THE YIELD OF POTATOES AND SPELT IN TERMS OF ORGANIC FARMING

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Abstract: Nitrogen fertilization cannot be used by actual needs of plants during vegetation in organic farming. The proper crop rotation and harmonic nutrition are necessary for good and quality products. The methods of treatment are mainly realized by cultivation of green manure crop and fertilizing by organic fertilizers. The aim of the long-term experiment was to evaluate the effect of different localities and different organic fertilizers on crop yield in organic farming. Variants of fertilization included in the experiment are: 1. Unfertilized control, 2. Green manure, 3. Green manure + renewable external sources, 4. Green manure + renewable external sources + auxiliary substances, 5. Green manure + farm fertilizers, 6. Green manure + farm fertilizers + auxiliary substances. Potatoes were fertilized and planted in experimental years 2015–2016. Winter wheat spelt was sown in the experimental year 2016–2017 and there were no fertilization with organic fertilizers in this year. Average yield of potatoes was the highest after combination with green manure + renewable external sources (compost + digestate) + auxiliary substances. This variant achieved yield about 34.1 t/ha, which is increased by 9.4 t/ha compared to the control variant. The highest yield of spelt was observed on the variant with green manure + farm fertilizers. This variant achieved yield about 5.5 t/ha, which is increased by 0.7 t/ha compared to the unfertilized variant. The result from this experiment indicated that farming without livestock may be similar to the production with livestock. However, these results are obtained only from two experimental years. Statistical difference of achieved yields was observed between each experimental station in both experimental years.

Key Words: potatoes, spelt, organic farming, yield

INTRODUCTION

Organic agriculture is currently a well-known concept among lots of people. Environmental protection is possible due to the restriction or prohibition of the use of certain burdensome substances, especially synthetic nitrogen fertilizers. However, content of nutrients from agro-ecosystem even in organic farming is decreasing because of production export and nutrient losses such as leaching or volatilization. The precursor for higher yield and quality of products is good and fertile soil (Dvorský and Urban 2014). Organic farming, in comparison with conventional farming methods, cannot count on the fact that plants can be fertilized directly to the roots according to actual needs in vegetation. The point of emphasis in organic farming is the content of organic matter and quality of humus in the soil (Martin and MacRae 2014).

The basis of nutrition in organic farming should be a proper crop rotation (Urban et al. 2003). The supply of nitrogen from external environment is primarily achieved by growing legumes and plants suitable for green manure. Another invaluable sources of nutrients are organic fertilizers, especially manure and slurry but also organic compost and increasing use of digestate. The combination of well-chosen crop rotation with adequate dose of properly selected organic fertilizer is very important and proves irreplaceable role for organic farming (Barker 2010).

This work is a part of a long-term experiment established in 2014 by the Central Institute for Supervising and Testing in Agriculture. The ultimate goal of this long-term experiment is to evaluate the effect of different intensity and fertilization in organic farming with and without breeding livestock on yield and quality of products, soil properties and nutrient balance. However, in this work, only the yield of potatoes and spelt from years 2016 and 2017 will be evaluated.
MATERIAL AND METHODS

Small plot field experiment was established as a precise and long-term research. The experiment took place at 5 different experimental stations representing different production areas (Table 1). The experiment tried to compare different organic fertilizers simulating systems with or without breeding livestock in organic farming. Each variant had three repetitions. The yields potatoes were evaluated in experimental year 2016. The yields of spelt were evaluated in the experimental year 2017.

Table 1 Characteristics of experimental stations

<table>
<thead>
<tr>
<th>Experimental station</th>
<th>MASL</th>
<th>Crop area</th>
<th>Soil type</th>
<th>Soil texture</th>
<th>Average annual precipitation (mm)</th>
<th>Average annual temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Věrovany</td>
<td>207</td>
<td>Sugar beet</td>
<td>Black Soil</td>
<td>Clay</td>
<td>502</td>
<td>8.7</td>
</tr>
<tr>
<td>Čáslav</td>
<td>260</td>
<td>Sugar beet</td>
<td>Black Soil</td>
<td>Clay</td>
<td>555</td>
<td>8.9</td>
</tr>
<tr>
<td>Jaroměřice nad Rokytnou</td>
<td>425</td>
<td>Cereals</td>
<td>Brown Soil</td>
<td>Clay</td>
<td>481</td>
<td>8.0</td>
</tr>
<tr>
<td>Hornižďovice</td>
<td>475</td>
<td>Potatoes</td>
<td>Cambisol</td>
<td>Sandy Loam</td>
<td>585</td>
<td>7.8</td>
</tr>
<tr>
<td>Lípa</td>
<td>505</td>
<td>Potatoes</td>
<td>Cambisol</td>
<td>Sandy Loam</td>
<td>594</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The application of compost and manure (for experimental year of 2016) was performed in August of 2015. Green manure crop (*Pisum sativum var. arvense*) was sown immediately after the incorporation of the organic fertilizers. The average yield of green manure ranged between 0.5 to 4.7 t/ha (depending on experimental station) in dry matter. Green manure was incorporated into the soil by mulching before winter. The fertilization of potatoes is described in Table 2. Planting of potatoes was carried out approximately 14 days after the incorporation of digestate and fermented urine to the soil in early April of 2016. The auxiliary substance for potatoes was applied two times in May. Auxiliary substance was based only on mixture of natural, water soluble oligopeptide, amino acids, magnesium, potassium and trace elements. Harvest of the potatoes was performed at the first half of September.

