Polish Crop Production

- Current Status and Potential -

Pawel Boczar, University of Poznan

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1 Introduction

The aim of this paper is to show the production potential of winter wheat, rye, maize, rapeseed, sugar beets and potatoes in Poland. The publication focuses on two basic factors that are conditioning the country's production potential, namely natural conditions and economic-organizational conditions. The natural conditions were characterized by means of the quality and quantity of soils and agricultural production space index, which allows not only controlling for soil conditions but also climate, terrain and hydrographical conditions. Due to the limited length of this publication, the effect of economic–organizational conditions was presented as the size of farms. It is certainly a simplification, but as research has shown, the size of the farm reflects the economic-organizational conditions on it. Small farms usually struggle with the problem of poor technical equipment, low levels of application of means of production (obviously, horticultural or vegetable farms could be an exception, but they are not the focus of our attention) and a large number of poorly skilled labor force. On the other hand, there are large farms, where the standard of technical equipment and applied means of production usually look better and the qualification of the labor force is better as well.

The study is divided into four sections. The first part characterizes Polish soil and climatic conditions, the structure of agricultural land, the agricultural production space index and the total quantity and structure of farms. The second part shows similar characteristics broken down by province. The third part presents the regional aspect of production, area under cultivation and crops of selected crops. The final part attempts to assess the production potential of selected crops.

2 Framework conditions for Polish agriculture

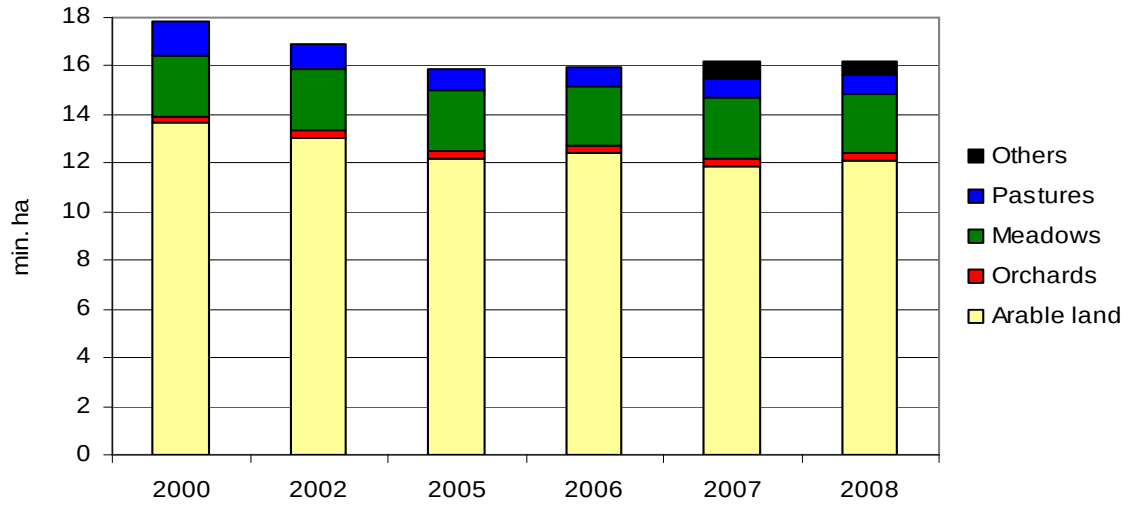
Poland is a lowland country, because more than 96 % of its territory lies below 350 m AMSL and only 2.9 % over 500 m AMSL. Poland lies in the boundary zone of the European continental climate with rather dry summers and cold winters and the moderate climate influenced by the Atlantic Ocean which creates rather unstable conditions for agricultural production. The average annual air temperature ranges between 6.0 and 8.8°C, and the length of the thermal growing season is about 220 days on average and only in the southwest does it exceed 230 days. The total average annual precipitation is 500-600 mm in the low land, 600-700 mm on the high land and exceeds 1000 mm in the mountains. Central Poland (Masovia, Greater Poland, and Kuyavia) is among the regions in Europe with the lowest precipitation, where the total annual precipitation does not exceed 550 mm.

From 2000 to 2008 the area of agricultural land in Poland decreased from 17.8 million ha to 16.2 million ha (Fig. 1). Of all agricultural land, arable land is the most prevalent, but in the period analyzed, its area was also reduced from 13.7 million ha to 12.1 million ha. Among grasslands in Poland, meadows occupy the largest area which remains at a fairly stable level of about 2.5 million ha. However, the pastures area dropped from 1.4 million ha in 2000 to 0.73 million ha in 2008. On the other hand, in the period presented the area of orchards increased by 50,000 ha to 330,000.

In Poland's crop structure, cereals predominate; in the period under examination, their share fluctuated from 70-75 % (Fig. 2). The area of cereal cultivation in that period remained

at about 8.5 million ha. Industrial crops such as rapeseed or sugar beets were second and their share rose from 6.5 % in 2000 to nearly 9 % in 2008, mainly due to the increase in the area of rapeseed cultivation. The area under cultivation of industrial crops was over 1 million ha in 2008, where rapeseed comprised about 800,000 ha. Forage crops were the next group in the cultivation structure, with a fairly stable share of about 7-8 % and the area under cultivation of about 900,000 ha. On the other hand, the cultivation of potatoes decreased from 10 % in 2000 to 5 % in 2008. In 2008 the area of potato cultivation was 550,000 ha. In the cultivation structure pulses had the smallest share of about 1 % and an area of about 120,000 ha.

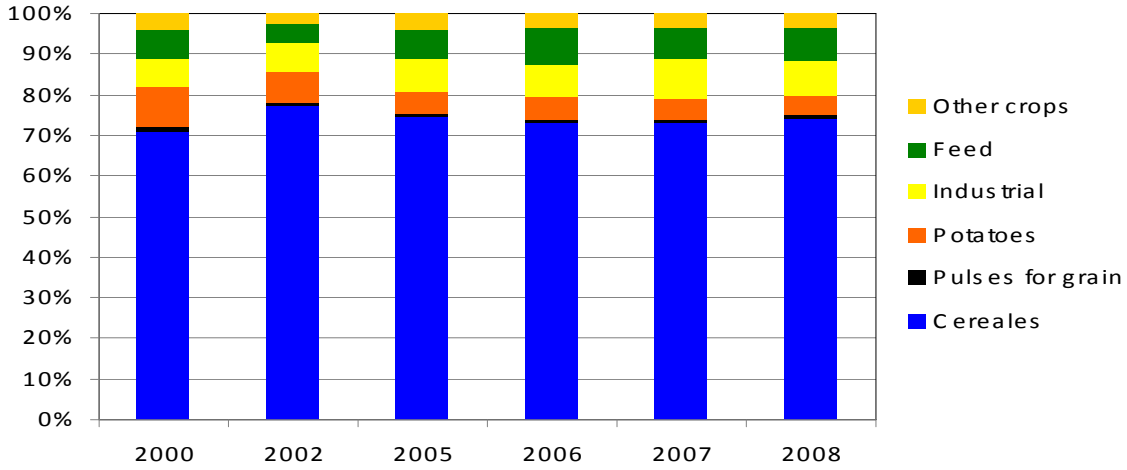
Figure 1: Structure of agricultural land in Poland from 2000 to 2008



Source: Statistical Yearbook of Agriculture 2009

Apart from the cultivation area of a particular plant, it is the quality of the soil in which the plant is cultivated that is crucial to potential crop production. Six classes of soil have been identified in Poland. As can be seen in Fig. 3, Class IV is prevalent in Poland – 7.4 million ha. It is an average quality soil. Class III soils have a large share – 4.2 million ha and they are considered to be good quality, whereas Class V soils - 4.2 million ha, are considered to be poor quality.

