Numerical Maps of Expected Income from Maize Production in Poland

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Abstract

The paper presents a method for calculating expected income from three maturity types of maize grown for grain: FAO 210, FAO 240 and FAO 270. 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 gross income per hour of farmer's own labour is from the FAO 270 maize and the lowest from the FAO 210 maize provided that the crop ripens. Spatial distribution of expected gross hourly income for the three maturity types of maize has been shown in maps against the assumed threshold of acceptable earning.

Keywords: maize, model of agroclimate, GIS, economic analysis, expected income

Introduction

Climatic conditions in Poland are diversified and regions suited for maize growing can be clearly defined in terms of thermal conditions. Maize grown for grain requires rather high sums of degree-days (Nawrocki St., Kozakiewicz J. 1975) and even in suitable regions some risk is always involved: the later a variety, the bigger the risk. Technically, the risk depends also to some extent on the flexibility of the farmer to adapt the strategy to arising difficult situation. Thus, if maize grown for grain does not ripen fully, it could be harvested with some loss at higher moisture content. In most cases however, corrections to strategy are hardly feasible after major decisions have been made. For instance, after the varieties have been selected and sown, there is not much to be done if the crop of maize does not ripen. In theory it could be harvested for silage if there was demand for such crop. However, if the silage cannot be fed or sold the labour would be wasted. It is therefore apparent that the farmer needs to know not only what yields and profits to expect but also the magnitude of risk involved in a choice associated with the type of production, before a decision is made.

Any decision needs criteria, for instance maximising profit or minimising losses. The farmer, even if he knows the probability of profit or loss for each decision, could hesitate what action to take. To solve this incertitude, the concept of mathematical expectation (Edwards, B.R. 1988) has been used in the paper.

Materials and procedures

In the current paper a method of calculating expected income from production of three maturity types of maize is demonstrated. The method combines results from two 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.

The Model of Agroclimate

The model of agroclimate developed at the IUNG takes advantage of the fact that climate has definite location, which can be described by geographic co-ordinates. The basic data for the model are contained in a point cover (Kreveld et al. 1997). The points are evenly spaced over the area of Poland and constitute a mesh 2 by 2 km. The attributes of points are latitude, longitude and height above sea level. 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 separate computer programs written in Delphi. The algorithms describe statistical distribution of basic climatic features by linking the yearly cycle of meteorological elements, determined with the aid of harmonic analysis, with their spatial image (Górski and Górska, 1998). It is possible to calculate mean values of climate elements as well as their variability (probability, risk etc.). All the values calculated in the model are stored in separate thematic tables. A possible form of output from the model is a cartographic one (creating map of climatic elements). The PC version of the model can be used with the ArcView or MapInfo GIS under Windows.

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 and runs under MS DOS. Data (such as exploitation data of machinery, tractors and agricultural buildings, dates of operations, doses of materials etc.) are input into operation sheets. The 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 as well as gross income per hour of farmer's own labour).

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. The present analysis was made for the area under maize of 20 hectares. Some assumptions made for creating maize-production operation sheets are presented in tab. 1. Differences in yields in relation to maturity type of maize were determined with the aid of regression analysis on the basis of results achieved in field experiments in the years 1971-1975 (Martyniak I. 1976). It has been determined that the yield grows by 13% with the increase in the FAO number equal to 50, provided that the crop ripens.

Table 1. Assumptions for creating maize production operation sheets.

No	Maize maturity type	Soil complex	P and K content	Dose of P_2O_5 [kg/ha]	Dose of K_2O [kg/ha]	Dose of N [kg/ha]	Plant density [p./ha]	Yield[1] [dt/ha]
1	FAO 210	rye	Medium	65	150	149	80000	74.40
2	FAO 240	rye	Medium	65	150	164	80000	82.20
3	FAO 270	rye	Medium	65	150	180	80000	90.00

[1] Yield of grain at 15% moisture content

For the economic analysis the 1998 prices were used. On the basis of the operation sheets direct costs, value of production, the farmer's own potential labour input and gross income per hour of the farmer's own labour were calculated. Indirect costs were excluded from the analysis. A threshold of acceptable earning (a minimum hourly gross income) of the farmer from maize production on the farm has been introduced and assumed to be equal to hourly wages for farm labourers (5 zł/h) for all three types of maize. Incomes below that threshold render production unprofitable for the farmer.

