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FERTILIZATION AND FARM FERTILIZING BALANCE AS AN AGRI-ENVIRONMENTAL INDICATOR

Summary

Bringing both mineral and natural fertilizers into soil is the basis for obtaining satisfactory crops. In practice, farms carry out highly diversified fertilizing management, dependent not only on nutritional needs of plants, but also taking into account environment protection requirements. Considering the last aspect, farms should make efforts to introduce rational fertilizing management, resulting in correct balance of basic macroelements: nitrogen, phosphorus and potassium. Raised balance, but also too low one, maintained for extended time, may result in deterioration of soil environment.
***Key words**: fertilization, the NPK balance, organic farm, conventional farm*

NAWOŻENIE I BILANS NAWOZOWY GOSPODARSTWA JAKO WSKAŹNIK ROLNOŚRODOWISKOWY

Streszczenie

Wnoszenie do gleby nawozów mineralnych, jak i naturalnych stanowi podstawę uzyskania zadowalających plonów. Gospodarstwa rolne prowadzą w praktyce bardzo zróżnicowaną gospodarkę nawozową, zależną nie tylko od potrzeb pokarmowych roślin, ale także uwzględniającą wymogi ochrony środowiska. Biorąc pod uwagę ten ostatni aspekt, należy w gospodarstwach rolnych dążyć do racjonalnej gospodarki nawozowej, skutkującej poprawnym bilansem podstawowych makroelementów: azotu, fosforu i potasu. Bilans zawyżony, ale także zbyt niski, utrzymujący się przez dłuższy okres może doprowadzić do degradacji środowiska glebowego.
***Słowa kluczowe**: nawożenie, bilans NPK, gospodarstwo ekologiczne, gospodarstwo konwencjonalne*

1. Introduction

Total nitrogen constitutes one of general indicators of soil quality and fertility. This is much the same as phosphorus and potassium, which play key role in plant feeding and the progress in many of their physiological processes. Supplying nutrients to soil, and in consequence to plants, in form of mineral, natural or organic fertilizers, is the basis for obtaining satisfactory crops. Soil quality also plays an important role - its natural abundance with nutrients. Knowledge in this field permits rational fertilizer proportioning so as not to allow over-fertilization and as a result unnecessary economic losses of nitrogen, phosphorus and potassium, and pollution of environment. Prolonged deficiency of nutrients in soil may also lead to its deterioration.

Considerable diversification is observed in Polish agriculture as regards the balance of fertilizing components and efficiency of their use [12]. Moreover, according to the Institute of Soil Science and Plant Cultivation (IUNG) data [13], nitrate nitrogen content in autumn constitutes an indicator of potential hazard for underground waters due to the excess of nitrogen washed out from soil. Very high content of N-NO_3 [kg N·ha^{-1}] in farm soil is characteristic for 3 Voivodeships (Lubusz, Greater Poland, Lower Silesian). Another four (Pomeranian, Warmian-Masurian, Masovian, Podlaskie) show its too low content. Other studies carried out by the IUNG [4] show that during four research periods the share of soils characterised by very low and low abundance with available phosphorus reached 38-42% of the examined profiles. Whereas, highly abundant soils constitute slightly over 20% of all examined profiles. In the case of available potassium, the share of profiles characterised by low and very low abundance with this element in the year 2010 reached 47% of all examined profiles and dropped compared to the year 1995 (55%). In 2010 the number of profiles characterised by very high abundance with potassium reached 23 compared to 1995 - 15.

When determining the N, P and K balance it is important to know soil abundance. When there is no such information, in order to determine the N balance it is important to assume that it is environmentally safe to keep it ranging from 30 to 70 kg·ha^{-1} of agricultural land (AL). (Code of Good Agricultural Practice specifies the value up to 30 kg·ha^{-1}). In case of P and K, rationally delivered volumes should be balanced to zero, but taking into account production needs and environmental effects as well as spatial variability of soil abundance with these macroelements, phosphorus balance should range within 1-4 kg per 1 hectare of AL, and potassium: 10-15 kg. [12].