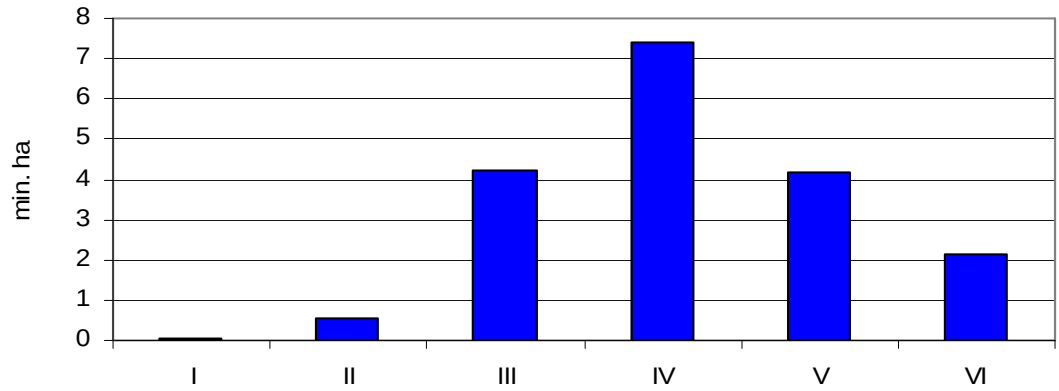
Figure 2: The structure of cultivation in Poland from 2000 to 2008



Source: Statistical Yearbook of Agriculture 2009

Class I and II soils, which make only 0.6 million ha in Poland, are very good and good quality. On the other hand, Class VI soils, which are very poor quality, cover an area of 2.1 million ha. To sum up the quality of soils in Poland, one can say that good and very good quality soils (Classes I-III) make up only 26 % of agricultural land, whereas poor and very poor quality soils (Classes V and VI) make up as much as 34 %.

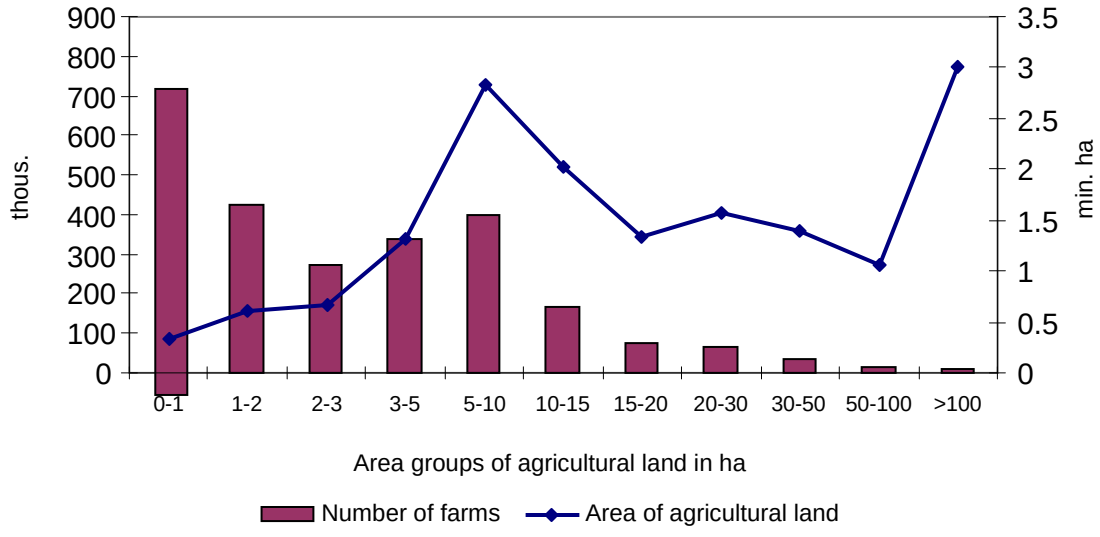
Figure 3: The quality of agricultural land in Poland in 2000



Source: Statistical Yearbook of Agriculture 2009

The production potential defined by natural conditions is not often realized due to the inappropriate agrarian structure of farms. The number of farms in Poland is relatively high. In 2007 there were about 2.5 million farms (Fig. 4). The highest percentage of farms consisted of those up to 1 ha as well as those with an area ranging from 1-2 ha and 5-10 ha. The lowest percentage of farms were the 8.1 thousand farms larger than 100 ha. However, the largest share of agricultural land, i.e. over 3 million ha, was concentrated in those farms. A large area of agricultural land is also concentrated in the farms ranging from 5-10 ha, i.e. 2.8 million ha. The average area of agricultural land per farm was slightly less than 8 ha.

Figure 4: Characteristics of agricultural farms by area groups of agricultural land in 2007



Source: Statistical Yearbook of Agriculture 2009

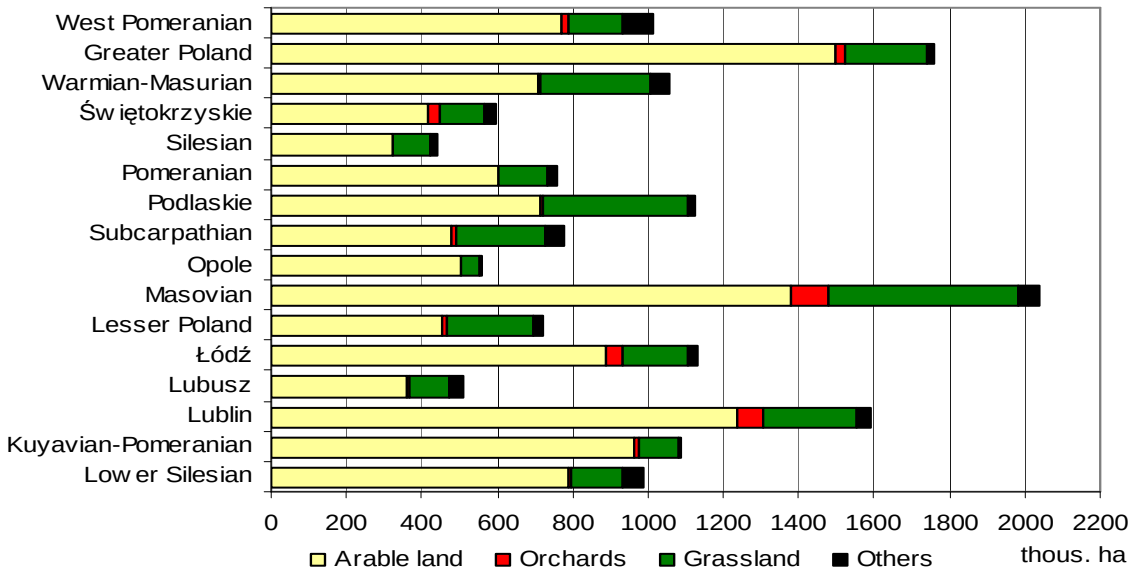
The organizational and economic limitations present on farms result in the relatively poor agro technical condition of Polish soils. It is estimated that about 80 % of the soil in agricultural land in Poland is acidified to a various extent. Very acidic soils make up 29 % of agricultural land, acidic soils make up 28 % and slightly acidic soils make up 24 %. The other 20 % consists of soils with a neutral or alkaline pH.

The relatively low level of natural mineral fertilization that has continued for more than a decade (on average about 100-120 kg of NPK is used in mineral fertilizers per 1 ha of agricultural land) in the conditions of 40-50 % share of soils with a very low or low level of nutrients, may lead to a decrease in their production potential. It is also necessary to stress that the average content of humus in Polish soils is low and is 2.2 % on average. According to our calculations, low-humus soils (<1.0 %) make up 6 % of the area of agricultural land in Poland, medium-humus soils (1.1-2.0 %) make up 50 % and high-humus soils (>2.0 %) make up about 33 %.

