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Impact of Farming System on Potato Yield and Tuber Quality in Northern Baltic Sea Climate Conditions

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Abstract: For finding more sustainable cropping systems, this study on how the farming system influences the yield and quality of potato tubers was carried out with long-term crop rotation experiment. The long-term five-field crop rotation field trial was established with the following farming system treatments: organic farming system treatments: Org I (organic control), Org II (organic crop rotation with winter cover crops) and Org III (organic crop rotation with winter cover crops and the addition of composted cattle manure); conventional farming system treatments: N0 (conventional system without fertilizers), N50 (conventional system with fertilization, N50P25K95), N100 (conventional system, N100P25K95) and N150 (conventional system, N150P25K95). The average yield (based on 3 trial years) of conventional systems was 25% higher, compared to organic systems. However, in organic systems, the yield was the most stable. The most fluctuating cropping system was the most intensively managed N150. In each trial year, the yield differed statistically and it varied from 4.7 t ha^{-1} up to 10.9 t ha^{-1}. Org I had the same dry matter yield as the N0 system, where chemicals were used, meaning that using chemicals for plant protection but no fertilizer for growth improvement had no positive effect. In each year, the yield in Org III system was similar to N50 system. Regarding the tubers per plant, there were no differences between farming systems but there was a significant difference between the trial years. The tubers in conventional systems had a lower starch content than the organic systems. It is possible to conclude that if cover crops and manure are used, organic farming practices provide just as good results as the conventional farming with low nitrogen level.

Keywords: conventional farming; cover crop; organic farming; potato yield; starch

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1. Introduction

Potato is a high-yielding crop and it has an important role in human diets. There is a wide variety of products which can be produced from potato starch, so the importance of this crop cannot be underestimated. The tuber yield of potato can vary in large ranges through growing seasons and therefore, it is important to understand how the farming system influences the yield and quality of tubers in different seasons. The large seasonal and yearly variations in moisture content, temperature and nutrient availability of the soil are also dependent on the farming system. Current environmental trends related to climate change, biodiversity loss, land degradation, water shortages and pollution threaten the long-term food security and are caused in part due to current diets and agricultural practices. Addressing these problems while producing more food for a growing population will require changes in current food systems [1]. To guarantee the sustainable human development means being able to feed the planet with an increasing population which is predicted to reach 9.7 billion people by 2050 [2]. Although, since 2000, GHG emissions have been growing in all sectors, except in agriculture, forestry and other land use sectors, still the agriculture has a key role in carbon storage in the soil and is one of the more impactful sectors regarding the future CO_2 emissions [3]. In order to develop more sustainable farming systems, we should minimize the external inputs by optimizing the farming systems. Better understanding should be developed of the diversification of crop rotations with cover crops and farming systems. The modern agriculture is heading in that direction with organic farming and integrated systems.

The total area of organic fields in the EU-27 was nearly 13.8 million hectares in 2019. The increase in organic area between 2012 and 2019 was 46% and the share of total organic area in the total utilized agricultural land within the EU rose from 5.9% to 8.5%. In Estonia, the total area of organically managed agricultural land is 22.3% [4], although organically produced potato has a minor share in Estonia. Potatoes are important components of human diet as they are rich in nutrients and bioactive components which are useful for maintaining a good nutritional status and wellness [5]. The decline in potato production and consumption is an unwanted development because the potato is one of the most environmentally friendly crops. Its production process has a low CO_2 emission footprint and it requires less area per similar dry matter yields than other crops [6]. On the other hand, the farming systems for potato production are often associated with soil degradation due to the excessive use of tillage and low production of crop residues [7]. It means that cover crops must be used in crops rotations to maintain the content of soil organic matter. In 2019, the total production of potato in Estonia was 120,000 tonnes. The production of organically grown potato was 2000 tonnes, which represents only 1.67% of the total potato production [8]. Low production efficiency of potato per hectare is not attractive and it challenges the agronomists to find better agricultural practices and understanding on the effects of different farming systems. Nitrogen fertilization and the use of cover crops are some of the most important management practices that affect many physical, chemical and biological characteristics of the soil which impact the yield and quality of potato tubers [9].

The need for more sustainable agriculture has brought deserved attention to soil and to efforts towards maintaining and improving the soil health [10]. The best options for improving the soil health is to turn croplands into grasslands and maximize crop residue management [11]. Recent estimates suggest that, given the present consumption patterns, the transition to a fully organic system would require 30% more land use than with conventional agriculture [10]. However, if the transition to organic agriculture was accompanied by a 50% drop in food waste and consumption of agricultural products, additional land resources would not be required [12].

Improving the soil health while ensuring high yield at the same time is a challenging task for agronomists. One of the most common yield increasing measures is the application of nitrogen fertilizers, but intensive agriculture entails several risks related to excessive fertilization. In Estonia, farmers are increasing the fertilizer input year by year and also more agricultural land is in active use [13]. The surplus of nutrients is an important source of ground and surface water pollution [14]. As a consequence, farmers must reduce their nutrient inputs to limit nutrient losses by leaching and runoff. Those facts have been published already 30 years ago, but farmers still use fertilizers excessively. Estonian rivers and lakes have different nitrogen exports and it is especially high in river Emajõgi, which is surrounded by large agricultural areas [15]. Cover cropping could potentially reduce the leaching of NO_3^-–N by 50–60% [16,17].

Developing progress in agronomy using pest, disease and weed management is minimizing the cap between the actual and the potential yield of crops [18], but new EU goals are forcing agronomists to minimize the use of chemicals and to prefer organic farming. A meta-analysis showed that yields in organic production are 25% lower than in conventional systems [19], but it is not known how much it differs in potato production in Estonian climate. One opportunity to increase organic yield is to use cover crops which enable to increase the nutrient content and provide additional carbon into the soil [20,21]. However, related to yield increase, some studies have shown that using manure is more efficient than using cover crops [22]. Anatosovsky et al. [23] found that the tuber yield is correlated positively with the increasing fertilization rate with all fertilizer types. It was also found that organic systems have significantly lower yields than conventional ones [24]. On the other hand, some studies have shown no significant difference in the potato yield between organic and conventional treatments [24,25]. Some studies highlight [23,26,27] that yields in organic farming fluctuate more and this makes it undesirable for farmers.

The aim of the research was to evaluate the influence of potato growing systems on the yield, yield stability and quality of tubers. Thus, we hypothesized that: (1) increased nitrogen level, winter cover crops and manure have positive impact on the yield and quality of potato tubers; (2) cover crops and manure-based farming produces more stable yield and quality.

