



# World Scientific News

An International Scientific Journal

WSN 139(2) (2020) 233-245

EISSN 2392-2192

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## Place of logistics in agricultural production management

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### ABSTRACT

The paper presents an analysis of the implementation of the process of supplying selected means of production used in field cultivation of cereals (mineral fertilizers, plant protection products, certified seed material) in logistics of production of farms of varied areas (4 - 95 ha) and production profiles (mixed production - cultivation cereals and animal husbandry, crop production - cereal cultivation). The source material for the study were the results of a survey carried out among farmers having and managing their own farms in the central and south-eastern part of the Siedlce County in the Mazowieckie Province. Mineral fertilisers were purchased by all the surveyed farmers, the most of them – multi nutrient NPK fertilisers; phosphate fertilisers were the least popular. It was indicated that 4/5 of the examined farms used plant protection products, and all of them – herbicides. The greater share in the purchases of fungicides and insecticides was observed at the farms specialised in the cereal cultivation. It was found that certified seed material was bought mostly at the ones at year, especially in farms specialised in plant production. On the whole, younger and better educated farmers were more willing to invest in the development of their farms through the purchase of suitable means of production in quantities and at dates optimal for the agricultural technology of plants being cultivated.

**Keywords:** supply chain, crop production, agricultural farm, means of production, the Siedlce County

## **1. INTRODUCTION**

Agriculture is an important sector of the Polish economy, producing food and raw materials for industry. The basic economic entity in the structure of agricultural production in Poland is an agricultural farm. According to Statistical Yearbook of Agriculture (2018), in 2017 there were 1,401.7 thousand natural person's agricultural farms, and their average area was 10.0 ha of arable land. In 2017, rural areas were inhabited by 15324000 population, of which 2309.2 thousand were entered in the register of agricultural producers. Agricultural production in Poland in 2017 amounted to PLN 115,611.7 million (in current prices), and a significant part of this value (90.2%) relates to individual farms. Intermediate consumption of inputs necessary for agricultural activities purchased from suppliers was estimated at PLN 65605.8 million, and gross value added was PLN 50005,9 million. During this period, Polish agriculture generated 2.4% of the Gross Domestic Product in the country.

The mechanisms of the free market of food production forced the introduction of the concept of logistics management (planning, organization, execution, control of material flows and information) in the agricultural business in order to gain and maintain the competitive edge and increase the profitability of food production. The efficiency of logistics processes affecting production by farms is dependent on the quality of agricultural production space, weather conditions, number of technological operations derived from agricultural technology, as well as socio-economic conditions (agrarian structure, qualifications of labour force, level of mechanisation, price of production means) (Condratchi 2014, Wajszczuk 2016, Ganeshkumar et al. 2017, Michlowicz, Mindur 2018, Nowicka-Skowron et al. 2018).

The planning of the logistics system in agricultural farm must, above all else, take into account the seasonality of production and long-term production cycles, which depend on the business profile – production of crops, animals or both (mixed profile), as well as horticulture (Czyżewski, Smędzik-Ambroży 2015).

The market of means of production (fertilisers, plant protection products, certified seed material, animal feed, agricultural machines, energy, services) facilitates and determines the quantity of agricultural production directly and indirectly (McCluskey, Rourke 2000).

The level of education of farmers and their age are among the factors influencing the acceptance of changing of economic conditions of agricultural production and the introduction of innovation in farm management, including attention to more effective supply and production logistics (Kołoszko-Chomentowska 2008, Dudzińska et al. 2017). The main added values for the farmers are the knowledge and new technology transfer in agriculture, focusing on modern farming systems of production, logistics and management in economic practice (Mor et al. 2015, Bucci et al. 2018, Stastna et al. 2019).

Logistics allow the effective management of the supply chain of goods and services necessary in business and the optimal use of potential and resources of the farm. The logistics of the supply of means of production is of strategic character, affecting the achievement of goals by a farm and shaping the efficiency of production and distribution logistics as economic decisions are made (Kherbach, Mocan 2016, Tavana et al. 2017, Nowicka-Skowron et al. 2018). Agricultural logistics information system is a production activity network of a supplier organization to work collaboratively to meet the farmers demand (Perdana 2012).