2. The purpose of the research

The purpose of completed studies was to calculate and assess the N, P and K balance on field surface for exemplary farms, carrying out plant and plant-animal production, and analysis of balance differences resulting from employed production method. Additionally, the assessment was carried out for farms divided into: organic (2 farms) and conventional (4 farms). Admittedly, presented results obtained for the studied farms cannot refer to the whole of agriculture and farms; however they may show unit, often frequent cases of wrong fertilizing management and its effects for environment.

A remedial programme was proposed in applications for those farms, where abnormalities resulting from faulty fertilizing management were observed. Research results concern farms located in Opole Voivodeship, period of analyses: years 2012-2013. The NPK balance was calculated using the data and information obtained through direct interviews with farmers, and the MacroBil application was employed to carry out computations.

Information obtained from farm owners included data concerning: arable land area, crops, harvests, after-culture crops, the amount of ploughed straw, stocking LU·ha^{-1} of AL (LU=Livestock Unit), brought-in natural and mineral fertilizers, soil quality.

3. Fertilization level and the NPK balance in Opole Voivodeship

Among all voivodeships in Poland, the Opole Region is characterised by highest NPK consumption per pure component. According to the data of General Agriculture Census [5], in business year 2009/2010 total consumption of mineral fertilizers (NPK) per pure component per 1 ha of AL reached 181.6 kg (Poland = 114.7 kg). According to the Census, 184.3 kg was used in good agricultural condition per 1 ha AL (Poland = 121.7 kg). The above is reflected in obtained harvests of e.g. basic cereals. As specified in the Census, in the same business year obtained harvest of basic cereals reached 48.5 dt·ha^{-1} compared to national average of 34.9 dt·ha^{-1}. At the same time, in Opole Voivodeship this yield belonged to highest in Poland. Taking into account division into individual macroelements in pure component, consumed amounts were as follows: nitrogen 99.8 kg·ha^{-1} of arable land, phosphorus 37.7 kg·ha^{-1} of AL, and potassium 44.1 kg·ha^{-1} of AL. At the same time, these were the highest values in the country.

The NPK fertilization level was also highest in Opole Voivodeship in successive years. Table 1 (below) compares the consumption of NPK mineral fertilizers (in pure component) in Opole Voivodeship and average for Poland in business years 2009/2010-2011/2012.

As we see, when compared to the year 2009/2010, successive years show rising trend in the consumption of mineral fertilizers. In 2012 the consumption slightly dropped, primarily due to freezing out of winter plants at the end of 2011 and the beginning of 2012. This resulted in considerable over-sowing of spring plants in 2012. On the one hand there was a demand for mineral fertilizers for these particular plants, and at the same time prices of mineral fertilizers grew, however farmers were limiting application of fertilizers due to high costs they incurred for extra sowing.

At the same time, the above statistical data show that the consumption of N, P and K from natural fertilizers, constituting the cheapest source of macroelements and significant for improving the quality of arable-humus layer, was dropping in Opole Voivodeship in successive years. This indicates decrease of livestock units.

Both high and low fertilization level (compared to the needs of soil and cultivated plants) affects the result of macroelement balances. According to the research carried out in 2007 by Institute of Agricultural and Food Economics - National Research Institute (IERiGŻ-PIB) [12] (approximately 10,000 farms were examined throughout the country, belonging to those implementing good agricultural condition), among other things intended to determine fertilizing balance for main macro-components at the level of an individual farm, every third farm in the country proved to have too high nitrogen balance, resulting from too aggressive fertilizing management (57% of the studied farms).

Table 1. Consumption of NPK pure component in mineral and natural fertilizers in Poland and in Opole Voivodeship in the years 2009/2010-2011/2012 [kg·ha^{-1}] [5-9]

Tab. 1. Zużycie czystego składnika (NPK) w nawozach mineralnych i naturalnych w Polsce oraz w województwie opolskim w latach gospodarczych 2009/2010-2011/2012 [kg ·ha^{-1}] [5-9]

Specification	Poland	Opole Voivodeship
2009/2010		
NPK	114.7	181.6
N	66.3	99.8
P	22.8	37.7
K	25.6	44.1
NPK in natural fertilizers	26.5	45.8
2010/2011		
NPK	126.6	222.4
N	70.7	129.0
P	26.4	41.9
K	29.5	51.4
NPK in natural fertilizers	40.1	41.9
2011/2012		
NPK	125.1	191.1
N	72.7	111.0
P	24.6	34.6
K	27.8	45.5
NPK in natural fertilizers	38.0	21.4

