Efficacy of the liquid biological product on the growth and development of potatoes

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ABSTRACT

The liquid-phase biological product (LBP) is a high-level biogenesity, nutritional value and physiological effect. This work considers an efficacy the LBP influence on the growth and development of potatoes. The research was conducted of a VNIIMZ test field (Tver Region, Russia). The LBP was used for potatoes flooding and spraying in various concentrations on the background of the basic organic fertilization. It has been revealed that the spraying was more effective. The maximum crop rise (14.9 % relative to the basic organic fertilizer background) was achieved by a triple spraying with the LBP working solution made by its dilution 1:300 by water. The LBP promoted the development of medium and large potato tubers - which finally formed almost 90% of the total productivity. This fact was caused by greater forming of new tubers: the number of them grew by 54% during the test period.

Key words: Biometry, Crop yield, Flooding, Liquid biological product, Potato, Spraying.

INTRODUCTION

Currently, a great number of various biological means, preparations and fertilizers for plant production are known. They include those for treating seeds, bulbs, tubers before sowing, as well as flooding and spraying in vegetation period (Kuldip Kumar et al. 2017; Walid Fediala Abd El-Gleel Mosa et al. 2017). A great variety of such products allows customers choosing this or that biological product according to individual criteria or combination thereof, particularly by their targets, composition, price, amount, consumption, storage conditions and duration. However, the foremost aim is to choose the product that activates plant growth and development, and forms the maximum amount of best-quality crops. In this connection, manufacturers of different biological products, when they mention the mechanism of action of the latter, imply their application results: higher germinability and germination energy of the sowing and planting materials, better plant root development, lower nitrate content in the crops, etc. (Products of EM technologies, 2017; Zlotnikov, 2011; Zakharov, 2015; Ulukan, 2005).

Most often, the biological product inventors themselves also describe the mechanism of action in the agronomic effectiveness of the biological product (Zavalin, 2010). For example, the mechanism of action of microbiological products on the plant can be reduced to atmosphere nitrogen fixation (improving the nitrogen nutrition), phosphorus nutrition optimization, growth and development stimulation (faster plant development and crops ripening), plant pathogens suppression and stress-stability elevation (Srivastava et al. 2016; Ratnakumar et al. 2017; Zavalin, 2005).

To reveal the mechanism of action of a product, high-precision plant biochemistry, physiology studies at the molecular, cellular and subcellular levels (in particular, using the stable 15N isotope) can be conducted. Nevertheless, simpler and mediated ways and methods can be also used to study the biological product effect on the plant.

The All-Russian Research Institute of Reclaimed Lands developed a unique fermentation and extraction technological line to manufacture various liquid-phase biological products including the LBP designed for plant growing and agriculture. The LBP features a high biogenic level: its agronomically useful microorganisms content reaches n*10^{12} colony-forming units/ml, especially high phosphorus and potassium contents reach 6.0-10.0 g/l and 6.0-9.5 g/l for P_{2}O_{5} and K_{2}O respectively, physiologically active substances occur (Rabinovich et al. 2014; Rabinovich, 2016).

Numerous laboratory and field experiments in VNIIMZ and other affiliated institutions allowed establishing a positive effect of the LBP comprising higher crop productivity, better crop quality parameters, agrochemical mobilization and microbiological activation of the soil (Rabinovich et al. 2009, 2015; Rabinovich, 2016).

We performed a test on our institute’s test field and grew Zhukovsky kind potatoes for the purpose of a studying

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the effects of the LBP on the potato plant growth and development. The research lasted for two years.

MATERIALS AND METHODS

The test was started on the light-loamy sod-podzol soil with the following characterization: \( \text{PH}_{\text{KCl}} = 5.72; \text{P}_{2}\text{O}_{5} \) (according to Kirsanov) – 323 mg/kg; \( \text{K}_{2}\text{O} \) (according to Kirsanov) – 141 mg/kg; humus (according to Tyurin) – 1.4 \%. The experiment was planned with four repeats on randomly distributed evaluation plots, with protection strips (Dospekhov, 1985).

