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FERTILIZERS CONSUMPTION ON LITHUANIAN FAMILY FARMS

Vida DABKIENĖ

Lithuanian Institute of Agrarian Economics, LAEI, V. Kudirkos st. 18–2, 03105, Vilnius, Lithuania, Phone: +370 5 262 2429, Email: vida@laei.lt

Corresponding author: vida@laei.lt

Abstract

The paper aimed to evaluate the differences of fertilizers consumption and land productivity across family farm types and farm size classes in Lithuania. Lithuanian FADN data from 2014 were obtained for the analysis. The research draws on a sample of 616 family farms. The analyses are carried out for specialist cereals, oilseeds and protein crops farm type (TF 15), general field cropping farm type (TF 16), horticulture farm type (TF 23) and various permanent crops combined farm type (TF 38). Results are presented in weighted averages by using weighting factors to achieve estimation for the total Lithuanian family farms. An overview of fertilizers consumption in Europe countries is presented. The results revealed that in 2010 fertilizers consumption averaged 90 kg/ha UAA in Europe, the highest level was recorded in Netherlands (more than 140 kg/ha UAA) and Romania reported the lowest level of fertilizers consumed, at just above 30 kg/ha UAA. In Lithuanian family farms the consumption of fertilizers averaged 169.9 kg/ha UAA across considered farm types and ranged from 20.2 kg/ha UAA on permanent crop farms to 195.4 kg/ha UAA on conventional field cropping farms in 2014. Nitrogen-based fertilizers accounted for 52% of the fertilizers consumed and 88.2 kg/ha UAA indicated large consumption level. Therefore, developing a suitable nutrient management system that optimize crop yields while minimizing nutrient losses is still needed as efficient fertilizers consumption management should ensure both enhanced and sustainable agricultural production and safeguard the environment.

Key words**:** *fertilizers, consumption, land productivity, family farms, FADN*

INTRODUCTION

Links between the natural environment and farming practices are complex: farming has contributed over the centuries to creating and maintaining a variety of valuable semi-natural habitats within which a wide range of species rely for their survival; on the other hand, inappropriate agricultural practices and land use can have an adverse effect on natural resources, through the pollution of soil, water and air, or the fragmentation of habitats and a subsequent loss of wildlife [2]. Fertilizers are an important factor in modern day agriculture. They are responsible for substantial increases in crop yields, and allow crops to be planted in soil that would otherwise be nutrient deficient. Therefore, fertilizers are widely used in agriculture to maintain soil fertility and to increase crop yields [5]. FAO [3] projected, that fertilizer consumption could increase to 263 million tonnes in 2050. Cereals, in particular wheat, rice and maize, account at present for some 60% of global fertilizer use, and are expected to still account for just over half of fertilizer consumption by 2050.

Going back shortly, as noticed by Fodor et al. [4] from the 1960s in many countries in the world production has gone through tremendous improvement due to introduced new, intensive cultivars and hybrids. Though, one of the main factors behind this development was the enormous increase in fertilizer use. The same trend could be observed in Lithuania. According to Central Statistical Office of Lithuania, in 1980, compared to 1960, fertilizers consumption in agriculture in terms of kg per hectare per year increased by 4.2 times (from 233 kg/ha to 996 kg/ha). Due to the geo-political and mostly the economic changes in the late 1980s and early 1990s fertilizers consumption decreased and accounted 227 kg/ha [6]. In Lithuania, in order to limit the environmental damage associated with excess nutrient application a number of legislative measures have been taken after the accession to the EU. As pointed by Velthof et al. [8], the Nitrates Directive has the most dominant influence. As a result of implemented measures, according to Eurostat, in 2010 the consumption of fertilizers decreased to 73.2 kg/ha of UAA, and it is rather low as compared to top fertilizers consumer countries in the EU. Though, during the period of 2004–2015, the number of cattle decreased by 8.8% in Lithuania. Obviously this trend limits the consumption of organic fertilizers and cause higher inputs of chemical fertilizers. According to Lithuanian FADN (Farm Accountancy Data Network) data, in 2014, as compared to 2004, the costs of fertilizers in the structure of costs per hectare of UAA in family farms, increased by 2.5 times.

