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# Cropping intensity vs. profitability of selected plant production activities in Poland

This study shows the impact of cropping intensity on the economic results of plant production in Poland. The real amount of production outlays, which in value terms represents the level of direct costs, was adopted as the intensity measure. The economic results diversification scale is reflected by the level of gross margin and income from management activity, as well as by the production profitability index in the activity types analysed. When using low-intensity, as compared to high-intensity, cropping technologies, the economic results of the activities in question become more favourable. The profitability analysis of various production factors points to a prevalence of agricultural farms with low intensity levels of the activity conducted. Lower outlays of production means contributed to a more effective utilisation of both the natural soil fertility, and labour combined with fixed assets. A lower use of chemical crop-enhancing agents forces the farmer to employ more environmentally-friendly methods to keep production at a profitable level. The results show that the use of modern technological achievements may contribute to reducing the unfavourable impact of chemical agents on the natural environment, consistent with maintaining high economic efficiency of agricultural production.

**Keywords:** Cropping intensity; direct costs; profitability; gross margin; income from management activity.

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## Introduction

Agriculture in Poland is the main administrator of the natural environment, accounting for 61% of the total area of the country. Although it has considerable production potential, it also poses certain risks to the environment (Jankowiak, 2009). Following the period of profound agricultural intensification in the latter part of the 20th century, the awareness of the unfavourable consequences of an excessive growth in mineral fertilising, or of a proliferated application of chemical plant protection agents, has become wider (Dincer, 2000; Runowski, 2002). At present, Polish agriculture is facing a serious dilemma. On the one hand, an increase in management effectiveness is essential but, on the other, so is product quality improvement. This problem is perceived by many researchers. Attention is focused on ensuring a certain level of yield while minimising the negative impact on the environment and maintaining biodiversity (Wit *et al*., 1987; Zilberman *et al*., 1999; Temme and Verburg, 2011).

The inputs directly contributing to a growth in agricultural production (mineral fertilisers and plant protection agents) are subject to the law of diminishing marginal returns. This means that increasing the utility level of such outlays results in a reduced unit income (Samuelson and Nordhaus, 1995). The outcomes of this process are two-fold: increasing the volume of inputs is more harmful to the natural environment, whereas a reduced income per unit worsens economic results, especially when the unit-based prices increase in connection with their limited supply (Zegar, 2009).

It is estimated that in Poland the agricultural economy interferes with the ecosystems balance to a much lower extent than it does in the countries with highly intensive agriculture. In Poland, there is a prevailing number of family farms, and the processes of industrialisation and agricultural modernisation are usually not advanced. However, the recent period has seen a creation of a group of farms which have already, or will soon, become competitive with the intensive western European agriculture. This phenomenon can be noted especially in the case of multi-commodity farms (Wielicki and Baum, 2008).

In Poland, a systematic increase in the use of mineral fertilisers has been observed in recent years. Its volume has already exceeded 100 kg NPK per hectare of arable land, similar to the ten EU countries (Belgium, the Czech Republic, Denmark, Finland, France, Germany, Ireland, Luxembourg, the Netherlands and Slovenia) with the highest mineral fertilisation rates. Fertilising is one of the most significant yield influencing factors and can also mitigate the effects of crop-limiting factors such as drought, soil reaction or improper rotation (Zalewski and Zalewski, 2010). Plant protection against harmful organisms is another significant element of plant production and in Poland the use of plant protection agents has been increasing. In 2008, it amounted to 1.7 kg of active substance per hectare of arable land, a 0.2 kg increase over 2007. In 2000 the amount was only 0.6 kg per hectare (Zalewski and Pruszyński, 2010).

A lower use of agrochemicals forces the farmer to employ more environmentally-friendly methods to maintain production at a profitable level. Benefiting from biological and technical achievements, it is possible to reduce the unfavourable environmental impact while at the same time maintain high economic efficiency. One of the key questions connected with developing Polish agriculture is whether Poland should follow the path of other developed countries. Agriculture is not only a domain of food production. It also calls for protecting the cultural heritage and landscape values of villages, as their low environmental pollution constitutes an unquestionable asset (Duer, 1996; Runowski, 2002; Woś, 2004).

The agricultural development model in Poland is largely dependent on developments in the European Union (EU) and in the global market. The objective motives which drive the behaviour of farmers, such as the intent to maximise income, also need to be considered. It is projected that in Polish agriculture the dual development path will develop; some farms will apply high economic efficiency-oriented production methods, while observing only the minimum environmental protection requirements, whereas others will opt for more environmental-friendly ones, contributing to the use of the existing environmental and socio-cultural assets. Therefore, the future development of Polish agriculture will be in line with three coordinates, production growth, environmental protection and competitiveness (Runowski, 2002; Zegar, 2009).

