JEE Journal of Ecological Engineering
Volume 19, Issue 6, November 2018, pages 146–152
https://doi.org/10.12911/22998993//91877

Received: 2018.05.30
Accepted: 2018.08.15
Published: 2018.11.01

Ecological Evaluation of Sustainable Development in the Studied Farms of Przysucha County

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ABSTRACT

The subject of the research involved the agricultural farms from the Przysucha county (Masovian Voivodeship, Poland). The assessment of ecological results from farms was the purpose of the thesis. Evaluation was made by using selected indicators: minerals balance, soil's organic substances balance and vegetation cover of soil's index. The research was carried out among 100 chosen agricultural farms, situated on light soil, i.e. rye soil. The ecological assessment of the examined farms showed that all of minerals balances (N, P, K) and soil's organic substances balances were positive. In the case of nitrogen, balances exceeded the limit value 30 kg $N \cdot ha^{-1}$. Vegetation cover of soil's index, as regards arable land, did not reach the recommended value, i.e. at least 60%. However, the cover of utilised agricultural area soil was similar to the recommended level (>70%). That was because of the large orchards and permanent crops share in horticultural farms, as well as large permanent grassland share in bovine and mixed farms.

Keywords: ecological assessment, result, agricultural farm

INTRODUCTION

The general concept of sustainable development covers all areas of human activity. The area of agriculture, which is featured by many connections with the natural environment [Fotyma, 2000] is particularly important. The rough definition of FAO, which is closer to the area of agriculture, recognizes sustainable development as management of natural resources, their protection and such a direction of technological and institutional changes which meets the needs of people now and in the future [Faber, 2007].

In practical terms, sustainable agriculture should simultaneously and harmoniously fulfill four main goals: production, economic, environmental and social ones [Fotyma, 2000]. The production goal is to produce the right amount of agricultural products (raw materials) with the qualities required by the consumer or the processing industry. The economic goal is to generate agricultural income that ensures a decent standard of living for the farmer and his family as well as enables the development of the farm. The ecological goal is to ensure the long-term balance of the agrosystem and to prevent the degradation of the natural environment. On the other hand, the social goal is defined quite generally as being reduced to the acceptance of non-agricultural part of the society for the actions of agricultural producers [Fotyma, 2000]. Thus, the essence of sustainable farming in agriculture can be defined as the aspiration to obtain both stable as well as economically and socially acceptable production, in a manner that does not threaten the natural environment.

The goals, tasks and ways of implementing sustainable development in Poland were defined in strategy programs [Strategy 1999; Strategy

2012], and a set of environment-friendly agricultural practices, the application of which will ensure sustainable development in the field of agricultural production, is included in the code of good agricultural practice [Duer ed al. 2002].

The issue of sustainable development of agriculture at the level of the region and the country as well as farms is the subject of investigation of research institutes and universities. In the studies carried out by research institutes at the farm level, the ecological (environmental) and economic criteria are mainly applied. The IAFE-PIB research uses the GUS (The Polish Central Statistical Office) data and the data from the FADN accounting system. Within the given criterion, individual research units apply slightly different sets of analytical indicators. The strength of the surveyed farms is very different, often depending on the implementation capacity and the sources of financing (FADN system, long-term programs, research projects, statutory topics). In this respect, IAFE – PIB is featured by the most comprehensive scope of research, using data from the Central Statistical Office (over 2,300,000 farms) and the FADN system (over 12,000 farms) [Wrzaszcz, 2012, Zegar, 2013]. In other scientific units studies, the number of farms is much smaller.

In the absence of a consistent approach to measuring sustainability, various criteria for assessing sustainable development are adopted. Three criteria (dimensions, ranges) of the assessment are most often taken into account: economic, ecological and social [Kotosz, 2012; Häni, 2004; Faber, 2007; Majewski, 2008; Faber et al.2010; Baum, 2011; Sadowski, 2012; Harasim 2014]. According to Majewski [2008, 2009], a sustainable and permanent development is featured by actions that should be economically viable, ecologically safe and socially acceptable. The ecological criterion is also defined as environmental or agri-environmental [Faber, 2007, Toczyński et al. 2009, Wrzaszcz, 2011, 2012].

