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SUSTAINABILITY LEVEL OF AGRICULTURAL PRODUCTION IN THE SELECTED ORGANIC FARMS

Summary

The paper analyses the sustainability level of agricultural production in the ecological, social and economic aspect in 50 organic farms located in the southern Poland. Material and energy inputs, balancing the organic substance, work burdening and economic and production effects were assumed as the measures used for the assessment of those three categories of balancing the production process. Area of agricultural land was accepted as a comparative criterion. It was found out that the assumed criteria of sustaining the production process are met in majority in the investigated farm groups. Statistical analysis proved a significant relation between the area of agricultural land and the basic measures of the production sustainability and the Duncan test showed significant differences between the area groups.
***Key words**: production sustainability, organic substance balance, work burden, agricultural income, organic farms, production organization intensity*

POZIOM ZRÓWNOWAŻENIA PRODUKCJI ROLNICZEJ W WYBRANYCH GOSPODARSTWACH EKOLOGICZNYCH

Streszczenie

W pracy analizowano poziom zrównoważenia produkcji rolniczej w aspekcie ekologicznym, społecznym i ekonomicznym, w 50 gospodarstwach ekologicznych, zlokalizowanych w regionie Polski południowej. Jako mierniki wykorzystane do oceny tych trzech kategorii zrównoważenia procesu produkcji przyjęto nakłady materiałowo-energetyczne, zbilansowanie substancji organicznej, obciążenie pracą oraz efekty ekonomiczno - produkcyjne. Za kryterium porównawcze przyjęto powierzchnię użytków rolnych. Stwierdzono, że przyjęte kryteria zrównoważenia procesu produkcyjnego są w większości spełnione w wyróżnionych grupach gospodarstw. Analiza statystyczna wykazała istotny związek między powierzchnią użytków rolnych a podstawowymi miernikami zrównoważenia produkcji, zaś test Duncana wykazał istotne różnice między grupami obszarowymi.
***Słowa kluczowe**: zrównoważenie produkcji, bilans substancji organicznej, obciążenie pracą, dochód rolniczy, gospodarstwa ekologiczne, intensywność organizacji produkcji*

1. Introduction

The idea of sustainable agriculture consists in rationalization of production intensity in order to improve the quality of natural environment [1]. This system may be discussed starting from the specific field, cultivation or other agricultural activity through the farm, local, regional and national level and ending with the continental and global one [2, 3].

The sustainable agricultural production is complex and is defined by:

- rational management of natural resources in order to maintain soil fertility, capacity to renew it and limit environment degradation;
- introduction of new technologies which provide not only production increase but also ensure reduction of effort, work safety and farmers' life comfort;
- the level of agricultural production and parity family income of a farmer referred to other domestic economy branches;
- supply of varied non-commercial goods and services including the social and cultural ones. Thus sustainability of agriculture includes and combines those environmental, agrotechnical, economic and socio-cultural aspects [4-8]. It should be emphasised that agriculture belongs to less numerous economy fields which play an important role in bringing into life the idea of sustainable development [3, 9].

The analysis carried out by the specialists shows that the principles of sustainable development in agriculture are executed in the most favourable way in a farm with the mixed production profile. Since, specialization intensifies a negative impact of agriculture on the environment and danger of decreasing soil fertility and biodiversity of agricultural habitats [10-12]. The basic factor which decides on the specialization trend in a farm includes the acreage of the owned agricultural land. Small farms usually produce for their own needs and as a rule they are multi-trend. On the other hand, a single trend occurs most often in average and bigger farms which was also confirmed in farms which are the subject of these analyses.

2. Objective, scope and methodology

The objective of the paper was to determine the level of production sustainability in organic farms in the ecological, social and economic aspect.

The scope of research covered 50 certified farms located in the southern Poland. The research was carried out in the form of a guided survey with farm owners. The collected informations concern their agricultural activity and allowed calculation of indexes which allow assessment of the production sustainability degree.