The LBP, first of all, is suggested to be used as a plant growth stimulator, so it is reasonable to use it on the background of a basic fertilizer. The LBP was used on the potato fields sequentially in phases of shoots, buds and flowers by flooding or spraying on the background of a multipurpose compost added locally, 4 ton/ha. The multipurpose compost was developed in VNIIMZ, actively used in fertilizer systems since 1990, awarded the State Prize of the Russian Federation. It is a high-effect environmentally safe organic fertilizer containing agronomically useful microorganisms (up to 10 billion cells/g), combination of major (nitrogen, phosphorus, potassium, calcium) and trace (copper, zinc, boron, magnesium, etc.) elements 50...65 kg d. v. NPK; nitrogen, phosphorus, potassium yielding 25...30 kg, 15...20 kg, 10...15 kg, respectively (Rabinovich, 2000).

The LBP was added in proportion of 1 cubic meter of the working solution for 1 hectare. The LBP was diluted with water 1:300 or 1:500 for flooding, and 1:100 or 1:300 for spraying. Test plots with the multipurpose compost (background) without fertilizers were used for reference.

A week after the treatment of the LBP into the flowering phase, several potato plants were dug out from every test variant of every repeat to evaluate their biometrical parameters (the number of stems, weight of stems, leaves, stolons, roots) formed by the LBP. At the end of the experiment, the crops yield was evaluated, its structure was analyzed (Maisurian, 1970). All the data obtained were statistically processed with the variance analysis.

RESULTS AND DISCUSSION

An intermediate evaluation of the biometrical parameters of the potato plants carried out a week after the last LBP treatment allowed finding out revealed that nutrients from the multipurpose compost and LBP penetrated the plant cell (Table 1). Here, both leaves and roots played their roles participating in the water and nutrient solution metabolism (Leopold, 1968). Table 1 shows that both the multipurpose compost and LBP in different concentrations and by different treatments stimulated the growth and development of the potato plants. It should be noted that the local treatment with the multipurpose compost produced the maximum stem and leaf mass, whereas the additional flooding potato plots with the LBP working solution (1:500) provided the maximum development of the root system.

Among the considered techniques for the LBP application, flooding the potato plots with the LBP working solution (1:500) featured not only well-developed root system, but also the tuber quantity and weight (Table 2). Here, the evaluated intermediate crops were formed (like in the reference with the multipurpose compost) mostly by the weight of the large-size tuber fraction.

### Table 1: Average intermediate biometrical parameters of potato plants under effect of LBP (average for two growing seasons).

| Experiment                          | Stems quantity, pieces | Stems mass, g (dry) | Leaves mass, g (dry) | Stolons mass, g (dry) | Roots mass, g (dry) |
|-------------------------------------|------------------------|---------------------|----------------------|-----------------------|---------------------|
| Reference (no fertilizers)          | 3.00                   | 5.12                | 17.42                | 2.05                  | 2.28                |
| multipurpose compost (4 ton/ha) as background | 4.67                   | 11.17               | 33.26                | 3.04                  | 3.29                |
| background + LBP 1:100 spraying     | 3.33                   | 9.00                | 29.49                | 4.41                  | 3.07                |
| background + LBP 1:300 spraying     | 4.00                   | 7.14                | 29.10                | 4.13                  | 3.22                |
| background + LBP 1:300 flooding     | 4.00                   | 6.86                | 25.71                | 3.15                  | 2.79                |
| background + LBP 1:500 flooding     | 6.33                   | 9.10                | 30.89                | 4.91                  | 3.53                |
| LSD_{0.5}                           | 0.371                  | 0.621               | 2.112                | 0.314                 | 0.251               |

### Table 2: Average data on the structure of the intermediate potato production formed with LBP (average for two growing seasons).