Moreover, there are proposals for a wider scope of assessment by adding other dimensions: institutional [Piontek, 2002, Adamowicz and Dresler, 2006, Florczak, 2008], spatial [Borys, 1998, Piontek, 2002, Adamowic and Dresler, 2006], and cultural [Bombik and Marciniuk-Kluska, 2010], moral [Piontek, 2002, Adamowicz and Dresler, 2006] and ethical [Runowski, 2007, Siemiński, 2011]. There are proposals of assessing the sustainable and permanent development taking into account six criteria, i.e. economic, ecological, spatial, technical and technological, socio-cultural and ethical [Siemiński, 2011], or in the assessment of administrative units (communes) divided into five ranges: economic, ecological, social, institutional and spatial [Adamowicz and Dresler, 2006]. According to Majewski [2008, 2009], five criteria of assessment: economic, ecological, social, organization of production and management, and quality of the production space, can be adopted as the basis for constructing the synthetic indicator of durability of the farm. In the opinion of Zegar [2007], the diversity of agriculture, i.e. natural conditions, economic entities, production technology and other circumstances, creates a difficulty in establishing uniform criteria for assessing the sustainability of agricultural holdings.

The basic elements of the ecological assessment of farms provide the balance of nutrients and soil organic matter, as well as the degree of soil cover with vegetation [Harasim and Włodarczyk, 2016]. In the case of crop production, the management of mineral components is very important, because its proper process determines the satisfactory crop yield, positively affects the change of soil fertility and reduces the soil and groundwater contamination with biogenes. The management of mineral components (nitrogen, phosphorus and potassium) and organic matter should be based on balance sheets, which take into account the revenues of components from all the sources and their outflows along with crops harvested from the field.

The nitrogen balance is generally upset and difficult to maintain at a certain level, because on farms there may be losses that are difficult to predict. Its gaseous forms can oxidize and infiltrate into the atmosphere, and nitrate forms can be washed out to deeper layers of soil and groundwater [Sainju, 2017]. According to the Code of Good Agricultural Practice [Duer et al., 2002], the environmentally safe balance of nitrogen should not exceed 30 kg N/ha UAA. In the case of phosphorus and potassium, their balances should be sought for (revenue = use). On the soils with very low phosphorus and potassium content, it is recommended to use higher doses of fertilizers (by about 50%) in relation to the absorption of these components in the yield of plants [Jadczyszyn, 2005]. However, on soils with very high abundance of these nutrients, their doses in fertilizers can be reduced by 50% in relation to the absorption along with the crops yield.

RESEARCH METHODOLOGY

The source material consists of the research carried out in Przysucha province, located in the southern part of Masovia Province in Poland. One hundred farms located on light soils, i.e. rye complexes were examined. The information and the source data from farms were obtained during a direct interview with the use of a questionnaire. A purposeful selection of research objects from farms cooperating with the Mazovian Agricultural Advisory Center was used. The division of the farms under examination into groups was carried out within particular evaluation criteria, such as the direction of production, the size of the farm area, the quality of the soils of agricultural land and the intensity of production.

When developing the material, a tabular-descriptive method with elements of horizontal analysis was used.

RESEARCH RESULTS

The assessment of sustainable development of farms can be made on the basis of various criteria, e.g.: production, economic, ecological. For the purpose of this study, the assessment of ecological conformity of agricultural practices to the principles of sustainable development of farms was made on the basis of quantitative indicators. The balance of minerals at the field level was evaluated (balance N, P, K in kg·ha^{-1} UAA) and organic matter in the soil (t·ha^{-1} AL) and soil cover with vegetation (% AF and UAA) (Table 1).