A similar view is shared by Ziętara (2009), who believes that the Polish agricultural model will be dominated by family farms in which more attention is given to the quality of the natural environment. Within this group, there is a polarisation phenomenon with, on the one hand, the formation of small farms (up to 5 ha) with poor market relations and, on the other hand, the emergence of commodity farms which tend to increase their area and quantity of production. The production intensity in such entities will be relatively high, though they will be forced to use environmental-friendly methods. Along with family farms, there will also be a number of other legal forms such as companies, but they will not play a crucial role.

Considering the unfavourable environmental impact exerted by an intensive agricultural model, the principal objective of this study was to determine the correlation between the intensity of plant production and its efficiency. The production diversity scale was exemplified using six types of plant production activities of relatively high economic significance in Poland (winter wheat, winter rye, winter triticale, spring barley, winter rape and sugar beet). The economic effectiveness in the groups of farms with differing production intensities was assessed using the profitability index, expressed as a quotient of production values to economic costs, in percentage terms. The levels of productivity and profitability of various production factors were also determined.

## Methodology

The empirical data were collected from private farms located countrywide in 2006-2009. The number of farms in the survey sample ranged from 122 to 275. The farms were selected from a representative sample which was monitored under the Polish FADN system. The choice of farms in each survey year was done on a separate basis. The agricultural production survey was conducted using the methods defined for the AGROKOSZTY system, as part of which the data on production levels, outlays incurred and directs costs is both collected and processed (Skarżyńska, 2007).

Agricultural intensity is reflected in the volume of outlays per one area unit. The attitude to this problem has been changing with time, mainly in the context of selecting the most suitable intensity assessment parameters (Manteuffel, 1984; Hernández-Rivera and Mann, 2008). In the surveys, the real amount of production outlays, which in value terms, represents the level of direct costs, was adopted as the intensity measure. Direct costs of plant production comprise the costs of sowing material, mineral fertilisers, plant protection agents and growth regulators; as well as specialised costs, which are directly related to a specific type of activity, and which increase the quality and value of the final product (e.g. the cost of water used for irrigation and the cost of soil analysis). The structure of such costs is in compliance with the requirements set by the EU in the context of standard gross margin (Augustyńska-Grzymek *et al*., 2000; Eurostat, 2003).

To analyse their intensity production, the farms sampled were ranked by the amount of direct costs incurred per hectare of the area cultivated as part of each activity type. Data were presented in quartiles and, to illustrate the scale of diversity, the results for the two extreme quartiles, i.e. for the groups of farms with low (A) and high (B) level of direct costs per hectare of crop area, are shown for each activity type.

The results were presented in a tabular system using a horizontal analysis based on comparing the parameters characterising the activities surveyed in the farms with low (A) and high (B) cropping intensity. To show the diversity scale, the data are presented as A/B in percentage terms (where the activity-related data for farms B equals 100). The surveys covered income, i.e. the value of potentially commodity-based production from 1 ha of the cultivated area, outlays, costs and economic effects. The level of gross margin and income from management activity was adopted as the principal measure of the effects achieved. These categories were calculated as follows:

- gross margin (direct surplus) =
  production value – direct costs
- income from management activity =
  production value – economic costs

The term *economic costs* relates to total production costs (Samuelson and Nordhaus 1995). These comprise direct costs, indirect costs and the costs of own production factors (i.e. labour, land and capital). Direct costs are those which can be easily assigned to a certain type of activity. Indirect costs include, without limitation, the costs of electricity, fuel, depreciation of fixed assets, current repair of machinery and buildings, taxes. The participation of the production value attributed to specific production types in the total production value was used as the key to distribute the indirect costs of a farm by specific production activity.

The costs of own production factors are treated as alternative costs. For analysis-related purposes, the outlays of own labour were assessed through the normative rate, determined on the basis of an annual average level of employee wages and salaries in the entire national economy (according to the data of the Central Statistical Office – CSO), assuming that one full-time employee works in agriculture for 2200 hours annually. The rent charge was adopted as the measure of land cost. It is expressed in decitonnes (dt) of wheat, which are converted into PLN, based on the average procurement price of wheat in the country (according to the CSO data). The capital cost comprises the cost of operational and fixed capital. The former is understood as the value of outlays incurred on current production assets (e.g. seeds, fertilisers, plant protection agents or fuel), whereas the latter corresponds to the cost of capital invested in own fixed production assets (e.g. buildings or machinery). The cost of capital was estimated through the interest rate for the deposit accounts in leading commercial banks in Poland (according to the CSO). It was assumed that the current capital was frozen for a period of six months and the fixed capital for a period of one year (Skarżyńska, 2010).