Lithuanian farmers are obliged to keep records of consumed fertilizers according to the EU Common Agricultural Policy support rules. Though the latest statistics about nitrogen, phosphorus and potassium consumption at a farm level was recorded in 2008 [1], as consequence of Order No. 3D-38 of 1 February 2007, issued by the Lithuanian Minister of Agriculture "On the information about used fertilizers in holding". In this document, it is declared that farmers from the year of 2007, having more than 10 ha of UAA, must record the amount of total fertilizers consumed on farms.

Whereas, data related to fertilizers consumed on farms is important for monitoring, the collection of information on the quantities of chemical fertilizers (nitrogen, phosphorus, potassium) applied on farms was launched on 1 January 2014 in Lithuania by FADN under the framework of the European Council Regulation (EU) No. 1320/2013.

MATERIALS AND METHODS

The aim of the paper is to evaluate the differences of fertilizers consumption and land productivity across family farm types and farm size classes in Lithuania. In the beginning, an overview of fertilizers consumption in Europe countries is presented. Lithuanian FADN data from 2014 were obtained for fertilizers consumption analysis in family farms. In this paper it was focused on four groups of farms depending on their production specialisation, based on the EU standard classification of 'Type of Farming' (TF). The criterion for farms' classification in TF is that at least 75 percent of their standard output must come from the specific production of the TF. Here the analyses are carried out for specialist cereals, oilseeds and protein crops (COP) farm type (TF 15), general field cropping farm type (TF 16), horticulture farm type (TF 23) and various permanent crops combined farm type (TF 38). Table 1 presents farms sample distribution according to the specialization.

Table 1. Farms sample distribution according to farm type and farm size classes

Farm types, classes	Number of farms	Average farm size (ha UAA)
COP farms (total)	453	87.5
Farm size classes of UAA		
Less than 30 ha	39	20.0
From 30 to50 ha	39	37.0
From 50 to 100 ha	103	69.0
From 100 to 200 ha	87	143.0
From 200 to 500 ha	126	287.0
500 ha or over	59	741.0
Conventional COP farms	428	89.1
Farm size classes of UAA		
Less than 30 ha	37	19.5
From 30 to50 ha	35	37.0
From 50 to 100 ha	96	70.6
From 100 to 200 ha	80	143.5
From 200 to 500 ha	122	289.8
500 ha or over	58	748.4
General field cropping farms	99	54.0
Farm size classes of UAA		
Less than 50 ha	22	20.5
From 50 to 200 ha	43	87.4
200 or over	34	412.1
Conventional field cropping farms	94	50.7
Farm size classes of UAA		
Less than 50 ha	21	20.2
From 50 to 200 ha	39	83.1
200 or over	34	412.1
Horticultural farms	39	6.8
Conventional horticultural farms	38	8.4
Permanent crops farms	25	36.8
Conventional permanent crops farms	16	36.7
Total (TF15,TF16, TF23, TF38)	616	76.2

For calculations data of 616 family farms were used. Alongside, the differences across farm size classes expressed in utilized agricultural land area (UAA hectares) were completed. Different farm size classes for COP and for field cropping farm types were estimated as any farm type (or size class) have to be large enough (it is advisable to present the results for a group of at least 15 farms) to comply with FADN confidentiality restrictions. Results are presented in weighted averages by using weighting factors to achieve estimation for the total Lithuanian family farms (COP, general field cropping, horticulture and various permanent crops combined). In addition, statistics were

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averaged also for conventional farms only, as chemical fertilizer was not purchased by organic farms. ANOVA test was used to measure statistical significance of the difference in the consumed fertilizers and land productivity values between the farm size classes. In addition there have been few attempts to assess relationship between land productivity and fertilizers consumption. Therefore, statistical analyses included non-parametric Spearman rank correlations between mentioned variables. The statistical package for social science (SPSS 21) was employed for processing and analysis of the data.