The proper implementation of the supply plan determines the timeliness of respective tasks related to agricultural technology, affecting the quantity and quality of plant and animal products generated in the process. An important element of logistics at a farm is the

maintenance of stocks in such quantity and during such a period as to ensure the continuity of production at the lowest costs possible (Vanecek, Kalab 2003, Pulina, Timpanaro 2012, Condratchi 2014, Mor et al. 2015, Wajszczuk 2016). The aim of the work was to analysis the supply of selected means of production used in field cultivation of cereals in the production logistics of farms of varied areas and production profiles in the Siedlce County

## **2. MATERIALS AND METHODS**

The source material for the study were the results of a survey carried out among farmers having and managing their own farms in the central and south-eastern part of the Siedlce County. This region is typically agricultural, located in the eastern parts of the Mazowieckie Province in Poland (Fig. 1). More then 60,0% of the Siedlce County population works in agriculture, the farmlands occupy about 77.5% of its general surface, including the arable lands – 70.8%, as well as meadows and pastures – 24.7%. There are about 15 000 farms. Their average size is 9.0 ha, but the area of as much as 70% of all farms does not exceed 10 ha. The region is dominated by soils of medium and poor quality (IV and V soils classes, 43.6% and 38.7%, respectively). Conditions of the natural environment and long-term family traditions have led to the development of a certain agricultural production model specific to this region. Cereal and potato cultivation dominate in plant production, while pig and dairy cattle breeding in animal production (Development strategy for the Siedlec County for the years 2015-2020).



**Figure 1.** Location of the Siedlce County on a map in scale 1:1000000 (Development strategy for the Siedlec County for the years 2015-2020)

The survey was conducted in 2018 for a group of 50 individual farms selected at random and specialised in cattle breeding and cereal crop cultivation – mixed production (60.0% of the farms under examination), and specialised in cereal crops cultivation – single profile of production (40.0%). The farms were divided into three groups of various areas: I - up to 10 ha, II - 10.1-30 ha and III – above 30.1 ha.

For the purpose of the research, a questionnaire was distributed among farmers having and managing their own farms. The survey was carried out in a form of a direct interview and personal filling in of the questionnaire by the respondent. It contained 24 closed-ended single- and multiple-choice questions, with the option of extending and supplementing certain answers. The respondents were asked to present the performance of agricultural production through the prism of the process of supplying their farms with mineral fertilisers, plant protection products, certified seed material and information on dates, frequency and structure of purchases and means of transport, and storage period. The results obtained were developed statistically in the Statistica 12 software.

### **3. RESULT**

The size of the farm expressed as the area of farmlands determines its production potential and options for development. The competition on the agricultural market necessitates increasing the area of farms, which is favourable to innovations in production processes and testifies to the better use of land resources as the underlying factor of agricultural production. The size of the farms surveyed was various, from 4 to 95 ha of agricultural lands. The most of the farms fell into the category of up to 10.0 ha (50.0%), the least – into the category of above 30.1ha (20.0%).The research proved that mixed production (animals and crops) was usually engaged in by farms smaller than 10 ha – 76.0%, whereas the single, crop profile of production was mainly a speciality of the farms with the area of upwards of 30.1 ha – 70.0% (Table 1). The configuration of production structures in agricultural farms is one of the most important determinants of their economic situation (Czyżewski, Smędzik-Ambroży 2015).

The average age of the owner of the surveyed farms was 46.8 years, the largest in the group of farms with an area up to 10.0 ha - 54.3 years, and the smallest - 38.6 years, on farms with an area over 30.1 ha. Analyzing the age structure, it was found that 80.0% of respondents were over 40 years old. Similar relationships were found in the neighboring Łuków County (Pakuła et al. 2018) and in the Radzyń Podlaski County (Gajownik-Łazuga, Łazuga 2014). The owners of the surveyed farms had vocational and secondary education mainly, 48% and 38.0% respectively, with vocational education prevailing in the group of farms up to 10.0 ha in size - 60.0%, and secondary in farms over 30.1 ha - 70% (Table 1). Education is a factor determining a farmer's openness to the changing environmental conditions. Better educated farmers accept changes in the market of means of production more readily, and are more willing to respond to emerging challenges in food production (Dudzińska et al. 2017).

