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Problems of Polish non-livestock farms

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Abstract. The study attempts to understand the problems of non-livestock farms. The analyzes were based on literature data and case studies. The study presents the following issues: typology of farms, reasons for the introduction of non-livestock management, the impact of non-livestock management on the environment, achieved production and economic effects and unique features of non-livestock farms in Poland. It has been shown that manure-free management is possible, but requires farmers to have knowledge and professional skills. Balances of mineral components and soil organic matter have to be done by farms with no livestock in order to optimize fertilization and achieve satisfactory yields and prevent soil degradation. In non-livestock farms, maintaining the optimal level of soil fertility depends on the straw management, beet leaves utilization for fertilization purposes and the cultivation of catch crops for green manure. Manure should also be purchased (if possible).

Key words: types of farms, non-livestock farms, soil fertility, production and economic effects

INTRODUCTION

Interest in crop farms with no livestock production, known as non-livestock farms, emerged in the 1960s (Andreae 1963, 1967; Blohm, 1969). In Poland, dedicated research on the effects of livestock-free management was undertaken in 1961 at PGR Krzyżowa as an experimental non-livestock farm (Ludwiczak, 1965; Zalecenia, 1966).

However, research in that respect has been scarce. The author's research was also undertaken on an individual farm on very light soils (Gruczek, 1994). On the other hand, more recent results come from the Agricultural Experimental Station IUNG-PIB in Błonie-Topola, where during the system transformation (after the introduction of market economy principles), due to the unprofitability of animal production, its continuation was abandoned. Since 2003, the facility mentioned above has been an example of a livestock-free farm, and the research results have been successively published (Harasim, 2012; Harasim, Matyka, 2020). These are case study in nature, and there is a lack of larger-scale work to provide a complete understanding of the causes and consequences of non-livestock management. There are also a few other studies related to livestock-free management (Krasowicz, 2005; Kuś, 2013; Kuś et al., 2008; Stalenga et al., 2004; Zegar, 2009). Thus, the research results are fragmented and scattered, which prompted the presentation of the problem of livestock-free farms as an overview study.

The study's primary aim was the profile of the non-livestock farms in terms of their environmental impact and the achievement of production and economic effects.

MATERIALS AND METHODS

The paper is a review in the absence of original research results on the issue of livestock-free farms. The problem is presented by reviewing the literature relevant to this issue. More detailed findings are discussed based on research examples from various authors that were case studies occurring in the farm production conditions. The characteristics of agricultural holdings specialising in field crops are provided following GUS (2006–2017) data. The issue of non-livestock farms requires purposeful research on a larger scale, especially in terms of achieving production and economic effects, to get a more comprehensive understanding of the problems of this group of farms.

RESULTS AND DISCUSSION

Principles of farm classification

Agriculture exhibits remarkable diversity in terms of farm types. Some farms focus on crop production, others specialise in animal husbandry, and others carry out mixed

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agricultural production, i.e. crop and animal production. In the European Union countries, farms are classified according to economic size and agrarian type. A systematisation of farm types is presented in Table 1. The classification is applied in farm structure studies conducted by EUROSTAT and in the Polish FADN system (Augustyńska-Grzymek et al., 2000). Depending on the accuracy degree, farm types are divided into 9 general types, 17 basic types, 50 detailed types and 31 sub-types.

The Polish FADN inspection area covers about 730 thousand farms, with a representative sample of over 12 thousand farms. Thus, on average, one farm participating in the system represents 60 farms in the Polish FADN scope of observation. As of 2020, there are 749646 commodity farms in the Polish FADN system, of which more than 42% are farms focused on field crops (Pawłowska-Tyszko et al., 2021).

Agricultural types of farms in Poland

Among the farm types practising agriculture, farms specialising in field crops predominate. Within this group, not all farms are unmanured. According to 2016 data, their share of the total number of farms was more than 56% (Table 2). On the other hand, data from 2020 show that the share of farms engaged exclusively in crop production was 55.8% (GUS, 2021), i.e. their share remains stable. Among farms specialising in field crops dominated those with

Table 1. Farm types according to the classification prevailing in the European Union countries.