Table 2 Variants of fertilization of potatoes used in the experiment (same for all locations, 2015–2016)

<table>
<thead>
<tr>
<th>Variants of fertilization</th>
<th>Application of organic fertilizers</th>
<th>Auxiliary substance (AS)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dose of fertilizer</td>
<td>Period</td>
</tr>
<tr>
<td>1. Unfertilized</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2. Green manure (GM)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3. GM + renewable external sources</td>
<td>27 t/ha of compost</td>
<td>Autumn 2015</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4. GM + renewable external sources + AS</td>
<td>27 t/ha of compost</td>
<td>Autumn 2015</td>
</tr>
<tr>
<td></td>
<td>5 l/ha</td>
<td>2x in May</td>
</tr>
<tr>
<td>5. GM + farm fertilizers</td>
<td>27 t/ha of manure</td>
<td>Autumn 2015</td>
</tr>
<tr>
<td></td>
<td>5 l/ha</td>
<td>2x in May</td>
</tr>
<tr>
<td>6. GM + farm fertilizers + AS</td>
<td>27 t/ha of manure</td>
<td>Autumn 2015</td>
</tr>
</tbody>
</table>

Legend: AS - Auxiliary substances: magnesium as MgO – min 4.0%, potassium as K2O – min 1.0%, boron as B – 0.04%, manganese as Mn – 0.1%, copper as Cu – 0.05%, molybdenum as Mo – 0.001%, zinc as Z – 0.2%, iron as Fe – 0.04%

Spelt was not fertilized by organic fertilizers in experimental year 2017. Only the application of auxiliary substance was performed in this year. The idea behind this is to simulate common praxis. If there is a good forecrop fertilized by organic fertilizers (potatoes in 2016), there is usually not necessary to fertilize in second year. The second reason for omitting fertilization of spelt was its low
level of resistance to lodging. The application of auxiliary substance to the soil on variants 4 and 6 was performed before sowing of spelt. Bacteria fertilizer was used as an auxiliary substance. Harvest of the spelt was performed at the end of July. The obtained results were evaluated by two factors analysis of variance (ANOVA) with subsequent verification based on Tukey test (P < 0.05). The data were processed using the STATISTICA CZ 12. Results are expressed as a mean ± standard deviation.

RESULTS AND DISCUSSION

Yield of potatoes in 2016

The impact of locality was evaluated as a statistically significant. The average estimated yield of potatoes in the Czech Republic in 2016 was about 29.4 t/ha (CZSO 2016). It is evident from Figure 1 that only two experimental stations (Jaroměřice nad Rokytnou and Lípa) achieved lower yields. However, it is a good result achieved in organic farming. For example, results obtained from experiment performed by El-Sayed et al. (2015) and Plaza et al. (2013) proved that organic production of potatoes could be an alternative method to conventional production without significant reduction of yield.

Each locality had different prerequisites for achieving the optimal yields. The experimental station in Věrovany was determined as a reference locality (100%) due to the best soil and climate conditions. The achieved yield on this locality was very high due to the optimal course of weather during the year. Potatoes yields achieved from every other station were detected lower compared to reference station (Figure 1). This fact was caused mostly by drought in these stations during the experimental year of 2016, especially in germination and after emergence of potatoes.

Figure 1 Average yield of potatoes in the experimental stations (2016)

Figure 2 Average yields of potatoes (2016)
There is also statistical difference between examined variants of fertilization (Figure 2). Unfertilized control and variant with only green manure provided similar yield. Green manure itself could not fully substitute the incorporation of organic fertilizers. Variants with organic fertilization provided better crop yield. This is a different result compared to the experiment performed by Makarewicz et al. (2015). Their results showed, that fertilization with green manure itself fully substituted manure in the production system of potato cultivation. Similar yield were achieved on variants 3 and 4 with GM + renewable external sources and then on the variants 5 and 6 with GM + farm fertilizers. The variants 3 and 4 with GM + renewable external sources provided the highest yield. The yield of these variants was increased by about 9.2 t/ha (37%) compared to the control variant. Most importantly, there was also an increase of yield compared to the variants with GM + farm fertilizers by 3.0 t/ha and 4.5 t/ha. These results were probably caused by higher content of nitrogen in organic fertilizers (compost + digestate) used in this variant compared to other variants.