2. Materials and Methods

2.1. Site Description

The potato was grown in a long-term field crop rotation experiment established in 2008 at the Estonian University of Life Sciences (58°22′ N, 26°40′ E). In the present study, the data on potato concerns the period 2018–2020. The soil type of the experimental site was Stagnic Luvisol [28]. The texture of the soil was sandy loam (56.5% sand, 34.0% silt and 9.5% clay) in the epipedon with a humus layer of 20–30 cm [29]. In 2018, the soil of the experiment contained, on average, the soil organic carbon (SOC) content of 15.1 g kg^{-1}, total nitrogen (N_{tot}) of 1.2 g kg^{-1} and pH_{KCl} was 6.0.

2.2. Experimental Design

This long-term field trial had three organic (Org) and four conventional (N) system treatments. During the rotation cycle, five different crops followed each other in the following order: spring barley (*Hordeum vulgare* L.) with undersown red clover, red clover (*Trifolium pratense* L.), winter wheat (*Triticum aestivum* L.), pea (*Pisum sativum* L.) and potato (*Solanum tuberosum* L.). The experiments were established as systematic block design in 4 replications and the size of plots was 60 m^2 [30].

The organic farming system had three treatments: Org I (organic control), Org II (organic crop rotation with winter cover crops) and Org III (organic crop rotation with winter cover crops and added composted cattle manure). Before, the potato winter turnip (cover crop) and after, the potato winter rye was grown. Cover crops were ploughed into the soil in spring as green manure. Composted cattle manure was applied in the Org III treatment (20 t ha^{-1}) in spring before potato. Chemical composition of the composted cattle manure was the following: 138 g C kg^{-1}, 9.7 g N kg^{-1}, 4.6 g P kg^{-1}, 8.6 g K kg^{-1}, average dry matter content 44.8%. The amounts of nutrient applied in 2018–2020 (each year) with manure were: 93–98 kg N ha^{-1}, 18–27 kg P ha^{-1} and 64–98 kg K ha^{-1}. Furthermore, in organic systems, neither mineral fertilizers nor synthetic pesticides were used.

During the growing season in the conventional farming systems, herbicide Titus 25 DF (50 g ha^{-1}, active ingredient rimsulfuron 12,5 g ha^{-1}), for late blight control fungicide and Ridomil Gold MZ 68 WG (2.5 kg ha^{-1}, metalaxyl-M 100 g ha^{-1} and mancozeb 1600 g ha^{-1}) were used. Depending on the rate of infestation, spraying was performed 2–4 times during the summer. Against Colorado beetle, insecticide Fastac 50 (0.3 l ha^{-1}, alpha-cypermethrin 100 g l^{-1}) and Decis Mega 50EW (0.15 l ha^{-1}, active ingredient deltamethrin 7.5 g ha^{-1}) were used.

2.3. Fertilizer and Crop Management

In the conventional farming systems, four fertilizer treatments were used: N0 (conventional without fertilizers), N50 (conventional with fertilization rate $N_{50}P_{25}K_{95}$), N100 (conventional with fertilization rate $N_{100}P_{25}K_{95}$) and N150 (conventional with fertilization rate $N_{150}P_{25}K_{95}$. There was no winter cover in the conventional farming systems.

The potato variety 'Teele' was planted after pea (*Pisum sativum* L.) at the beginning of May and harvested at the beginning of September. Before planting, the potato plots were ploughed at 20–23 cm depth and then harrowed up to 4–5 cm depth. During the vegetation period, the potato rows were harrowed 2x to control the weeds.

Potato yield and quality were measured from samples taken just before trial harvest. From each plot, 10 consecutive plants were taken, weighted and the yield structure elements (dry matter yield, marketable tubers, weight of a tuber, number of tubers per plant) were measured. Total yield, tuber weight and marketable yield were calculated based on these samples. The content of starch was found using Parov's weight.

2.4. Data Analysis

The statistical analysis of collected data was performed with the software Statistica 13 (Quest Software Inc., Aliso Viejo, CA, USA). Full-factorial analysis of variance (ANOVA) was used to test the statistical significance of year, farming system and their interaction effects on tuber properties (number of tubers per plant, marketable tubers, weight of a tuber, starch content, starch yield, dry matter yield). The significance of the effects on the same properties was assessed with one-way ANOVA. In the comparison of the differences between plots, Tukey HSD (honest significant difference) post hoc test ($p < 0.05$) was used [31]. Correlation analysis was used as linear correlation coefficients between variables and the significance of coefficients was taken as $p < 0.001$, $p < 0.01$, $p < 0.05$ or ns (not significant).

2.5. Weather Conditions

Weather data were collected from Eerika weather station of the Institute of Agricultural and Environmental Sciences of the Estonian University of Life Sciences. Weather conditions (Table 1) varied considerably during the study period, especially in 2018, compared to 2019 and 2020. Years 2020 and 2019 were similar to the long-term average weather data, considering precipitation and temperature. In 2020, total precipitation was 23.4 mm higher than the long-term average, but compared to 2018, the precipitation was 154.6 mm higher which is an extremely large difference. In 2019, the precipitation was 41.1 mm lower than the long-term average and temperatures were higher by 0.7 °C. The highest temperatures were recorded in 2018: 2.9 °C higher than the long-term average and the interaction with low precipitation (141.1 mm less than long-term average) amplified the unfavorable effects. At the beginning of vegetation period in 2018, there were only 16.2 mm of rain during first 4 decades, compared to 2019 (61.2 mm) and 2020 (62.2 mm). Fluctuating weather conditions impacted the results of the field trial between the years significantly.

Table 1. Weather conditions during 2018–2020 * and the long-term average (1964–2020).