3 Regional breakdown of Polish crop production

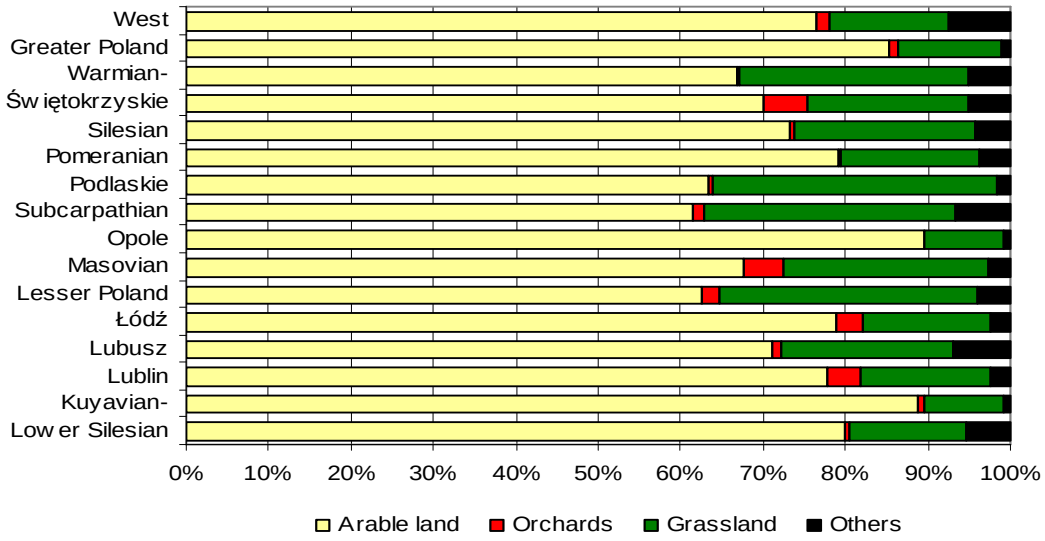
Poland is divided into 16 provinces (voivodeships). There are different natural and economic-organizational conditions in each province and thus different production potentials. As can be seen in Fig. 5 the voivodeships with the largest area of agricultural land are: Masovian, Greater Poland and Lublin. The voivodeships with the smallest area of agricultural land are: Silesian, Lubuskie, Opole and Świętokrzyskie. In the structure of agricultural land arable land prevails, especially in the Opole and Kuyavian-Pomeranian Voivodeships, where the share reaches almost 90 % (Fig. 6). On the other hand, the Podlaskie, Subcarpathian and Lesser Poland Voivodeships have the highest share of grassland amongst its agricultural land – about 30 %.

Figure 5: Agricultural land use structure within voivodeships in 2008



Source: Statistical Yearbook of Agriculture 2009

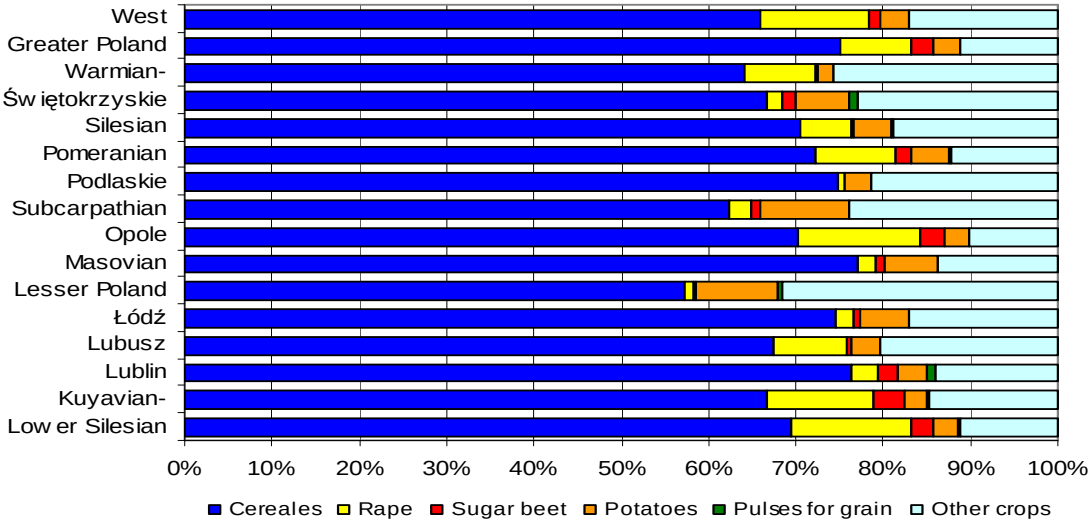
Figure 6: Structure of agricultural land use within voivodeships in 2008



Source: Statistical Yearbook of Agriculture 2009

On the other hand, cereals prevail on the arable land in individual voivodeships (Fig. 7). The highest share of cereals – more than 75 % - was in the Lublin and Masovian Voivodeships. As far as rapeseed is concerned, the highest share of over 10 % of the crop area can be found in the Lower Silesian, Kuyavian-Pomeranian, Opole and West Pomeranian Voivodeships.

Figure 7: Structure of agricultural land use by voivodeships in 2008

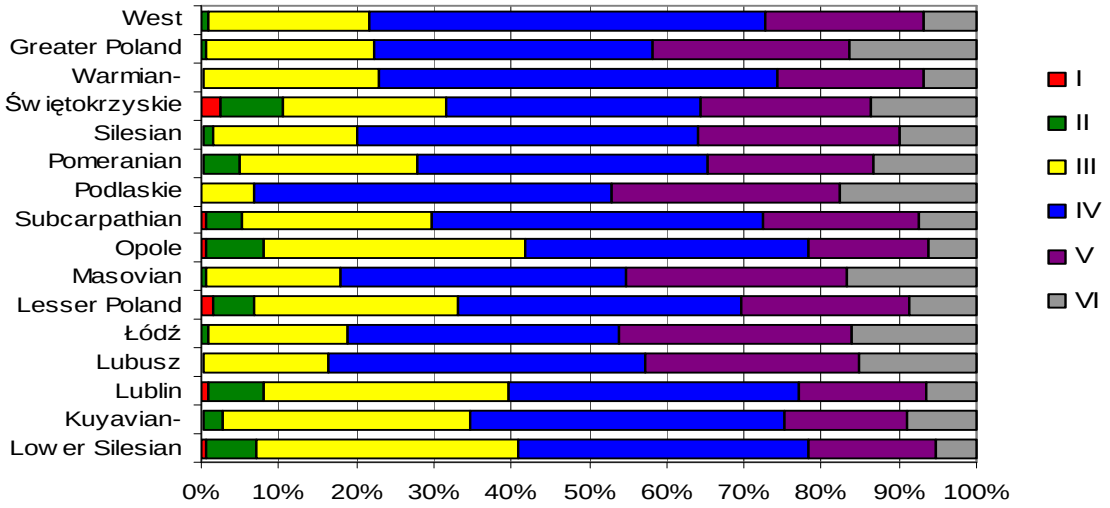


Source: Statistical Yearbook of Agriculture 2009

According to soil class evaluation, the voivodeships with the best soils are: Lower Silesian, Lublin and Opole (Fig. 8). In those voivodeships Class I, II, and II soils, i.e. very good and good soils make up about 40 %. On the other hand, the Lubusz, Łódź, Masovian and

Greater Poland voivodeships have the highest share of poor and very poor quality soils (Class V and VI); the share of those soils in agricultural land is higher than 40 %.

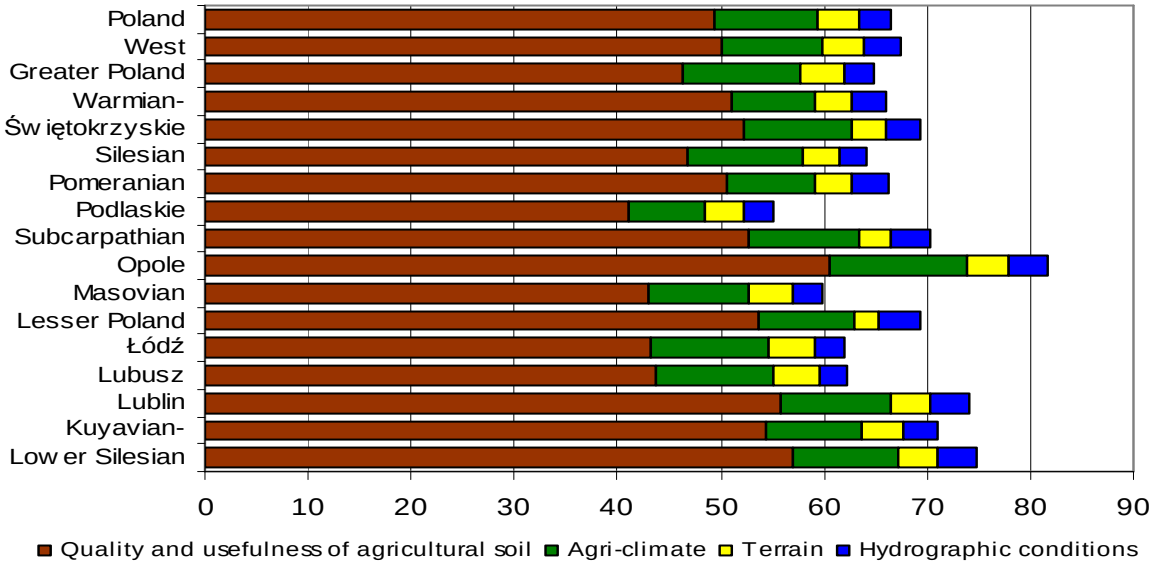
Figure 8. Structure of soil classes and by voivodeships in 2000



Source: Statistical Yearbook of Agriculture 2009

In the evaluation system of agricultural production area that has been in use in Poland since the 1970s, the following statistical evaluation indexes of individual elements of the habitat are taken into consideration: the quality and usefulness of agricultural soil, soil humidity, terrain and agro climate. The assessment of natural conditions was done on the basis of quantitative dependence between the crops and the quality of habitat and climate.