General type	Primary type
1. Specialized in field crops	13. Cereals, oilseeds and legumes
	14. Other field crops
2. Specializing in horticultural crops	20. Horticultural crops
3. Specializing in permanent crops	31. Vineyards
	32. Fruit trees and bushes
	33. Olive groves
	34. Other permanent crops
4. Specializing in grazing livestock	41. Dairy cattle
	42. Beef cattle
	43. Cattle in total
	44. Sheep, goats
5. Specializing in the rearing of animals fed on concentrated feed	50. Animals fed on concentrated feed
6. Various crops in total	60. Horticultural and permanent field crops
7. Various animals in total	71. Various animals predominantly fed on grazing
	72. Various animals predominantly fed with concentrated feeds
8. Various crops and animals in total	81. Crops and grazing livestock in total
	82. Various crops and animals in total
9. Unclassified farms (did not meet the required conditions for types 1–8)	

Source: Augustyńska-Grzymek et al. (2000)

Table 2. Agricultural holdings engaged in agricultural activities by type of farming in Poland [%].

Farms with an agricultural type	2005	2007	2010	2013#	2016#
Total (thousands)	2476.5	2391.0	1891.1	1429.1	1410.7
Specializing in:					
I – field crops	28.0	27.1	39.9	49.2	56.5
II – horticultural crops	2.1	1.5	2.4	1.9	1.8
III – permanent crops	5.7	5.3	4.3	4.5	4.1
IV – rearing of animals fed in the grazing system (with roughage)	13.3	17.1	9.7	11.3	11.0
V – in the rearing of animals fed with concentrated feeds	5.6	4.9	5.6	2.5	2.3
Mixed:					
VI – miscellaneous crops	8.9	8.9	4.1	3.4	3.2
VII – various animals	11.1	10.0	7.0	5.6	3.5
VIII – miscellaneous crops and animals	19.3	20.6	20.7	19.5	15.9
IX – unclassified	6.1	4.6	6.3	2.1	1.7

Data from 2013 and 2016 do not cover farmland holders not engaged in agricultural activity and farmland holders with < 1 ha of UAA (GUS, 2006–2017).

Source: in-house studies based on GUS, 2006–2017.

a relatively small utilized agriculture area (UAA) (Table 3). In the range of 1–10 ha of UAA, they accounted for 82%, and the share of farms larger in the area (above 10 ha of UAA) was only 18%. Thus, the feature of this type of farm is generally high fragmentation and a small scale of production.

Table 3. Structure of farms in the agricultural type specializing in field crops in 2016.

Utilized Agricultural area [ha]	Farms	
	total number [thousands]	share [%]
Total > 1 ha	788.4	100
1–2	177.6	22.5
2–3	134.2	17.0
3–5	168.4	21.4
5–10	166.2	21.1
10–15	58.1	7.4
15–20	24.7	3.1
20–30	22.2	2.8
30–50	16.5	2.1
50–100	11.9	1.5
> 100	8.6	1.1

Source: in-house studies based on GUS data (Charakterystyka gospodarstw rolnych w 2016 r. – GUS, 2017 from GUS, 2006–2017)

It should be noted that agrarian fragmentation is common in Polish agriculture. In 2020, the largest area of UAA under sowing was occupied by farms in the area group of 100 ha and more, which accounted for 25.6% of the total number of farms. Farms with an area of 1–2 ha covered 40% of the sown area of UAA (GUS, 2021).

The holdings with an area of 1–2 ha of UAA accounted for the largest proportion of those engaged only in crop production (almost 70%). Their share exceeded 60% in holdings with an area of 2–5 and 100 ha and more and 50% in holdings with an area of 5–10 ha of UAA (GUS, 2021). This means that crop production farms grew intensive crops and, if less intensive, in large areas, ensuring the profitability of their production.