Sustainability of agricultural production within meeting the ecological quality requirements was determined based

on the reproduction or degradation index namely the balance of the organic substance renewal ($t \cdot ha^{-1}$) and the value of material inputs incurred on production ($PLN \cdot ha^{-1}$) [13].

Sustainability of agricultural production within the scope of meeting the quality social requirements was determined based on the work equipment expressed in $kWh \cdot ha^{-1}$ and $kWh \cdot man\text{-}hour^{-1}$, labour inputs in $man\text{-}hour \cdot ha^{-1}$, degree of mechanization of the work process and work burden expressed with man-hour per a non-disabled person. A Non-disabled person - is a person who works in a farm, calculated per indexes which express its performance in relation to the age and sex [14].

Sustainability of agricultural production within the scope of meeting economic quality requirements was determined based on the level of the obtained commodity production expressed in $GU \cdot ha^{-1}$ and $GU \cdot non\text{-}disabled\ person^{-1}$. Moreover, the size of the gross agricultural income referred to the unit of the field area and a full-time worker was determined. A full-time worker means a person working full time in a farm throughout a year who may obtain an income parity.

The production scale which is related to the agricultural land resources is one of the main factors which distinguish production sustainability, except for the trend. Thus, in order to carry out a comparative analysis, the objects were divided into four area groups i.e. up to 5 ha; from 5.01 – 10.00 ha; from 10.01 – 20.00 ha and above 20 ha.

3. Research results

Among the investigated farms the biggest number of them was qualified to the II group i.e. with the area from 5 to 10 ha (table 1). In the remaining three groups, on the other hand, the number of farms was comparable and was 12,11 and 10 respectively in group I, III and IV. The average area of agricultural land was at the level of 12.91 ha and was within 3.32 to 32.00 ha. In the use structure of land, green lands prevailed and they were 53%. Arable land was 43% of the area of agricultural land and orchards and perennial plantations constituted a supplement (4%). Only the biggest farms, where the participation of meadows and pastures was as much as 70%, influence such a structure because in the remaining groups arable land prevailed. In the sowing structure there are grains and forage plants, which constituted on the average 43 and 35%. However, one should emphasise that participation of grains decreased along with the increase of the farm size for the benefit of plants with higher commodity nature, e.g. vegetables.

In the animal production department in the structure of a herd, cattle prevailed and on the average per 1 ha there was 0.83 LSU. A higher livestock was reported in smaller farms i.e. up to 10 ha.

Intensity of production organization according to Kopeć's scale was on average 21.82 points. In the distinguished farm groups there is a relation that the intensity increases along with the area of agricultural land. A considerably low intensity of plant production organization (on average 15.34 points) resulted from the use structure of land and sowing in the investigated facilities, namely a high participation of meadows and pastures, grains and fodder plants which have the lowest calculation index. However, the participation of plant production intensity, which was within 56% to 82%, prevailed. In case of animal production the intensity of organization was affected by the number of cow herds on account of the calculation index for this animal group. Therefore, in the biggest farms, which in majority specialized in milk production it was a few times higher than in the remaining groups.

The replacement value of the machinery park was on average 32.31 thousand $PLN \cdot ha^{-1}$ AL. This value decreased in particular groups along with the increase of the acreage. Only farms from 5 to 10 ha differ. They have more varied sowing which forces them to have a more developed machinery park which results in a higher replacement value (61.99 thousand $PLN \cdot ha^{-1}$). On the other hand, one should indicate that a few times lower value of technical means in the biggest farms results from the production specialization and thus from shrinking of the machinery park to the machines used for strictly determined type of activity.