The methodology allowed the economic efficiency of the plant production activities surveyed to be assessed in line with the productivity and profitability of individual production factors. Classic economy comprises a concept of three production factors, labour, land and capital. In private farms, the correlation between these is reflected in the relationship between the production value and individual factors, i.e. in the productivity of production factors. In turn, factor-based profitability was represented as the correlation between gross margin and income from management activity, in relation to each specific factor.

When assessing the economic efficiency of the activities surveyed, the focus was on analysing the level of production value and the economic costs incurred to generate this value. The correlations between those variables are reflected in the production profitability index:

$$\text{Production profitability index of the activity analysed [\%]} = \frac{\text{production value}}{\text{economic costs}} \times 100 \quad (1)$$

If the index is lower than 100, the production is unprofitable, whereas the more it exceeds 100, the higher the profitability (Manteuffel, 1984). The following statistical measures were applied to define and estimate the degree of variability: 5% and 95% percentiles, median, quartile deviation, typical variability area and positional variability ratio.

# Results

## Production and economic results of the surveyed activities

The surveys conducted indicate a diverse level of economic results for the production plant activity, depending on the cropping intensity. Of note is the correlation between the amount of direct costs and the cultivation area. In low-intensity farms (A), the area of the activity surveyed lay within the range from 5.9 to 16.8 ha, whereas for the high-intensity ones (B) it ranged from 8.5 to 34.6 ha. It is assessed that the amounts of crop-enhancing agents used in larger-scale farming were purposefully higher, as the farmers expected better production and economic results. This finds confirmation in the fact that in farms B the soil was usually of a better quality. Its utility value (in points) lay within the range from 0.94 to 1.48, whereas in low-intensity farms (A) it ranged from 0.59 to 1.22. Among the factors diversifying the crop volume, the level of direct costs can be, to a large extent, controlled by the farmer. Nevertheless, plant production entails a considerable risk and uncertainty, given the changeable climate factors, which are beyond a farmer's control.

The diversification of cost, production and income categories within the activities surveyed was expressed as a correlation, comparing their level per hectare in low-intensity farms (A) to high-intensity ones (B), in terms of cultivation technologies. The values were given in percentages. The direct costs in group A accounted for 28.4 to 59.0% of those recorded in group B. This means that the figures in low-intensity units (A) – as compared to the high-intensity ones (B) – were between 41.0 and 71.6% lower, depending on the activity and year surveyed.

Two elements dominate within the structure of direct costs, namely the cost of mineral fertilisers and the cost of plant protection agents, their total share amounting from 60.1 to 88.9%. The cost of mineral fertilisers in group A farms accounted for 20.4 to 66.6% of the level attained by group B, whereas the cost of plant protection agents varied from 10.4 to 63.2%. The reason for this could partly stem from the differing purchase prices. However, the largest impact in the case of plant protection agents was exerted by the number of treatments applied, connected with the amount of the active substance used. On the other hand, the diversified cost of mineral fertilisers resulted mainly from differing doses of NPK, which in farms A were considerably lower than in farms B (from 23.2 to 80.0%; Table 1).

The level of fertilising is closely connected with fertilising efficiency. Increasing the efficiency of fertiliser use is essential and recommended, but a serious drawback stems from the fact that soil analyses for fertiliser elements are conducted only sporadically, which often results in irrational fertilising practices. Instead of bringing a positive outcome, fertilising can also result in lower yields (Gębska and Filipiak, 2006).

With a view to assessing the efficiency of the NPK applied, an average gross efficiency was calculated which corresponds to the crop yield expressed in kg per 1 kg NPK. The average gross fertilising efficiency index was higher for group A farms, i.e. those where the NPK dose per hectare was lower. It is assessed that the fertilising practices applied in farms B (with high cropping intensity) were not fully rational, hence their limited impact on crop production. In turn, the practices applied in farms A (with low cropping intensity) created a considerably lower burden on the natural environment and had an additional benefit of better production results for cultivated plants.

The analysis took into account the level of economic costs. The results obtained indicate that their development trend corresponds to the direct costs-related trends. In the farms with low cropping intensity (A), as compared to farms B, the economic costs were lower by 25.6 to 53.9%. This was not only due to direct costs, but also to indirect costs and production factor costs. In farms A, those costs were usually lower than in group B; however, the impact of direct costs on the level of economic costs was considerable. This is reflected in their place within the structure of economic costs, which for group A farms amounted from 28.3 to 46.2%, and for group B farms from 48.0 to 61.6%. Thus the level of direct costs, which are mainly controlled by the farmer, is the factor determining the level of economic costs.