Month	Decade	Temperatures (°C)				Precipitation (mm)			
		2018	2019	2020	1964–2020	2018	2019	2020	1964–2020
May	I	12.4	6.9	10.0	9.6	6.9	17.4	6.0	12.4
	II	17.6	13.1	6.3	11.5	0.9	24.8	17.8	20.7
	III	17.8	14.0	12.1	13.0	0.0	17.6	8.4	19.6
June	I	14.2	19.6	15.1	14.9	8.4	1.4	30.0	16.3
	II	17.6	18.8	19.5	15.4	22.5	39.6	40.6	28.7
	III	15.8	17.4	20.5	16.3	29.9	9.8	46.8	26.3
July	I	15.6	14.4	15.9	17.0	10.7	9.0	19.0	21.3
	II	22.7	15.3	16.9	17.2	3.0	18.6	5.4	23.8
	III	23.7	19.1	16.2	17.9	0.2	13.2	44.4	23.6
August	I	22.6	14.9	18.4	17.5	2.3	8.8	10.6	28.9
	II	17.9	17.1	16.8	16.1	38.2	33.8	6.6	25.0
	III	16.3	17.9	15.4	14.8	18.9	15.4	47.0	26.5
September	I	18.2	16.8	14.2	13.1	17.0	2.2	34.8	20.3
	II	14.7	10.5	12.5	10.9	12.7	60.0	8.8	19.2
May–September	I-III	17.6	15.4	15.0	14.7	171.6	271.6	326.2	312.7

* data from Eerika weather station, Estonia.

3. Results and Discussion

Our research showed that the farming system has statistically significant impact on all the categories except the number of tubers per plant ($F_{6,63} = 0.44$; $p = 0.846$, Table 2).

Table 2. Analysis of variance on the dry matter yield of tubers, marketable tubers, weight of a tuber, number of tubers per plant, starch yield and starch content.

Factor	Dry Matter Yield, t ha^{-1}	Marketable Tubers, %	Weight of a Tuber, g	Number of Tubers per Plant	Starch Yield, t ha^{-1}	Starch Content, %
Year (Y)	$F_{2,63} = 71.57$; $p < 0.001$ *	$F_{2,63} = 11.69$; $p < 0.001$ *	$F_{2,63} = 10.17$; $p < 0.001$ *	$F_{2,63} = 83.24$; $p < 0.001$ *	$F_{2,63} = 81.57$; $p < 0.001$ *	$F_{2,63} = 28.84$; $p < 0.001$ *
Farming system (FS)	$F_{6,63} = 13.69$; $p < 0.001$ *	$F_{6,63} = 7.59$; $p < 0.001$ *	$F_{6,63} = 12.16$; $p < 0.001$ *	$F_{6,63} = 0.44$; $p = 0.846$	$F_{6,63} = 15.65$; $p < 0.001$ *	$F_{6,63} = 20.33$; $p < 0.001$ *
Y x FS	$F_{12,63} = 3.81$; $p = 0.001$ *	$F_{12,63} = 2.06$; $p = 0.033$ *	$F_{12,63} = 1.98$; $p = 0.041$ *	$F_{12,63} = 0.88$; $p = 0.575$	$F_{12,63} = 3.69$; $p < 0.001$ *	$F_{12,63} = 5.18$; $p < 0.001$ *

* $p < 0.05$.

This field trial showed that on average of three years, the cover crops increased the yield by 0.6 t ha^{-1}. Each year, Org II plots had higher yield than Org I plots. One benefit of cover crops is also their ability to control weeds. Crystal-Ornelas et al. [32] reported that the addition of organic fertilizer improves the soil nutrient content and increases the soil organic matter content on average by 24%. The increase of soil organic matter has also been proven on the same trial site where SOC increased the most in Org II and Org III plots [29]. Potato tuber DM yields in Org III were even higher than in conventional cropping which is using chemical treatments but no fertilizer (N0 plots). As the use of cover crops increases the soil organic matter and improves soil health, it should also benefit the plant growth and therefore, the yield [32]. Although effective disease control strategies are limited for organic potato cultivation and those systems are more vulnerable to late blight than conventional potato production systems [33], it is still possible to achieve yields in organic farming as high as in conventional systems, if the soil has enough nutrients. Long-term organic crop rotation systems can have even more nitrogen in the soil than the conventional farming systems [34]. Runno-Paurson et al. [35] also reported that the addition of manure will increase the early blight pressure, but it does not affect the yield.

3.1. Dry Matter Yield of Tubers

Dry matter (DM) yield of tubers is a good indicator of how effective the plant growth has been—higher tuber yield indicates good nutrient and water usage throughout the vegetation period. In our trial, the organic cropping system had the lowest DM yield of tubers in each year, although the yield was most stable compared to conventional systems (Table 3). This finding is contrary to Lammerts van Bueren et al. [36] where the tuber yield of organic potato was fluctuating more than in conventional treatment. The dry matter yields of tubers in organic treatments did not show any statistical difference ($p < 0.05$), compared to the three-year average. DM yield in Org I treatment was the same as in N0 system, where chemicals were used. This means that using chemicals for plant protection but no fertilizers for growth improvement had no positive effect on the DM yield of tubers. We also recognized that N150 did not result in higher tuber yield, compared to N100. The average yield in 3 years in both systems was 7.3 t ha^{-1}. Moreover, Org III had statistically similar results every year as N50, which means that cropping system which uses cover crops and manure, but no chemicals, can provide the same results as conventional farming with low nitrogen application. Org III had higher DM yield because the cover crops and added manure increased the amount of biomass which, after mineralization, increases the content of nitrogen in the soil [37].

Table 3. Average dry matter yield of potato tubers depending on the farming system.

Farming System	Tuber Dry Matter Yield, t ha^{-1}			
	2018	**2019**	**2020**	**2018–2020**
Org I	3.7 ^{A1a2} ± 0.1	4.5 ^{Aab} ± 0.2	5.1 ^{Ab} ± 0.5	4.5 ^{A} ± 0.2
Org II	3.9 ^{Aa} ± 0.2	4.6 ^{Aa} ± 0.2	6.9 ^{ABb} ± 0.4	5.1 ^{AB} ± 0.4
Org III	4.7 ^{Aa} ± 0.6	6.5 ^{Bab} ± 0.5	7.8 ^{ABCb} ± 0.6	6.3 ^{AB} ± 0.5
N0	4.3 ^{Aa} ± 0.5	5.2 ^{ABa} ± 0.7	5.4 ^{Aa} ± 0.9	5.0 ^{AB} ± 0.4
N50	4.8 ^{Aa} ± 0.4	6.4 ^{Bab} ± 0.4	9.4B ^{Cb} ± 1.2	6.9 ^{AB} ± 0.7
N100	5.2 ^{Aa} ± 0.4	6.2 ^{Ba} ± 0.7	10.6 ^{Cb} ± 0.6	7.3 ^{B} ± 0.8
N150	4.7 ^{Aa} ± 0.5	6.4 ^{Bb} ± 0.3	10.9 ^{Cc} ± 0.5	7.3 ^{B} ± 0.8

[1] Means followed by different capital letters within each column indicate significant influence of farming systems (Tukey HSD post hoc test, $p < 0.05$). [2] Means followed by different small letters within each row indicate significant influence of year (Tukey HSD post hoc test, $p < 0.05$). ± denote the standard errors, $n = 4$ (one year), $n = 12$ (2018–2020).