Figure 9: Index of agricultural production space by voivodeship



Source: The Institute of Soil Science and Plant Cultivation

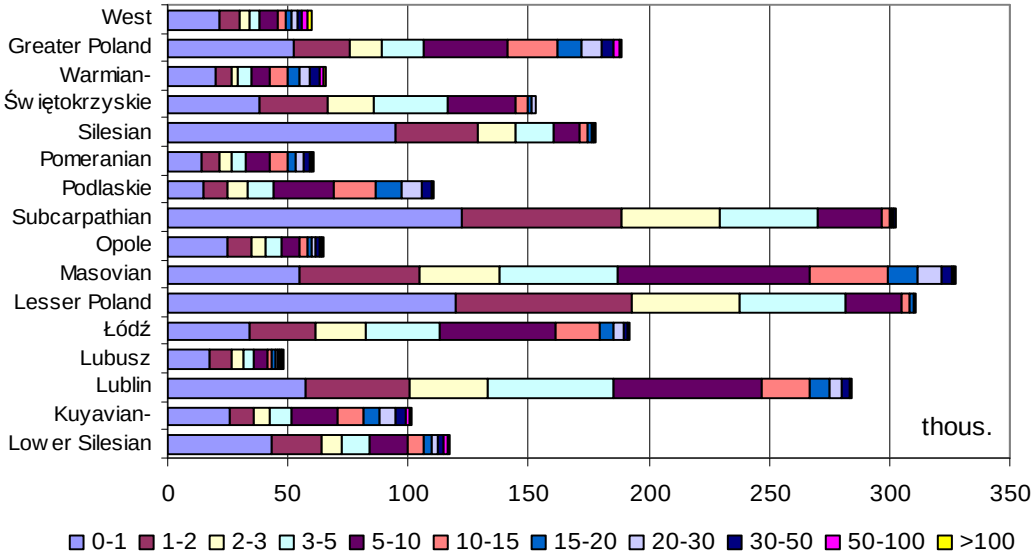
The evaluation of soil and natural conditions made by means of statistical analysis was aggregated to the collective level and a total agricultural production space evaluation index

(APSVI) was calculated as a measure of the production potential of the habitat. The weight of individual factors on the evaluation reflects their rank in their influence on the crops. Soil conditions play a particularly important role in the assessment of agricultural production space; just by the function of soil quality and the evaluation index on its own, is it possible to account for about 70 % of the observed crops changeability. The influence of the other factors is much lesser and makes up about 30 % in total. The share of the agro-climate partial index, which encompasses a complex variety of climatic factors, is contained within the range of 1-15 points, the share of hydrographical conditions ranges between 1 and 5 points and the share of the terrain index between 0.1 and 5 points.

From Fig. 9 it is possible to read that in terms of the agricultural production space evaluation index, the best conditions for plant cultivation are in the Opole Voivodeship (the index value is 82) and the worst in the Podlaskie Voivodeship (the index value is 55). The average index value for Poland is 67.

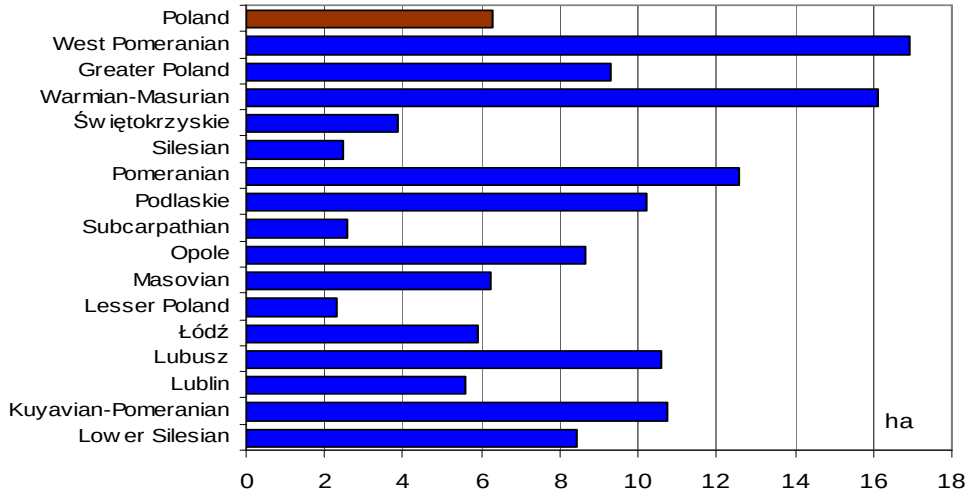
The highest number of farms, more than 300,000 can be found in the following voivodeships: Subcarpathian, Masovian and Lesser Poland. On the other hand, the smallest number of farms, less than 70,000 can be found in the following voivodeships: West Pomeranian, Warmian-Masurian, Pomeranian, Opole and Lubusz (Fig. 10). The largest average area of the farm is in the West Pomeranian Voivodeship – 17 ha, whereas the smallest average area can be found in the Silesian, Subcarpathian and Lesser Poland Voivodeships – about 2.5 ha. In 2008 the average area of the Polish farm was 6.3 ha (Fig. 11).

Figure 10: Farms by voivodeship in 2008



Source: Statistical Yearbook of Agriculture 2009

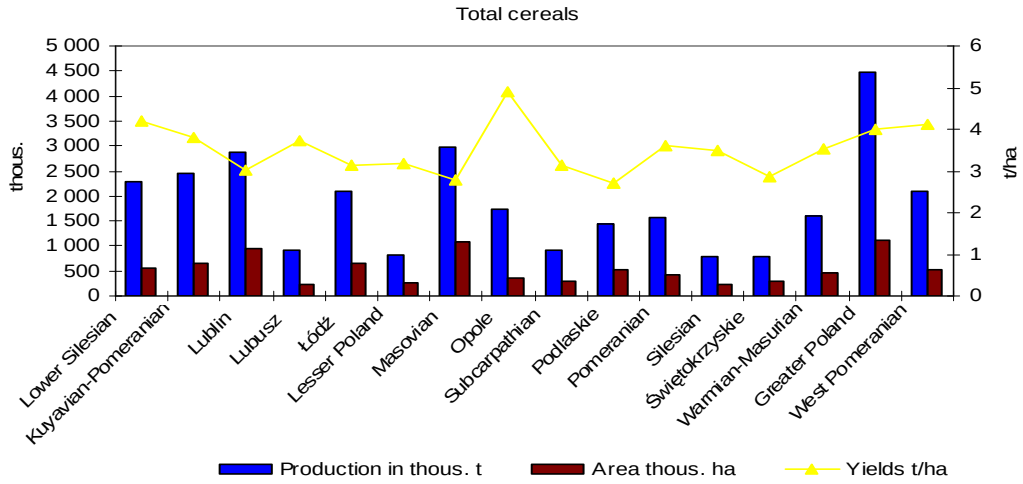
Figure 11: Average farm size by voivodeship in 2008



Source: Own calculations based on the Statistical Yearbook of Agriculture 2009

The following section presents production of selected crops by region. Figures 12-18 show the production, area under cultivation, and crops of selected crops in Poland in 2009. The Greater Poland voivodeship was characterized by the largest area and production of cereals, i.e. 1.12 million ha and 4.5 million tons (Fig. 12).