**Yield of spelt in 2017**

The results show statistically significant difference between experimental localities as can be seen from Figure 3. Konvalina (2013) is describing average yield of spelt in terms of organic farming about 2.8 t/ha in Czech Republic and 2.2 t/ha in Austria. Average yield of spelt achieved in this experiment was 5.2 t/ha. This result was probably caused by good forecrop (potatoes) fertilized two times by organic fertilizers (Table 2). The concerns about lodging of spelt have not been confirmed, spelt at each experimental station endured at upright position during whole vegetation. This fact has also contributed to the reduction of harvest losses.

*Figure 3 Average yields of spelt in the experimental stations (2017)*

![Figure 3](image)

*Figure 4 Average yields of spelt (2017)*

![Figure 4](image)
was caused by drought during experimental year in combination with worse soil conditions at these localities. The highest yield, 6.1 t/ha, was achieved at station Jaroměřice nad Rokytnou. Experimental station Věrovany, which is determined as a reference station due the best soil and climate conditions, achieved slightly lower average yield (6.0 t/ha), probably due to the high occurrence of diseases (*Blumeria graminis*) and pests (*Oulema melanopus, Oulema lichenis*).

Figure 4 is describing average yields of grain and their statistical significance for each variant of fertilization in year 2017. The lowest yield with no statistical difference was observed on Unfertilized variant and variant with Green manure alone. This result is similar to experimental year 2016. However, the highest yields about 5.5 t/ha were provided by both variants with GM + farm fertilizers. This result is an interesting change in comparison with the result in previous year. Highest yield of potatoes provided by variants with GM + renewable external resources in year 2016 were caused by higher content of quickly available nitrogen in digestate and compost. Fertilization with organic matter was not performed in year 2017, so the spelt was only taking up rest of the nutrients from previous year. The result from this year indicates that fertilization with farm fertilizers (manure + fermented urine) provided more nutrients in second year after fertilization in comparison with renewable external resources (digestate + compost). Similar results were observed in experiment performed by Rieux et al. (2013), Miller et al. (2010), Hradil et al. (2007) and Gale et al. (2006). They have also described application of manure as preferable variant in comparison with compost. On the other hand, there are also results supporting fertilizing with compost as a superior choice (Miller et al. 2009, Larney et al. 2006, Sanchez et al. 2004).

**CONCLUSION**

The results obtained from the experimental year 2016 showed that any application of organic fertilizers either from green manure itself, renewable external resources or farm fertilizers proved the increasing yield compared to unfertilized variant. This result was not obviously surprising. However, in organic farming, it is not possible to rely on crop fertilizing during vegetation according to the current needs. The application of any organic fertilizers played therefore a crucial role for plants and yields. The results from the year 2017 confirmed that the variant with green manure itself provided better yields compared to unfertilized variant but the difference was not detected as statistically significant. Highest yields were observed on variants fertilized by organic fertilizers before forecrop.

A statistical difference between the examined variants of fertilization was found out in both experimental years. The obtained results showed, that the highest yields of potatoes were provided by the combination of compost and digestate. Organic fertilizers used in these variant contained more quickly available nitrogen in comparison to other variants of fertilization. The idea came out that compost provided more nutrients for plants in the first year after the incorporation compared to manure which was supported by the result of this experiment. The result obtained from the year 2017 showed, that the highest yield of spelt were provided by the combination of manure and fermented urine. This result supports the idea, that manure provides more nutrients for longer time after incorporation to the soil in comparison with compost.

A lot of auxiliary substances are allowed to be used in organic farming. The results obtained from this experiment showed that the application of auxiliary substances in organic farming did not provide any statistically different yield compared to the same variant of fertilization without AS.

Statistical difference of achieved yields was observed between each experimental station in both experimental years. This result was only a confirmation that the production of yields is heavily dependent on the content of nutrients in soil, good soil condition and optimal course of weather (mostly precipitation) during vegetation.

The result from this experiment indicated that farming without livestock may be similar to the production with livestock. However, these results are obtained only from two experimental years. It is going to be interesting to watch the difference between renewable external resources and farm fertilizers in the future of this long-term experiment.
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REFERENCES