RESULTS AND DISCUSSIONS

According to Eurostat data, in 2011–2012 the consumption of manufactured fertilisers by agriculture in the EU amounted 13.6 million tonnes, of which nitrogen (N) accounted for 76.4%, potassium (K) – 16.0% and phosphorus (P) – 7.6%. Velthof et al. [8] stated that there are large differences among the EU of the nitrogen consumption. Total nitrogen inputs range from less than 50 kg nitrogen per hectare per year in regions in Central Europe (e.g. in Bulgaria, Estonia, Latvia, and Romania) to more than 300 kg nitrogen per hectare per year in regions with intensive livestock systems in Belgium, France, Germany, Ireland, Italy, Spain and the Netherlands.

Mažeika, Lazauskas and Staugaitis [7] the consumption of N in the Europe Union divided into four categories: 1) countries consuming very large amounts of N (up to 150 kg/ha); 2) countries consuming large amounts of N (up to 100 kg/ha); 3) countries consuming average amounts of N (ranged from 50 to 80 kg/ha); 4) countries consuming small amounts of (from 25 to 50 kg/ha); 5) countries consuming very small amounts of N (less than 25 kg/ha). In 2010 nitrogen-based fertilizers accounted for the vast majority of the fertilizers consumed, with an estimated consumption of 68 kg/ha UAA across the Europe countries, ranging from 120.1 kg/ha UAA in the Netherlands to 27.0 kg/ha UAA in Romania (Table 2).

Table 2. Fertilizer consumption by agriculture in Europe, 2010

Country	Nitrogen (N), tonnes	Phosphorus (P), tonnes	Potassium (K), tonnes	UAA 1000 hectares*	Nitrogen (N) kg/ha UAA	Phosphorus (P) kg/ha UAA	Potassium (K) kg/ha UAA
Belgium	143,500	5,500	-	1,350	106.3	4.1	-
Bulgaria	199,000	17,000	15,000	3,548	56.1	4.8	4.2
Czech Republic	270,500	13,500	32,000	3,464	78.1	3.9	9.2
Denmark	190,000	11,000	40,000	2,548	74.6	4.3	15.7
Germany	1,569,000	102,500	360,000	16,493	95.1	6.2	21.8
Estonia	28,500	2,500	7,000	832	34.3	3.0	8.4
Ireland	362,500	29,500	74,000	4,130	87.8	7.1	17.9
Greece	196,000	29,000	40,000	3,000	65.3	9.7	13.3
Spain	941,000	147,500	295,000	18,106	52.0	8.1	16.3
France	2,080,000	177,000	454,000	25,693	81.0	6.9	17.7
Italy	589,500	88,000	123,000	11,320	52.1	7.8	10.9
Cyprus	4,000	1,000	2,000	117	34.2	8.5	17.1
Latvia	59,500	7,000	12,000	1,291	46.1	5.4	9.3
Lithuania	144,000	15,500	36,000	2,672	53.9	5.8	13.5
Luxembourg	13,500	500	-	131	103.1	3.8	-
Hungary	281,500	20,000	41,000	3,988	70.6	5.0	10.3
Netherlands	219,500	13,500	30,000	1,828	120.1	7.4	16.4
Austria	105,000	12,500	28,000	2,321	45.2	5.4	12.1
Poland	1,027,500	154,000	378,000	14,163	72.5	10.9	26.7
Portugal	103,000	18,000	21,000	2,333	44.1	7.7	9.0
Romania	306,000	54,000	29,000	11,332	27.0	4.8	2.6
Slovenia	28,000	3,500	10,000	433	64.7	8.1	23.1
Slovakia	106,500	7,000	11,000	1,801	59.1	3.9	6.1
Finland	156,500	12,500	33,000	2,268	69.0	5.5	14.6
Sweden	168,000	10,000	21,000	3,021	55.6	3.3	7.0
United Kingdom	1,016,000	80,000	235,000	11,865	85.6	6.7	19.8
Norway	84,000	8,000	25,000	851	98.7	9.4	29.4

Note:* excluding common land units, rough grazing and permanent grassland no longer used for production. Common land is included in for a minor part in Spain, Italy and Germany (minor part) and in its total in Slovenia, Cyprus and Norway.
Source: Eurostat

The consumption of phosphorus averaged 6.2 kg/ha UAA across considered Europe countries in 2010, ranging from 11 kg/ha UAA in Poland to 3.0 kg/ha UAA in Estonia. The consumption of potassium fertilizers averaged 14.1 kg/ha UAA, ranging from 2.6

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kg/ha UAA in Romania to 29.4 kg/ha UAA in Norway. According to the 2009 data, the consumption of potassium was also high in Belgium and Netherlands (more than 30 kg/ha UAA).