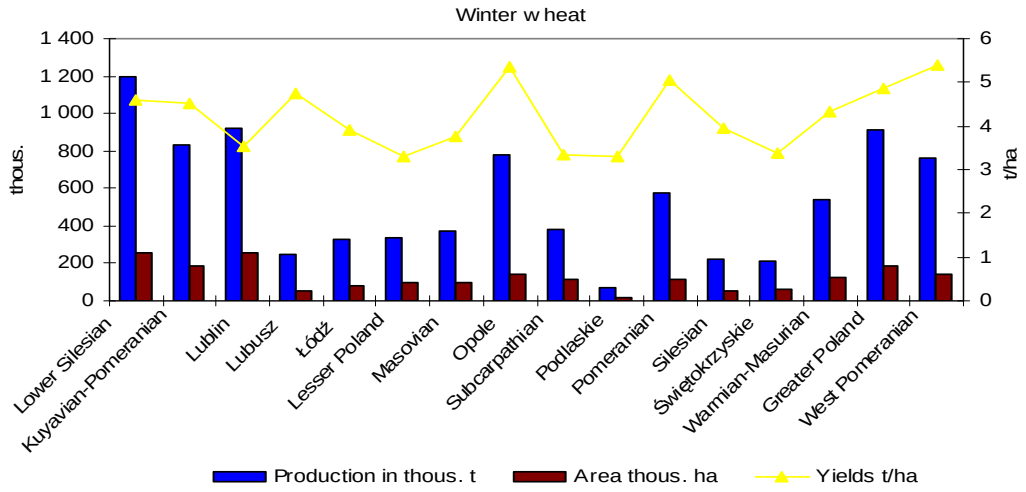
Figure12: Cereal production in Poland in 2009(1,000 t, 1,000 ha and t/ha)



Source: Central Statistical Office 2010

On the other hand, the Opole voivodeship gained the highest average cereal crops at 4.9 tons per ha. Winter wheat production is mainly located in the following voivodeships: Lower Silesian, Kuyavian-Pomeranian, Lublin, Opole, Pomeranian, Warmian-Masurian, Greater Poland and West Pomeranian (Fig. 13). In 2009 75 % of winter wheat production in Poland was concentrated in those voivodeships. As far as rye is concerned, the following voivodeships take the lead: Łódź, Masovian, Greater Poland and West Pomeranian (Fig. 14). The total volume of rye production in those voivodeships was 2.1 million tons, which equaled 57 % of national production. Maize production is concentrated in three voivodeships: Lower Silesian, Opole and Greater Poland (Fig. 15).

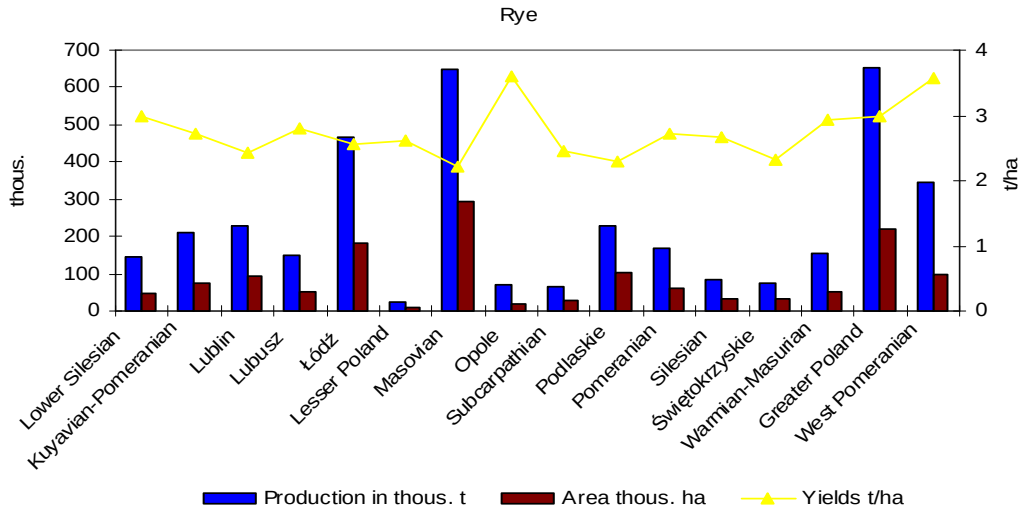
Figure 13: Winter wheat in Poland in 2009 (1,000 t, 1,000 ha and t/ha)



Source: Central Statistical Office 2010

The voivodeships produced 50 % of the national volume of maize in 2009. The key production of winter rapeseed is located in seven voivodeships: Lower Silesian, Kuyavian-Pomeranian, Opole, Pomeranian, Warmian-Masurian, Greater Poland and West Pomeranian (Fig. 16). They are mainly voivodeships situated west of the River Vistula. The total production volume in those voivodeships was 2.1 million tons in 2009, which made up 87 % of the national production. Sugar beets are mainly grown in the Lower Silesian, Kuyavian-Pomeranian, Lublin and Greater Poland voivodeships (Fig. 17). In 2009 the voivodeships produced 7.1 million tons of sugar beets, which equaled 65 % of the national production volume.

Figure 14: Rye production in Poland in 2009 (1,000 t, 1,000 ha and t/ha)

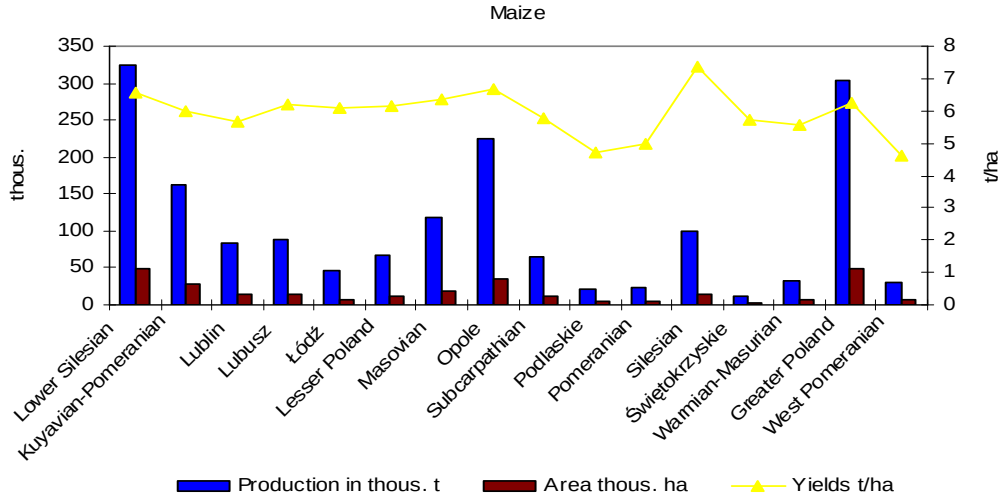


Source: Central Statistical Office 2010

As far as the location of potato production is concerned, it is possible to observe (Fig. 18) that in contrast to the abovementioned crops, potato production is almost evenly distributed, which confirms the fact that potatoes are grown on a very large number of farms and that they are in the first place produced for subsistence. The Masovian voivodeship is the

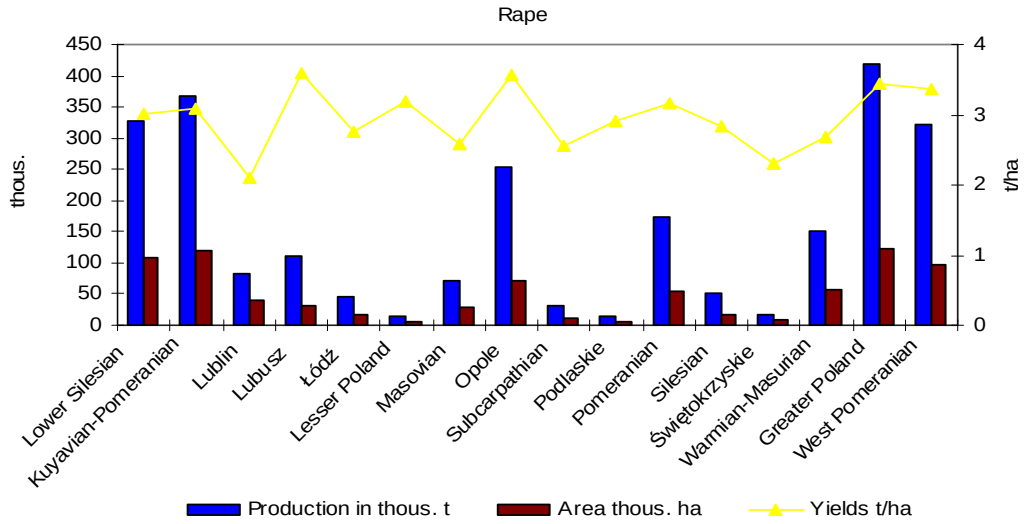
leader in potato production (1.4 million tons). However, considerable quantities are also produced in the Łodź and Greater Poland voivodeships (about 1 million tons each).