Expected profit calculation

For the purpose of the present work the model of agroclimate has been extended by a program computing expected income from the three modes of maize. The values of earning and loss were input into the program manually after they had been computed with the Agroefekt program.

The main idea behind expected income calculation is presented in fig. 1 (after Edwards, 1988).

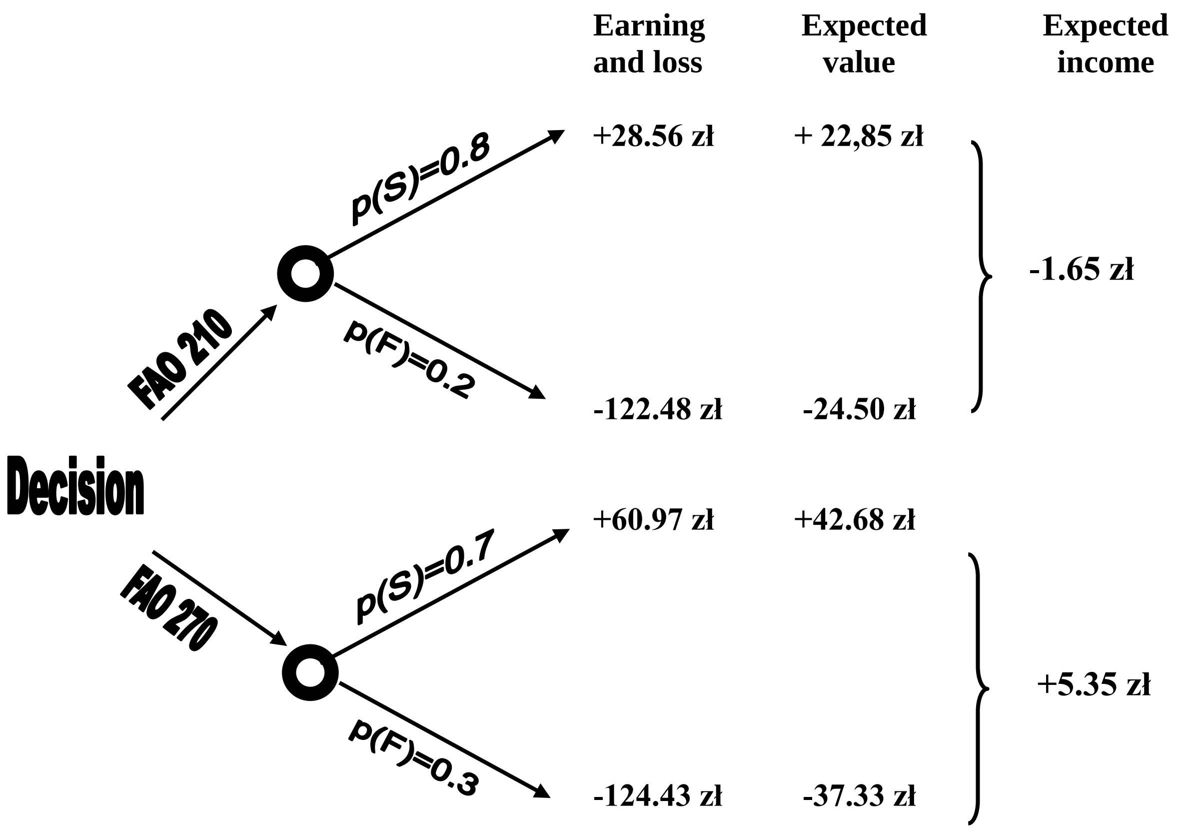

Figure 1. Possible choices in a decision. P(S) – probability of success, p(F) - probability of failure.