However, in majority the studied farms showed lowered nitrogen balance result. Similar situation was observed in the case of potassium. Only ca. 4% of the studied farms proved to have optimal balance, and 2/3 had lowered balance result. In the case of phosphorus, optimal balance result concerned 17% of farms and 46% of them showed negative result. On average for Opolskie Voivodeship, in the studies referred to above optimal nitrogen balance concerned 4% of farms (ca. 7% of the examined arable land area), 22% of farms showed raised balance (30.5% of the examined arable land area), and lowered balance was observed in as many as 74% of farms (63% of arable land area in the studied farms). Therefore, one may conclude that Opolskie Voivodeship was characterised by unbalanced fertilizing management for this component, primarily as regards its deficit. However, it is worth having in mind the fact that Opolskie Voivodeship belongs to regions characteristic of highest consumption of mineral fertilizers, and raised balances apply to farms constituting potentially very high hazards for natural environment, especially for water. Whereas, considering that the studies covered sample of farms in good agricultural condition, the result obtained for larger group, also for the rest of farms, may be different.

More recent statistical data [8] indicate that many voivodeships in Poland prove excessive nitrogen balance per 1 ha of arable land (on average for the years 2010-2012), and also its not entirely efficient utilisation (Table 2). Therefore, it is necessary to verify the amount of applied fertilizers (in particular mineral) compared to nutritional needs of plants.

As regards phosphorus balance, according to the research (research were made on farms with good agricultural practices) [12] in Opolskie Voivodeship, 19,3% of farms proved to have optimal result (19% of the individual farms arable land area), excessive balance result was observed in ca. 37,6% of farms (50,5% of the individual farms arable land area), and 42,3% of farms (30,5% of the individual farms arable land area) had negative balance result. On average, phosphorus balance for Opolskie Voivodeship reached 4 kg P per 1 ha of arable land. In the case of potassium, Opolskie Voivodeship was distinguished by highest share of farms with steady balance (4,9% of the studied farms; 7,1% of the individual farms arable land area). 26,9% of farms had raised balance (39,3% of the individual farms arable land area), and in as many as 67,4% of farms balance result was negative (53,7% of the individual farms arable land area. However, according to [2], Opolskie Voivodeship belongs to the regions characterised by highest share of soils with very low and low abundance with available potassium.

4. Results and their analysis

The N, P and K balance results were analysed for 6 farms located in Opolskie Voivodeship: four conventional farms and two organic farms. In the group of conventional farms there were two farms with plant production (K1, K2) and two with mixed production (K3, K4). In the group of organic farms – one of the farms was carrying out plant production only (E1), and the other mixed production: plant and animal (E2). Table 3 below presents general characteristics of farms.

The analysed farms, conventional and organic, were characterised by typical agricultural production. In arable lands (ArL), corn growing in main crop usually prevailed (25% - 100% in 2012 and 42%-100% in successive year). In conventional farms, other crops included mainly rape and maize. The structure of crops included almost only soil-degrading plants, which wasn't advantageous for soil. In an extended period, this situation may lead to humus content reduction, and humus constitutes the reserve of stored nutrients. Apart from crops specified above, the following were cultivated in conventional farms in smaller area: leguminous plants, papilionaceous plants and corn-leguminous mixes. Operation of the discussed conventional farms is based on the implementation of good agricultural practice principles. It manifests itself e.g. in protection of soils against erosion and loss of nutrients in wintertime, through the share of green fields. Only in the case of farm K3 - in 2012 - there was no coverage of ArL in wintertime due to securing feed base for fattening cattle. Main crops in the farm were: spring corn mix (nutritive fodder) and maize for ensilage (bulky feed). Whereas, since 2013 the farm has diversified its crop rotation due to the participation in an agricultural-environmental programme, in the "sustainable agriculture" package. Fertilization in conventional farms was based on using N, P and K both in form of mineral fertilizers, and natural ones in case of farms carrying out animal production. Nutrients were also brought-in from ploughed straw of e.g. leguminous or oil-bearing plants, and straw of corns. One may observe that animal stock in conventional farms (0.07-1.12 LU·ha^{-1} of AL), in particular in farm K4, delivered slight amounts of natural fertilizers as compared to the needs of farms. At the same time, in farm K3 the share of nutrients brought-in with natural fertilizers was higher than in the case of farm K4.