In the ecological assessment, the mineral balance at the field level was calculated taking into account as the incomings of the components used in mineral and natural fertilizers including straw for plowing, and in the case of nitrogen the extra amount of this component from atmospheric precipitation (10 kg N·year). On the outflows side, there were certain quantities of components extracted from the soil with main and side yields. The content of minerals (NPK) in the main and side yields as well as in the manure and straw (plowed) was adopted as the standard ones from the literature [Krusze, 1984, Fotyma and Mercik, 1985, Maćkowiak and Żebrowski, 2000, Gorlach and Mazur, 2001]. The soil balance of the organic matter was calculated with the use of the reproduction and degradation rates of humus [Duer et al., 2002]. The indices of arable land cover with vegetation in winter and cover of agricultural land with vegetation during the year were calculated in accordance with the methodology included in Harasim's study [2004]. The study also assessed the intensity of the organization of agricultural production according to the Kopec's method [1987]. The above-mentioned indicators, due to the availability of source data, are most often included in the works pertaining to the problem of sustainable development of farms [Fotyma and Kuś 2000; Faber 2001; Kuś and Krasowicz, 2001; Kopiński, 2002; Krasowicz, 2005, 2006; Kuś, 2006; Harasim and Włodarczyk, 2007].

In the analysis of selected ecological indicators, the amount of the soil balance of the organic substance (t d.m·ha AL) and the index of soil cover with vegetation (%) were very important. The balance of organic matter in soil determines the fertility and productivity of soils. If the balance was negative in the long term, the soil could degrade. The index of soil covering with vegetation significantly affects the impact of an agricultural holding on the environment [Kuś and Krasowicz, 2001]. Higher values of this index indicate a lower risk of nitrate leaching and better soil protection against erosion. The essence of the correct crop structure on arable land is to run such an economy to have as large area of "green fields" in the winter time as possible. From the point of view of the principles of good agricultural practice in flat areas, the cover of soil with vegetation should reach at least 60% of arable land [Duer et al., 2002].

Table 2 presents the data connected to the balances of the basic minerals and soil organic substance as well as the soil coverage index. In regard to the nitrogen balance, it can be concluded that all types of farms exceeded the safe value of the balance of this component (30 kg N·ha^{-1}). The largest exceeding of the recommended bal-

Table 1. Indicators for assessing the ecological conformity of agricultural practices with the principles of sustainable development

Quantitative indicators	Hazard values
Balance:	
- nitrogen (N)	< 30 kg N·ha^{-1} UAA > 0
- phosphorus (P_2O_5)	balance ≥ 0
- potassium (K_2O)	balance ≥ 0
- organic matter in the soil	balance ≥ 0
Soil cover by plants:	
- arable land	> 60% area AL
- utilised agricultural area	> 70% area UAA

Table 2. Ecological indicators featuring particular types of farms.

Specyfication	Farms in total	Direction of production			
		orchards	vegetables	mixed	cattle
Balances of mineral components (inflow-outflow), (kg/ha of UAA):					
- N	49.6	62.4	53.5	46.9	39.0
- P_2O_5	49.6	35.1	54.8	48.7	56.7
- K_2O	66.7	78.8	88.0	57.2	51.2
Amount of soil organic substance balance (t d.m.·ha^{-1} AL)	0.34	0.47	0.33	0.15	0.37
Index of soil cover with vegetation (%):					
- arable land	42.6	36.3	33.7	51.4	48.5
- utilised agricultural area	67.5	79.7	53.8	69.7	67.3

ance by 108% was recorded in the fruit farms, followed by the vegetable farms with a surplus of 78% and next the mixed (56%) and the cattle ones (30%). Nitrogen surplus may affect the pollution of deeper layers of soil and groundwater with nitrates. In cattle farms, exceeding the recommended nitrogen balance was the lowest. In this group of farms, fertilization was based largely on its own natural fertilizers and supplemented in mineral form. In contrast, the other types of farms, especially those with horticultural production, were mostly based on mineral fertilizers and did not conduct a rational management of this component. In the case of phosphorus and potassium, it is recommended that their balances on soils with medium abundance in these components should be balanced (income = expenses) [Harasim and Włodarczyk 2016].