The values in the "Earning and loss" column are gross income per hour of the farmer's own labour (for earning) and the sum of direct costs of all operations except for harvesting (for loss). It is assumed that in the worst case (total failure) no yield is harvested; nevertheless the costs of tillage have been incurred since the failure will not be known until the time of harvest.

Results and discussion

The results of economic analyses are presented in fig. 2 (the calculations concern the case when the crops fully ripen). It follows from the chart that the FAO 270 maize has the biggest

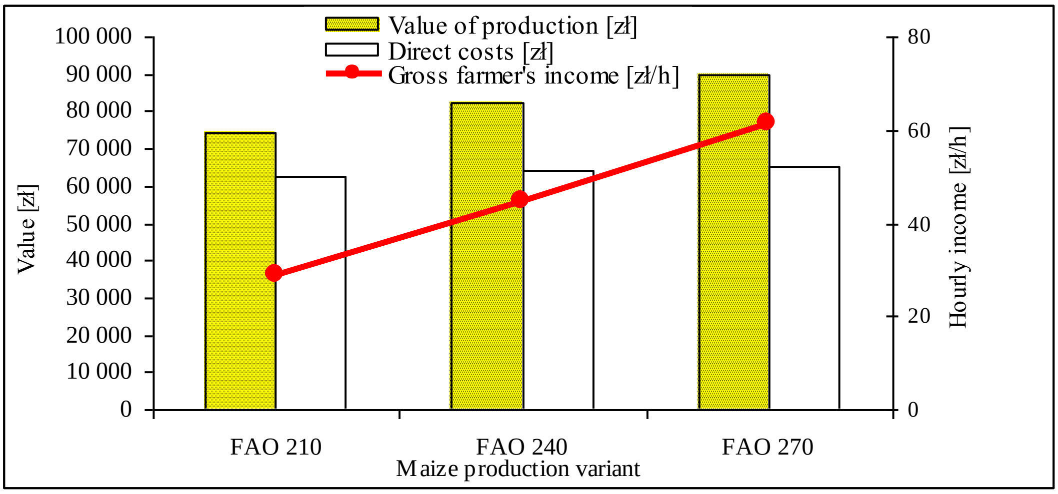

Figure 2. Value of production, direct costs of production and gross income per hour of the farmer's own labour (area of 20 hectares). Full ripeness of crop is assumed.

