The effect of biologized methods of potato cultivation in organic farming on its yield

D A Maksimov, V B Minin, A A Ustroev, S P Melnikov and E A Murzaev

1Institute of Agroengineering and Ecological Problems of Agricultural Production, branch of FNATC VIM, 3, Filtrovskoe Highway, St. Petersburg - Tyarlevo, 196625, Russia
2St. Petersburg State Agrarian University, 2 Peterburgskoye Highway, St. Petersburg - Pushkin, 196601, Russia

E-mail: agrotehinvest@mail.ru

Abstract. The results of experimental studies of the dependence of potato yields on the application of the BIOCUM compost, biological plant protection products and technological methods of tillage and plant care are presented. The experimental and analytical methods were used. The whole range of agricultural practices has a significant impact on the potato yield. The deep loosening between rows is promising and can increase the yield by 57%. The use of Vitaplan, SP has a significant effect on the potato yield. It increased the yield from 17.8 t/ha to 25.3 t/ha, i.e. by 7.5 t/ha or 42%. The use of biofungicide along with the compost made it possible to produce the yield of 29.2 t/ha, and increase it by 64%. The dependencies can be used for developing biologized technologies of potato cultivation in specific economic conditions.

1. Introduction

Organic agriculture aims to ensure a favorable environment, improve human health, preserve and restore soil fertility [1].

An important task is the use of biological resources of varieties by selecting appropriate machine agrotechnologies, organic fertilizers and agrochemicals, biological protective and stimulating drugs, as well as rational technological methods of tillage and plant care.

In order to develop these technologies, since 2016, the IAEP and SPSAU have been carried out comprehensive studies of the impact of biologized technological methods on plant productivity and soil properties [2,3].

This paper presents the results of experimental studies of potato productivity taking into account the effect of compost, biological products and technological methods of tillage and plant care.

2. Materials and methods

The authors used experimental and analytical methods, assessed the influence of elements of machine organic agrotechnology on potato cultivation productivity in the field of crop rotation of organic farming. Experimental studies were carried out at the experimental station of the IAEP in the field crop rotation of organic farming.

Experiment 1 was conducted to study the provision of potato fields with means for improving mineral nutrition and protecting plants from diseases. Experiment 2 was conducted to study the effect of various methods of tillage and plant care on the potato yield.
The soil was sod-podzolic light loamy, formed on the residual carbonate moraine. It was characterized by a neutral reaction, an increased content of humus and a medium content of mobile forms of phosphorus and potassium.

The scheme of field experiment 1 is presented in Table 1.

To ensure the mineral nutrition of potato plants under organic farming conditions, the BIOHUM compost was used. It was produced in the IOEP bioconvector on the basis of chicken manure. Two doses of compost were used. They were calculated from the successively increasing amount of nitrogen: 0, 80, 160 kg/ha corresponding to the optimum (as recommended by HELCOM) and high levels of potato productivity.

To protect potato plants from diseases, the following biopreparations were selected: a biological fungicide based on the bacterium Bacillus subtilis: Vitaplan, SP (VKM-B-2604D and VKM-B-2605D strains), the VIZR’s development [4] and Flavobacterin with a nitrogen-fixing function developed by the ARIAMB [5].

Table 1. Scheme of field experiment 1 for assessing the effect of compost and biological products on the potato yield

| Variant number | Compost dose | Vitaplan, SP | Flavobacterin |
|----------------|--------------|--------------|---------------|
| 1              | 0            | 0            | 0             |
| 2              | 0            | X            | 0             |
| 3              | 0            | X            | X             |
| 4              | 80 kg N      | 0            | 0             |
| 5              | 80 kg N      | X            | X             |
| 6              | 80 kg N      | X            | 0             |
| 7              | 160 kg N     | X            | 0             |

The area of the experimental plot was 61.6 m², the final accounting area was 25.2 m². The repetition is fourfold. Potatoes were cultivated on ridges with a 70 cm wide row spacing. The variety Udacha (elite) zoned for the conditions of Leningrad Region was planted.

Pre-tillage was carried out by a KCHN-3 chisel cultivator to the depth of the arable horizon. Inter-row processing was carried out by an experimental sample of a tilled cultivator-deep-ripper (Figure 1) which ensures the formation of ridges before planting potatoes, loosening and hilling of ridges, destruction of weeds, deep loosening of rows at a depth of 30 cm.