The lowest phosphorus balance occurred in the fruit farms (Table 2). In the other farms, too high surpluses of this component have no rational justification. In the case of potassium balance, they were higher than with phosphorus. The largest balance of potassium was found in the vegetable farms (88.0 kg $K_2O \cdot ha^{-1}$) and the orchards (78.8 kg $K_2O \cdot ha^{-1}$). In the other types of farms, i.e. the mixed and cattle ones, the potassium balance was significantly lower (Table 2). Such significant balances of all components prove that the farmers did not examine the soil and did not use fertilization on the basis of analysis results and recommendations of the advisory services, and the fertilizer doses resulted rather from their own habit of using them with individual crops (higher fertilization in the horticultural production, and lower in the other crops). In this case, the principle of rational fertilization was not respected, and the use of excessive fertilization may have had a negative impact on the natural environment and negatively affected the efficiency of crop production.

The balance of organic matter determines the fertility and productivity of soils (Duer et al. 2002). Out of the 4 types of farms considered, the fruit farms were marked by the largest amount of the soil organic substance balance (Table 2), which results from the use of a large amount of natural fertilizers on the fields for new plantings of fruit trees. The lowest balance of organic matter was found in the mixed farms, featured by a high share of cereals in the crop structure (82.6%), which significantly contribute to the degradation of organic matter in the soil.

The index of soil cover with vegetation in winter, so-called "green fields" is also a very important indicator of ecological assessment [Harasim, 2004]. As regards AL, the highest ratio was found in the mixed farms (51.4%) and the lowest in the vegetable ones (33.7%) with the lowest share of cereals in crops (63.3%). However, no type of farms had a 60% level of covering arable land with green plants during the winter, which could expose soil to erosion and nitrate leaching to groundwater. With regard to the area of arable land, only the group of the vegetable farms with the index of 53.8% did not exceed the safe level of 60% of the level of soil cover with green plants (Table 2). However, the largest index (79.7%) characterized fruit farms. The level of this index in the mixed and cattle farms was affected by the share of permanent grassland in the structure of utilized agricultural area. This share for the mixed farms was 25.2%, and for the cattle ones – 34.8%.

The ecological indicators did not show a clear dependence on the area of farms (Table 3). In the group of farms with the area of 7–15 ha UAA, the highest values were achieved by the balance of nitrogen and phosphorus. Only the phosphorus balance increased along with the growing area of the farm. The amount of the soil organic matter balance was the highest in the large farms with the area > 15 ha of UAA, which is related to their livestock production. They had their own manure, but their crop structure was more varied.

The index of soil cover with plants on arable land reached the highest values in small (<7 ha) and large (> 15 ha) farms (Table 3). In small farms, the higher index comparing to the medium farms can be explained by the cultivation of green plants for plowing in the spring to enrich the fields with organic matter for new planting of fruit trees or by spring vegetables production, which partially replaces the manure fertilization. In the farms over 15 ha, the higher index indicates a high share of winter cereals in the crop structure. However, no type of farms achieved a safe 60% for the rate of soil cover with vegetation. The correlation of this index on the utilized agricultural area was similar. Farms with the area of <7 ha were marked by the highest index (71.2%), which is connected with fruit production. In medium and large farms (7–15 and> 15 ha of UAA), permanent grassland appeared, being the main feed base for the cattle kept on the cattle and mixed farms.

In the assessment of the ecological indicators, depending on the quality of utilized agricultural area, the largest balances of basic nutrients (nitrogen, phosphorus and potassium) were recorded in farms with very poor soils (Table 4). The use of higher fertilization on very poor soils has a logical explanation, because farmers wanting to obtain satisfactory yields use a higher level of fertilization. However, it should be remembered that very poor (light) soils are particularly susceptible to leaching the excess components into ground and surface waters. Therefore, mineral fertilization on these soils should be under special control, so as not to expose the natural environment to pollution with these components [Harasim and Włodarczyk, 2007].