A study of organic farms carried out in 2012 by Nachtman (2014) shows that attributes such as the area of plant farms and the area under cereals and their share of sown crops were significantly higher than on farms with livestock production (Table 4). Furthermore, they required approximately 2 times less labour input than the labour intensity of farms with livestock production.

According to 2016 data, the average area of farms focusing on crop production amounted to 8.6 hectares of UAA, while for farms rearing animals fed with roughage and concentrated feed, the sizes were much larger, 16.0 and 11.8 hectares of UAA, respectively (GUS, 2006–2017). Whereas the share of cereals in the sown area was 68.9%, the labour input level reached 9.8 annual work unit

Table 4. Organic farms with crop and livestock production according to Polish FADN data in 2012.

Specification	Farms	
	with crop	with livestock production
Area of the farm [ha of UAA]	61.4	28.9
Area under cereal crops [ha]	28.7	7.9
Share of cereals in sowings [%]	46.8	27.3
Total labor input per 100 ha of UAA [AWU]#	3.32	6.42

UAA – utilized agricultural area
AWU (Annual Work Unit) – full-employed persons
Source: Nachtman (2014)

(AWU) per 100 ha UAA, which is lower than on farms with livestock production (11.7 and 17.8 AWU). Livestock-free holdings dominate in the Zachodniopomorskie and Dolnośląskie voivodeships, as well as their percentage is also significant in the other 'post-state-owned farm' voivodeships (Zegar, 2009; Zegar, Wilk, 2007).

The reasons for implementing an livestock-free management

Drawing from the literature, the reasons for introducing an livestock-free management include:

- the volatile and unfavourable relationship between agricultural product prices and input prices (Andreae, 1963; Harasim, 2012; Harasim, Matyka, 2020),
- higher prices for crop products than for animal products (Andreae, 1963),
- lack of profitability of livestock production (Harasim, 2012; Harasim, Matyka, 2020; Nachtman, 2014),
- the lower labour intensity of crop production compared to the labour inputs incurred on livestock or mixed production farms (Harasim, Matyka, 2020; Nachtman, 2014),
- labour shortages and the potential for substitution of live labour by mechanical labour (Andreae, 1963, 1967; Ludwiczak, 1965),
- the high degree of mechanization of crop production technology (Harasim, Matyka, 2020; Kuś, 2013),
- specialization of farms (simplification of production organization) to reduce production costs (Kuś, 2013),
- lack of capacity to handle livestock production on the farms of bi-vocational farmers and shifting production and consumption patterns.

Environmental impact of non-livestock farms

At the farm level, mineral nutrients and soil organic matter balances assess the potential threat to the natural environment (Harasim, 2018). Every type of farm exerts pressure on the environment to a greater or lesser extent.

A farm's specialization (type of production) significantly impacts the natural environment, including crop-oriented arable farms. Due to negative mineral balances, they risk reducing soil fertility, capability[1] and biological activity (Kuś, 2013; Harasim, 2018; Ulén et al., 2013). Similar threats to the soil environment are caused by unsustainable organic matter management (Kuś, 2013; Kuś, Kopiński, 2012). On the other hand, farms oriented towards livestock production are generally characterized by large positive balances of fertilizer components (N, P, K), posing a risk of contamination of ground and surface water with these components (Duer et al., 2004; Harasim, 2014; Kuś, 2013; Ulén et al., 2013). In agricultural practice, it is recommended to maintain at least a sustainable balance of soil organic matter (Harasim, 2014). Besides preserving soil fertility and capability, the correct management of organic matter is essential for environmental protection and reducing the greenhouse effect (Kuś, Kopiński, 2012). A decrease in the soil organic matter content (degradation) increases greenhouse gas emissions, while an increase in the amount of organic matter in soils (fixation – sequestration) contributes to reducing the warming effect. According to Andreae (1967), under certain conditions, it is possible to manage without livestock and manure but never without humus.