Tuber yield is correlated to aboveground biomass and duration of the growing season [38]. A healthy haulm has a positive effect on the tuber yield [39,40]. Therefore, it is critical to ensure the growth of healthy haulms to maximize the yield. If the plant vegetative area is small the amount of N application should be reduced. In earlier results from the same trial, Keres et al. [41] showed that in conventional cropping system, the yield was higher by 24–25% than in organic system. This result is similar to potato dry matter yield as well, where average (3 years) organic yield was 5.3 t ha^{-1} and conventional yield was 6.6 t ha^{-1} (25% higher). Lower yield can be resulted from the lack of nutrients. Some trials have shown the decrease of main nutrients in the soil of organic systems [42]. This is the main reason why organic systems cannot compete with conventional farming. Potato is a high nitrate-demanding crop [43]. The average yield of tuber dry matter differs statistically between Org I, N100 and N150 cropping systems. In 2018, cropping system did not influence the dry matter yield, because very hot and dry conditions were limiting the plant growth and fertilizer effect could not occur. Most stable yield was seen in N0 cropping system where there was no statistically significant difference between the years. The yield was the most fluctuating in the cropping system with the highest nitrogen application (N150), where the tuber yield varied from 4.7 t ha^{-1} up to 10.9 t ha^{-1} and each year, the yield was statistically different. It shows that intensive cropping system is mostly influenced by the weather conditions that makes yield prediction difficult. Brisson et al. [44] also found that high input farming is more sensitive to climate. From our trial results, we could conclude that N100 gives, on average, the same yield as N150 and the additional 50 kg ha^{-1} nitrogen did not increase the yield.

Dry matter yield of tubers is strongly affected by the factors of a year ($F_{2,63} = 71.57$; $p < 0.001$), farming system ($F_{6,63} = 13.69$; $p < 0.001$) and the interaction of year and farming system ($F_{12,63} = 3.81$; $p < 0.001$, Table 2).

3.2. The Impact of Farming System on the Share of Marketable Tubers

One important factor which is influencing farming profitability is the marketable yield. Marketable yield is impacted by tuber size and damage. Marketable tubers are considered sized from 35 mm and larger. In 2018, the marketable yield was between 92.2% (Org I) and 98.1% (N50) and there were no significant differences between farming systems (Table 4). In 2019, the marketable yield was significantly different between farming systems. Higher nitrogen fertilizer rates also increased the marketable yield. In organic system, the addition of manure had positive impact on the share of marketable tubers. In 2020, farming system had also significant effect on the marketable tubers. The application of nitrogen, using cover crops and manure resulted in higher marketable yields than in control systems Org I and N0.

Table 4. Average share of marketable potato tubers depending on the farming system.

Farming System	Marketable Tubers, %			
	2018	2019	2020	2018–2020
Org I	92.2 ^{A1a2} ± 2.1	84.4 ^{Aa} ± 3.4	78.4 ^{Aa} ± 6.4	85.0 ^{A} ± 2.8
Org II	97.0 ^{Ab} ± 0.6	88.3 ^{ABa} ± 3.7	87.0 ^{ABa} ± 1.6	90.7 ^{AB} ± 1.8
Org III	95.3 ^{Aa} ± 2.3	93.9 ^{BCa} ± 2.1	91.1 ^{ABa} ± 1.0	93.4 ^{B} ± 1.1
N0	95.7 ^{Ab} ± 0.7	92.7 ^{BCab} ± 2.1	80.0 ^{Aa} ± 5.9	89.5 ^{AB} ± 2.8
N50	98.1 ^{Aa} ± 0.5	94.8 ^{BCa} ± 1.5	94.4 ^{Ba} ± 1.1	95.8 ^{B} ± 0.8
N100	93.7 ^{Aa} ± 2.5	96.4 ^{Ca} ± 1.0	94.2 ^{Ba} ± 1.6	94.7 ^{B} ± 1.0
N150	95.7 ^{Aa} ± 1.1	97.5 ^{Ca} ± 0.5	96.2 ^{Ba} ± 0.8	96.5 ^{B} ± 0.5

[1] Means followed by different capital letters within each column indicate significant influence of farming systems (Tukey HSD post hoc test, $p < 0.05$). [2] Means followed by different small letters within each row indicate significant influence of year (Tukey HSD post hoc test, $p < 0.05$). ± denote the standard errors, $n = 4$ (one year), $n = 12$ (2018–2020).

Considering the average of three experimental years, we can conclude that higher nitrogen rates and cover crop with manure increases the percentage of marketable tubers significantly. Although, on average, the best result of marketable tubers was in conventional farming systems, but it was not statistically significant ($p > 0.05$) between conventional systems. The lowest amount of marketable tubers was measured in farming system Org I, but after using cover crops and manure, the organic systems had statistically similar results as conventional systems.

The share of marketable tubers was strongly affected by the factors of year ($F_{2,63} = 11.69$, $p < 0.001$), farming system ($F_{6,63} = 7.59$; $p < 0.001$) and the interaction of year and farming system ($F_{12,63} = 2.06$; $p = 0.033$, Table 2).

3.3. Average Weight of a Tuber

Weight of a tuber depends on the photosynthetic productivity in the reproductive stages of the potato. In case of low moisture or nutrient deficit, the total amount of assimilates is reduced and tubers do not mature [45]. Other important factors also include a healthy shoot system and high leaf area index which plays an important role in the photosynthesis. Any damage by pests or fungal diseases reduces the size of tubers. Use of pesticides and fungicides in conventional farming systems reduces the risk of leaf area damage and plant photosynthetic capacity lasts longer than in organic farming systems. This relationship was evident also in our trial. Additionally, the water shortage is critical, particularly in the early growth stages.

On average, Org I had the smallest tubers (41.9 g) and N150 had the biggest tubers (74.4 g, Table 5).

Table 5. Average weight of a tuber depending on the farming system.