The amount of soil organic substance balance was higher in the farms with very poor and medium soils. The index of soil cover with vegetation on arable land was the highest in the farms with very poor soils (52.6%), which is associated with a large share of winter cereals in the crop structure. The lowest index of soil coverage (28.7%) occurred on medium soils which were used more often for fruit and vegetable cultures. The index of coverage of the utilized agricultural area by vegetation did not show a clear dependence on its quality.

Table 3. Ecological indicators depending on the area of the farm

Specification	Farms in total	Size of a farm (area of UAA in ha)		
		<7	7–15	>15
Balances of mineral components (inflow-outflow), (kg/ha of UAA)				
- N	49.6	49.1	54.4	40.5
- P_2O_5	49.6	44.6	47.5	52.9
- K_2O	66.7	66.6	76.5	54.8
Amount of soil organic substance balance (t d.m·ha^{-1} AL)	0.34	0.37	0.27	0.54
Index of soil cover with vegetation (%):				
- arable land	42.6	46.0	37.1	47.0
- utilised agricultural area	67.5	71.2	65.2	66.2

Table 4. Ecological indicators depending on the quality of utilized agricultural area

Specification	Farms in total	Soil quality (UAA valuation indicator)		
		very poor (<0.5 points)	poor (0.5–0.7 points)	average (>0.7 points)
Balances of mineral components (inflow-outflow), (kg/ha of UAA)				
- N	49.6	56.2	46.0	50.8
- P_2O_5	49.6	58.3	48.2	43.0
- K_2O	66.7	76.8	63.0	68.9
Amount of soil organic substance balance (t d.m.·ha^{-1} AL)	0.34	0.44	0.31	0.42
Index of soil cover with vegetation (%):				
- arable land	42.6	52.6	43.9	28.7
- utilised agricultural area	67.5	66.7	67.4	68.8

Table 5. Ecological indicators depending on the intensity of production (direct costs)

Specification	Farms in total	Intensity of production (direct costs in PLN/ha UAA)		
		extensive (<600 PLN)	mid-intensive (600–1200 PLN)	intensive (>1200 PLN)
Balances of mineral components (inflow-outflow), (kg/ha of UAA)				
- N	49.6	45.2	42.5	60.0
- P_2O_5	49.6	51.3	44.1	57.8
- K_2O	66.7	58.4	64.3	79.1
Amount of soil organic substance balance (t d.m.·ha^{-1} AL)	0.34	0.31	0.30	0.47
Index of soil cover with vegetation (%):				
- arable land	42.6	49.6	47.7	31.8
- utilised agricultural area	67.5	69.0	68.9	65.2

Table 5 presents the ecological indicators depending on the intensity of production measured by the level of incurred direct costs. The highest balances of minerals (NPK) occurred under the conditions of intensive production, which features the profile of fruit and vegetable farms. Lower balances of nitrogen and phosphorus appeared in the medium-intensive farms, and in the case of potassium – in the extensive ones.

The amount of soil organic substance balance was the highest in the intensive farms (Table 5). The index of soil cover with vegetation on arable land was more dependent on the intensity of production than the index of utilized agricultural area cover. In the first case, the least favorable soil cover with vegetation was found in farms with intensive production with a small share of winter cereals in crops. This concerns mainly the farms specializing in the horticultural and vegetable production. The level of the index referring to utilized agricultural area was quite similar in the groups of farms with varying intensity of production.

CONCLUSIONS

1. To sum up the ecological assessment, it can be concluded that the balances of all mineral components (NPK) and soil organic matter were positive. In the case of nitrogen, the balance exceeded the limit value of 30 kg N·ha^{-1}. Under the conditions of very light soils and with a higher level of production intensity, the balances of mineral components reached the highest values.
2. The principle of rational fertilization in the surveyed farms was not respected, and the use of excessive fertilization may have had a negative impact on the natural environment and negatively affected the efficiency of crop production.
3. The index of soil cover with vegetation in relation to arable land did not reach the recommended value, i.e. at least 60%. In the case of utilized agricultural area the index of soil cover with vegetation was close to the recommended level (> 70%), which was affected by a large share of orchards and permanent plantations in the fruit farms and permanent grassland in the cattle and mixed farms.

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