Examples of livestock-free management

Studies conducted on three IUNG-PIB Agricultural Experimental Stations indicate that the arable and mixed farms were characterized by low plant diversity (4 and 5 species), while the cattle farms cultivated almost 2 times the number of plant species (Table 5). Thus, specialization and intensification of crop production limit the number of crop plant species grown on arable land, leading in many cases to monoculture cultivation and monotony of the landscape (Feledyn-Szewczyk, 2014; Matyka, 2017). Cereals were the dominant group of crops on the abovementioned farm types.

An exceptionally high share of cereals (89%) occurred on a farm with a mixed production profile run on light soils. The proportion of cereals in the sowing should not exceed 66% (Kuś, 1995). The crop farm was distinguished by the highest intensity of crop protection (more than 6 treatments) on arable land. Unfavourable negative mineral balances were found in the single crop and cattle farms, while quite correct NPK balances were observed in a farm with a mixed production profile (Table 5).

1 Soil fertility and soil capability are the potential to satisfy the plants' requirements and produce yields.

Table 5. The production and environmental indicators of the IUNG-PIB Agricultural Experimental Stations as a function of production directions (average from 2011–2016).

Indicators	Production directions		
	A. crop	B. cattle	C. combined
Soil category	medium	medium	light
Area of the farm [ha of UAA]	222.2	138.6	402.5
Share of permanent grassland [% of UAA]	28.2	18.9	5.1
Number of crop species	4	9	5
Share of cereals in sowings [%]	66	50	89
Number of plant protection treatments	6.5	1.4	5.4
Livestock density [LU ha^{-1}]	-	0.83	0.28
Balance of nutrients [kg ha^{-1}]:			
N	35	-35	38
P_2O_5	-10	6	8
K_2O	-5	-28	34
Balance of soil organic matter [t d.m. ha^{-1}]	0.17	0.62	0.08

UAA – utilized agricultural area
Source: in-house study

Regarding organic matter balance, the farms surveyed showed a fairly accurate status, with the specialized cattle farm having the highest organic matter balance due to using manure in higher quantities. On the crop and mixed farms, a positive balance of soil organic matter was gained through using straw for fertilizer and the cultivation of catch crops for green manure. According to Mazur et al. (2003), the manure rate of 7.5 t ha^{-1} applied in a 3-field crop rotation can be replaced by fertilization with straw and green manure intercrops. The agricultural machinery currently used for cultivation and sowing generally does not pose problems with straw ploughing.

The consequences of a change in the agricultural production profile can be presented (Table 6) following the example of the Agricultural Experimental Station in Błonie-Topola (belonging to IUNG-PIB). From 1971 to 1990, the farm carried out multilateral plant and animal production (cattle, pigs), and in the subsequent years, animal production was terminated due to unprofitability. At the beginning of the transition to a market-oriented national economy, farm employment was reduced, the level of mineral fertilization (mainly NPK) was decreased, and the number of crop plant species was diminished, leading in consequence to negative phosphorus and potassium and soil organic matter balances (Table 6). Only from 2010 onwards was a positive soil organic matter balance achieved due to fertilization with straw and sugar beet leaves, the sowing of catch crops for green manure, and partly the purchase of manure from neighbouring farms. Between 2007 and 2010, straw was ploughed on 48% of the field area and sugar beet leaves on 34%, while stubble catch crops (mainly white mustard) were grown for ploughing on 36% of the area (Harasim, Matyka, 2020). Currently, sowings on arable land (wheat complexes) are dominated by cereals (62%) – mainly winter and spring wheat,

Table 6. The long-term consequences of organizational changes in the Agricultural Experimental Station in Błonie-Topola.