Total fertilizers consumption in Europe calculated by summing up the consumption of nitrogen, phosphorus and potassium averaged 90 kg/ha UAA, the highest level was recorded in Netherlands (more than 140 kg/ha UAA). In contrast, Romania reported the lowest level of fertilizers consumed, at just above 30 kg/ha UAA.

In Lithuania in 2013, as compared to 2010, was observed an increase of consumption of fertilizers. The consumption of nitrogen-based fertilizers increased by 4.2% and comprised 56.1 kg/ha UAA. Although the consumption of phosphorus fertilizers was lower by 6% in Lithuania, than the average in considered Europe countries. In 2013 the consumption of phosphorus increased by 12%, as compared to 2010, and accounted for 6.5 kg/ha UAA. The use of potassium fertilizers in considered period increased by 15% and averaged 15.5 kg/ha UAA.

The results of analysis on the fertilizers consumption in Lithuanian family farms are presented below in Tables 3-7. The results of fertilizers consumption on COP farms across farm size classes are shown in Table 3. The fertilizers consumption averaged 170.6 kg/ha UAA, ranging from 71.7 kg/ha UAA in the small-sized farms less than 20 ha UAA to 255.7 kg/ha UAA in large-sized farms 500 ha or over. Respectively, the consumption of fertilizers in small-sized farms comprised 42% of average consumption, and the large-sized farms consumption was by 50% higher than average. Nitrogen-based fertilizers accounted for 52% of the fertilizers consumed, with an estimated consumption of 89 kg/ha UAA, ranging from 37.1 kg/ha UAA on farm class less than 30 ha UAA to 134.7 kg/ha UAA on the largest-sized class 500 ha UAA or over. The highest land productivity level expressed by total output per hectare of UAA was reached in large-sized farms. As compare to the lowest result obtained by small-sized farms, it was by 2.1 times higher, and by 38% higher as compared to average land productivity of COP farms.

Table 3. Fertilizers consumption and land productivity of COP farms by farm size classes

Farm size classes of UAA	N	P	K	Total fertilizers	Total output EUR/ha UAA
Specialist cereals, oilseeds and protein crops					
Less than 30 ha	37.1	14.4	20.2	71.7	389.6
From 30 to 50 ha	41.9	16.0	15.8	73.7	346.8
From 50 to 100 ha	76.3	31.9	40.1	148.3	476.6
From 100 to 200 ha	78.2	30.7	40.7	149.6	570.6
From 200 to 500 ha	106.5	43.9	55.7	206.1	685.3
500 ha or over	134.7	56.5	64.5	255.7	820.7
Total	**89.0**	**36.4**	**45.2**	**170.6**	**593.5**
$F_{(5,447)}$	13.9	7.7	8.4	13.4	20.3
Significance	***	***	***	***	***
Index (total specialist cereals, oilseeds and protein crops=100)					
Less than 30 ha	42	40	45	42	66
From 30 to 50 ha	47	44	35	43	58
From 50 to 100 ha	86	88	89	87	80
From 100 to 200 ha	88	84	90	88	96
From 200 to 500 ha	120	121	123	121	115
500 ha or over	151	155	143	150	138

Note: *p<0.05; **p<0.01; ***p<0.001; ****p>0.05.
Source: own calculation.

Analysing the results of the conventional COP farms it was observed the same fertilizers consumption trends, as compared to all COP farms (Table 4). The fertilizer consumption in considered farms averaged 182.9 kg/ha UAA, i.e. by 12.3 kg/ha UAA more than in all COP farms. Nitrogen-based fertilizers consumption ranged from 40.2 kg/ha UAA on farm class less than 30 ha UAA to 139.3 kg/ha UAA on the largest-sized class 500 ha UAA or over. According to the nitrogen consumption classification presented by Mažeika, Lazauskas and Staugaitis [7] the conventional COP farms consume large and very large amounts of nitrogen, except for the first two farm size classes.