Polish farms purchase a sufficient assortment of means of production, requisite to ensure the optimal yield of cultivated crops. This activity, focused on the development of farms, is reflected in the issues connected with agrilogistics (Nowicka-Skowron et al. 2018). On farms, the use of mineral fertilizers increases with the increase in the utilized agricultural area. In 2017, 76.3% of agricultural holdings used mineral fertilizers, the consumption of which amounted to 141.6 kg NPK on average per 1 ha of agricultural land. In order to optimise crop production,

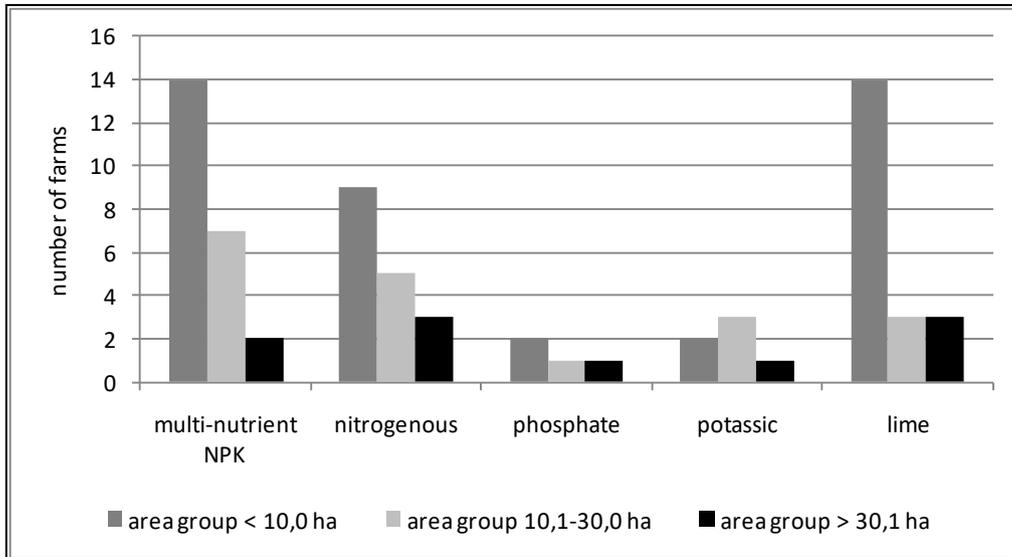
mainly nitrogenous fertilisers (80.4 kg/ha), in smaller amounts potassic fertilisers (38.1 kg/ha) and phosphate ones (23.1 kg/ha) were used (Means of production in agriculture in the 2017/18 farming year, Statistics Poland 2019).