Specification	Years				
	1971–1980	1981–1990	1991–2000	2001–2010	2011–2021
Farm employment [persons]	57	46	23	5	5
Livestock density [LU ha^{-1} of UAA]	0.89	0.91	0.54	-	-
Mineral fertilization [kg NPK ha^{-1} of UAA]	365	316	162	246	320
Sowing structure [% of AL]					
– root crops	22	23	24	32	29
– basic cereals	39	38	72	66	62
– other crops	39	39	4	2	9
Number of crop species	11	9	6	4	4
Balances:					
– fertilizer components [kg ha^{-1} of AL]					
N	7.7	13.2	3.8	15.9	34.4
P_2O_5	58.3	42.0	-1.3	-5.9	-14.2
K_2O	59.7	33.4	-11.2	-20.3	-14.8
– soil organic matter [t d.m. ha^{-1} of AL]	0.14	0.16	-0.30	-0.28	0.18

LU – large unit, UAA – utilized agricultural area, AL – arable land
Source: in-house study

with the remainder of the land sown to sugar beet (about 30%) and maize grown for grain.

When selecting crop species for sowing for green manure, it is essential to be familiar with their yield levels and nitrogen inputs. The cultivation of leguminous (faba bean) crops is particularly recommended (Table 7). In practice, cruciferous crop intercropping is of primary importance as it enhances soil biological activity and reduces disease incidence but has less effect on humus balance (Kuś et al., 2008).

Table 7. Dry matter and total nitrogen yields of legumes grown for green manure.

Crop	Main yield			Intercrops		
	aerial parts	roots	total	aerial parts	roots	total
Dry matter [t ha^{-1}]						
Yellow lupine	6.06	2.30	8.36	4.31	1.74	6.05
Serradella	4.61	2.95	7.56	3.50	2.24	5.74
Field pea	4.55	2.14	6.69	3.90	1.83	5.73
Nitrogen mass [kg ha^{-1}]						
Yellow lupine	157.6	49.6	207.2	129.3	35.0	164.3
Serradella	105.6	51.9	157.5	80.2	39.4	119.6
Field pea	141.5	46.0	187.5	138.4	43.2	181.6

Source: Mazur et al. (2003)

Production and economic effects

The management without livestock allows to achieve positive production and economic effects. At PGR Krzyżowa, before the reorganization, the farm resulted in a financial loss (Zalecenia, 1966). Therefore, livestock production was eliminated, low-yielding pastures were turned into arable fields, and straw fertilization was applied. By-product crops (straw, beet leaves, potato patches) were left in place, providing the soil's primary source of organic matter. The organizational adjustments made meant that the farm became profitable. The above example demonstrates that, under certain conditions, a shift to rational no-livestock management can be justified (Ludwiczak, 1965). Alterations in the sowing structure and the use of by-products for fertilization increased crop yields and labour productivity, significantly improving crop production's profitability.

If we can maintain soil fertility and capability without manure, a non-livestock farm can give adequate production results and, with low inputs, achieve a positive financial outcome and high labour productivity (Gruczek, 1994; Ludwiczak, 1965). Specialization of farms in crop production, especially for larger farms with better soils, enables high labour productivity and relatively high incomes (Kuś, 2013). Crop-only farms with an area of around 100 ha on better soils, where sugar beet, oilseed rape and maize for grain were grown in addition to cereals other than maize, were economically efficient, while on weaker soils, they produced too little income (Kuś et al., 2008; Zegar, 2009). Livestock-free farms can generate a similar level of agricultural income as those that keep livestock (Kuś et al., 2008). However, livestock–free farms require a much larger land area and the use of quite intensive production technologies. In the case of organic crop farms, profit maximization is mainly achieved by increasing the land area, which increases the scale of production and allows greater subsidies to be obtained (Nachtman, 2014). In each scenario, a change in the production profile influences production (yields) and economic effects, which, in addition to external and internal factors on the farm, depend to a large extent on the farm's knowledge and management skills (Kuś et al., 2008; Ludwiczak, 1965; Nachtman, 2014). Intense professional preparation and systematic education of the farm owner (operator) is essential.