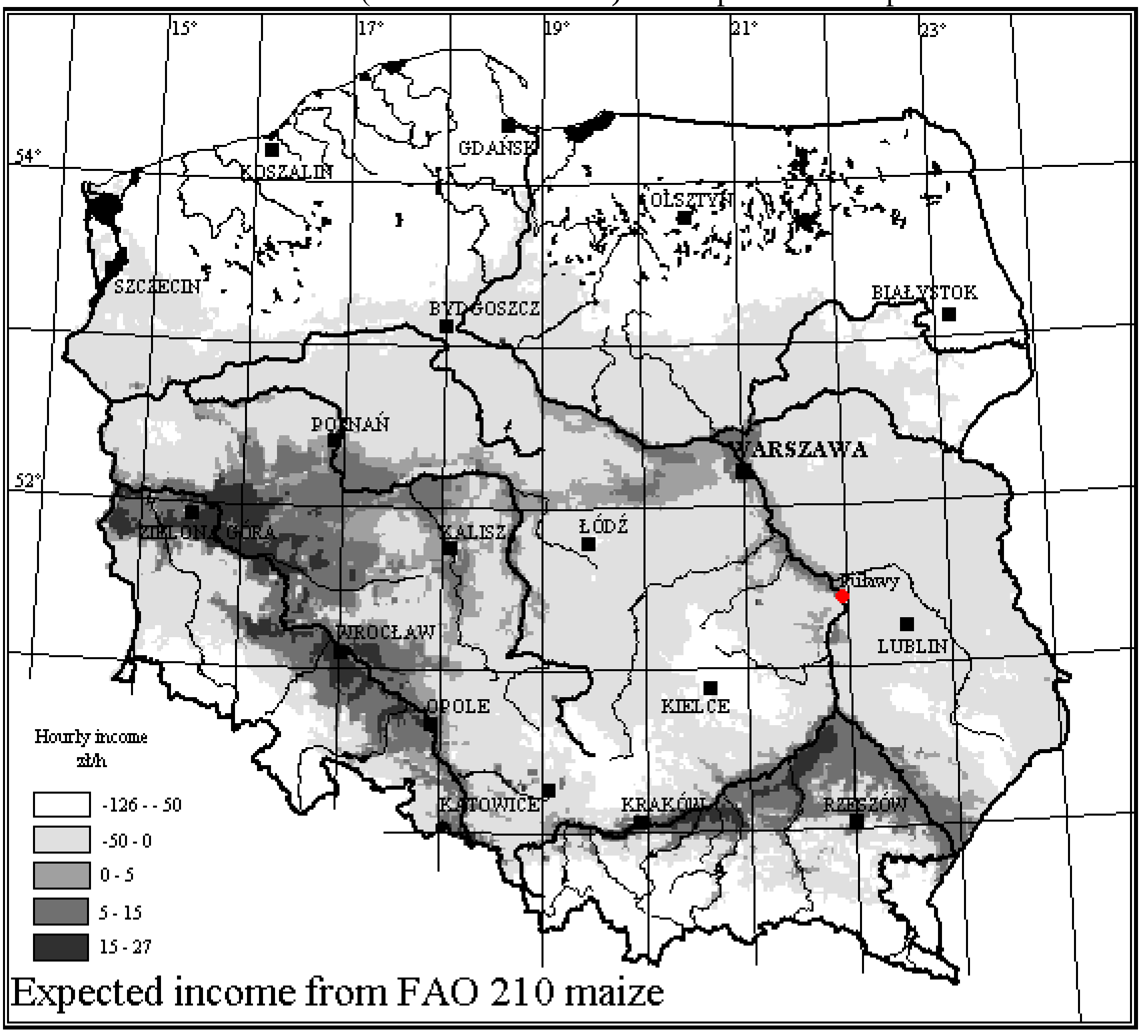

Figure 3. The map of expected income from the FAO 210 maize for grain (area of 20 hectares)

value of production and maize FAO 210 the least value. The gross income per hour of the farmer's own labour is rather high, nevertheless as indirect costs have not been taken into account, the real income will be less.

Costs of production for the three maturity types of maize differ little (the highest in FAO 270 – 65,092 zł as compared to 62,733 zł in FAO 210). Farmer's own labour is the same (408.5 man-hours) for all three maturity types of maize. These values are very close because of little difference in main tillage operations between the modes. The main differences are in fertilisation doses and harvest costs.

