Effects of compost and bio-fungicide application on organic potato yields in northwestern Russia

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Zusammenfassung

Organische landwirtschaftliche Methoden erleben heute eine rasante Entwicklung in Russland, es fehlt dabei aber an Empfehlungen zur Anwendung moderner Bio-Landbautechnologien, was besonders in der Region Nordwest für Schwierigkeiten sorgt, da die lokalen klimatischen Bedingungen für einige landwirtschaftliche Pflanzen wenig günstig sind. Ziel der Forschung ist es, marktfähige Technologien für den organischen Pflanzenbau zu entwickeln, einschließlich einer populären Kultur wie Kartoffeln. Die Arbeit begann mit einer Reihe von Feldversuchen, in denen die Wirkung verschiedener Kompostarten und biologischer Schutzmittel auf die Kulturpflanzen und ihre Qualität untersucht wurde. 2016 startete der organische Anbau von Kulturpflanzen in einer Sechsfelderfolge auf einer drei ha großen Versuchsstation des Institutes. Anbaumethoden von Feld- und Hackkulturen sind Schwerpunkt der Forschung. Nach zwei Jahren wurde in einheimischen Kartoffelsorten ein Ertrag von 24 bis 26 Tonnen pro Hektar mit hoher Produktqualität auch bei ungünstigen Wetterbedingungen erreicht, was die Wirksamkeit der Komposte, der biologischen Pflanzenschutzmittel und der relevanten technischen Maßnahmen deutlich zeigt.

Abstract

The production and consumption of organic products in Russia is currently growing rapidly. However, recommendations on how to apply relevant modern technologies are not available to organic farmers. This creates difficulties, especially in northwestern Russia, where local conditions for cultivation of some crops are not favourable. The aim of this research was to develop competitive technologies for organic crop production, including popular crops such as potatoes. The effect of organic fertilizers and biological plant protection agents on the development and quality of farm crops was studied in a number of field experiments. In 2016, a field trial with an area of 3 ha and a six-year organic crop rotation was started at the IEEP experimental station, investigating techniques in row and field crop cultivation. After two years, yields of local potato varieties grown in unfavourable weather conditions were 24-26 t/ha and product quality was high, demonstrating the effective application of composts, biological plant protection agents and appropriate technology.

1 Introduction

Organic production in Russia is currently growing rapidly. Studies by the Russian Organic Farming Union show that 27% of farmers are willing to convert to organic farming if there are distribution guarantees. However, they lack both financial support and knowledge of

state-of-the-art, efficient technologies (Korshunov S 2018). Organic research started at IEEP in 2014 with micro- and small-plot field experiments, in which more resistant plant varieties, biological fungicides and composts were used (Minin et al. 2017).

2 Materials and Methods

In 2016 a field trial with an area of 3 ha and a six-year organic crop rotation was started at the IEEP experimental station, which is located in southeastern St. Petersburg (59°39'15.7"N 30°24'39.3"E). The crop rotation consisted of potato, beetroot, barley and grasses (Table 1). All field operations were mechanized, including weed control**.** The soil at the experimental site is sod-podzolic light loamy on residual carbonate moraine loam.

Tab. 1: Crop rotation

Number of the field	Culture
1	Potato
2	Beetroot
3	Barley with additional seeding of Clover and Timothy
4	Clover and Timothy
5	Clover and Timothy
6	Clover and Timothy followed by winter rye for green manure

Two factors were studied in the experiment: 1) crop nutrition management with compost application; 2) application of Flavobacterin, a biological crop protection agent. Flavobacterin is based on *Flavobacterium sp.30* and can fix nitrogen and suppress the growth and development of phytopathogenic fungi and bacteria.

The plant protection agent Extrasol, based on *Bacillus subtilis*, was applied to the leaves of the potato crop during planting and flowering in all treatments in 2016. In 2017, the potato crop was treated in two replications with the bio-fungicide Vitaplan SP and in two replications with the bio-fungicide Kartofin (strain I5-12/23) (Novikova et al. 2015). The potato variety Udacha (elite) was grown. Three doses of compost, industrially produced from chicken manure, were applied the day before planting potatoes. The compost amount was determined based on the nitrogen content: 40, 80 and 160 kg N/ha (Table 2). The experiment has four replications. Biomass growth rates, phytosanitary conditions and soil properties were examined four times according to potato development phases in selected plots. Nitrate and ammonium content in the soil and plants was determined using the ionometric technique.

Tab. 2: Experimental design

No	Varient
1	Reference
2	Flavobacterin
3	Compost 40 kg N/ha
4	Compost 40 kg N/ha+Flavobacterin
5	Compost 80 kg N/ha
6	Compost 160 kg N/ha

3 Results and Discussion

It is well known that in northwestern Russia, the main factors affecting potato plant development and yield are the air temperature, amount of precipitation and related soil humidity, and nitrogen supply. The effects of all these factors were clearly observed in the experiments. Weather data for the summer months during the research period are shown in Tabel 3.