In view of such high differences in cropping intensity, it may be useful to examine its impact, i.e. the low and high level, on production results. In low-intensity farms (A) plant cropping was 4.1 to 38.6% lower than in the high-intensity ones (B). However, in most cases, this negative difference for farms A was around 20%. Sugar beet in 2007 was the only exception. Despite lower outlays, their crop production was higher in farms A (5.8%), which could have stemmed from better soil quality (the soil valuation index in farms A was 1.22 whereas in farms B it equalled 1.13), and from closer attention to the timeliness and quality of agro-techni-

**Table 1:** Plant production activity results for the surveyed farms in the lowest (A) and highest (B) quartile of cropping intensity in Poland in the years 2006-2009.

| Activity | Survey year | Farm group | Crop, dt/ha | Sales price, PLN/dt | Average fertilising efficiency, kg | Data per 1 ha expressed as an A/B correlation, in % | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | NPK dose | Production value | Direct costs | Economic costs | Gross margin | Income from management activity |
| Winter wheat | 2006 | A | 37.4 | 48.05 | 37.74 | 31.0 | 72.6 | 39.7 | 60.7 | 101.1 | 151.7 |
| | | B | 50.2 | 49.70 | 15.65 | | | | | | |
| | 2008 | A | 45.2 | 49.61 | 31.59 | 41.5 | 60.4 | 44.3 | 62.9 | 71.0 | 52.2 |
| | | B | 69.5 | 53.37 | 20.14 | | | | | | |
| Winter rye | 2006 | A | 16.7 | 43.26 | 31.45 | 26.3 | 67.2 | 30.7 | 61.2 | 112.8 | 405.3 |
| | | B | 27.2 | 39.89 | 13.45 | | | | | | |
| | 2008 | A | 31.1 | 40.56 | 41.99 | 31.2 | 66.8 | 31.5 | 46.3 | 103.3 | x |
| | | B | 44.9 | 41.93 | 18.77 | | | | | | |
| Winter triticale | 2006 | A | 28.3 | 43.27 | 43.51 | 21.9 | 83.3 | 28.4 | 56.4 | 161.4 | 645.7 |
| | | B | 36.9 | 40.80 | 12.44 | | | | | | |
| | 2009 | A | 37.4 | 36.12 | 56.64 | 30.2 | 71.6 | 33.0 | 46.1 | 131.8 | x |
| | | B | 51.8 | 35.84 | 23.76 | | | | | | |
| Spring barley | 2007 | A | 35.2 | 61.81 | 48.26 | 30.6 | 88.8 | 42.2 | 71.2 | 112.4 | 127.4 |
| | | B | 38.5 | 63.90 | 16.24 | | | | | | |
| | 2009 | A | 38.1 | 35.22 | 80.96 | 20.0 | 76.6 | 35.6 | 54.2 | 149.4 | x |
| | | B | 45.9 | 38.12 | 19.63 | | | | | | |
| Winter rape | 2006 | A | 24.6 | 93.22 | 9.04 | 69.4 | 78.8 | 43.4 | 57.9 | 125.9 | 346.5 |
| | | B | 31.3 | 92.83 | 7.99 | | | | | | |
| | 2008 | A | 27.8 | 121.15 | 11.43 | 54.9 | 75.8 | 43.2 | 58.1 | 102.0 | 159.1 |
| | | B | 35.4 | 125.40 | 8.01 | | | | | | |
| Sugar beets | 2007 | A | 568 | 10.68 | 165.60 | 76.8 | 102.2 | 56.9 | 74.4 | 143.4 | 225.5 |
| | | B | 537 | 11.13 | 120.40 | | | | | | |
| | 2009 | A | 579 | 11.40 | 220.15 | 64.6 | 94.1 | 59.0 | 73.9 | 123.9 | 269.2 |
| | | B | 604 | 11.69 | 148.77 | | | | | | |

Farm group: A – 25% of farms in the survey sample with a lower level of direct costs, low cropping intensity; B – 25% of farms in the survey sample with an upper level of direct costs, high cropping intensity.
x – means that in group B farms the income from management activity was a negative figure; for rye the loss per 1 ha amounted to PLN – 111, for triticale to PLN – 224, and for barley to PLN – 279.
Source: Institute of Agricultural and Food Economics – National Research Institute, in Poland.

cal treatments on the part of group A farmers.