Table 4. Fertilizers consumption and land productivity of conventional COP farms by farm size classes

Farm size classes of UAA	N	P	K	Total fertilizers	Total output EUR/ha UAA
Specialist cereals, oilseeds and protein crops (organic farms excluded)					
Less than 30 ha	40.2	15.6	21.8	77.6	408.3
From 30 to 50 ha	46.7	17.8	17.6	82.1	357.9
From 50 to 100 ha	83.2	34.8	43.7	161.7	499.7
From 100 to 200 ha	87.1	34.2	45.3	166.6	595.4
From 200 to 500 ha	111.6	46.0	58.4	216.0	704.7
500 ha or over	139.3	56.3	67.0	262.6	843.0
Total	**95.5**	**38.8**	**48.6**	**182.9**	**617.5**
$F_{(5,423)}$	12.9	6.7	7.6	12.4	19.0
Significance	***	***	***	***	***
Index (total specialist cereals, oilseeds and protein crops(organic farms excluded)=100)					
Less than 30 ha	42	40	45	42	66
From 30 to 50 ha	49	46	36	45	58
From 50 to 100 ha	87	90	90	88	81
From 100 to 200 ha	91	88	93	91	96
From 200 to 500 ha	117	119	120	118	114
500 ha or over	146	145	138	144	137

Note: *p<0.05; **p<0.01; ***p<0.001; ****p>0.05.
Source: own calculation.

The results of fertilizers consumption on farms specialized in field cropping across farm size classes are presented in Table 5. The consumed fertilizers amounts differ significantly in considered farm size classes. In small-sized farms estimated the lowest level and in the large-sized farms the highest level of fertilizers consumption, 62.8 kg/ha UAA and 353.0 kg/ha UAA, respectively. The indicated highest level of fertilizers consumption, as compared to lowest level, was by more than 2 times higher.

Table 5. Fertilizers consumption and land productivity of field cropping farms by farm size classes

Farm size classes of UAA	N	P	K	Total fertilizers	Total output EUR/ha UAA
Field cropping					
Less than 50 ha	36.6	12.0	14.2	62.8	457.7
From 50 to 200 ha	64.5	26.8	31.6	122.9	494.6
200 ha or over	174.2	80.6	98.3	353.0	1358.8
Total	**87.1**	**37.6**	**45.3**	**170.0**	**719.7**
$F_{(2.96)}$	11.3	5.7	8.7	10.9	5.7
Significance	***	**	***	***	**
Index (field cropping=100)					
Less than 50 ha	42	32	31	37	64
From 50 to 200 ha	74	71	70	72	69
200 ha or over	200	214	217	208	189

Note: *p<0.05; **p<0.01; ***p<0.001; ****p>0.05.
Source: own calculation.

Table 6 contains results of applied fertilizers on conventional farms specialized in field cropping. The fertilizer consumption on conventional field cropping farms averaged 195.4 kg/ha UAA, i.e. by 25.4 kg/ha UAA more than in all field cropping farms.

Table 6. Fertilizers consumption and land productivity of conventional field cropping farms by farm size classes

Farm size classes of UAA	N	P	K	Total fertilizers	Total output EUR/ha UAA
General field cropping (organic farms excluded)					
Less than 50 ha	37.7	12.4	14.7	64.9	461.6
From 50 to 200 ha	87.0	36.1	42.6	165.7	594.8
200 ha or over	174.2	80.6	98.3	353.0	1358.8
Total	**100.2**	**43.2**	**52.0**	**195.4**	**795.2**
$F_{(2,91)}$	10.2	5.6	8.2	10.3	4.6
Significance	***	**	**	***	*
Index (general field cropping (organic farms excluded)=100)					
Less than 50 ha	38	29	28	33	58
From 50 to 200 ha	87	84	82	85	75
200 ha or over	174	186	189	181	171

Note: *p<0.05; **p<0.01; ***p<0.001; ****p>0.05.
Source: own calculation.