![Figure 1. Experimental sample of the tilled cultivator-deep-ripper: 1 – frame; 2 – support wheel; 3 – spring strut with loosening paw; 4 – rigid stand with loosening paw; 5 – earthing body; 6 – rotary harrow.](image)

The design and an experimental sample of equipment were developed for applying biological protective stimulating preparations during planting and growing seasons.
The flow rate of the working fluid of the Vitaplan, SP biopreparation was 10 l/t. For processing potato tops, it was 300 l/ha. The technical characteristics of the equipment are presented in Table 2, and the flow chart is presented in Figure 2.

Table 2. Specification of the equipment

| Number of steps | Submersible, centrifugal, multistage |
|-----------------|--------------------------------------|
| Pump capacity, l/min | 10 – 15 |
| Nominal pressure, MPa | 0.15 |
| Nominal power, W | 90 |
| Power supply, V | 12 |
| Tank capacity for the solution, l | 200 |
| Number of nozzles, pcs | 8 |

Figure 2. Technological scheme of the equipment: 1 – electric pump; 2 – electric pump panel; 3 – capacity; 4 – frame; 5 – pressure regulator; 6 – flow meter (rotameter); 7 – stopcock; 8 – distributor; 9 – manometer; 10 – a set of tees with shut-off valves and filters; 11, 12 – nozzles; 13 – potato planter coulters.

The scheme of field experiment 2 is presented in Table 3.

Table 3. The scheme of experiment 2 for assessing the impact of technological methods of tillage and planting on potato yields.

| Variant number | Variants of technological processes and operations | Planting care |
|----------------|-----------------------------------------------|---------------|
| 1              | Minimum tillage (moisture closure)             | Pre-emergence harrowing + hilling with harrowing + hilling |
| 2              | Cultivation (moisture closure) + deep tiller loosening + cultivation | Deep loosening of row spacing with pre-emergence harrowing + hilling + hilling |
| 3              | Cultivation (moisture closure) + plowing + cultivation | Pre-emergence harrowing + hilling with hilling + hilling |
| 4              | Deep loosening of row spacing with pre-emergence harrowing + hilling + hilling | Pre-emergence harrowing + hilling with hilling + hilling |
| 5              | Deep loosening of row spacing with pre-emergence harrowing + hilling + hilling | Pre-emergence harrowing + hilling with hilling + hilling |
| 6              | Deep loosening of row spacing with pre-emergence harrowing + hilling + hilling | Pre-emergence harrowing + hilling with hilling + hilling |

The studies were conducted on a separate plot of the experimental field which is a continuation of the plot under potatoes in a field crop rotation of organic farming.
Potato cultivation was carried out without the use of composts using the biological fungicide Vitaplan, SP.

3. Results and Discussion
The results of experiment 1 show that due to soil fertility, even in the variant which does not involve using biological preparations and compost, the yield was 17.8 t/ha (Table 4, Figure 2). The use of biological products, in particular Vitaplan, SP increased the by 6.2 – 7.5 t/ha. At the same time, the effectiveness of compost not combined with biological products was even less than the effectiveness of biological products. Vitaplan, SP activates biological processes [4,6]. It increased the nutrient supply and improved the photosynthetic ability of plants. The share of small potatoes in the total biological yield decreased (Table 4). The application of compost together combined with biological preparations made it possible to increase the potato productivity to 29 t/ha. However, the effectiveness of the second dose of compost did not differ from the first one, and the share of small potatoes increased. Solar energy was not enough to ensure an increase in potato productivity. The nitrate content in potato tubers ranged from 30 to 95 mg/kg.

Table 4. The effect of compost and biological products on the potato yield

| Variant number | Biological preparations | Standard Yield | The yield of small potatoes in the total biomass |
|----------------|-------------------------|----------------|-----------------------------------------------|
|                | Standard | Vitaplan | Flavobacterin | Compost kg, N/ha | t/ha | % |
| 1.             | 0 0     | 17.8    | 1.45          | 7.5 |
| 2.             | 0 0     | 25.3    | 1.42          | 5.3 |
| 3.             | 0 0     | 24.0    | 1.09          | 4.4 |
| 4.             | 0 0     | 24.5    | 2.09          | 7.8 |
| 5.             | 0 0     | 27.6    | 1.48          | 5.1 |
| 6.             | 0 0     | 29.2    | 2.02          | 6.5 |
| 7.             | 0 0     | 29.3    | 2.61          | 8.2 |

| HCP 0.95       | 1.8     | 0.9 |

Figure 3. The effect of compost and biological products on the potato yield. Protection system: 1 – without protection; 2 – application of Vitaplan, SP; Row 1 – control (without compost); row 2 – the first dose of compost; row 3 – the second dose of compost.