Figure 15: The area under cultivation, crops and yield of maize in Poland in 2009



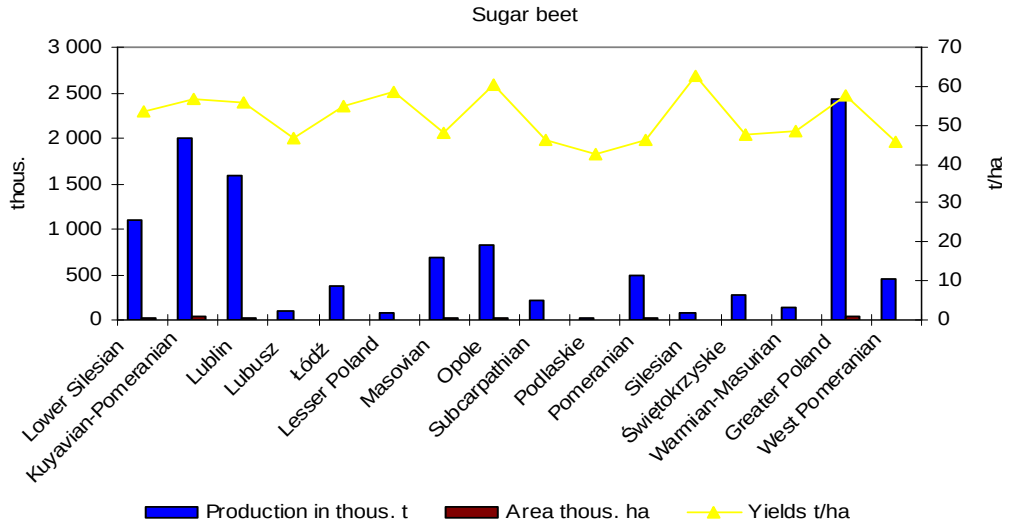
Source: Central Statistical Office 2010

Figure 16: Winter rapeseed in Poland in 2009 (1,000 t, 1,000 ha and t/ha)



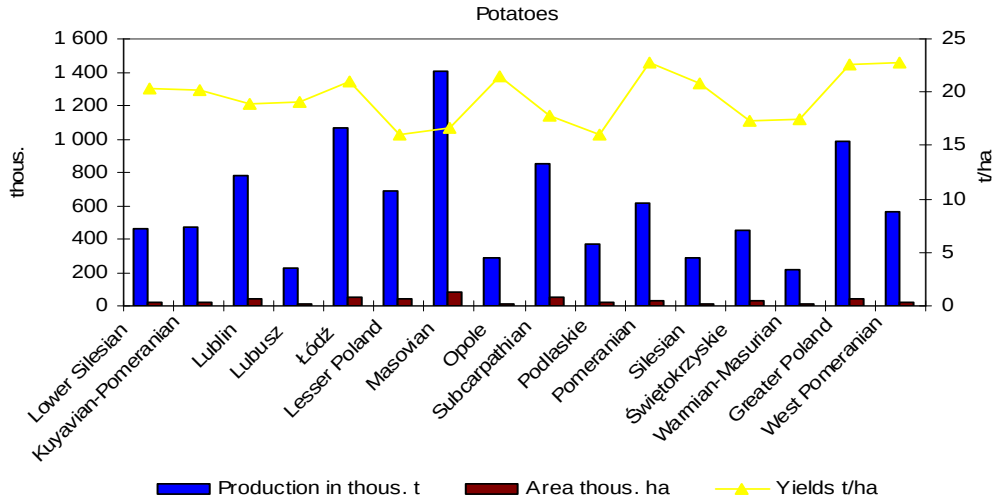
Source: Central Statistical Office 2010

Figure 17: Sugar beet production in Poland in 2009 (1,000 t, 1,000 ha and t/ha)



Source: Central Statistical Office 2010

Figure 18: Potato production in Poland in 2009 (1,000 t, 1,000 ha and t/ha)



Source: Central Statistical Office 2010

4 Crop production potential of Poland

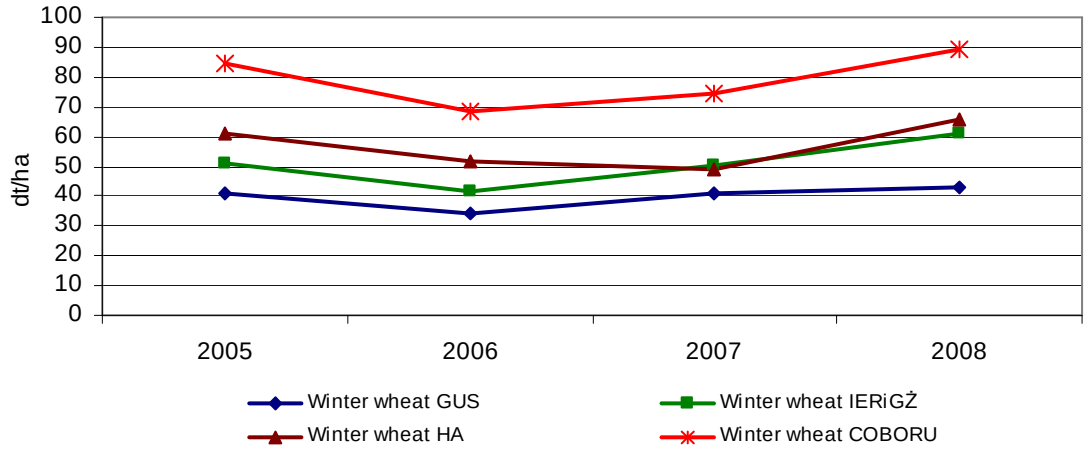
In order to assess the production potential of selected crops a comparison of yield presented by the following entities can be realized:

- the yield from the Central Statistical Office is the average yield obtained by Polish farms,
- the yield figures presented by the Institute of Agricultural and Food Economics are the yield from farms which take part in production activities research within the Agricultural Product Data Collection System. The farms which take part in the research are economically stronger and achieve a higher level of production than most individual farms in Poland,
- the yield data from farms using professional counseling in agricultural engineering provided by a German counseling company Hanse Agro Beratung & Entwicklung GmbH (HA). It must be noted that the quoted yields come from farms with an area larger than 100 ha,

- the yield figures obtained by the Research Centre for Cultivar Testing is the yield obtained on test plots located in different regions of the country. The yields show the crops' production potential under optimal conditions, which normally are not realized under real life farming conditions.

Figures 19-24 show yield data for winter wheat, rye, winter rapeseed, maize, sugar beets and potatoes. Due to the availability of data, the yields data from those crops were presented for the period from 2005 to 2008. The lowest yields of the crops presented are the average yields from the Central Statistical Office, whereas the highest yields are those obtained by the Research Centre for Cultivar Testing. Between the two extremes are the yields from Hanse Agro farms (the second place in winter wheat, rye and rapeseed yields) and the Institute of Agricultural and Food Economics (the second place in sugar beets).