SUMMARY

Based on a reference review, it is possible to present the livestock-free farms' attributes compared to farms with livestock and mixed production. Non-livestock farms are mainly characterized by:

– a simplified sowing structure – a low number of cultivated crop species (Harasim, 2012; Harasim, Matyka, 2020),
– an increased share of cereals (Harasim, Matyka, 2020),
– often negative balances of soil mineral nutrients and organic matter, leading to reduced soil fertility and capability (Harasim, 2018; Kuś et al., 2008),
– the comparatively to livestock production, the low labour intensity of crop production (Harasim, Matyka, 2020; Nachtman, 2014),
– the application of straw and beet leaves for soil fertilization (Harasim, 2012; Harasim, Matyka, 2020),
– catch crops cultivation for green manure (Kuś et al., 2008; Mazur et al., 2003).

On non-livestock farms, to maintain optimum soil fertility and capability levels, straw and sugar beet leaves are recommended to be used as soil fertilizer, and intercrops are grown for green manure (Buczak, 1964; Harasim, 2012; Harasim, Matyka, 2020; Kuś et al., 2008; Mazur et al., 2003; Reisch, Zeddies, 1995). The possibilities of replacing manure with other raw materials enriching the soil with minerals, and maintaining a balanced balance of soil organic matter depend on the conditions of the individual farm. The effects of a manure shortage can also be mitigated by purchasing it (Harasim, 2012; Harasim, Matyka, 2020). Changes in the sowing structure and the use of by-product crops for fertilization contribute to an increase in crop yields and labour productivity, which considerably improves the profitability of crop production.

Crop production on a non-livestock farm requires the preparation of mineral nutrient (macronutrient) and organic matter balances to optimize fertilization to achieve satisfactory crop yields and prevent soil degradation (Harasim, 2012, 2018; Harasim, Matyka, 2020; Mazur et al., 2003).

REFERENCES

Andreae B., 1963. Organizacja i ekonomika produkcji roślinnej. PWRiL Warszawa, 323 pp.

Andreae B., 1967. Gospodarstwo uproszczone. PWRiL Warszawa, 208 pp.

Augustyńska-Grzymek I., Goraj L., Jarka S., Pokrzywa T., Skarżyńska A., 2000. Metodyka liczenia nadwyżki bezpośredniej i zasady typologii gospodarstw rolniczych. FAPA Warszawa, 55 pp.

Blohm G., 1969. Nowe zasady prowadzenia gospodarstw. PWRiL Warszawa, 165 pp.

Buczak E., 1964. Wpływ zielonych nawozów poplonowych letnich i międzyplonowych ozimych na wytwarzanie azotanów i wzrost substancji organicznej w glebie. Roczniki Nauk Rolniczych, ser. A, 88(3): 619-638.

GUS, 2021. National Agricultural Census 2020. Report on the results. Warszawa, 96 pp. [in Polish]

GUS, 2006–2017. Charakterystyka gospodarstw rolnych w 2005, 2007, 2010, 2013, 2016 r., GUS (Central Statistical Office) Warszawa, 515, 473, 468, 449, 389 pp.

Duer I., Fotyma M., Madej A., 2004. Kodeks dobrej praktyki rolniczej. IUNG Puławy, 93 pp.

Feledyn-Szewczyk B., 2014. Bioróżnorodność roślin jako element zrównoważonego rozwoju rolnictwa. Studia i Raporty IUNG-PIB, 40(14): 163-177.

Gruczek T., 1994. Gospodarka bezobornikowa na glebie lekkiej. Fragmenta Agronomica, 2(42): 72-82.

Harasim A., 2012. Crop production on arable lands: a long term single-farm case study. Monografie i Rozprawy Naukowe, IUNG- PIB Puławy, 34, 63 pp.