Table 1. Characteristic of the investigated farms
Tab. 1. Charakterystyka badanych gospodarstw

Specification	Unit	Area group				Total
		up to 5 ha (I)	5.01-10.00 ha (II)	10.01-20.00 ha (III)	above 20.00 ha (IV)	
Number of farms	items	12	17	11	10	50
Arable land	ha	1.93	4.22	7.84	9.57	5.54
Grasslands	ha	0.66	1.97	7.10	22.43	6.88
Orchards and perennial plantations	ha	0.73	0.71	0.31	–	0.49
Agricultural land	ha	3.32	6.90	15.25	32.00	12.91
Livestock density	$LSU \cdot ha^{-1}$ AL	0.92	1.11	0.69	0.46	0.83
Intensity of production organization including	number of points	9.31	15.49	28.07	45.61	21.82
in plant production		5.61	11.23	23.02	25.55	15.34
in animal production		3.70	4.26	5.05	20.06	6.49
Replacement value of the machinery park	thousand $PLN \cdot ha^{-1}$	43.14	61.99	37.35	17.47	32.31

Source: own work/Źródło: opracowanie własne

Table 2. Organic sustainability
Tab. 2. Zrównoważenie ekologiczne

Specification	Unit	Area group				Total
		up to 5 ha (I)	5.01-10.00 ha (II)	10.01-20.00 ha (III)	above 20.00 ha (IV)	
Organic substance renewal balance including: plant production	$t \cdot ha^{-1}$	0.48	1.01	0.83	1.67	1.08
		0.11	0.22	0.49	1.02	0.68
Non-agricultural material inputs	$PLN \cdot ha^{-1}$	492	308	221	244	320
Agricultural material inputs	$PLN \cdot ha^{-1}$	727	1001	484	630	750

Source: own work/Źródło: opracowanie własne

Table 3. Social sustainability
Tab. 3. Zrównoważenie społeczne

Specification	Unit	Area group				Total
		up to 5 ha (I)	5.01 - 10.00 ha (II)	10.01-20.00 ha (III)	above 20.00 ha (IV)	
Installed power index	$kWh \cdot ha^{-1}$	1081.95	293.35	223.38	520.23	407.46
	$kWh \cdot man\text{-}hour^{-1}$	1.61	0.82	0.98	4.75	2.62
Work inputs including:	$man\text{-}hour \cdot ha^{-1}$	1109	1264	1238	1071	1179
in plant production	$man\text{-}hour \cdot ha^{-1}$	891	1082	1186	1028	1045
in animal production	$man\text{-}hour \cdot ha^{-1}$	218	182	52	43	134
Participation of manual works	%	62	57	59	46	56
Work burden	$Man\text{-}hour \cdot non\text{-}disabled\ person^{-1}$	696	911	910	1652	1007

Source: own work/Źródło: opracowanie własne

Balance of organic substance renewal, which is one of the factors which allow assessment of organic sustainability was on average at the level of 1.08 $t \cdot ha^{-1}$ AL (tab. 2). In the distinguished area farms it was within 0.48 $t \cdot ha^{-1}$ AL in the smallest farms to 1.67 $t \cdot ha^{-1}$ AL in the biggest farms. These results allow the statement that all area groups prove a satisfactory or high level of organic substance renewal since according to the specialists the level of 0.4-1.5 $t \cdot ha^{-1}$ is satisfactory. Undoubtedly, such favourable balance was obtained due to animal production which is almost indispensable in organic farms. It is confirmed by other authors who emphasise that the livestock is one of the factors which decide on the agricultural production sustainability since it influences inter alia the balancing of the organic substance renewal and the level of nitrogen fertilization [15].

The value of agricultural material inputs was at the average over 2 times higher than of the non-agricultural means value and was respectively 750 and 320 $PLN \cdot ha^{-1}$ (tab. 2). Operation of organic farms is based on own, natural production means thus this advantage is the most appropriate. It should be mentioned that in case of non-agricultural inputs, their value in the III and IV area group was similar (respectively 221 and 244 $PLN \cdot ha^{-1}$). Therefore, based on the obtained results one may risk the statement that the area of 10 ha above which the unit value of non-agricultural inputs decreases considerably is crucial. On the contrary, the unit value of agricultural inputs was at the similar level in the smallest and the biggest farms (respectively 727 and 630 $PLN \cdot ha^{-1}$). The facilities which have the acreage from 5 to 10 ha, where per 1 ha of AL inputs in the amount of PLN 1001 were incurred, differ considerably.