In organic farm E1, besides after-crop, ploughland was protected by cultivation of winter crops. Farm E1 was involved in corn production only, which wasn't advantageous from point of view of biological diversity needs in biological production. In farm E2, besides corns, the main crop included cultivation of corn-leguminous mixes and papilionaceous plants, which covered ArL in wintertime as well. The examples of analysed organic farms indicate diversification in carried out fertilizing management. In farm E1, in the years 2012-2013 delivered fertilizers were delivered only in the form of: straw made of the whole cultivated corn plants and ploughed green mass of after-crops. In previous years there were also red clover crops present, which were ploughed. In farm E2 (leading), fertilization was based on dung and liquid manure. Moreover, cultivated papilionaceous plants and leguminous plants mixed with corns were the source of input for nutrients.

Different fertilization translated into yielding. For conventional farms it was – specified in GU – 33-34% higher, on average.

Table 2. Income and utilisation of nitrogen and its balance and consumption efficiency in 2012 [8]
Tab. 2. Przychód i wykorzystanie azotu oraz jego bilans i efektywność wykorzystania w roku 2012 [8]

Voivodeships	Income [kg·ha^{-1} of AL]	Utilisation [kg·ha^{-1} of AL]	Balance	Consumption efficiency
Poland	138,0	80,2	57,8	58,0
Lower Silesian	131,5	82,7	48,8	62,9
Kuyavian-Pomeranian	167,3	89,2	78,1	53,3
Lublin	115,5	69,6	45,9	60,2
Lubusz	114,5	63,6	50,9	55,6
Łódź	148,0	77,8	70,2	52,6
Lesser Poland	94,0	76,1	17,9	81,0
Masovian	130,6	75,4	55,2	57,7
Opolskie	170,5	106	64,5	62,2
Subcarpathian	84,4	65,2	19,2	77,2
Podlaskie	141,6	91,9	49,7	64,9
Pomeranian	140,0	76,8	63,2	54,9
Silesian	134,8	78,5	56,3	58,3
Świętokrzyskie	113,0	64,9	48,1	57,4
Warmian-Masurian	142,9	87,2	55,7	61,0
Greater Poland	181,2	89,9	91,3	49,6
West Pomeranian	128,5	72,7	55,8	56,6

Table 3. General characteristics of the studied organic and conventional farms in the years 2011/2012-2012/2013
Tab. 3. Ogólna charakterystyka badanych gospodarstw ekologicznych i konwencjonalnych w latach 2011/2012-2012/2013

Specification	Farms					
	K1	K2	K3	K4	E1	E2
Farm agricultural land area [ha]						
2011/2012	31.51	13.26	20.44	36.04	65.33	10.22
2012/2013	31.78	14.03	20.44	35.84	65.33	10.17
Arable land area [ha]						
2011/2012	31.51	11.51	16.69	33.40	65.33	8.90
2012/2013	31.78	12.28	16.69	33.20	65.33	8.90
Permanent grassland area [ha]						
2011/2012	0.00	1.75	3.75	2.64	0.00	1.32
2012/2013	0.00	1.75	3.75	2.64	0.00	1.27
Soil quality	Light soils in valuation classes: IV, V	Light and medium soils in valuation classes: III and IV	Light and medium soils in valuation classes: IV and V	Heavy soils (fen type) in valuation class III and light soils, class V and VI	Light and medium soils in valuation classes: III, IV, V	Medium soils in valuation classes: III, IV, V
Yield in GU* [dt·ha^{-1} of AL]						
2011/2012	53.70	34.60	35.00	46.90	26.20	30.70
2012/2013	51.90	42.30	41.80	44.00	32.10	29.60
Yield in GU [dt·ha^{-1} of crops area]						
2011/2012	53.70	39.90	42.90	50.70	26.20	35.20
2012/2013	51.90	48.30	51.20	47.50	32.10	33.90
Applied fertilization	Mineral, ploughed straw	Mineral, ploughed straw	Mineral, natural, ploughed straw	Mineral, natural, ploughed straw	Ploughed straw	Natural, ploughed straw
Animal production [LU·ha^{-1} of AL]						
2011/2012	0.00	0.00	1.12	0.07	0.00	0.46
2012/2013	0.00	0.00	1.12	0.07	0.00	0.46
Area of green fields [ha]						
2011/2012	27.80	3.17	0.00	15.03	21.27	2.93
2012/2013	24.07	8.58	12.01	17.32	35.33	2.77
The share of corn-growing [%]						
2011/2012	36.00	51.00	69.00	25.00	100.00	54.00
2012/2013	63.00	44.00	43.00	42.00	100.00	70.00