| Experiment                          | The number of tubers from a plant | The weight of tubers from a plant | Average |
|-------------------------------------|-----------------------------------|----------------------------------|---------|
|                                     | Total, pieces                     | Proportion of fractions large:medium: small(>100 g):(50-100 g): (< 50 g) | Total, g | Proportion of fractions large:medium: small(>100 g):(50-100 g): (< 50 g) | Tubers mass, g |
| Reference – no fertilizers          | 4.7                               | 0.0:0.57:0.43                  | 285.1    | 0.0:0.65:0.35                  | 60.7        |
| multipurpose compost (4 ton/ha)- background | 6.2                               | 0.25:0.25:0.50                 | 329.6    | 0.57:0.23:0.20                  | 53.2        |
| background + LBP 1:100 spraying     | 6.0                               | 0.11:0.50:0.39                 | 368.6    | 0.28:0.56:0.16                  | 61.4        |
| background + LBP 1:300 spraying     | 5.0                               | 0.14:0.79:0.07                 | 378.7    | 0.29:0.69:0.02                  | 75.7        |
| background + LBP 1:300 flooding     | 6.0                               | 0.06:0.25:0.69                 | 349.5    | 0.15:0.41:0.44                  | 58.3        |
| background + LBP 1:500 flooding     | 6.4                               | 0.23:0.35:0.42                 | 424.3    | 0.60:0.28:0.12                  | 66.3        |
| LSD_{0.5}                           | 0.54                              | 58.35                           | 5.12     |                                    |             |
In the spraying of the potato plots with the LBP working solution (1:300), the second-amount intermediate crops were observed (Table 2). It was predominantly formed by the medium-size tuber fraction and the maximum average mass of the tuber. Despite the minimum number of the tubers from a plant, almost all tubers have medium and large size in this LBP application variant. To the contrast, the corresponding reference without fertilizers had almost the same number of tubers from a plant, but no large-size tuber fraction at all.

At this stage of the research, comparison among all variants of the LBP application showed that the flooding with the LBP working solution (1:300) was the worst in all parameters: the average biometrical parameters of the potato plants were low, so despite the quite high number of tubers from a plant, 70 % of the tubers belonged to the small-size fraction.

Drawing an intermediate conclusion, it should be noted that the potatoes flooding and spraying with the LBP on the multipurpose compost background, undoubtedly, promoted the active development of the plants expressing in the growth of not only the biometrical parameters of the plants themselves, but rather their tubers. So, the local application of the multipurpose compost in potato sowing caused, first of all, greater tops, whereas the biometrical parameters of the tubers were lower than those with the LBP. The additional flooding with a more diluted LBP working solution (flooding with the LBP, 1:500) provided the greatest root system to absorb nutrients more actively. As a result, this option gave the maximum intermediate crops.

As noted earlier, the research was done after applying the LBP thrice, which corresponded to the vegetation period of tuber growth. Consequently, the conclusions drawn require comparison to the data obtained for ripe potatoes.

In the first and second years of the research, the tops of the early-ripe potatoes faded to the moment of the end of the small-plot experiments, so the evaluation of the crops yield and its structure were the main criteria of the assessment of the LBP effect on the plants (Tables 3 and 4).

Table 3 shows that LBP spraying on the background of the multipurpose compost provided the most crops increase. The maximum productivity was observed in case of the potato plants spraying with the more diluted LBP working solution. There, the commercial productivity reached nearly 90 % of the total productivity, and the large-size tuber fraction was the champion both in the tuber number and weight (Table 4).

An interesting fact should be noted: when comparing such an averaged parameter as “the number of tubers from a plant” in Tables 2 and 4, spraying gave the maximum number of new tubers for a certain period of time. In other words, LBP nutrients uptake through the leaves and stems turned out more effective than root fibrilla one in case

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**Table 3:** Potato productivity with LBP effect (average for two growing seasons).

| Experiment                                      | Total | Increase over reference | Commercial | Increase over reference |
|-------------------------------------------------|-------|-------------------------|------------|-------------------------|
|                                                  |       | no fertilizer           | multi purpose compost | no fertilizer | multi purpose compost |
| Reference – no fertilizers                      | 18.0  | -                       | 15.4       | -                       |
| multipurpose compost (4 ton/ha) as background   | 21.5  | 3.5                     | 18.5       | 3.1                     |
| background + LBP 1:100 spraying                 | 24.0  | 6.0                     | 21.1       | 5.7                     |
| background + LBP 1:300 spraying                 | 24.7  | 6.7                     | 22.2       | 6.8                     |
| background + LBP 1:300 flooding                 | 23.0  | 5.0                     | 19.3       | 3.9                     |
| background + LBP 1:500 flooding                 | 23.3  | 5.3                     | 19.6       | 4.2                     |
| LSD<sub>0.05</sub>                              | 1.45  | 1.18                    |