**Table 1.** Characteristic of investigated farms in the Siedlce County

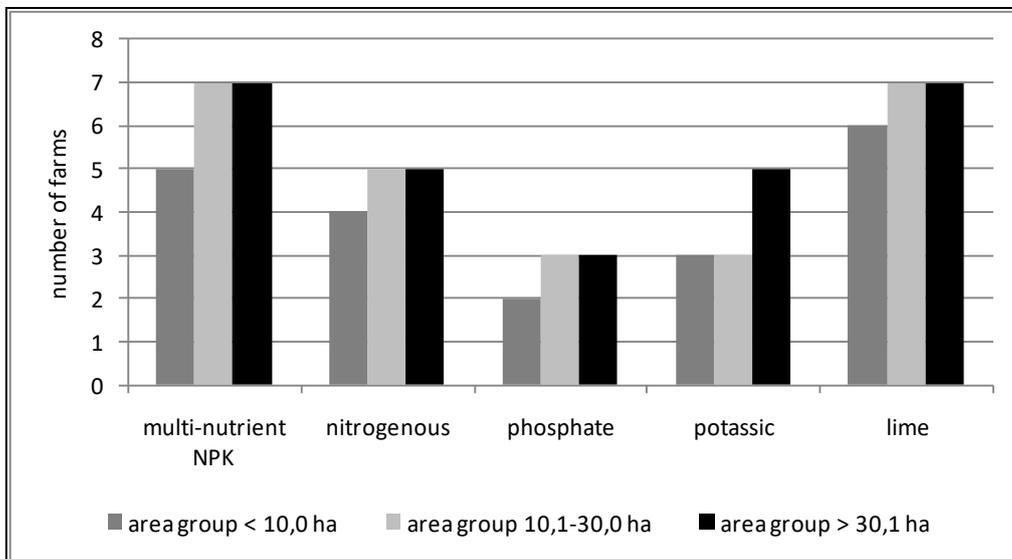
	Area group (ha)		
	< 10.0	10.1-30.0	> 30.1
Area of farm (ha)			
Mean	6.1	18.1	53.4
SD	1.4	3.9	20.1
RSD %	22.5	2.,8	37.6
Production profile (number of farms)			
mixed	19	8	3
crop	6	7	7
Age of the farmer (years)			
Mean	54.3	43.7	38.6
SD	7.2	10.6	9.7
RSD %	13.3	24.3	25.2
Level of education (number of farmers)			
primary	2	1	0
vocational	15	7	2
secondary	7	5	7
higher	1	2	1

Source: own study, SD – standard deviation, RSD – coefficient of variation

Mineral fertilisers were procured by all the farms included in the survey; multi-nutrient NPK were bought by 85.8%, nitrogenous ones by 63.3%, potassic ones by 37.5% and phosphate ones by 29.2% of them. Farms specializing in crop production bought more fertilizers (Fig. 2, Fig. 3). The smaller demand for potassic and phosphate fertilisers may be attributable to the fact that farmers, especially ones with mixed farms, supplement the content of these nutrients in soil by using natural fertilisers produced on site (Owsiak et al. 2013).



**Figure 2.** Number of researched farms with mixed production in which mineral fertilizers were purchased



**Figure 3.** Number of researched farms with crop production in which mineral fertilizers were purchased

The majority of the farmers in the survey (70.0%) purchased mineral fertilisers twice a year, before the growing season (spring or autumn); their decision was determined by nutritional requirements of plants planned to be cultivated and the improvement of the soil nutrient content (Table 2).

According to Statistical Yearbook of Agriculture (2018) in the last 5 years, the consumption of lime fertilizers increased by over 60.0%; in 2017 it amounted to 55.1 kg CaO/ha

on average. It is estimated that over 58.0% of the farmlands in the Mazowieckie Province require liming due to the acidic and very acidic reaction of soils, which limits the quantity of plant production and quality of raw materials acquired. The examined farms stood out among other Polish farms because as many as 83.3% of them used liming during the last year (especially the ones with the crop production profile, irrespective of the area covered) (Fig. 2, Fig. 3). It was observed that more than 70.0% of the farms included in the survey purchase them once at least two years.

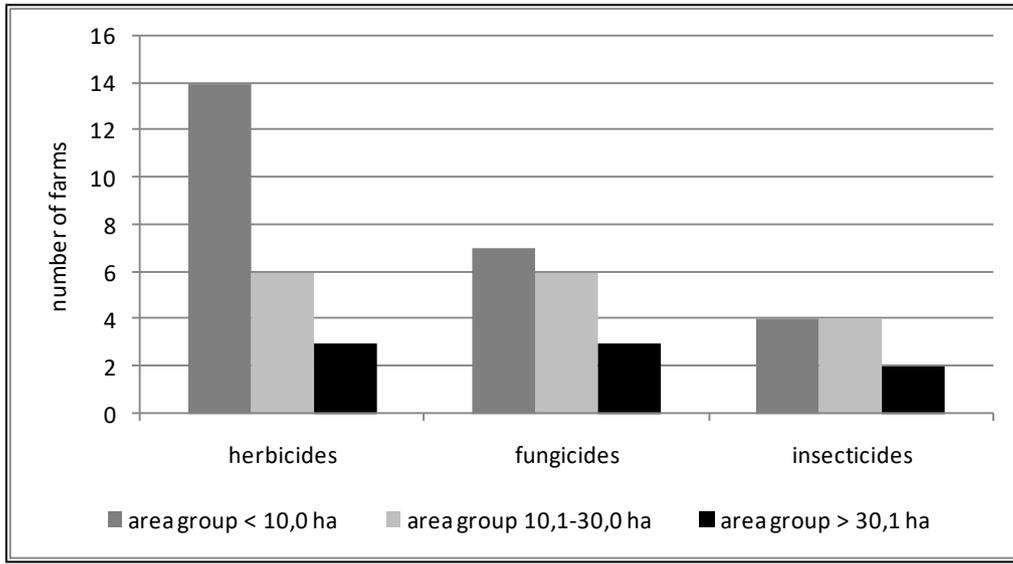
**Table 2.** Frequency of means of productions purchase in the investigated farms in the Siedlce County