*GU - Grain Unit

Source: Own study on the basis of data and information obtained from the farms / Źródło: Opracowanie własne na podstawie danych i informacji uzyskanych z gospodarstw

Table 4. Data (average of two years) for input and output of the N, P, K, and the results of the N, P, K balances
Tab. 4. Dane (średnio z dwóch lat) dla wnoszenia i wynoszenia N, P, K oraz wyniki sald N, P, K

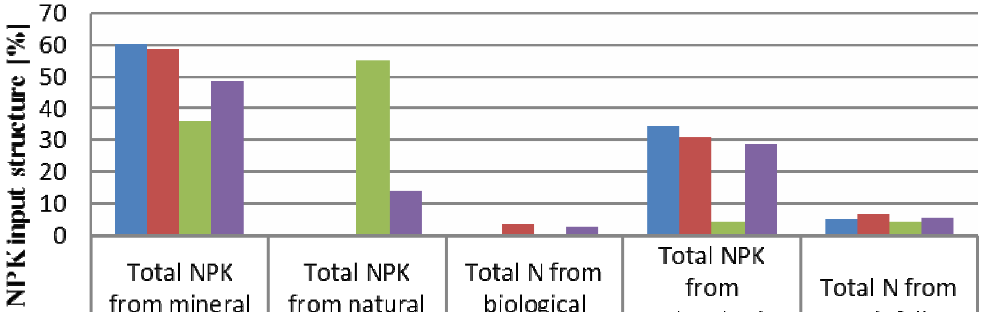
Specification	Farms					
	K1	K2	K3	K4	E1	E2
N [kg] input from mineral fertilizers	3018.00	994.00	1312.50	3066.00	0.00	0.00
N [kg] input from natural fertilizers	0.00	0.00	1274.50	491.00	0.00	293.50
N [kg] input from biological fixation	0.00	106.00	0.00	238.50	0.00	153.50
N [kg] input from all sources	4422.00	1580.00	2949.00	5264.00	2446.50	605.00
P [kg] input from mineral fertilizers	820.50	248.50	340.50	530.00	0.00	0.00
P [kg] input from natural fertilizers	0.00	0.00	388.50	150.50	0.00	98.50
P [kg] input from all sources	1002.00	297.00	745.50	846.50	328.50	101.00
K [kg] input from mineral fertilizers	1560.50	473.00	647.50	986.50	0.00	0.00
K [kg] input from natural fertilizers	0.00	0.00	1843.00	687.50	0.00	363.50
K [kg] input from all sources	3506.00	1034.00	2678.00	3269.00	2980.00	395.50
N [kg] output, total	3846.50	1347.00	2124.00	4270.00	5018.50	891.50
P [kg] output, total	785.00	250.50	406.00	810.50	996.00	143.50
K [kg] output, total	2606.50	872.00	1763.00	2947.00	3796.50	584.00
N balance [kg/ha of arable land]	18.00	17.50	40.50	28.00	-39.50	-28.00
P balance [kg/ha of arable land]	7.00	3.50	17.00	1.00	-10.00	-4.00
K balance [kg/ha of arable land]	28.00	11.50	45.00	9.00	-12.50	-10.00

Source: Own study on the basis of data and information obtained from the farms / Źródło: Opracowanie własne na podstawie danych i informacji uzyskanych z gospodarstw