As regards sales prices, no significant differences were found between the two farm groups analysed, which shows that the price can hardly be controlled by the farmer. The crop and price coefficient is reflected in the production value per hectare, which in farms A accounted for 60.4 to 94.1% of the level attained in farms B (except for sugar beet in 2007). Lower crop yield was the principal factor contributing to this situation (Table 1).

Gross margin and income from management activity were adopted as the measure to assess the economic effects (Table 1). A positive gross margin was realised for all activity types in both farm groups (A and B), though its level was higher in low-intensity farms (A) – the difference amounting from 1.1 to 61.4% (winter wheat in 2008 was an exception). The trend for the level of income from management activity was identical as for the gross margin, given that the favourable difference for low-intensity farms (A) was considerably higher. Indeed, in the case of high cropping intensity (farms B), income from management activity was negative for as many as three activity types: winter rye cultivated in 2008, and winter triticale and spring barley in 2009, where the economic costs were only partly covered, i.e. 94.4%, 89.4% and 86.3%, respectively.

## Profitability index

The statistical methods applied confirmed the conclusions drawn from the tabular data analysis. In low-intensity farms (A) the profitability index median was higher than in the high-intensity ones (B). In group A farms, it fell within the range from 117.5 to 169.4%, whereas in group B it was between 83.2 and 142.8%. Notably, in group B farms the median was lower than 100% for three activity types (rye in 2006, and triticale and barley in 2009), which means that this crop production was unprofitable in most farms.

The positional variability ratio was used to compare the variable production profitability in the two farm groups. In low-intensity farms (A) the ratio fell within the range from 13.5 to 30.9%; whereas for the high-intensity ones (B) it ranged from 10.6 to 22.2%. The results indicate that the variability of the production profitability in group A was higher than in group B.

Quartile deviation illustrates the degree of dispersion of a given feature in the sample. In group A farms, the quartile deviation ranged from 18.5 to 46.8 percentage points; whereas in group B it lay between 11.6 to 24.1 percentage points. This means that in group A the profitability index dispersion around the median was higher for the two middle quartiles within the sample, than in group B. This phenomenon finds confirmation in the area determined by percentiles 5% and 95%. The area occupied by 90% of all observations in farms A was wider than in farms B (Table 2).

**Table 2:** Selected statistics describing the production profitability index for the surveyed farms in the lowest (A) and highest (B) quartile of cropping intensity in Poland in the years 2006-2009.

| Activity | Survey year | Farm group | Percentile 5% | Median | Percentile 95% | Quartile deviation, percentage point | Typical variability area | Positional variability ratio | Percentage of farms with the profitability index exceeding 100 |
|---|---|---|---|---|---|---|---|---|---|
| Winter wheat | 2006 | A | 78.7 | 129.6 | 205.2 | 29.5 | (100.1 ; 159.1) | 22.8 | 83 |
| | | B | 76.8 | 115.1 | 155.4 | 13.9 | (101.2 ; 129.0) | 12.1 | 72 |
| | 2008 | A | 79.2 | 153.6 | 243.4 | 29.8 | (123.8 ; 183.4) | 19.4 | 79 |
| | | B | 76.2 | 121.0 | 187.0 | 22.4 | (98.6 ; 143.4) | 18.5 | 71 |
| Winter rye | 2006 | A | 56.2 | 117.5 | 231.6 | 36.3 | (81.3 ; 153.8) | 30.9 | 68 |
| | | B | 69,0 | 94.2 | 143.3 | 15.3 | (78.9 ; 109.5) | 16.3 | 42 |
| | 2008 | A | 104.8 | 137.3 | 252.4 | 18.5 | (118.9 ; 155.8) | 13.5 | 97 |
| | | B | 69.8 | 102.7 | 161.4 | 22.8 | (80.0 ; 125.5) | 22.2 | 52 |
| Winter triticale | 2006 | A | 84.0 | 152.1 | 292.1 | 46.8 | (105.3 ; 198.9) | 30.7 | 83 |
| | | B | 65.3 | 111.5 | 160.3 | 24.1 | (87.4 ; 135.6) | 21.6 | 63 |
| | 2009 | A | 72.5 | 120.8 | 220.7 | 27.9 | (92.9 ; 148.7) | 23.1 | 77 |
| | | B | 55.6 | 92.1 | 129.4 | 15.6 | (76.5 ; 107.8) | 17,0 | 40 |
| Spring barley | 2007 | A | 100.0 | 169.4 | 276.4 | 39.4 | (129.9 ; 208.8) | 23.3 | 94 |
| | | B | 84.0 | 142.8 | 210,0 | 21.9 | (120.9 ; 164.7) | 15.4 | 88 |
| | 2009 | A | 70.3 | 123.1 | 202.6 | 32.9 | (90.2 ; 156.0) | 26.7 | 71 |
| | | B | 46.3 | 83.2 | 123.5 | 15.8 | (67.4 ; 98.9) | 19,0 | 29 |
| Winter rape | 2006 | A | 53.6 | 118.1 | 234.1 | 27.4 | (90.7 ; 145.4) | 23.2 | 71 |
| | | B | 62.9 | 119.7 | 149.2 | 15.4 | (104.4 ; 135.1) | 12.8 | 81 |
| | 2008 | A | 58.6 | 154.4 | 244.7 | 44.3 | (110.1 ; 198.7) | 28.7 | 77 |
| | | B | 77.1 | 110.6 | 156.9 | 19.2 | (91.4 ; 129.8) | 17.3 | 69 |
| Sugar beets | 2007 | A | 100.1 | 153.7 | 219.6 | 24.2 | (129.5 ; 177.9) | 15.8 | 93 |
| | | B | 85.9 | 114.8 | 158.7 | 14.5 | (100.3 ; 129.4) | 12.7 | 76 |
| | 2009 | A | 84.5 | 138.8 | 198.9 | 31.2 | (107.5 ; 170.0) | 22.5 | 77 |
| | | B | 71.3 | 109.0 | 138.8 | 11.6 | (97.4 ; 120.6) | 10.6 | 60 |