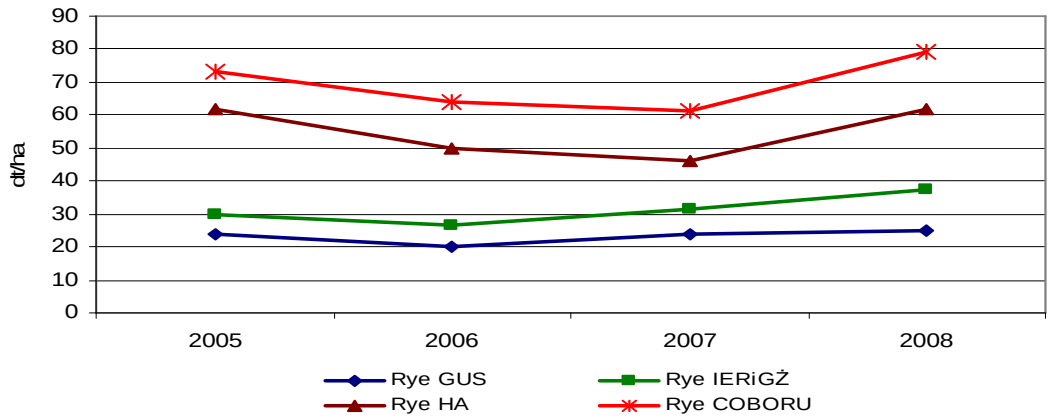
Figure 19: Comparison of wheat yield data from different sources (2005 to 2008)



GUS – Central Statistical Office
IERiGŻ – Institute of Agricultural and Food Economics
HA – Hanse Agro Beratung & Entwicklung
COBORU – Research Centre for Cultivar Testing
Sources: Central Statistical Office 2010, Skarżyńska 2010, Descriptive list of cultivars 2007, 2008 and 2009, Hanse Agro Beratung & Entwicklung 2009

We can see that the yields achieved by the Research Centre for Cultivar Testing are twice as high as the average yields in Poland. As far as the yields quoted by the Institute of Agricultural and Food Economics or Hanse Agro farms are concerned, they are better, but there is still a margin for increase, which means there is still work to be done.

Figure 20: Comparison of rye yield data from different sources (2005 to 2008)

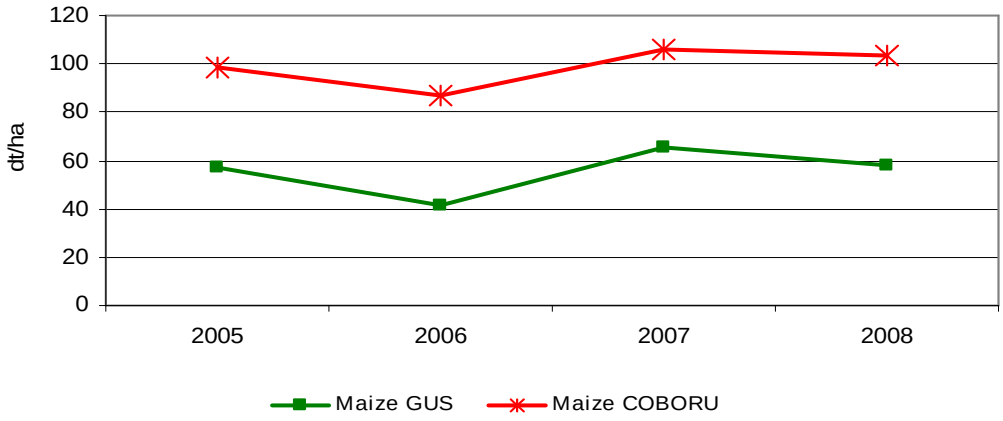


Source and explanations the same as in Fig. 19

It is necessary to note that the yields achieved by the Research Centre for Cultivar Testing are not the upper limit of yield potential. It is known from practical experience that there are farms which achieve even higher yields than those obtained in the experiments of the Research Centre for Cultivar Testing, but it is a small minority of farms. Those farms are usually characterized by very good natural conditions and very good economic and organizational conditions as well as a high level of know-how in production technologies.

For our needs, i.e. to assess the production potential of selected crops in Poland, we considered the yields achieved in the farms of the Institute of Agricultural and Food Economics, Hanse Agro farms and experiments conducted by the Research Centre for Cultivar Testing to be the most relevant ones.

Figure 21: Comparison of maize yield data from different sources (2005 to 2008)

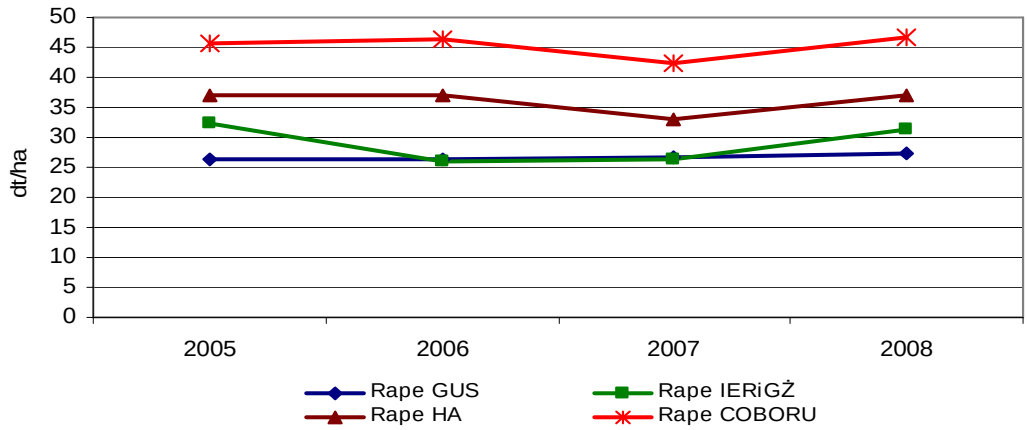


Source and explanations the same as in Fig. 19

However, as far as the cultivation area is concerned, the acreage from 2008 was assumed and the 'maximum' area of cultivation or where it is possible to grow a specific plant was estimated. Table 1 was drawn up for that purpose and it shows in which locations a particular plant can be grown. For wheat it was assumed that it can be grown where wheat, barley, maize and rapeseed are grown at present. For rye, weaker locations were designated, i.e. the areas currently taken by rye, triticale, maize and rapeseed. For maize, similar

assumptions were made as those made for wheat, but they were limited to the following voivodeships: Lower Silesian, Opole, Greater Poland, Silesian, Łódź, Masovian and Lublin. Assumptions similar to those made for wheat were also made for rapeseed. However, the potential for rapeseed was calculated with two variants: Given the agronomical issues created by a high rapeseed density in the rotation a maximum share of rapeseed of 25 % and 33 % alternatively was used.

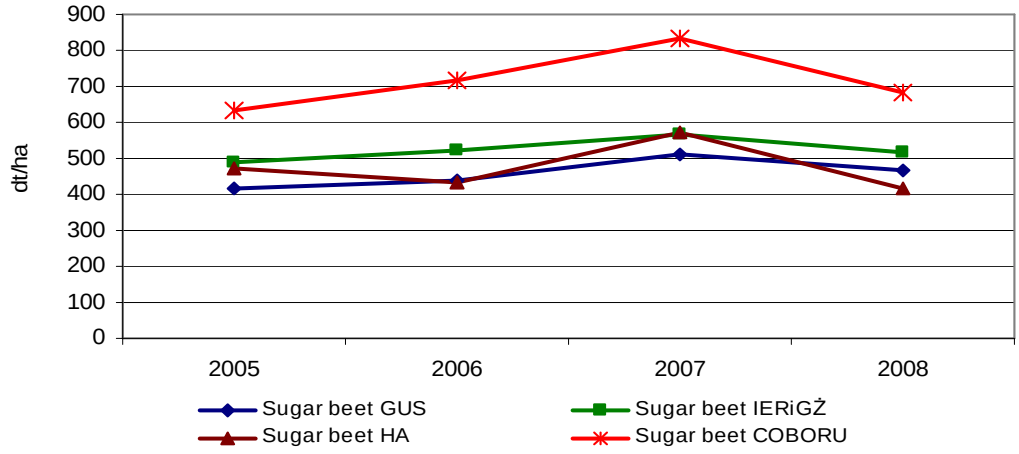
Figure 22: Comparison of rapeseed yield data from different sources (2005 to 2008)



Sources and explanations the same as in Fig. 19

It can be assumed that production of sugar beets and potatoes is not very likely to be increased: In the case of sugar beets because of the quota system and in the case of potatoes due to limitations in demand and the lack of export market. Therefore no acreage expansion of these crops was assumed. Rather the acreage needed to produce the current quantities needed was accounted for. In Poland the current demand for potatoes is about 10 million tons. The maximum Polish sugar beet production can easily be derived from the current quota for Polish sugar production which is about 1.4 million tons. Assuming a 16 % sugar content a total sugar beet production of about 9 million tons is required to fulfill said quota.