Nitrogen-based fertilizers accounted for 51% of the fertilizers consumed. The nitrogen consumption ranged from 37.7 kg/ha UAA on farm class less than 50 ha UAA to 174.2 kg/ha UAA on the largest-sized class 200 ha UAA or over. Average value of nitrogen of conventional field cropping farms indicates large consumption level with regard to the nitrogen consumption classification presented by Mažeika, Lazauskas and Staugaitis [7]. Land productivity differs considerably across the farm size classes, particularly between small-sized and large-size farms. The highest productivity level was achieved on farm size class of 200 ha UAA or over and, as compare to the average value, it was by 1.7 times higher.

Table 7 presents the results of fertilizers applied and land productivity on horticultural and permanent crops farms. The consumption of fertilizers of conventional farms specialized in horticulture averaged 156.3 kg/ha UAA and comprised 85% of total (TF 15, TF 16, TF 23, TF 38) fertilizers consumption.

Table 7. Fertilizers consumption and land productivity of specialist horticulture and permanent crops combined farms

Type of farming	N	P	K	Total fertilizers	Total output EUR/ha UAA
Horticulture	58.2	31.9	54.7	144.7	2974.5
Conventional horticulture	62.8	34.4	59.1	156.3	3109.8
Permanent crops	10.5	4.9	4.8	20.2	387.4
Conventional permanent crops	20.3	9.5	9.2	39.0	518.8
Total (TF 15,TF 16, TF 23, TF 38)	88.2	36.4	45.1	169.6	620.9
Index (TF15, TF16, TF23, TF 38=100)					
Horticulture	66	88	121	85	479
Conventional horticulture	71	95	131	92	501
Permanent crops	12	13	11	12	62
Conventional permanent crops	23	26	21	23	84

Source: own calculation.

The fertilizer consumption on conventional permanent crops farms averaged 39.0 kg/ha UAA and it made just 23% of total (TF 15, TF 16, TF 23, TF 38) fertilizers consumption. Land productivity in conventional horticultural farms was by 5.0 times higher than in considered farm types. In contrast, permanent crops farm type, recorded just 62% of average land productivity.

The applied fertilizers on farms calculated for considered in farm types averaged 169.6 kg/ha UAA. Nitrogen-based fertilizers accounted for 52% of the fertilizers consumed and recorded 88.2 kg/ha UAA of nitrogen indicates large consumption level.

The Spearman's rank correlation coefficient between fertilizers consumption and land productivity was conducted. The total fertilizers amounts applied on farms per hectare of UAA (kg/ha UAA) and total output per hectare (EUR/ha UAA) were employed as variables for correlation (Table 8).

Table 8. Spearman's rank correlation coefficients between fertilizers consumption and land productivity in farms

	COP farms	Field cropping farms	Horticultural farms	Permanent crops farms
Spearman's rank correlation coefficient	0.719	0.745	0.357	0.097
Significance	***	***	*	****

Note: *p<0.05; **p<0.01; ***p<0.001; ****p>0.05.
Source: own calculation.

A positive statistically significant correlation was found for COP, field cropping and horticultural farms. The use of chemical fertilizers indicated its influence on crop growth and productivity.

CONCLUSIONS

The results of an overview of fertilizers consumption in Europe countries revealed, that total fertilizers consumption in Europe averaged 90 kg/ha UAA, the highest level was recorded in Netherlands (more than 140 kg/ha UAA). In contrast, Romania reported the lowest level of fertilizers consumed, at just above 30 kg/ha UAA.

In Lithuania in 2013, as compared to 2010, was observed an increase of consumption of fertilizers. The consumption of nitrogen-based fertilizers increased by 4.2% and comprised 56.1 kg/ha UAA. The consumption of phosphorus increased by 12% and accounted for 6.5 kg/ha UAA and the use of potassium fertilizers increased by 15% and averaged 15.5 kg/ha UAA.

The results of analysis on the consumption of fertilizers across considered farm types in Lithuania showed, that consumption of fertilizers averaged 169.9 kg/ha UAA and ranged from 20.2 kg/ha UAA on permanent crop farms to 195.4 kg/ha UAA on conventional field cropping farms in 2014.

Nitrogen-based fertilizers accounted for 52% of the fertilizers consumed and 88.2 kg/ha UAA indicated large consumption level. Therefore, developing a suitable nutrient management system that optimize crop yields while minimizing nutrient losses is still needed as efficient fertilizers consumption management should ensure both enhanced and sustainable agricultural production and safeguard the environment.

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