Farming System	Average Weight of a Tuber, g			
	2018	2019	2020	2018–2020
Org I	42.1 ^{A1a2} ± 5.2	45.5 ^{Aa} ± 4.9	38.1 ^{Aa} ± 5.8	41.9 ^{A} ± 2.9
Org II	56.9 ^{Aa} ± 4.7	50.2 ^{ABa} ± 7.4	44.0 ^{ABa} ± 2.0	50.4 ^{AB} ± 3.1
Org III	54.8 ^{Aa} ± 8.6	61.4 ^{ABCa} ± 2.9	52.3 ^{ABa} ± 2.2	56.1 ^{ABC} ± 3.1
N0	49.5 ^{Aab} ± 6.9	66.4 ^{BCb} ± 5.1	40.2 ^{Aa} ± 5.9	52.0 ^{AB} ± 4.5
N50	67.0 ^{Aa} ± 8.7	73.3 ^{Ca} ± 6.4	60.4 ^{BCa} ± 3.2	66.9 ^{BCD} ± 3.8
N100	60.6 ^{Aa} ± 8.6	76.9 ^{Ca} ± 6.2	72.3 ^{Ca} ± 5.9	69.9 ^{CD} ± 4.2
N150	55.4 ^{Aa} ± 7.4	95.2 ^{Db} ± 5.8	72.7 ^{Ca} ± 2.4	74.4 ^{D} ± 5.7

[1] Means followed by different capital letters within each column indicate significant influence of farming systems (Tukey HSD post hoc test, $p < 0.05$). [2] Means followed by different small letters within each row indicate significant influence of year (Tukey HSD post hoc test, $p < 0.05$). ± denote the standard errors, $n = 4$ (one year), $n = 12$ (2018–2020).

Throughout the experiment, the average weight of tubers in organic systems (49.5 g) was lower by 33% than in conventional systems (65.8 g). Tuber weight was fluctuating the most in N150 system where the difference between 2018 and 2019 was 71.84%, accordingly 55.4 g and 95.2 g per tuber. From that, we can conclude that tuber size is strongly impacted by the application of nitrogen. If the purpose of the production is to produce the seed potato, where large tubers are not favorable, the nitrogen levels should stay lower. Average weight of a tuber is strongly affected by the factors of year ($F_{2,63} = 10.17$; $p < 0.001$), farming system ($F_{6,63} = 12.16$; $p < 0.001$) and the interaction of year and farming system ($F_{12,63} = 1.98$; $p = 0.041$, Table 2)

3.4. Average Number of Tubers per Plant

When drought occurs in spring and early summer, the quantity and quality of the tubers might be drastically reduced [46]. Number of tubers is mostly impacted by the growing conditions at the beginning of vegetation and it is also considered a variety specific parameter which is not influenced by the farming system ($F_{6,63} = 0.44$; $p = 0.846$) The number of tubers per plant is affected by year ($F_{2,63} = 83.24$; $p < 0.001$) and not by the interaction of year and farming system ($F_{12,63} = 0.88$; $p = 0.575$, Table 2). From the results in our trial, no significant difference was seen in the number of tubers per plant between farming systems, but significant difference occurred between experimental years. The same finding was concluded in the field trial held between 2012–2016, where the cropping system did not have any influence on the average number of tubers [47]. In 2020, the highest precipitation was recorded at the beginning of crop vegetation period and this resulted in high number of tubers per plant (Table 6).

Table 6. Average number of tubers per plant depending on the farming system.

Farming System	Average Number of Tubers per Plant			
	2018	2019	2020	2018–2020
Org I	7.5 ^{A1a2} ± 0.9	8.3 ^{Aa} ± 0.9	12.4 ^{Ab} ± 0.9	9.4 ^{A} ± 0.8
Org II	5.3 ^{Aa} ± 0.2	8.1 ^{Aa} ± 1.2	13.6 ^{Ab} ± 0.7	9.0 ^{A} ± 1.1
Org III	7.0 ^{Aa} ± 0.5	8.6 ^{Aa} ± 0.9	13.7 ^{Ab} ± 0.6	9.8 ^{A} ± 0.9
N0	7.4 ^{Aab} ± 0.7	6.9 ^{Aa} ± 1.4	12.1 ^{Ab} ± 1.6	8.8 ^{A} ± 1.0
N50	6.9 ^{Aa} ± 0.7	7.9 ^{Aa} ± 0.7	14.5 ^{Ab} ± 2.0	9.8 ^{A} ± 1.2
N100	7.9 ^{Aa} ± 0.9	7.5 ^{Aa} ± 1.1	13.4 ^{Ab} ± 1.	9.6 ^{A} ± 1.0
N150	8.2 ^{Aa} ± 0.8	6.5 ^{Aa} ± 0.4	13.9 ^{Ab} ± 1.0	9.5 ^{A} ± 1.0

Note. [1] Means followed by different capital letters within each column indicate significant influence of farming systems (Tukey HSD post hoc test, $p < 0.05$). [2] Means followed by different small letters within each row indicate significant influence of year (Tukey HSD post hoc test, $p < 0.05$). ± denote the standard errors, $n = 4$ (one year), $n = 12$ (2018–2020).

3.5. Average Yield of Starch

Starch is one of the most important components in the potato tuber. A wide variety of products, including dietary and industrial applications, could be produced from starch. Total starch yield is mostly impacted by tuber yield, because the starch content is more stable between farming systems than the tuber yield.

In 2018, when the growing conditions were unfavorable because of low moisture level (Table 1), all the cropping systems had statistically similar starch yield. Three-year average starch yield was the lowest in Org I system (Table 7) and the highest in cropping system N150.

Table 7. Average starch yield depending on the farming system.

Farming System	Average Starch Yield, t ha^{-1}			
	2018	2019	2020	2018–2020
Org I	2.6 ^{A1a2} ± 0.1	3.1 ^{Aab} ± 0.1	3.8 ^{Ab} ± 0.3	3.2 ^{A} ± 0.2
Org II	2.6 ^{Aa} ± 0.2	3.2 ^{Aa} ± 0.2	5.0 ^{ABb} ± 0.4	3.6 ^{AB} ± 0.3
Org III	3.3 ^{Aa} ± 0.4	4.4 ^{BCab} ± 0.3	5.7 ^{ABCb} ± 0.5	4.5 ^{BC} ± 0.4
N0	2.9 ^{Aa} ± 0.4	3.6 ^{ABa} ± 0.5	3.8 ^{Aa} ± 0.6	3.4 ^{AB} ± 0.3
N50	3.6 ^{Aa} ± 0.3	4.7 ^{BCab} ± 0.3	6.9 ^{BCb} ± 1.0	5.1 ^{BC} ± 0.5
N100	3.5 ^{Aa} ± 0.3	4.5 ^{Ca} ± 0.5	7.6 ^{Cb} ± 0.4	5.2 ^{BC} ± 0.6
N150	3.3 ^{Aa} ± 0.3	4.9 ^{Cb} ± 0.2	8.2 ^{Cc} ± 0.4	5.5 ^{C} ± 0.6

[1] Means followed by different capital letters within each column indicate significant influence of farming systems (Tukey HSD post hoc test, $p < 0.05$). [2] Means followed by different small letters within each row indicate significant influence of year (Tukey HSD post hoc test, $p < 0.05$). ± denote the standard errors, $n = 4$ (one year), $n = 12$ (2018–2020).