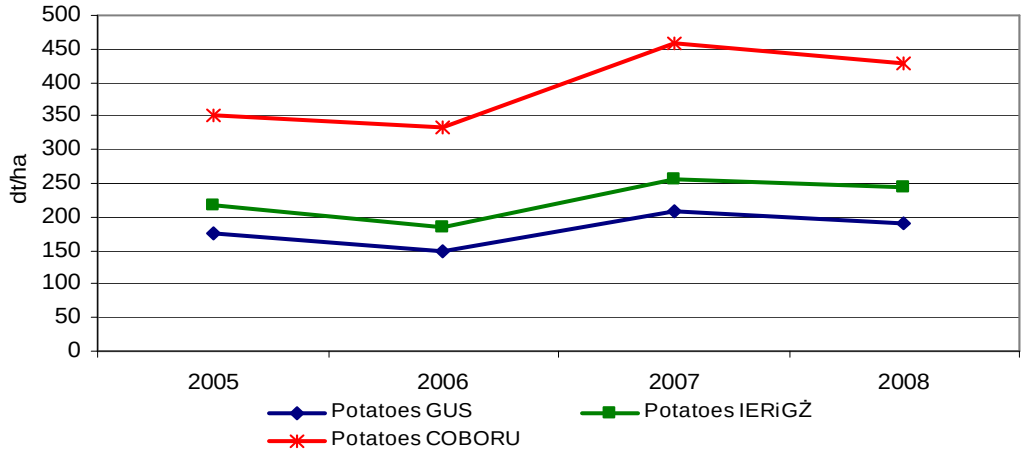
Figure 23: Comparison of sugar beet yield data from different sources (2005 to 2008)



Sources and explanations the same as in Fig. 19

This study shows a certain method of calculation. Naturally the reader may disagree with the assumptions and make his own specific assumptions individually concerning the area of cultivation. Showing the yield volumes achieved by various groups of agricultural producers is a valuable component of this study. On its basis, each reader can make specific estimates concerning production increase with their own estimates concerning the area of cultivation.

Figure 24: Comparison of potato yield data from different sources (2005 to 2008)



Sources and explanations the same as in Fig. 19

Table 2 shows the calculations concerning the capacity to produce the analyzed crops with the assumptions of specific areas of cultivation and achieved yields. Naturally, some of the results obtained may seem to be rather high, e.g. the production of 38.5 million tons of wheat or 37 million tons of rye by Poland. However, these calculations were supposed to show a certain production range. Thus, at the current area of wheat cultivation and average yield, the volume of wheat production in Poland is about 8 million tons. If it were possible to increase the yield to the yields achieved by the farms taking part in the research done by the Institute of Agricultural and Food Economics or Hanse Agro farms, the production volume would rise to nearly 10 million and 11 million tons respectively. As far as rapeseed is concerned, we can see that there is great potential to increase the cultivation area even up to 1.6 million ha or more. By increasing average rapeseed yield to the yields achieved by Hanse Agro farms, i.e. 36 dt/ha Poland will be able to increase the national production to about 3.2 million tons. By doing so, it would be possible to satisfy the demand for human consumption (1.2 million tons) as well as to satisfy 80 % of the future demand for bio-diesel in 2013.

As far as sugar beets and potatoes are concerned, apart from improved production efficiency, higher crop yields will result in freeing a certain acreage of arable land which may be used for other crops.

Increasing the production through better crop yields will result in an even stronger position for the regions that are leaders in the production volume of particular crops. In most cases it is possible to extend the production of the crops in discussion to other regions. Wheat, being a plant for good and very good soils, will be grown in the regions with the best soils. On the other hand, rye will be grown in provinces with poorer soils. As far as soil conditions for rapeseed are concerned, there may be a big potential for production increase in the Lublin, Silesian, Warmian-Masurian or Świętokrzyskie Voivodeships. However, the main limiting factors are: the size of farms (the Silesian and Świętokrzyskie Voivodeships), distance to markets – this primarily applies to the Lublin Voivodeship, difficult climatic conditions,

shorter growing season – the Warmian-Masurian Voivodeship, or simply absence of a tradition for growing the crop and consequently a lack of skills. Considering the current climatic conditions, growing maize has a chance of developing mainly in the southern provinces, i.e. Lower Silesian, Opole, Greater Poland, Silesian, Łódź, Masovian and Lublin Voivodeships. The best region to grow potatoes is the coastal strip. It has better humidity conditions than Central Poland and a lower risk for diseases and the necessity to replace seed potatoes than the south of Poland. Growing sugar beets for energy production could develop in the regions guaranteeing a higher yield than 60 dt/ha. These are the current centers of sugar beet production.

Table 1: Structure of current arable land use (2008) and the potential to grow crops

Suitability for selected crops Current cropping acreage	thous. ha	Winter wheat	Rye	Maize	Rapeseed	Sugar beet	Potatoes
Winter wheat	1,933						
Spring wheat	345						
Rye	1,397						
Winter barley	176						
Spring barley	1,031						
Oats	551						
Mixed cereals for grain	1,444						
Winter Triticale	1,225						
Spring Triticale	109						
Maize for grain	317						
Other cereals	73						
Rapeseed	771						
Sugar beets	187						
Other industrial	45						
Potatoes	550						
Pulses for grain	115						
Feed	929						
Total	**11,198**	**4,875**	**5,349**	**2,644**	**4,875**	**187**	**550**

Source: The author's compilation based on the data from the Central Statistical Office 2010

Table 2: Simulated production volumes of selected crops in Poland

Crop	Sown area thous. ha	Yields* dt/ha				Production (million t)			
		GUS	IERiGŻ	HA	COBORU	GUS	IERiGŻ	HA	COBORU
Winter wheat	1,933	40	51	57	79	7.7	9.9	11.0	15.3
	4,875(1)					19.5	24.9	27.8	38.5
Rye	1,397	23	31	55	69	3.2	4.3	7.7	9.6
	5,349(1)					12.3	16.6	29.4	36.9
Maize	317	56	n.d.	70	99	1.8	n.d.	2.2	3.1
	2,644(1)					14.8	n.d.	18.5	26.2
Rapeseed	771	27	29	36	45	2.1	2.2	2.8	3.5
	1,219(1)					3.3	3.5	4.4	5.5
	1,609(1)					4.3	4.7	5.8	7.2
Crop	Production min. t	Yields* dt/ha				Sown area (thous. ha)			
		GUS	IERiGŻ	HA	COBORU	GUS	IERiGŻ	HA	COBORU
Sugar beets	9	458	525	474	717	196.5	171.4	189.9	125.5
Potatoes	10	181	225	n.d.	393	552.5	444.4	n.d.	254.5

Source: Author's calculations
* average from years 2005-2008; GUS figures (marked in grey) represent current output.
(1) These figures are author's estimates for potential acreage
GUS – Central Statistical Office
IERiGŻ – Institute of Agricultural and Food Economics
HA – Hanse Agro Beratung & Entwicklung
COBORU – Research Centre for Cultivar Testing

5 Conclusions

The results obtained show a huge potential to increase production volumes, even though it should be highlighted that especially with regard to soils and climatic conditions a number of brave assumptions had to be made. Hence figures should be treated with some care. However, when only looking at the key crops wheat and rapeseed an increase of more than 300 % per cent seems to be technically possible. Maize, an emerging crop in Poland could even be taken to an increase of far more than 1,000 % per cent. In general it can be concluded that Poland has the potential to become a bigger player in international commodity markets for arable products.

However, in order to achieve this, it is necessary to make changes aimed at the improvement of economic and organizational factors on farms and the agro technical condition of soils. Production output can be increased by increasing the area of cultivation and better crop yields. In the author's opinion, increasing crop yields is the easier task. In increasing the area of cultivation, one encounters competition with other crops, limitations resulting from crop rotation or other natural conditions. On the other hand, it is necessary to remember that sometimes in the conditions of specific cost/price relations, it is better to harvest 6 tons of wheat at lower outlay and be satisfied with the profit rather than harvest 8 tons of wheat, for instance, which will not cover the outlay.

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