The farms are characterised by different fertilizing management, primarily due to mineral fertilization applied by conventional farms. Data contained in Table 4 and Figs. 1 and 2 allow observing that in conventional farms carrying out plant production, the share of mineral fertilization in the delivery of nutrients ranged from 50% to 60%. The remaining fertilization was from ploughed straw (31%-35%). In farm K2 there was a slight share of N delivered from biological fixation. In conventional farms, carrying out animal production at the same time, there is a visible drop in consumption of mineral fertilizers accompanied by an increase in brought-in natural fertilizers. In farm K4, additionally there was biological fixation from cultivation of papilionaceous plants. In both farms (K3, K4) N, P and K was brought-in also with ploughed straw (4%-29%). The share of rainfall in N input in conventional farms was slight (4%-7%).

In farm E1, the only source of N, P, K input was ploughed straw, and in the case of N - rainfall. Farm E1 wasn't carrying out correct crop rotation management, and the presence of corn crops only every year, and lack of natural and organic fertilizers and structure-forming plants may result in soil fertility drop. It may also deteriorate soil structure. In farm E2, different situation was the consequence of carried out animal production, which allowed using natural fertilizers. On average during two years their share in delivery of nutrients reached almost 70%. The rest of brought-in N came from biological fixation (much higher share than in conventional farms) and from rainfall.

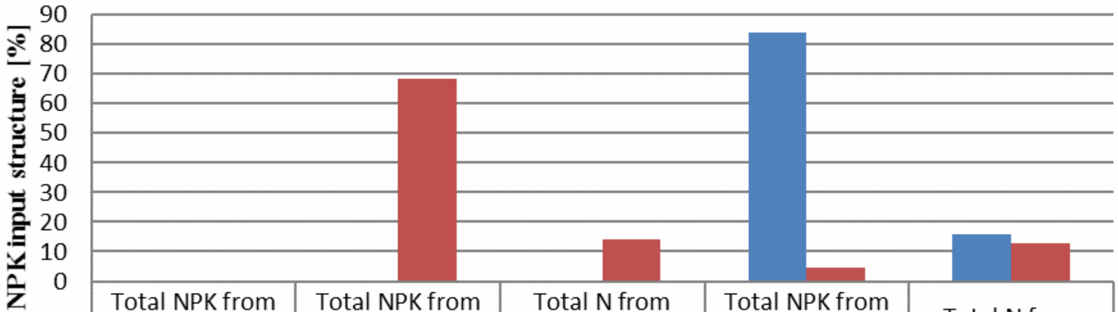
Different fertilizing management translated into the N, P, K balance results. Using the Macrobil application, computations were carried out which indicate that both organic farms, and farms K1 and K3 gave adverse results on average from two years. In case of organic farms, the N, P, K balance was negative. Similar results for organic farms are also given by other authors [1, 10, 11].



	Total NPK from mineral fertilisers	Total NPK from natural fertilisers	Total N from biological fixation	Total NPK from ploughed straw mass	Total N from rainfall
K1	60	0	0	35	5
K2	59	0	4	31	7
K3	36	55	0	4	4
K4	49	14	3	29	5

Source: Own study on the basis of data and information obtained from the farms / Źródło: Opracowanie własne na podstawie danych i informacji uzyskanych z gospodarstw

Fig. 1. The structure of input for nutrients [%] in conventional farms (an average of two years)
Rys. 1. Struktura dopływu składników pokarmowych [%] w gospodarstwach konwencjonalnych (średnio z dwóch lat)



	Total NPK from mineral fertilisers	Total NPK from natural fertilisers	Total N from biological fixation	Total NPK from ploughed straw mass	Total N from rainfall
E1	0	0	0	84	16
E2	0	68,5	14	4,5	13

Source: Own study on the basis of data and information obtained from the farms / Źródło: Opracowanie własne na podstawie danych i informacji uzyskanych z gospodarstw