Source and farm groups: see Table 1.

The typical variability area for the production profitability index was determined, based on the median and quartile deviation. The variability area for the profitability index in group A farms was higher than for group B. In eight out of twelve cases under consideration, it was comprised of only those farms in which the profitability index exceeded 100%, which means that the production efficiency was relatively high. In group B farms, such a situation occurred only in four instances.

The results indicate that the variability of the production profitability in low-intensity farms (A) was higher than in the high-intensity ones (B), but the level of profitability was also higher. The preponderance of group A farms is considerable, reflected also in a higher percentage of farms in which the crop production under analysis was also profitable.

## Productivity of production factors

Productivity represents production calculated per one unit of the production factor in value (monetary) terms (Manteuffel, 1984). This index reflects both the technical and economic aspect of the activity conducted (Coelli *et al*., 2005). In Table 3 the factor-specific productivity represents the level of the production value per hectare of land involved in cultivating the plants analysed, per 1 hour of labour expended (own and external), and per PLN 1 of the fixed assets depreciation, involved in the production process. The depreciation cost reflects the consumption of fixed assets (i.e. fixed capital) in the manufacturing process.

In the surveys conducted, the productivity analysis of the production factor outlays was intended to determine to what extent the direct cost management translates itself into the efficiency of the production factors' transposition into the newly-developed products.

As regards land productivity, there is a marked positive correlation between its level and the production intensity. In high-intensity farms (B), land productivity was higher, as compared to the low-intensity ones (A). The cultivation of sugar beet in 2007 was the only exception, with land productivity being comparable for both intensity levels. When comparing productivity in terms of the activity type, it can be clearly inferred that the land intended for sugar beet cultivation showed the highest productivity level, followed by rape and wheat production, respectively. In turn, the lowest land productivity concerned rye. The results indicate that the diversified productivity of land depends, to a large extent, on the mode of its exploitation (which is connected with land fertility), as well as on the availability and use of both labour force and capital.

Labour productivity was also higher in high-intensity farms (except for sugar beet in 2007). The scope of its diversification between specific farm groups was often higher than for land productivity. These disproportions stem from the differences in the production-specific labour consumption, which in high-intensity farms (B) was usually lower. This means that labour efficiency was also influenced by the degree of production mechanisation. Similarly, the productivity of fixed assets was often higher in high-intensity farms (B). Finally, compared to other productivity types analysed, this one showed the lowest variation.

**Table 3:** Productivity expressed in PLN of the production factors involved per 1 ha of crop within the analysed plant production activities for the surveyed farms in the lowest (A) and highest (B) quartile of cropping intensity in Poland in the years 2006-2009.