Frequency of purchase	Area group (ha)		
	< 10.0	10.1-30.0	> 30.1
Mineral fertilizers			
Once a year	6* 0**	3* 0**	1* 0**
Twice a year	13 5	4 6	2 5
More often	0 1	1 1	0 2
Plant protection products			
Once a year	4* 0**	2* 0**	0* 0**
Twice a year	6 6	4 7	1 0
More often	1 0	1 0	1 7
Qualified seed material			
Once a year	1* 6**	2* 7**	0* 7**
Once a two year	1 0	2 0	2 0
Less often	2 0	1 0	1 0

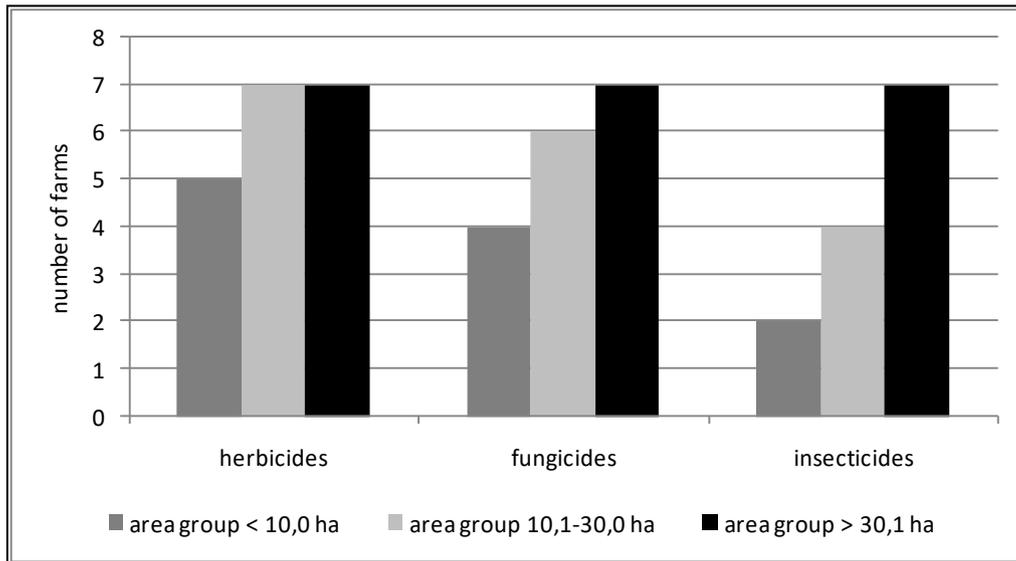
Source: own study, \*number of farms with crop production, \*\* number of farms with mixed production

The chemical protection of plants ensures the reduction of losses in plant cultivation caused by pathogens, pests and weed. The efficiency of such treatments is the condition on which suitable preparations are selected and rules for their use are observed (Pogacean, Gavrilescu 2009). In 2017, plant protection treatments were applied by 63.2% of farms on a national scale; herbicides, including haulm destructors, accounted for 60.2%, fungicides for 24.4%, and insecticides for 7.6% of the total sales (Means of production in agriculture in the 2017/18 farming year, Statistics Poland 2019).