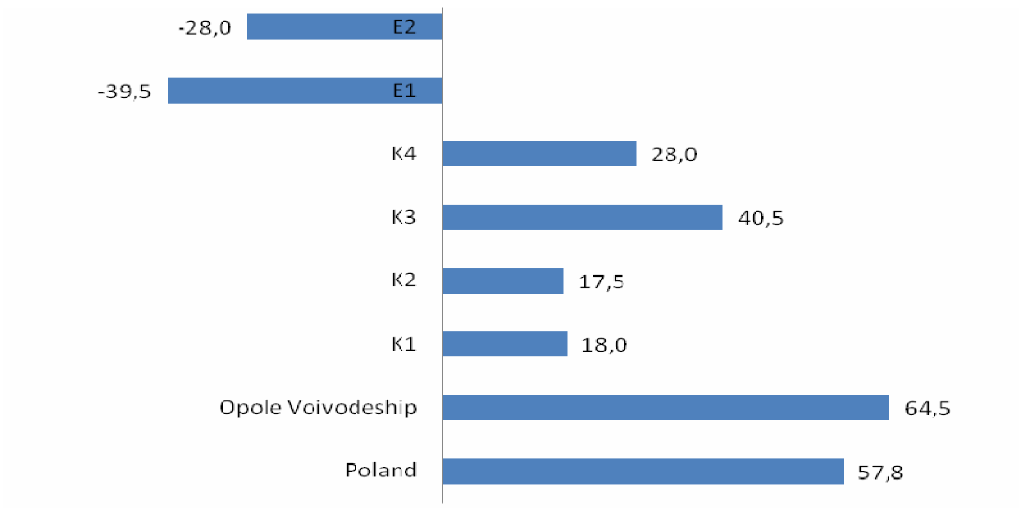
Fig. 2. The structure of input for nutrients [%] in organic farms (an average of two years)
Rys. 2. Struktura dopływu składników pokarmowych [%] w gospodarstwach ekologicznych (średnio z dwóch lat)

The result for farm E2 was slightly more advantageous, which was connected with bringing in natural fertilizers and biological fixation of N. The situation involving negative results of N, P and K balances is frequent in organic farms, which in order to compensate deficiencies should absolutely introduce larger numbers of cultivated papilionaceous plants, leguminous plants, mixes of grasses and papilionaceous plants, and first of all apply natural fertilizers. Unfortunately, in farm E1 biodiversity of crops is very poor, natural fertilizers are not used, and in the case of farm E2 – stock of animals is too low compared to fertilization needs.

Farms K2 and K4 proved steady fertilizing balance. Results in case of farms K1 and K3 were excessive (for P and K in farm K2 and for N, P and K for farm K3).

When we additionally compare the results of nitrogen balance for the analysed farms, with reference to the data contained in Table 2 (Fig. 3), we admittedly observe lower results compared to the data for Opolskie Voivodeship and for Poland, however its correct value was obtained only in case of K1, K2, K3.

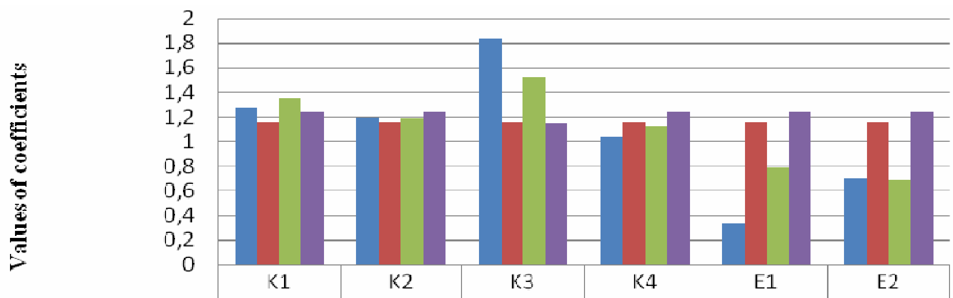
Additionally calculated values of balance coefficient for P and K indicate that the farms should improve fertilization quality. Balance coefficient higher than 1 means that recommended component dose in fertilizers should be higher than fertilization needs. Applied surplus is intended to improve soil abundance. For soils characterised by high and very high P and K content, at coefficient lower than 1, component dose in fertilizer will be lower than fertilization needs, and component deficiency will be covered from soil reserves [3]. Fig. 4 below presents values (average for two years) of P and K balance coefficients, and their recommended values for each farm.