Equipment of work, expressed with kWh referred to the unit of the surface area, was on the average 407.46 and referred to the number of of man-hours - 2.62 (table 3). The highest index of the installed power per one hectare of agricultural land (1081.95 $kWh \cdot ha^{-1}$) was reported in the smallest farms, where it exceeded by several times the one obtained in farm groups. It may indicate exceeding technical investment of small farms, mainly in agricultural tractors. This problem has been present in literature for years. In case of calculation per one man-hour the highest number of kWh (4.75) was reported in the biggest facilities. It results from the fact that the previously mentioned specialization in big farms, mainly in animal production slightly limits the work inputs and the saturation with power is very high. It should be mentioned that the index of the installed power expressed in both units ($kWh \cdot ha^{-1}$ and $kWh \cdot man\text{-}hour^{-1}$), in the II and III area group i.e. within the area from 5-20 ha was comparable.

On the average in the investigated farms the work inputs at the level of 1179 $man\text{-}hour \cdot ha^{-1}$ were incurred. These inputs in the distinguished farm groups were similar and were within f 1264 to 1071 $man\text{-}hour \cdot ha^{-1}$. Work incurred on plant production prevailed in all groups which was on the average 89%. It also prevailed in milk producing farms because it was incurred on preparing bulky feed for cattle, including cultivation, harvesting and maintenance of fodder plants. On the other hand, limitations in the organic production system force out to carry out some work manually which is proved by their high participation in the total work inputs (table 3). It justifies high labour inputs incurred on plant production in the investigated farms. Per one non-

disabled person, there was at the average 1007 man-hour, thus the burdening with work was half lower than the admissible one (acc. to AWU – Annual Work Unit – 2120 man-hour per a worker in a year). In this case, farms with the smallest and the biggest acreage diverge considerably from the average (respectively 696 and 1652 man-hour·non-disabled person^{-1}). While in the II and III group the burden was almost the same and its level was respectively 911 and 910 of man-hour·non-disabled person^{-1}.

To sum up, it can be noticed that the indexes which serve for evaluation of the social sustainability in the II and III area group, i.e. in farms with the area from 5 to 20 ha were comparable. Clear differences take place in farms with the acreage to 5 and above 20 ha.

The objective of each farm is to obtain the income which ensures family welfare and farm development. It may be obtained through high commodity production and work efficiency. In the investigated group of farms the average size of commodity production was at the level of 345 GU which per one hectare of agricultural land provided 24 GU and per one non-disabled person it was 144 LU (table 4). The biggest commodity production was obtained by the farms with the area exceeding 10 ha (503 and 481 GU, respectively for the group III and IV). This production exceeded the one obtained by the farms with the area exceeding 10 ha (144 and 163 GU, respectively for the group I and II). After calculation per the agricultural land area, the biggest production effects (39 and 33 LU·ha^{-1}) were obtained by smaller farms (up to 5 ha) and with the acreage from 10 to 20 ha. The fact of the increase in the work performance expressed in the GU per a non-disabled person should be mentioned along with the increase in the farm size.

The unit gross agricultural income in the I, II and IV group of farms, i.e. with the area up to 10 and above 20 ha was comparable and was within 3.33 to 3.57 thousand PLN·ha^{-1}. The double fold income in the objects with the acreage from 10 to 20 ha (III area group). It is a derivative of the biggest commodity production occurring in this group of farms. It results from a slightly different sowing structure than in the remaining groups. Since, in these objects 24% of the area of arable land was covered by vegetables, 15% by fodder plants, 6% by herbs cultivated only in this one group. Therefore, plants with great commodity were backed up with less participation of grains and fodder plants. Taking into consideration the index which reflects the participation of the obtained agricultural income to the minimum wage which was binding in the year, when calculations were made; the income parity was not achieved only by the smallest farms. In the remaining groups the economic effect of the sustainable agricultural production was obtained.