Total starch yield was mostly impacted by potato yield which is higher in intensive cropping systems (Table 3), but on the other hand, the starch content in tubers was lower in intensive cropping systems (Table 8). Similar results were found in field trials conducted between 2008–2012, where intensive cropping systems had higher starch yield but lower starch content [48].

Table 8. Average starch content depending on the farming system.

Farming System	Starch Content, %			
	2018	2019	2020	2018–2020
Org I	17.3 ^{D1b2} ± 0.3	16.1 ^{Ca} ± 0.2	15.8 ^{Ba} ± 0.2	16.4 ^{C} ± 0.2
Org II	17.2 ^{Db} ± 0.2	16.1 ^{Ca} ± 0.1	15.8 ^{Ba} ± 0.4	16.3 ^{C} ± 0.2
Org III	17.4 ^{Db} ± 0.3	15.9 ^{BCa} ± 0.3	15.1 ^{Aa} ± 0.2	16.1 ^{BC} ± 0.3
N0	16.2 ^{Cb} ± 0.2	15.8 ^{BCb} ± 0.2	15.0 ^{Aa} ± 0.1	15.6 ^{ABC} ± 0.2
N50	15.6 ^{BCa} ± 0.3	15.4 ^{ABa} ± 0.2	14.9 ^{Aa} ± 0.1	15.3 ^{AB} ± 0.2
N100	15.1 ^{Ba} ± 0.3	15.0 ^{Aa} ± 0.2	15.0 ^{Aa} ± 0.1	15.0 ^{A} ± 0.1
N150	14.7 ^{Aa} ± 0.2	14.9 ^{Aab} ± 0.2	15.4 ^{ABb} ± 0.1	15.0 ^{A} ± 0.1

[1] Means followed by different capital letters within each column indicate significant influence of farming systems (Tukey HSD post hoc test, $p < 0.05$). [2] Means followed by different small letters within each row indicate significant influence of year (Tukey HSD post hoc test, $p < 0.05$). ± denote the standard errors, $n = 4$ (one year), $n = 12$ (2018–2020).

Average starch yield is strongly affected by the factors of year ($F_{2,63} = 81.57$; $p < 0.001$), farming system ($F_{6,63} = 15.65$; $p < 0.001$) and the interaction of year and farming system ($F_{12,63} = 3.69$; $p < 0.001$) (Table 2). These indicators are strongly related to farming systems, but also year characteristics influence the results. This shows that crop quality parameters are not only influenced by weather conditions, but also by cropping systems. This finding is contrary to the results from similar trials [24,47], where the starch content was not influenced by farming system.

On average of three years (2018–2020), the starch content of potato tubers differed significantly between the mineral and organic fertilization scheme. Average starch content is strongly affected by the factors of year ($F_{2,63} = 28.84$; $p < 0.001$), farming system ($F_{6,63} = 20.33$; $p < 0.001$) and the interaction of year and farming system ($F_{12,63} = 5.18$; $p = 0.001$). The tubers in conventional system had lower starch content than the tubers in organic system. The same result was found in the field trial conducted in Finland by Roinila et al. [21]. The biggest differences in starch content were observed between the mineral and organic fertilization system in 2018, when growing conditions were unfavorable and total dry matter yield between systems was also insignificant (Table 2). In 2020, when the growing conditions were favorable and yields increased significantly, the starch content was lower. In treatments with mineral fertilizers, the starch yield was the most stable in N50 and N100 systems, whereas the starch yield remained nearly constant in each year. Cover crops or additional manure did not impact the starch content in any of the trial years.

4. Conclusions

Formulated hypotheses were proven correct that farming systems had significant influence on the growth of potato. These factors influenced the potato DM yield, starch content and tuber weight. Only the number of tubers per plant was unaffected and probably, this is a variety-specific indicator and is not significantly influenced by the farming system.

Mineral fertilizers had the best effect in N50 and N100 farming systems but in N150, although the tuber size increased, the starch content in tubers decreased and the total DM yield did not increase. Additionally, the most intensively managed N150 treatment was the most fluctuating cropping system, regarding the yield. On the contrary, in organic systems, the yield was the most stable. Org I had the same DM yield as the N0 system, where chemicals were used, meaning that using chemicals for plant protection but no fertilizer had no positive effect. Additionally, the second hypothesis was proven correct, that cover crops and manure-based farming results in more stable yield and quality than the high nitrogen-based systems. Therefore, we can conclude that if cover crops and manure are used, organic farming practices provide just as good results as in conventional farming with low nitrogen level. Moreover, composted manure and cover crops have a key role to ensure high yields in organic farming.

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References

1. Rose, D.; Heller, M.C.; Roberto, C.A. Position of the society nutrition education and behavior: The importance of including environmental sustainability in dietary guidance. *J. Nutr. Educ. Behav.* **2019**, *51*, 3–15.e1. [CrossRef] [PubMed]
2. FAO. Food and Agriculture Organization of the United Nation. Sustainable Food Systems. Concept and Framework. 2018. Available online: http://www.fao.org/3/ca2079en/CA2079EN.pdf (accessed on 26 October 2020).
3. Climate Change 2014. In *Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*; Pachauri, R.K.; Meyer, L.A. (Eds.) IPCC: Geneva, Switzerland, 2014; 151p.
4. Eurostat. Organic Farming Statistics. 2022. Available online: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Organic_farming_statistics#cite_note-3 (accessed on 10 March 2020).
5. Ingallina, C.; Spano, M.; Sobolev, A.P.; Esposito, C.; Santarcangelo, C.; Baldi, A.; Daglia, M.; Mannina, L. Characterization of local products for their industrial use: The case of Italian potato cultivars analyzed by untargeted and targeted methodologies. *Foods* **2020**, *9*, 1216. [CrossRef] [PubMed]
6. Gustavsen, G.W. Sustainability and potato consumption. *Potato Res.* **2021**, *64*, 571–586. [CrossRef]
7. Carter, M.R.; Peters, R.D.; Sanderson, J. Conservation tillage in potato rotations in Eastern Canada. In *Land Degradation and Desertification: Assessment, Mitigation and Remediation*; Zdruli, P., Pagliai, M., Kapur, S., Faz Cano, A., Eds.; Springer: Dordrecht, The Netherlands, 2010; pp. 627–637.
8. Stat 2022. Orgaaniliselt Kasvatatud Kartuli Osakaal. (Share of Organically Grown Potatoes). Available online: https://andmed.stat.ee/et/stat/majandus__pellumajandus__pellumajandussaaduste-tootmine__taimekasvatussaaduste-tootmine/PM0281 (accessed on 10 May 2021). (In Estonian).