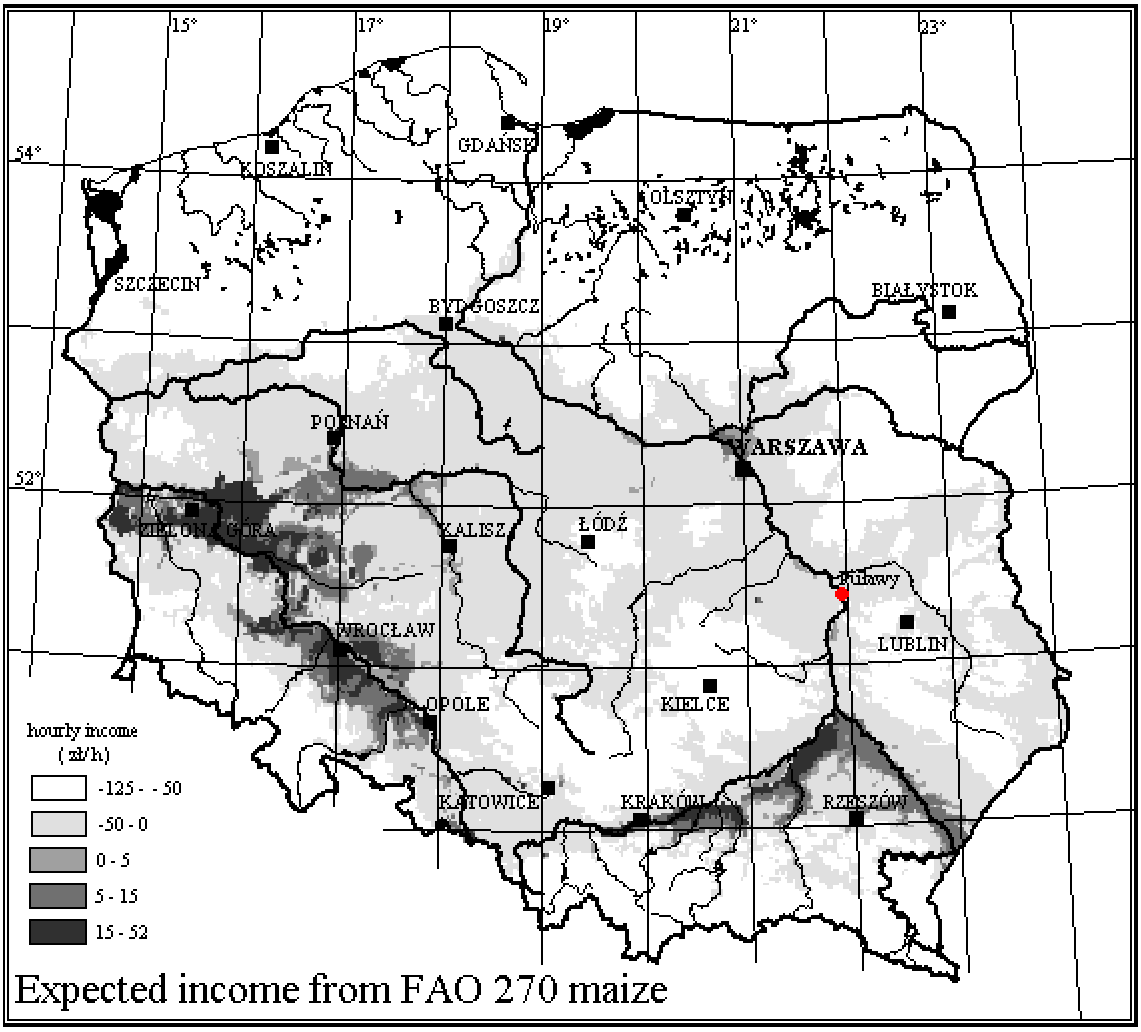

Figure 4. The map of expected income from the FAO 270 maize for grain (area of 20 hectares)

The results obtained from the economic analysis were input to the program of the model of agroclimate. The program calculates probabilities of maize ripening on the basis of degree-days (the sum temperatures over +6ºC, beginning on the day when the normal temperature reaches 11ºC and ending on the day when it drops below 10ºC). It also calculates the expected income for the three maturity types of maize (fig. 1), after the economic data has been input. These calculations are done for all the points of the point cover. The results are written into a separate table, which then may be connected to the spatial database of the point cover in the GIS and the results can be presented on maps. In fig. 3, 4 and 5 sample maps are shown. The maps cover the area of Poland and show the expected income as depending on the maturity type of maize.