| Activity | Survey year | Farm group | Land | Labour | Fixed assets | Activity | Survey year | Farm group | Land | Labour | Fixed assets |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Winter wheat | 2006 | A | 1,813 | 150 | 7.7 | Spring barley | 2007 | A | 2,198 | 200 | 8.9 |
| | | B | 2,499 | 207 | 8.4 | | | B | 2,476 | 291 | 10.0 |
| | 2008 | A | 2,241 | 224 | 7.1 | | 2009 | A | 1,342 | 143 | 6.3 |
| | | B | 3,708 | 431 | 8.0 | | | B | 1,752 | 231 | 5.4 |
| Winter rye | 2006 | A | 730 | 94 | 5.1 | Winter rape | 2006 | A | 2,292 | 201 | 7.4 |
| | | B | 1,086 | 114 | 8.4 | | | B | 2,909 | 277 | 9.1 |
| | 2008 | A | 1,260 | 118 | 6.8 | | 2008 | A | 3,366 | 411 | 7.8 |
| | | B | 1,885 | 222 | 7.0 | | | B | 4,442 | 548 | 9.0 |
| Winter triticale | 2006 | A | 1,275 | 140 | 7.8 | Sugar beets | 2007 | A | 6,121 | 199 | 10.9 |
| | | B | 1,531 | 141 | 9.6 | | | B | 5,992 | 186 | 10.5 |
| | 2009 | A | 1,350 | 145 | 6.9 | | 2009 | A | 6,637 | 213 | 6.7 |
| | | B | 1,885 | 181 | 5.6 | | | B | 7,052 | 265 | 6.6 |

Source and farm groups: see Table 1.

## Profitability of production factors

The profitability analysis of production factors, measured through gross margin and income from management activity, indicated that in the farm groups surveyed the development trend for the profitability of production factors was different from their productivity levels. Except in one case, land profitability was higher in the farms applying low-intensity cropping technologies. The diversification between farms A and B was especially marked when profitability was measured through income from management activity. Such a correlation also occurred in the case of labour and fixed assets profitability. This reflected the impact on the results for the economic costs level and the correlation between production factors (Table 4).

In most cases, labour profitability was higher in group A farms. However, it was subject to considerable changes resulting from different labour consumption, which was usually higher in group A farms, due to poorer technical means of production. In this case, the income generated per hectare, i.e. the gross margin or income from management activity, was the factor determining higher levels of labour profitability.

The profitability analysis of fixed assets involved in the production process leads to similar conclusions. The fixed assets profitability for low-intensity farming (A) was higher than in high-intensity farms (B), due to the level of income

**Table 4:** Profitability expressed in PLN of the production factors involved per 1 ha of crop within the analysed plant production activities for the surveyed farms in the lowest (A) and highest (B) quartile of cropping intensity in Poland in the years 2006-2009.

| Activity | Survey year | Farm group | Land | Labour | Fixed assets | Land | Labour | Fixed assets |
|---|---|---|---|---|---|---|---|---|
| | | | Profitability measures | | | | | |
| | | | Gross margin | | | Income from management activity | | |
| Winter wheat | 2006 | A | 1,352 | 111.7 | 5.7 | 496 | 41.0 | 2.1 |
| | | B | 1,337 | 110.5 | 4.5 | 327 | 27.0 | 1.1 |
| | 2008 | A | 1,591 | 159.1 | 5.0 | 448 | 44.8 | 1.4 |
| | | B | 2,241 | 260.6 | 4.8 | 859 | 99.9 | 1.9 |
| Winter rye | 2006 | A | 546 | 70.0 | 3.8 | 77 | 9.9 | 0.5 |
| | | B | 484 | 50.9 | 3.8 | 19 | 2,0 | 0.1 |
| | 2008 | A | 959 | 89.6 | 5.1 | 335 | 31.3 | 1.8 |
| | | B | 928 | 109.2 | 3.5 | -111 | -13.1 | -0.4 |
| Winter triticale | 2006 | A | 1,020 | 112.1 | 6.2 | 452 | 49.7 | 2.8 |
| | | B | 632 | 58.0 | 4.0 | 70 | 6.4 | 0.4 |
| | 2009 | A | 971 | 104.4 | 5.0 | 378 | 40.6 | 1.9 |
| | | B | 737 | 70.9 | 2.2 | -224 | -21.5 | -0.7 |
| Spring barley | 2007 | A | 1,845 | 167.7 | 7.5 | 987 | 89.7 | 4.0 |
| | | B | 1,641 | 193.1 | 6.6 | 775 | 91.2 | 3.1 |
| | 2009 | A | 944 | 100.4 | 4.4 | 242 | 25.7 | 1.1 |
| | | B | 632 | 83.2 | 1.9 | -279 | -36.7 | -0.9 |
| Winter rape | 2006 | A | 1,571 | 137.8 | 5.1 | 731 | 64.1 | 2.4 |
| | | B | 1,248 | 118.9 | 3.9 | 211 | 20.1 | 0.7 |
| | 2008 | A | 2,509 | 306.0 | 5.8 | 1,238 | 151.0 | 2.9 |
| | | B | 2,459 | 303.6 | 5.0 | 778 | 96.0 | 1.6 |
| Sugar beets | 2007 | A | 4,495 | 145.9 | 8.0 | 2,480 | 80.5 | 4.4 |
| | | B | 3,135 | 97.4 | 5.5 | 1,100 | 34.2 | 1.9 |
| | 2009 | A | 4,729 | 152.1 | 4.8 | 1,968 | 63.3 | 2.0 |
| | | B | 3,817 | 143.5 | 3.6 | 731 | 27.5 | 0.7 |

Source and farm groups: see Table 1.

generated from 1 ha. It is worth noting that the production techniques used in low-intensity farms were more cost-efficient, and the consumption of fixed assets in the production process was lower than in the farms using high-intensity technologies. This also had a bearing on the profitability level.