Harasim A., 2014. Przewodnik do oceny zrównoważenia rolnictwa na różnych poziomach zarządzania. IUNG- PIB Puławy, 91 pp.

Harasim A., 2018. Environmental consequences of specialization of farms. Roczniki Naukowe SERiA, 20(2): 65-71. [in Polish + summary in English]

Harasim A., Matyka M., 2020. Changes in crop production and their consequences: a long term single-farm case study. Monografie i Rozprawy Naukowe, IUNG- PIB Puławy, 62, 96 pp. [in Polish + summary in English]

Krasowicz S., 2005. Assessment of sustainable development potential of the farms with different production specialisation. Roczniki Naukowe SERiA, 7(1): 144-149. [in Polish + summary in English]

Kuś J., 1995. Rola zmianowania roślin we współczesnym rolnictwie. IUNG Puławy, 35 pp.

Kuś J., 2013. Specjalizacja gospodarstw rolnych i jej konsekwencje produkcyjne, ekonomiczne i siedliskowe. Studia i Raporty IUNG- PIB, 32(6): 167-185.

Kuś J., Kopiński J., 2012. The soil organic matter management in the contemporary agriculture. Zagadnienia Doradztwa Rolniczego, 2: 5-27. [in Polish + summary in English]

Kuś J., Krasowicz S., Kopiński J., 2008. Ocena możliwości zrównoważonego rozwoju gospodarstw bezinwentarzowych. pp. 11-38. In: Z badań nad rolnictwem społecznie zrównoważonym (5); ed. J.S. Zegar; IERiGŻ – PIB Warszawa, 87.

Ludwiczak J., 1965. Efektywność ekonomiczna gospodarstwa bezinwentarzowego (na przykładzie PGR Krzyżowa). Zagadnienia Ekonomiki Rolnej, 67(1): 136-141.

Matyka M., 2017. Evaluation of regional diversification in sown area structure in the context of impact on the natural environment. Roczniki Naukowe SERiA, 19(3): 188-192. [in Polish + summary in English]

Mazur T., Sądej W., Mazur Z., 2003. Organic fertilization in farms with no livestock. Zeszyty Problemowe Postępów Nauk Rolniczych, 494: 287-293. [in Polish + summary in English]

Nachtman G., 2014. Competitiveness of organic crop farms at the background of farms with animal production. Zagadnienia Ekonomiki Rolnej/Problems of Agricultural Economics, 341(4): 131-143. [in Polish]

Pawłowska-Tyszko J., Osuch D., Płonka R., 2021. Wyniki standardowe 2020 uzyskane przez gospodarstwa rolne uczestniczące w Polskim FADN. Cz. I. IERiGŻ-PIB, Warszawa 2021, 61 pp.

Reisch E., Zeddies J., 1995. Wprowadzenie do ekonomiki i organizacji gospodarstw rolnych. T. 2. Wyd. AR Poznań, 504 pp.

Stalenga J., Jończyk K., Kuś J., 2004. Nutrient balance in the organic and conventional crop production systems. Annales UMCS, sec. E Agricultura, 59(1): 383-389. [in Polish + summary in English]

Ulén B., Pietrzak S., Tonderski K.S., (ed.)**, 2013.** Samoocena gospodarstw w zakresie zarządzania składnikami nawozowymi i oceny warunków środowiskowych. ITP Falenty, 99 pp.

Zalecenia agrotechniczne, 1966. IUNG Puławy, ser. P(11), 474 pp.

Zegar J.S., 2009. Z badań nad rolnictwem społecznie zrównoważonym (10). Raport końcowy, synteza i rekomendacje. IERiGŻ-PIB Warszawa, 175, 97 pp.

Zegar J.S., Wilk W., 2007. Zrównoważenie indywidualnych gospodarstw rolnych w świetle wybranych kryteriów. pp. 9-65. In: Z badań nad rolnictwem społecznie zrównoważonym (4); ed. J.S. Zegar, IERiGŻ-PIB Warszawa, 59.

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