9. Sapkota, T.B.; Mazzoncini, M.; Bàrberi, P.; Antichi, D.; Silvestri, N. Fifteen years of no till increase soil organic matter, microbial biomass and arthropod diversity in cover crop-based arable cropping systems. *Agron. Sustain. Dev.* **2012**, *32*, 853–863. [CrossRef]
10. Muller, A.; Schader, C.; Scialabba, N.E.H.; Brüggemann, J.; Isensee, A.; Erb, K.; Smith, P.; Klocke, P.; Leiber, F.; Stolze, M.; et al. Strategies for feeding the world more sustainably with organic agriculture. *Nat. Commun.* **2017**, *8*, 1290. [CrossRef]
11. Minasny, B.; Malone, B.P.; McBratney, A.B.; Angers, D.A.; Arrouays, D.; Chambers, A.; Chaplot, V.; Chen, Z.S.; Cheng, K.; Das, B.S.; et al. Soil Carbon 4 Per Mille. *Geoderma* **2017**, *292*, 59–86. [CrossRef]
12. Tal, A. Making conventional agriculture environmentally friendly: Moving beyond the glorification of organic agriculture and the demonization of conventional agriculture. *Sustainability* **2018**, *10*, 1078. [CrossRef]
13. Iital, A.; Pachel, K.; Deelstra, J. Monitoring of diffuse pollution from agriculture to support implementation of the WFD and the Nitrate Directive in Estonia. *Environ. Sci. Policy* **2008**, *11*, 185–193. [CrossRef]
14. Kücke, M.; Kleeberg, P. Nitrogen balance and soil nitrogen dynamics in two areas with different soil, climatic and cropping conditions. *Eur. J. Agron.* **1997**, *6*, 89–100. [CrossRef]
15. Povilaitis, A.; Stålnacke, P.; Vassiljev, A. Nutrient retention and export to surface waters in Lithuanian and Estonian river basins. *Hydrol. Res.* **2012**, *43*, 359–373. [CrossRef]
16. Fraser, P.M.; Curtin, D.; Harrison-Kirk, T.; Meenken, E.D.; Beare, M.H.; Tabley, F.; Gillespie, R.N.; Francis, G.S. Winter nitrate leaching under different tillage and winter cover crop management practices. *Soil Sci. Soc. Am. J.* **2013**, *7*, 1391–1401. [CrossRef]
17. Raave, H. Lämmastiku leostumisest ja selle vähendamise võimalustest pärast vedelsõnniku sügisel põllule laotamist (N leaching and possibilities for its reduction after autumn application of liquid manure). In *Agronomy 2021*; Tupits, I., Tamm, Ü., Tamm, S., Toe, A., Vanamb, E., Eds.; Eesti Maaülikool: Tartu, Estonia, 2021; pp. 39–51. (In Estonian)
18. Ewert, F.; Rounsevell, M.D.A.; Reginster, I.; Metzger, M.J.; Leemans, R. Future scenarios of European agricultural land use. I. Estimating changes in crop productivity. *Agric. Ecosyst. Environ.* **2005**, *107*, 101–116. [CrossRef]
19. Seufert, V.; Ramankutty, N.; Foley, J.A. Comparing the yields of organic and conventional agriculture. *Nature* **2012**, *485*, 229–232. [CrossRef] [PubMed]
20. Doltra, J.; Olesen, J.E. The role of catch crops in the ecological intensification of spring cereals in organic farming under Nordic climate. *Eur. J. Agron.* **2013**, *44*, 98–108. [CrossRef]
21. Roinila, P.; Väisänen, J.; Granstedt, A.; Kunttu, S. Effects of different organic fertilization practices and mineral fertilization on potato quality. *Biol. Agric. Hortic.* **2003**, *21*, 165–194. [CrossRef]
22. Shah, A.; Margrethe, A.; Rasmussen, I.A.; Jimenez, E.M.C.; Olesen, J.E. Productivity of organic and conventional arable cropping systems in long-term experiments in Denmark. *Eur. J. Agron.* **2017**, *90*, 12–22. [CrossRef]
23. Antosovsky, J.; Ryant, P.; Prudil, M.; Gruber, M.; Komprsová, I. Effect of localities and organic fertilizers on yield in conditions of organic farming. *Acta Univ. Agric. Silvic. Mendelianae Brun.* **2017**, *65*, 799–806. [CrossRef]
24. Tein, B.; Kauer, K.; Eremeev, V.; Luik, A.; Selge, A.; Loit, E. Farming systems affect potato (*Solanum tuberosum* L.) tuber and soil quality. *Field Crops Res.* **2014**, *156*, 1–11. [CrossRef]
25. Warman, P.R.; Havard, K.A. Yield, vitamin and mineral contents of organically and conventionally grown potatoes and sweet com. *Agric. Ecosyst. Environ.* **1998**, *68*, 207–216. [CrossRef]
26. Simson, R.; Tartlan, L.; Nugis, E.; Eremeev, V. The effect of fertilizer and growing season on tuber dry matter and nitrate content in potato. *Agron. Res.* **2016**, *14*, 1486–1493.
27. Tamm, L. The future challenge and prospects in organic crop protection. In Proceedings of the IFOAM 2000, the World Grows Organic: Proceedings, 13th International IFOAM Scientific Conference, Basel, Switzerland, 28–31 August 2000; Alföldi, T., Lockeretz, W., Niggli, U., Eds.; vdf Hochschulverlag AG an der ETH Zürich: Zürich, Switzerland, 2000; pp. 106–109.
28. FAO. *World Reference Base for Soil Resources 2006, World Soil Resource Report 103*, 2nd ed.; Food and Agriculture Organization: Rome, Italy, 2006.
29. Kauer, K.; Pärnpuu, S.; Talgre, L.; Eremeev, V.; Luik, A. Soil particulate and mineral-associated organic matter increases in organic farming under cover cropping and manure addition. *Agriculture* **2021**, *11*, 903. [CrossRef]
30. Alaru, M.; Talgre, L.; Eremeev, V.; Tein, B.; Luik, A.; Nemvalts, A.; Loit, E. Crop yields and supply of nitrogen compared in conventional and organic systems. *Agric. Food Sci.* **2014**, *23*, 317–326. [CrossRef]
31. Statsoft. *Statistica 7.0*; Copyright 1984–2005; StatSoft Inc.: Tulka, OK, USA, 2005; 716p.
32. Crystal-Ornelas, R.; Thapa, R.; Tully, K.L. Soil organic carbon is affected by organic amendments, conservation tillage, and cover cropping in organic farming systems: A meta-analysis. *Agric. Ecosyst. Environ.* **2021**, *312*, 1–12. [CrossRef]
33. Runno-Paurson, E.; Laaniste, P.; Eremeev, V.; Tahtjarv, T.; Kaurilind, E.; Tosens, T.; Niinemets, Ü.; Williams, I.H. Does winter oilseed rape as a winter cover crop influence potato late blight development in an organic crop rotation? *Biol. Agric. Hortic.* **2020**, *36*, 71–83. [CrossRef]
34. Eremeev, V.; Talgre, L.; Kuht, J.; Mäeorg, E.; Esmaeilzadeh-Salestani, K.; Alaru, M.; Loit, E.; Runno-Paurson, E.; Luik, A. The soil microbial hydrolytic activity, content of nitrogen and organic carbon were enhanced by organic farming management using cover crops and composts in potato cultivation. *Acta Agric. Scan. Sect. B Soil Plant Sci.* **2020**, *70*, 87–94. [CrossRef]
35. Runno-Paurson, E.; Hansen, M.; Tein, B.; Loit, K.; Jõgi, K.; Luik, A.; Metspalu, L.; Eremeev, V.; Williams, I.H.; Mänd, M. Cultivation technology influences the occurrence of potato early blight (*Alternaria solani*) in an organic farming system. *Zemdirb.-Agric.* **2014**, *101*, 199–204. [CrossRef]