The results of the comparative analysis, focusing on the average profitability of material production factors, indicate that the production potential was exploited to a higher extent in the low-intensity farms (A). Lower outlays (in terms of the current capital) were used in a more efficient way, which also contributed to a better exploitation of labour force and fixed capital. Farmers' decisions regarding crop intensity within the plant production analysed were reflected in the profitability of production factors.

## Discussion

It is commonly believed that conventional farming, characterised by intensive production technologies employing large amounts of industrial means of production, causes degradation of the natural environment. Both sustainable and organic agriculture are proposed as alternative environmentally friendly ways of farming (Helander, 1997). In Poland, due to the big diversity of natural, organisational and economic conditions these three systems can coexist. However, sustainable farming systems, which apart from the function of food production can also shape the landscape and provide benefits to the natural environment, should predominate.

Under the influence of economic factors resulting from the operation of the Common Agricultural Policy, Polish farms are still better adapted to the natural conditions and some of them can also exploit their advantages, such as relatively large labour resources, which stimulate the growth of environmentally friendly production. The re-evaluation of the quantitative development concept takes place in favour of the qualitative solutions. The cultivation technology is improved taking into account not only the production and economic effects, but also the safety of the natural environment. In recent years increasing attention is given to the management of nitrogen and phosphorus in the context of the risks associated with their dispersal in the environment. This dispersal is proportional to the levels of application of mineral fertilisers and the headage of animals. National actions in this area are in line with Council Directive 91/676/EEC (the 'Nitrates Directive', EC, 1991), one of the first European Union (EU) legal acts aimed at controlling pollutants and improving water quality. Agricultural production considerably interferes with the natural circulation of mineral elements mainly through the intensification of production.

Research shows that further increases in nitrogen and phosphorus application are unlikely to be as effective at increasing yields because of diminishing returns. All else being equal, the highest efficiency of nitrogen fertiliser is achieved with the first increment of added nitrogen; efficiency declines at higher levels of application. At present, only 30-50% of applied nitrogen fertiliser and ca. 45% of phosphorus fertiliser is taken up by crops: a significant amount of the applied nitrogen and a smaller portion of the applied phosphorus are lost from agricultural fields (Tilman *et al*., 2002).

The results show that the high intensity does not ensure the relatively highest crop yields, nor the highest level of incomes. In Poland the highest yield of winter wheat (ten year average, 1997-2006) was achieved in the sustainable farm production system (6.5 t/ha). In the intensive farming system the yield of winter wheat was lower by 6%, and in the case of organic – 34%, than in the sustainable farm production system (Jończyk *et al.,* 2007). Other authors also show that high yields can be obtained by using environmentally friendly farming practices, which also have a lower negative impact on the environment (Tuomisto *et al.,* 2009).

The studies conducted in Poland also show the benefit of technology with lower intensity of production. Forms of production using lower input levels contributed to a better use of not only land and its natural fertility, but also labour force and fixed assets. Both at the level of gross margin and income from management activity, the economic results of plant production activities were better than in farms with high intensity production. Profitability of the production factors was also at the higher level. Production efficiency measured by the profitability index was also higher for farms applying technologies at lower intensity cropping. High production efficiency is the key in the search for a model of development of Polish agriculture. However this model cannot exclude the pace of transformation of the whole economy to improve its competitiveness and the processes taking place in the EU.

The model of intensive farming in European conditions is losing its importance. In addition to its economic function, the social and ecological functions of agriculture are being increasingly recognised. The concern for human health, the environmental protection and cleanliness, and the preservation of landscape suggest a slightly different direction for the future development of farms (Zilberman *et. al*., 1999; EC, 2011). By 2050, the global population is projected to be by 50% larger than at present. Further increases in agricultural output are essential for global political and social stability and equity. A major challenge is to maintain the food production at the appropriate level. But doing so in such a way that does not disturb the environmental balance and threaten public health is a greater challenge still. This direction of agricultural development, however, should predominate as the net benefits to society will be much higher in comparison to the highly intensive agriculture.

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