargy 1997). The agroclimate model takes advantage of the fact that climate has definite location, which can be described by geographic co-ordinates. The IUNG agroclimate model was developed first in the Arc/Info GIS but now it is also available in the ArcView and MapInfo GIS under Windows. The main calculation procedures for the PC version are realised by separate computer programs written in Delphi. The basic data for the model are points with three co-ordinates: latitude, longitude and height above sea level (a point cover). The points are evenly spaced over the area of Poland in a mesh 2 by 2 km and thus constitute a simple digital model of terrain (Kreveld et al. 1997). The values of the elements of agroclimate (temperature, precipitation and radiation) at each point in any arbitrary period can be computed with the aid of algorithms implemented in the programs. The algorithms describe statistical distribution of basic climatic features (Górski and Górska, 1998). They link the yearly cycle of meteorological elements (determined with the aid of harmonic analysis) with their spatial image (as a function of geographic co-ordinates). Thus it has been made possible to describe mean values of climate elements as well as their variability (probability, risk etc.). One of the possible forms of output from the model may be point covers of climatic elements on the basis of which maps that present distribution of elements of agroclimate over a given area may be created. All the values calculated in the agroclimate model are kept in separate tables and the point cover can be connected to each table with the aid of a one-to-one relation.

The Agroefekt program

The Agroefekt has been used for economic analysis required in this paper. The program had been developed from 1988 to 1994 at the IUNG. It operates under MS DOS. Data (such as exploitation data of machinery, tractors and agricultural buildings, dates of operations, doses of materials etc.) may be input into the sheets from the program’s interface or from the MS Access, for instance. Operation sheets are organised into a cropping plan. The program, in order to make calculations, takes advantage of the data in the operation sheets, the cropping plan and in databases containing prices and exploitation data of tractors and implements as well as prices of materials (Hołaj and Zaliwski, 1999). Useful information about the farm can be derived with the aid of the program (e.g. direct costs, value of production, farmer’s own potential labour input and hired labour input).

The methodology of economic analysis is incorporated into the Agroefekt program and has been based on the available literature (Lorencowicz 1987, Witney 1984) and some other methodology sources.

For the purpose of the present study three operation sheets were created: for grain, CCM and silage. The area of field for each sheet was assumed to be 20 ha since much smaller area could not allow for machinery and tractors to work to their potential resulting in high costs of machinery. The main idea was to make sheets differ as little as possible in order to capture the important tillage differences in the three maize utilisation modes. A general characteristic of tillage assumptions is given in tab. 1. These data are based on research conducted at the IUNG.

For the economic analysis the 1998 prices were used. The prices for CCM and silage were derived from the feeding value of forage because normally these crops are not the object of trade. Direct costs, value of production and farmer’s own potential labour input were calculat-
ed on the basis of the operation sheets. Indirect costs were assumed to be 25% of the total costs of production. A threshold of productivity (minimum net income) for the farm has been introduced and assumed about equal to the mean product of the farmer’s labour and the hour pay (10 zł/h) for the three types of production (about 4 000 zł). Incomes below the threshold render production unprofitable for the farmer.

**Expected profit calculation**

For the purpose of the present work the model of agroclimate has been extended, in the form of a computer program, to compute expected profit from the three modes of FAO 270 maize. The values of profit and loss are input into the program manually after they have been computed with the Agroefekt program.

The main idea behind expected profit calculation is presented in fig. 1 (after Edwards, 1988). The values in the “Profit and loss” column are net income (for profit) and total costs (for loss). Taking total costs of production in the “loss case” causes the costs to be a little higher than they really would but it simplifies the calculations a lot. The maximum error thus introduced for silage production is 33%; nevertheless such case never happens in our analysis. It is assumed that in all cases some of the yield is harvested. Costs for partial yield harvesting are variable, hence this simplification.

**Results and discussion**

The results of economic analyses are presented in fig. 2. It follows from this chart that maize for silage has the biggest value of production and maize for grain the least value. In fact the production of maize for grain is below the threshold of productivity (3 210 zł as compared to 4 000 zł). The net income the farmer can achieve from silage and CCM is rather high, nevertheless only part of a real farm’s production activity has been modelled in the present analysis. In the real world the important part is pigs or livestock.

Costs of production for the three utilisation modes of maize do not differ much (the highest in grain – 86 790 zł as compared to 74 633 zł in CCM). Farmer’s labour is almost the same for all the utilisation modes. These values are almost identical because of little difference in main tillage operations between the modes.

The results obtained from the economic analysis were used as input to the climate model. The model calculates probabilities of maize ripening on the basis of degree-days (the sum temperatures over +6°C, beginning on the day when the normal temperature reaches 11°C and ending on the day when it drops below 10°C). For the purpose of the present analysis, the procedure mentioned was adapted, in the form of a computer program, to calculate highest profit for the three utilisation modes of maize (fig. 1). This brought the total number of programs in the PC model of agroclimate to eleven. The program computes first probabilities of ripening for the three modes of maize, and, after the economic data has been input, expected value of profit and loss (which is here net income and total cost of production) for each utilisation mode. Lastly, it computes expected profit. These calculations are done for all the points of the digital model of terrain. The results are written into a separate table, which is then connected to the spatial database (the DTM) in the GIS, and maps may be created. Maps for all three utilisation modes have been made, but in fig. 3 only a sample map is presented. The map covers the area of Poland and shows the expected profit for silage.
Conclusion

The objective of the present work was to show a method for calculating expected profit from production of three utilisation modes of FAO 270 maize: grown for grain, silage and CCM. Spatial distribution of expected profit has been shown in the map. In the analysis some elements of technology of maize production have been simplified and some assumptions could be discussed. E.g. indirect costs have been calculated in proportion to direct costs with the aid of a straightforward coefficient, i.e. 25% of direct costs). The data necessary are not always available and one of the tasks of such complex analyses is also determination of gaps in the existing data and suggestions as to further directions of research. Nevertheless the method can be used successfully to present spatial differentiation of expected profit caused by climatic conditions.

References


Table 1. Assumptions for creating maize production operation sheets.

<table>
<thead>
<tr>
<th>No</th>
<th>Maize utilisation mode</th>
<th>Soil complex</th>
<th>P and K content</th>
<th>Dose of P$_2$O$_5$ [kg/ha]</th>
<th>Dose of K$_2$O [kg/ha]</th>
<th>Dose of N [kg/ha]</th>
<th>Plant density [p./ha]</th>
<th>Yield$^1$ [dt/ha]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Grain</td>
<td>rye</td>
<td>Medium</td>
<td>65</td>
<td>150</td>
<td>180</td>
<td>80000</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>CCM</td>
<td>rye</td>
<td>Medium</td>
<td>65</td>
<td>150</td>
<td>180</td>
<td>80000</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>Silage</td>
<td>rye</td>
<td>Medium</td>
<td>35</td>
<td>120</td>
<td>190</td>
<td>100000</td>
<td>500</td>
</tr>
<tr>
<td>4</td>
<td>CCM-rescue$^2$</td>
<td>rye</td>
<td>Medium</td>
<td>65</td>
<td>150</td>
<td>180</td>
<td>80000</td>
<td>400</td>
</tr>
</tbody>
</table>

$^1$ Yield of grain at 15% moisture content, yield of green plants at field moisture content

$^2$ Cultivation as for CCM, harvest for silage
Figure 1. A tree diagram representing possible choices and their consequences in terms of expected profit. $P(S)$ – probability of success, $p(F)$ - probability of failure.

Figure 2. Value of production, direct costs of production and farmer’s own labour input.
Figure 3. The map of expected profit from maize for silage (20 hectares area)