In experiment 2, there were three fundamental differences between the variants (intensity of presowing tillage). In each variant of presowing treatment, two planting care schemes were implemented (Table 3). The maximum potato yield of 28.3–28.8 t/ha was achieved in the third and fourth variants (Figure 3) which were characterized by a rather mild impact on the surface horizon of the soil and deep
unaligned loosening of the underlying horizon. Under these conditions, a fairly uniform soil profile was formed to the depth of the arable layer which ensured a decrease in the upward flow of soil moisture to the surface. Accordingly, the potato tubers and the biological product were in the most favorable soil conditions. A slightly lower yield (24.6 – 24.8 t/ha) was achieved in the variants with minimal pre-sowing treatment (1 and 2) due to less favorable soil conditions. However, the lowest yield was obtained under the dumping plowing. In variant 5 (the traditional treatment system was used), the yield was 16.5 t/ha. Plowing dried up the soil which had a negative effect on potato plants. In variant 6, deep loosening of row spacing improved the situation, and the potato yield was 19.6 t/a.

![Graph showing impact of technological methods of tillage on potato yield]

**Figure 4.** The impact of technological methods of tillage on the potato yield.

### 4. Conclusion
The following regularities were established. The use of compost at a dose of 80 kg/ha increased the potato yield from 17.8 t/ha to 24.5 t/ha (by 6.7 t/ha or 37.64%).

The varied composition of technological methods of tillage and planting had a significant impact on the yield. The yield increased from 16.5 t/ha to 28.8 t/ha due to dump plowing without deep loosening between rows. The use of the basic tillage method with deep loosening between rows increased the yield by 12.3 t/ha (75% of the control yield). The sharp decrease in the yield (up to 16.5 t/ha) due to bulk dumping of the main tillage is explained by the insufficient amount of moisture during the growing season. Similar results were obtained in the studies carried out in Vladimir region [7].

The use of biofungicide with a phytostimulating function and Vitaplan, SP had a significant impact on the yield. Its use at a dose of 20 g/t and subsequent two–fold treatment of the leaf surface increased the yield from 17.8 t/ha to 25.3 t/ha which exceed the yield in the control variant by 7.5 t/ha or 42 %. This is due to the activation of potato plants and the microflora in the rhizosphere of potato plants which made it possible to obtain the additional amount of nutrients. The use of biofungicide combined with compost made it possible to produce 29.2 t/ha, and increase the yield by 11.4 t/ha or 64%.

### 5. Acknowledgments
In 2018, even without using compost and biopreparations, the yield was 17.8 t/ha. The analysis of research results of indicates a high efficiency of the combined use of industrial compost, the modern system of biological plant protection, new technological methods and modified technical means to produce potato in the amount of 29.3 t/ha.

The dependencies can be used for developingbiologized technologies of potato cultivation in specific economic conditions.

### References
[1] Lipkovich E I, Beltyukov L P, Bondarenko A M 2014 *Equipment and Equipment for the Village* 8 2–7
[2] Minin V B, Maksimov D A, Ustroev A A, Mbaykholoyel E 2018 *All–Russian Sci.–Practical Conf. with Int. Participation* pp. 331–338
[3] Kalinin A, Teplinsky I, Ustroev A 2018 17th *International Scientific Conference* pp. 392–399
[4] Novikova I I, Titova Yu A, Boykova I V, Zeyruk V N, Krasnobaeva I L 2017 *Biotechnology* **33**(6) 68–76
[5] Laktionov Yu V, Popova T A, Andreev O A, Ibatullina R P, Kozhemyakov A P 2013 *Current approaches in the biotechnology of the Republic of Tatarstan*. p. 34–38
[6] Novikova I I, Shenin Y D 2011 *Applied Biochemistry and Microbiology* **47** 817–826
[7] Korchagin A A, Bibik T S, Mazirov M A, Petrosyan R D, Markov A A, Pavlova A A 2016 *All-Russian Scientific–Practical Conf. with Int. Participation*. pp. 148–153