Based on the research, it was found that 80.0% of the farms purchased plant protection products (the majority of them fell into group > 30 ha 90.0%, the fewest – into group < 10 ha 72.0%) including all of them (100%) – herbicides, 69.2% – fungicides and 49.2% (Fig. 4, Fig 5). It was indicated that the share of the farms specialising in the production of cereal, regardless of their sizes, is larger in the acquisition of fungicides and insecticides when compared to farms of mixed production. More than 80.0% of the examined farms bought plant protection products in the growing season due to the occurrence of disease symptoms.



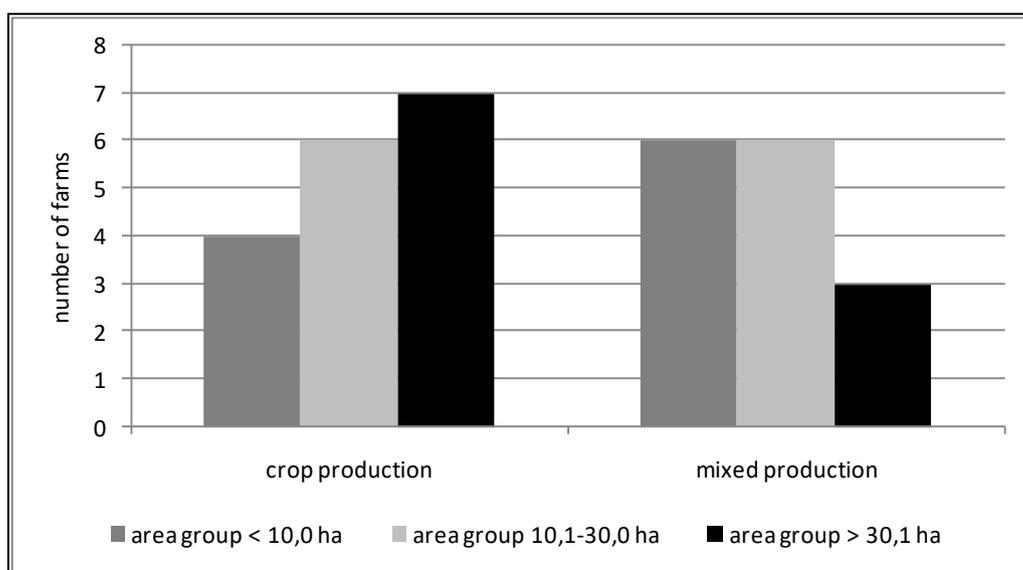
**Figure 4.** Number of researched farms with mixed production in which plant protection products were purchased



**Figure 5.** Number of researched farms with crop production in which plant protection products were purchased

The frequency of the purchases of plant protection products varied – twice a year (48.0% of the farms, including all the ones specialised in the production of cereal crops on the area of up to 30.0 ha), more frequently than twice a year (20.0% – mainly the farms specialised in the production of cereal crops with the area of > 30.1 ha) and once a year -12.0% farms with the mixed production (Table 2). The frequency of the purchases and use of pesticides corresponded with the number of plant protection treatments. As to the farms with mixed production, less attention is paid to protection treatments because a part of yield is used for livestock feed. The cultivation technology should also be improved, to include not only production and economic effects but also safety of the natural environment (Skarzyńska 2017).

To produce high yield in plants of good qualitative parameters, it is necessary to use high-quality certified seed (Abebe, Alemu 2017, Raina et al. 2018). Between 2005 and 2017, the supply of certified seed of cereal crops in the agricultural sector increased by 31.6% (Means of production in agriculture in the 2017/18 farming year, Statistics Poland 2019). Irrespective of the production profile, seed material was bought in all of the examined farms with the area larger than 30.1 ha; as to the group of the farms smaller than 10 ha, it was only 40.0% (Fig. 6).



**Figure 6.** Number of researched farms which certified seed material were purchased

The frequency of the purchases of seed material at the farms under examination varied – once a year (46.0% of the farms, including all the ones specialised in cereal crop production) and once every two years (10.0% - the farms with mixed production), once every three years (8.0% - the majority of the farms with the smallest area and mixed production) (Table 2).