Source: Own study on the basis of data and information obtained from the farms / Źródło: Opracowanie własne na podstawie danych i informacji uzyskanych z gospodarstw

Fig. 3. The value of nitrogen balance [kg·ha^{-1}] for the studied farms (average of the years 2012-2013) for the background data for Opolskie Voivodeship and Poland (data from 2012)

Rys. 3. Wartość salda azotu [kg·ha^{-1}] badanych gospodarstw (średnio z lat 2012-2013) na tle danych dla województwa opolskiego i Polski (dane z roku 2012)



	K1	K2	K3	K4	E1	E2
Current value of balance coefficient P	1,28	1,20	1,84	1,04	0,34	0,71
Recommended value of balance coefficient P	1,16	1,16	1,16	1,16	1,16	1,16
Current value of balance coefficient K	1,35	1,19	1,52	1,12	0,79	0,69
Recommended value of balance coefficient K	1,24	1,24	1,15	1,24	1,24	1,24

Source: Own study on the basis of data and information obtained from the farms / Źródło: Opracowanie własne na podstawie danych i informacji uzyskanych z gospodarstw

Fig.4. Values (average for two years), the coefficients of P and K balance

Rys. 4. Wartości (średnio dla dwóch lat) współczynników bilansowych P i K

In case of farms K1, K2, and particularly K3, current value of balance coefficients for phosphorus and is higher than its recommended value. It means that in farms there were unnecessary losses of this component, which remains unutilised. It is much the same in the case of potassium, for which especially in farm K3 the value of balance coefficient was considerably higher than recommended. Only farms K4 and K2 (for the value of balance coefficient K) proved to have the values of coefficients matching nutritional needs and abundance of soil.

Different situation was observed in analysed organic farms. The following values of balance coefficients are recommended for them: P = 1.16 and K = 1.24. For both farms their actual values were below zero. In both farms it is possible to apply much larger dose of fertilizers.

5. Conclusions and remedial programme for farms

Presented analysis of conventional and organic farms regarding fertilizing management and N, P, K balances shows that:

1. In case of farms: K1, K3, E1, and E2 it is necessary to verify fertilization quality and applied crop rotation.
2. In crop rotation, both in organic farms (especially in E1) and conventional ones it is worth to introduce more varied structure of crops, taking into account papilionaceous plants. Crop diversification may be an important element allowing crop rotation varying. During the next campaign of direct subsidies, two groups of crops will be required for plants in area group 10-30 ha. Whereas, farms with area exceeding 30 ha of ploughland will have to possess minimum three crop groups.
3. For farm K3, it is required to apply reduced mineral fertilization due to carried out animal production, which delivers natural fertilizers.
4. In case of organic farms, obtained results of N, P and K balances are significantly underrated, which may bring about soil deterioration in an extended time. Considering the above, especially in farm E1, it is required to make efforts to obtain natural or organic fertilizers, or apply fertilizer containing nitrogen, which is permitted for use in organic farms.
5. In conventional farms, the results of N, P and K balances for farms K2 and K4 remained according to standards. In farms K2 and K3 it is required in particular to verify the amounts of delivered potassium fertilizers.
6. In conventional farms, and first of all in K1 and K3, it is necessary to introduce rational utilisation of mineral fertilizers. This will reduce cultivation costs, and thus increase plant production profitability.
7. It would be a considerable advantage to increase animal production in stock-breeding farms and to introduce it plant production farms. However, the majority of farms reduces their stock of animals or completely gives it up. This is due to its low profitability and at the same time high labour consumption. Part time farming occurs in farms K1 and K2, which considerably reduces possibility of returning to animal production.
8. Due to the fact that as part of the new system of direct payments it is planned to introduce the obligation of implementing agricultural practices, which are more favourable for climate and environment, farms larger than 15 ha of AL will have to possess places supporting protection of natural and agricultural environment. In 2015, total area of these places is expected to reach 5% of ploughland area. These places will include nitrogen-fixing crops, intercrops and fallowed lands.
9. Both in organic and conventional farms it is recommended to carry out periodic checks of soil abundance and its pH.

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