| Experiment                                      | The number of tubers from a plant | The weight of tubers from a plant | Average tuber mass, g |
|-------------------------------------------------|-----------------------------------|-----------------------------------|-----------------------|
|                                                  | Total, pieces                     | Proportion of fractions large/medium: small(>100 g):(50-100 g): (< 50 g) | Total, g | Proportion of fractions large/medium: small(>100 g):(50-100 g): (< 50 g) |                      |
| Reference – no fertilizers                      | 6.1                              | 0.26:0.28:0.46                   | 475.0    | 0.56:0.25:0.19 | 74.2                  |
| multipurpose compost (4 ton/ha) as background   | 6.9                              | 0.28:0.33:0.39                   | 537.5    | 0.56:0.30:0.14 | 77.9                  |
| background + LBP 1:100 spraying                 | 7.7                              | 0.32:0.30:0.38                   | 600.0    | 0.60:0.28:0.12 | 77.9                  |
| background + LBP 1:300 spraying                 | 7.7                              | 0.35:0.32:0.33                   | 617.5    | 0.62:0.28:0.10 | 80.2                  |
| background + LBP 1:300 flooding                 | 7.1                              | 0.31:0.31:0.38                   | 575.0    | 0.58:0.26:0.16 | 81.0                  |
| background + LBP 1:500 flooding                 | 7.3                              | 0.32:0.33:0.35                   | 582.5    | 0.57:0.27:0.16 | 79.8                  |
| LSD<sub>0.05</sub>                              | 0.61                             | 63.87                            | 5.85                  |
of flooding, because that technique provided both a longer period of tuber generation and their more active development (Table 4).

Since the multipurpose compost was applied in potato sowing locally, then its effect had already occurred in the whole potato plants (including the number of tubers from a plant) by the moment of the biometrical tuber evaluation, and this parameter was higher than in the no-fertilizer reference – in all tests with multipurpose compost application. And, because the most tubers had already formed in the reference with the multipurpose compost, later on that parameter stayed practically the same. The only difference was in redistribution of proportions among the tuber size fractions (Tables 2 and 4). As for the no-fertilizer experiments, the crops increase was lower than in all the other ones - in spite of a significant increase in the number of tubers (Table 4).

Returning to the crops yield data analysis (Table 3), it should be noted that the above-mentioned best test (LBP flooding) finally turned out worse than spraying in the weight and number of tubers from a plant, and, consequently, productivity. That situation could be also caused by an insignificant change in the number of tubers from a plant closer to the test end: the LBP consumption through the roots undoubtedly had played its role in the middle of the tests (LBP potential was used at once – but, finally, that way of potato growth stimulation proved to be less effective.

Our tests included same-concentration (1:300) LBP working solution application by both flooding and spraying to compare the two mechanisms of LBP effect on the potato plants growth and development, other things being equal. Despite of the a priori obvious priority of flooding, LBP uptake by leaves and stems proved to be more effective on all criteria – which can be seen from Tables 1-4.

CONCLUSION

Despite the fact that provided the LBP application on the multipurpose compost background, it was substantial for the plants from the physiological point of view: the potato plants were supplied with nutrients from the organic fertilizer at the start of their development, and the additional LBP helped at crucial stages of the potato plants development. The LBP undoubtedly helped their development and provided a more active creation of the total and commercial potato productivity. At the same time, nutrient uptake by cells in different plant parts (through flooding and spraying), as well as nutrient migration along the phloem and xylem as a whole had a little effect on the plant biomass increase compared to the reference (multipurpose compost). This situation was promoted by the rich composition of the LBP containing not only much agronomically useful microorganisms and physiologically active substances, but also much mobile phosphorus and potassium (Rabinovich, 2016), which are especially necessary for the potato plants at certain vegetation periods (Potapov et al. 1971).

The results of the test showed that spraying proved to be more effective than flooding. The best result was obtained with the most diluted LBP working solution (1:300). There, a three-time spraying increased the new-tuber origination during the research time period significantly (by 54%) and stimulated the active tubers growth. Subsequently, those factors provided the maximum increase in the total productivity – mostly by the commercial-value potato tubers. In those tests, the total and commercial productivity increase (compared to the multipurpose compost reference) was 14.9% and 20%, respectively.

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