Transport is an important element of the production process, regardless of the production profile of a farm. It allows the movement of means of production from the seller to the buyer and delivery to the target destination at a certain time, and affects production costs (Condratchi 2014, Macheke et al. 2017, Shankar et al. 2018). As to the farms included in the survey, it was observed that for the procurement and production processes mainly own means of transport were used; these, for the most part, were agricultural tractors and trailers (72.0% of the respondents); the larger the area of a group, the greater the share of the transport offered by the

supplier of production means– lorries of various load-bearing capacities (farms with the area of < 10.0 ha – 28.0%, 10.1-30.0 ha – 46.6 ha, > 30.1 - 70.0%), and the larger the involvement of own means of transport to handle the production process – application of production means within the bounds of farmlands (agricultural tractors, trailers, manure spreaders, fertiliser spreaders, seeders, sprayers, etc.).

Ensuring the continuity of agricultural production necessitates the maintenance of a certain level of stocks. Farmers most often store mineral fertilisers and plant protection products from 1 to 3 months. A longer period of storage requires the observance of strict conditions and having premises sufficiently prepared for this purpose, especially in the case of plant protection products (Owsiak et al. 2013). In the investigated farms, mineral and lime fertilisers were stored for the period of up to 3 months (Table 3).

**Table 3.** Storage period of means of productions purchase in the investigated farms in the Siedlce County

Storage period	Area group (ha)		
	< 10.0	10.1-30.0	> 30.1
Mineral fertilizers			
Up to 7 days	8* 5**	4* 5**	2* 6**
Up to 4 weeks	5 1	2 2	1 1
Up to 3 moths	6 0	2 0	0 0
Plant protection products			
Up to 7 days	6* 5**	3* 5**	1* 7**
Up to 4 weeks	4 1	3 2	1 0
Up to 3 moths	1 0	1 0	0 0
Cerified seed material			
Up to 7 days	1* 4**	2* 5**	2* 5**
Up to 4 weeks	2 2	2 2	1 2
Up to 3 moths	1 0	1 0	0 0

Source: own study, \* number of farms with crop production, \*\* number of farms with mixed production

The most numerous were the farmers who stored fertilisers within the period of up to 7 days (60.0%), generally running the largest farms, irrespective of the production profile. The least numerous were the farmers who stored mineral fertilisers for the period of up to 3 months (16.0%), managing the farms smaller than 30 ha and with the mixed profile of production.

Similar measures were taken in the case of plant protection products; however, more respondents (62.5%) stored them within the period of up to 7 days, especially at the larger farms, oriented towards the production of cereal crops. Having been purchased, certified seed material ended up in storage premises, depending on the planned date of sowing and its actual performance, for the maximum period of up to 7 days (59.4% of the farms) or up to 4 weeks (34.4%), regardless of the production profile.

#### **4. CONCLUSIONS**

Logistics are of strategic character for the functioning and management of a farm. The effective system of the supply of means of production guarantees the maintenance of the continuity of agricultural production. The quantity of agricultural production depends on means of production used, whose type and quantity are selected by the agricultural manufacturer based on owned resources, production profile and economic accounts.

Mineral fertilisers were purchased by all the surveyed farmers, the most of them – multi nutrient NPK fertilisers; phosphate fertilisers were the least popular. In more than 80% of the examined farms also bought lime fertilisers to decrease soil acidification and improve the efficiency of mineral fertilising. It was indicated that 4/5 of the examined farms used plant protection products, and all of them – herbicides. The greater share in the purchases of fungicides and insecticides was observed at the farms specialised in the cultivation of cereal crops. It was found that certified seed material was bought mostly at the ones at year, especially in farms specialised in plant production.

On the whole, younger and better educated farmers were more willing to invest in the development of their farms through the purchase of suitable means of production in quantities and at dates optimal for the agricultural technology of plants being cultivated.

Mineral fertilisers (aside from lime ones) and plant protection products were the most often bought twice a year and stored for the period of up to 7 days, generally at the larger farms, irrespective of the production profile. At certain smaller farms, their storage period extended to 3 months. It was observed that for the procurement and production processes in the investigated farms mainly own means of transport were used; but the larger of farms area - the greater the share of the transport offered by the supplier of production means.

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