36. Lammerts van Bueren, E.T.; Struik, P.; Jacobsen, E. Ecological concepts in organic farming and their consequences for an organic ideotype. *Neth. J. Agric. Sci.* **2002**, *50*, 1–26. [CrossRef]
37. Talgre, L.; Eremeev, V.; Tein, B.; Madsen, H.; Luik, A. Winter cover crops impact on plant nutrients in an organic crop rotation. In Proceedings of the 19th Nitrogen Workshop. Efficient Use of Different Sources of Nitrogen in Agriculture—From theory to Practice, Skara, Sweden, 27–29 June 2016; Delin, S., Wetterlind, J., Aronsson, H., Engström, L., Carlsson, G., Eds.; SLU: Skara, Sweden, 2016; pp. 382–383.
38. Juzl, M.; Štefl, M. The effect of leaf area index on potatoes yield in soils contaminated by some heavy metals. *Rostilinna Vyroba.* **2002**, *48*, 298–306. [CrossRef]
39. Eremeev, V.; Lõhmus, A.; Jõudu, J. Effects of thermal shock and pre-sprouting on field performance of potato in Estonia. *Agron. Res.* **2007**, *5*, 21–30.
40. Eremeev, V.; Lõhmus, A.; Lääniste, P.; Jõudu, J.; Talgre, L.; Lauringson, E. The influence of thermal shock and pre-sprouting of seed potatoes on formation of some yield structure elements. *Acta Agric. Scand. Sect. B Soil Plant Sci.* **2008**, *58*, 35–42. [CrossRef]
41. Keres, I.; Alaru, M.; Eremeev, V.; Talgre, L.; Luik, A.; Loit, E. Long-term effect of farming systems on the yield of crop rotation and soil nutrient content. *Agric. Food Sci.* **2020**, *29*, 210–221. [CrossRef]
42. Mulders, P.J.S.M.; van den Heuvel, E.R.; van den Borne, J.; van de Molengraft, R.; Heemels, W.P.M.H.; Reidsma, P. Data science at farm level: Explaining and predicting within-farm variability in potato growth and yield. *Eur. J. Agron.* **2021**, *123*, 126220. [CrossRef]
43. Munoz, F.; Mylavarapu, R.S.; Hutchinson, C.M. Environmentally responsible potato production. *J. Plant Nutr.* **2005**, *28*, 1287–1309. [CrossRef]
44. Brisson, N.; Gate, P.; Gouache, D.; Charmet, G.; Oury, F.X.; Huard, F. Why are wheat yields stagnating in Europe? A comprehensive data analysis for France. *Field Crops Res.* **2010**, *119*, 201–212. [CrossRef]
45. Obidiegwu, J.E.; Bryan, G.J.; Jones, H.G.; Prashar, A. Coping with drought: Stress and adaptive responses in potato and perspectives for improvement. *Front. Plant Sci.* **2015**, *6*, 542. [CrossRef]
46. MacKerron, D.K.L.; Jefferies, R.A. The influence of early soil moisture stress on tuber numbers in potato. *Potato Res.* **1986**, *29*, 299–312. [CrossRef]
47. Eremeev, V.; Talgre, L.; Alaru, M.; Kuht, J.; Loit, E.; Luik, A. Viljelusviiside mõju kartuli saagile, saagi kvaliteedile ning mulla toiteelementide sisaldusele. (The effect of crop production system on the potato yield, quality and soil nutrient content). In *Agronomy 2018*; Alaru, M., Ed.; Eesti Maaülikool: Tartu, Estonia, 2018; pp. 53–58. (In Estonian)
48. Eremeev, V.; Tein, B.; Luik, A. Kartul mahe-ja tavaviljeluse süsteemide võrdluskatses aastatel 2008–2012. (Potato production in organic and conventional management systems in 2008–2012). In *From Science to Organic Farming*; Metspalu, L., Luik, A., Eds.; Eesti Maaülikool: Tartu, Estonia, 2012; pp. 25–27. (In Estonian)