Tab. 3: Temperature and precipitation in summer, 2014-2017

	Temperature and precipitation in summer	Years				
Month	Atmospheric indicator	2014	2015	2016	2017	Norm
May	Temperature, C°	13	11,8	14,7	9,4	11,3
	Precipitation, mm	94	46	30	13	46
June	Temperature, C°	15	15,9	16,4	13,6	15,7
	Precipitation, mm	75	21	99	69	71
July	Temperature, C°	21,2	16,9	19	16,5	18,8
	Precipitation, mm	44	86	151	123	79
August	Temperature, C°	18,8	18,3	17,2	17,4	16,9
	Precipitation, mm	101	47	190	148	83

In 2016, May and June featured higher air temperatures and sufficient precipitation, and active soil mineralization began. By the beginning of the experiment (25.05.2016), the soil in all plots had accumulated a large amount of mineral nitrogen (34.8 +2.5 mg/kg of soil) before compost application (Table 4).

Tab. 4: Effect of compost on soil accumulation of mineral nitrogen, mg/kg

	Effect of compost on mineral nitrogen accumulation in soil , mg/kg					
Variant	24.05.2016	25.05.2017	10.06.2016	14.06.2017	22.06.2016	05.07.2017
Reference	39	12	40	17	33	24
Compost 40 kg N/ha	34	14	91	17	127	31
Compost 80 kg N/ha	38	14	140	21	142	28
$LSD_{0.05}$	No difference	No difference	29,8	No difference	29,8	No difference

Compost started mineralizing rapidly, resulting in accumulation of additional inorganic N (50-100 mg N/kg soil) in the soil. Over a period of about two weeks, the soil retained a high amount of inorganic N, which correlated with the compost application rate. However, the final stage of potato development, late July-August, featured extremely wet weather conditions and late blight grew rapidly despite application of the bio-fungicide Extrasol. By early August, the potato above-ground biomass had been destroyed and the tubers failed to form properly. Yields were low and the share of standard tubers of total yield was 20-40% (Table 5). A reliable increase in yield was obtained only in the treatment with Flavobacterin application. However, if we consider the yield of standard tubers, the

greatest increase was provided by the second dose of compost. The differences between the control and the other treatments were not significant.

In 2017, May and June were cold (9-13 °C). The content of inorganic N in the soil was 1.4 times lower compared to 2016 in the control and 4-5 times lower in the treatments with compost application. By the end of summer, however, the air temperature had increased and the nitrogen nutrition of the potato plants improved. In addition, despite high precipitation rates, the biological preparations protected the potato plants against late blight. The total loss of tubers due to disease during a storage period of 4 months amounted to 2-3% of the total potato yield.

The cultivator KON – 2.8 M (Figure 1) was regularly used (twice a month) and destroyed up to 95-97% of various weeds. The cultivator could not be used in very humid conditions as the tractor was not used on wet soil but these only occurred at the end of summer 2016.

Fig. 1: Cultivator KON – 2.8 M, a rotational weed harrow

Tab. 5: Effect of compost and Flavobacterin on potato yield

		Yield of all tubers, t/ha		Yield of standard tubers, t/ha	
No	Varient	2016	2017	2016	2017
1	Reference	9,89	18,38	1,82	14,02
2	Flavobacterin	12,46	17,24	2,15	14,32
3	Compost 40 kg N/ha	8,17	20,16	1,65	18,5
4	Compost 40 kg N/ha + Flavobacterin	-	21,31	-	16,89
5	Compost 80 kg N/ha	11,5	20,91	2,4	18,7
6	Compost 160 kg N/ha	9	23,27	2,09	19,92
$LSD_{0.05}$		1,89	1,57	0,39	1,35

As a result, three yield levels were determined (Maksimov et al., 2017):

• The first level was 17-18 t/ha. This productivity was provided by the natural soil fertility and the effect of bio-fungicides. A large proportion of small tubers was recorded (Tab. 5).

• The second level was 20.2-21.3 t/ha (an increase of 3.2-4 t/ha). This was due to the first and second doses of compost.

• The third, maximum level was 23.3 t/ha (an increase of about 5 t/ha) when three doses of compost were applied.

4 Conclusions

1. To promote organic agriculture, integrated competitive farming technologies, adapted to local conditions, need to be developed and offered to farmers.
2. The research results demonstrate that it is possible to achieve potato yields of 22-24 t/ha, even in poor weather conditions, by using composts, appropriate technology and the biological fungicides Vlavobacterin, Vitaplan SP and Kartofin.
3. Mineralisation of soil organic matter and composts is determined by the weather conditions and this must be taken into account to ensure mineral nutrition of crops.
4. Research should continue, concentrating on predicting the availability of nutrients to plants depending on the weather conditions, and developing technological solutions, machines and equipment for weed control in vegetable crops.

5 References

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