Correlation and regression analysis proved a significant positive relation between the area of agricultural land and the organic substance balance work burden and annual agricultural income (table) 5). This relation did not occur in case of a unit income i.e. referred to the full time worker and the area of agricultural land. Based on regression equations one may state that the increase in the area of agricultural land by 1 ha causes increase in organic substance renewal by 1.19 t·ha^{-1}, work burden by 27.06 man-hour·non-disabled person^{-1} and the annual income by 3.68 thousand PLN.

Table 4. Economic sustainability
Tab. 4. Zrównoważenie ekonomiczne

Specification	Unit	Area group				Total
		up to 5 ha (I)	5.01 - 10.00 ha (II)	10.01-20.00 ha (III)	above 20.00 ha (IV)	
Commodity production	GU·farm^{-1}	144	163	503	481	345
	GU·ha^{-1}	39	24	33	17	24
	GU·non-disabled person^{-1}	58	74	186	229	144
Gross agricultural income	thousand PLN·ha^{-1}	3.33	3.57	6.25	3.46	4.02
	thousand PLN·non-disabled person.$^{-1}$	28.85	11.08	199.32	89.84	72.51
Index: relation of the agricultural income to the monthly minimum wage*		0.71	1.16	4.41	5.64	2.69

Source: own work/Źródło: opracowanie własne

**) Pursuant to the Ordinance of the Council of Ministers on the amount of the minimum wage in 2013 namely, the year for which calculations were made, was PLN 1600 gross per month*

Table 5. Coefficient of correlation and regression equations
Tab. 5. Współczynniki korelacji i równania regresji

Variable	Sustainability				
	organic	social	economic		
	Organic substance balance (OSB) (t·ha^{-1})	Work load (WL) (man-hour·non-disabled person^{-1})	Agricultural income (AI) (thousand PLN·year^{-1})	Agricultural income (thousand PLN non-disabled person^{-1})	Agricultural income (thousand PLN·ha^{-1})
Area of AL (ha)	OSB = -6.12 + 1.19·AL	WL = 669.65 + 27.06·AL	AI = 5.71 + 3.68·AL	AL = 30.4 + 3.37·AL	AI= 4.09 - 0.006·AL
	r = 0.95	r = 0.37	r = 0.51	r = 0.21	r = -0.009

Source: own work/Źródło: opracowanie własne

Duncan test allows the statement that the average balance of organic substance renewal and annual income obtained in farms from the III and IV area group i.e. with the area exceeding 10 ha differs significantly from the one obtained in the objects from I and II area group i.e. with the area of up to 10 ha. Also, the work burden was significantly different in farm above 20 ha (IV group) than the one on smaller objects (group I, II and III).

4. Conclusions

The lowest work inputs incurred per one hectare of agricultural land in the smallest and biggest farms (i.e, respectively to 5 and above 20 ha) are balanced with the highest energy equipment of work expressed in kWh·man-hour^{-1}. At the same time, in those two farm groups, respectively the lowest and biggest work burden referred to a non-disabled person working in a farm are reported. This burden was growing along with the increase of acreage and also resulted in the increasing size of commodity production in GU·non-disabled person^{-1}. On the other hand in any of the analysed groups it did not exceed an admissible index and the average burden was only 48%.

All area groups proved a satisfactory or high level of organic substance renewal. Simultaneously, the growing trend of the level of organic substance reproduction along with the AL area was reported.

The index which describes a relation of the agricultural income to the minimal wage indicates that only the smallest farms (to 5 ha) did not achieve the income parity. In the remaining groups the economic effect of the sustainable agricultural production was obtained.

Statistical analysis proved a significant positive relation between the area of agricultural land and the basic measures of the organic, social and economic sustainability.

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