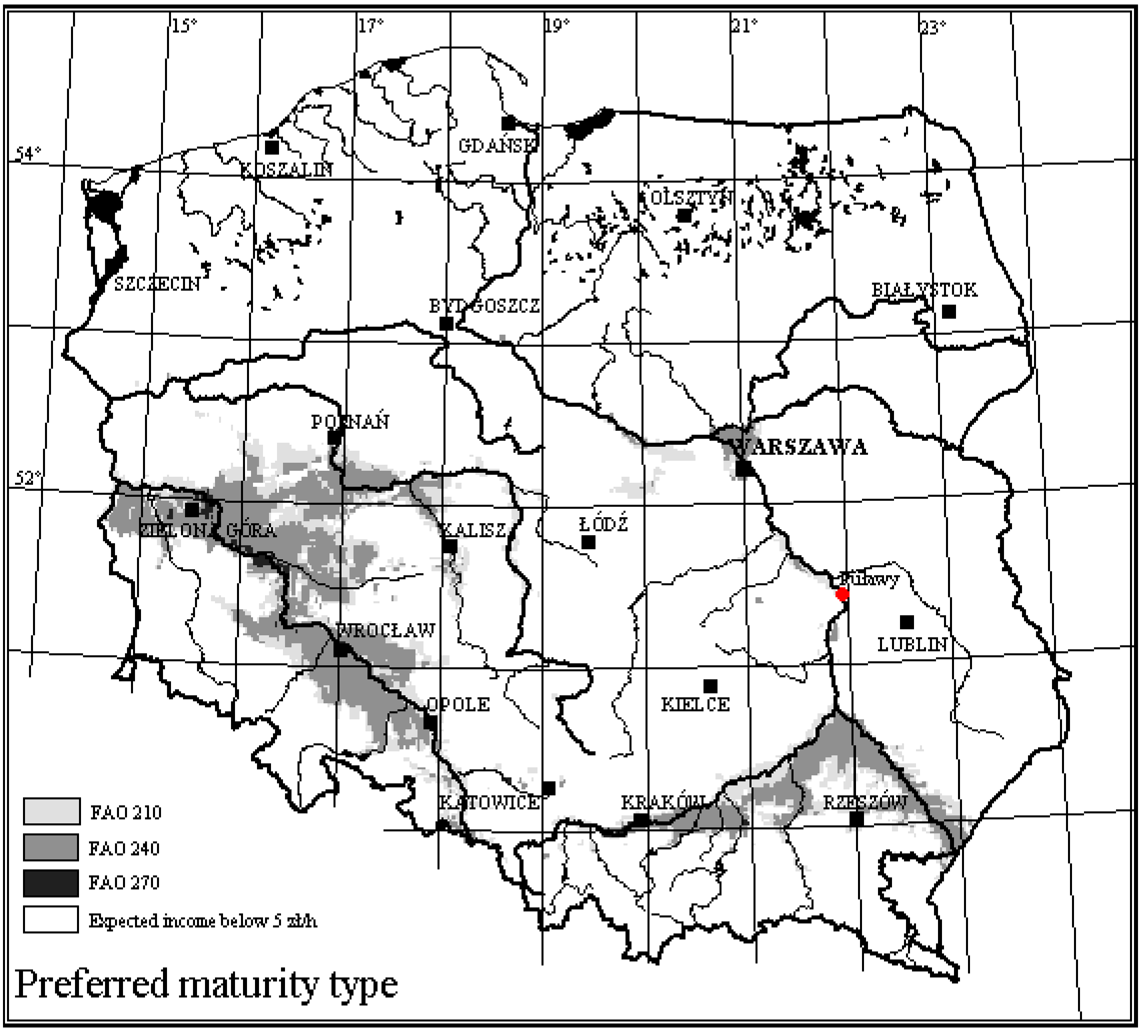

Figure 5. The map of preferred maturity type of maize for grain (area of 20 hectares)

Conclusion

The objective of the present work was to show a method for calculating expected income from production of three maturity types of maize grown for grain: FAO 210, FAO 240 and FAO 270. Spatial distribution of expected income has been shown in the map. Some assumptions made in the analysis can be discussed. E.g. indirect costs have been omitted entirely from the analysis, which could create a false impression that production of maize for grain is profitable in Poland, while it is not. Indirect costs were assumed equal for all three variants of production and excluded from the analysis because the important point was the difference between the variants. Notwithstanding these minor approximations, the method can be used successfully to present spatial differentiation of various economic aspects of farm activities caused by climatic conditions, expected incomes among this number.

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