Yield and cost-effectiveness of ORMISS-responsive pea varieties

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Abstract. The paper presents the results of the assessment of yield and economic efficiency of pea varieties that are responsive to treatment with organo-mineral stimulating compositions (ORMISS). The field experiment began in 2015-2017 on the fields of the Azov-Black Sea Engineering Institute of Don State Agrarian University in Zernograd. For the treatment of pea seeds and plants, the ORMISS combined fertilizers – Cu/B and Cu/Mo were used at a dosage of 2 l/t and 2 l/ha, respectively. The yield was evaluated and the cost-effectiveness of various options of treatment of three pea varieties of Don breeding with these agents was calculated. It was found that all studied pea varieties were responsive to treatment and had a reliable yield increase relative to control. The maximum yield was reached when treating the Aksaysky usatyi 5 variety with ORMISS Cu/Mo – for vegetating plants (3.34 t/ha), Alliance variety – when combining pre-treatment of seeds with foliar nutrient in the 3-5 leaf phase (3.49 t/ha), when treating Ataman variety with ORMISS Cu/B – in case of two-fold out-root treatment (3.68 t/ha). The highest economic effect was obtained according to these processing options and amounted to 15620 rubles/ha in the Aksaysky usatyi 5 peas variety, Alliance – 11850 rubles/ha, Ataman – 9759 rubles/ha.

1. Introduction

One of the world’s problems in the field of crop production is the production of protein in quantities sufficient to provide the population with high-quality food and animal husbandry with full-fledged feed. The main source of valuable vegetable protein is legume crops, which in terms of raw protein content exceed cereal crops 2.2-2.5 times. One such crop is peas, which provides high harvest of protein substances, as well as increases soil fertility.

The role of pulses in ensuring food security and nutrition is very important. Emphasizing their significant role the UN General Assembly proclaimed 2016 the International Year of Pulses in order to promote increased interaction throughout the food chain: effective use of plant proteins, improvement of crop rotation, increase of the world production and solution to the problems of pulses trade [1].

In Russia, over the past 20 years, the area of pulse crops has grown 2.5-3 times. In 2017-2019 they occupied 2164-2754 thousand hectares, the gross grain harvest as a whole for these crops amounted to 3.3-4.3 million tons, and the average yield was 1.3-2.0 t/ha [2].

It should be noted that the fulfillment of the genetic potential of many field crops in production conditions is still low, and the level of yield by year is extremely unstable.

The formation of high crop and the accumulation of nutrients in seeds is the end result of complex biochemical and physiological processes ensuring their quality indicators. The direction of all these
processes depends on the genetic characteristics of the variety, which are influenced by weather conditions and a set of cultivation techniques that ensure that the specific needs of the variety are met.

To better fulfill the potential of various crops, the methods of exogenous effects on plants were developed: biological, physical and chemical. A number of researchers applied the effects of electric and magnetic field on plant seeds and seedlings [3-7]. Positive results were obtained on the use of biological agents based on the useful groups of microorganisms and growth regulators [8-10].

Numerous domestic and foreign studies confirmed the important role of microelements in plant life. Along with biological molecular systems, microelements ensure the most important exchange processes of intracellular metabolism. Lack, excess or imbalance of microelements in soils inevitably affects plant productivity, quality of production, animal and human health [11, 12].

In recent years, for the needs of agriculture, a number of different agents with microelements was developed for the treatment of seeds before sowing and for vegetating plants. Organo-mineral fertilizers in chelate form are particularly interesting, which were almost not fixed in the soil absorption complex, remained accessible to plants for a long time and did not damage the environment, which leads to the environmental safety of the utilized technologies.

A number of authors noted an increase in the productive capacity of various field crops as a result of treatment of seeds and vegetating plants with organo-mineral fertilizers [13-16]. However, pea varieties differ significantly in the nature of their reaction to such treatments.

Organo-mineral stimulating compositions (ORMISS) are a unique development of Russian scientists on the basis of major research agrarian institutes.

The purpose of our research was to assess the yield and cost-effectiveness of food-friendly pea varieties that are responsive to the ORMISS effects.

2. Materials and methods

The research material included the pea varieties of the Federal Rostov Agrarian Scientific Center: Aksaysky usaty 5, Alliance and Ataman.

The study was carried out on the experimental fields of the Agrotechnological Center of the Azov-Black Sea Engineering Institute of Don State Agrarian University in Zernograd, in 2015-2017. The soil of the site is ordinary heavy-carbon low-humus carbonate chernozem with the following agrochemical characteristic: pH – 7.1; P₂O₅ – 19.6 mg/kg of soil; K₂O – 395 mg/kg of soil; humus – 3.3%.

The climate of the southern zone of Rostov Region is semi-arid. The average annual rainfall is 450-600 mm. The sum of the active temperature for the vegetation period is 3400-3600 °C. During the summer period, there were 60-65 dry days.

The weather conditions of the growing period in 2015-2017 slightly differed in temperature, but had significant differences in water regime. So, over the period of pea vegetation in 2015, the amount of precipitation amounted to 299, in 2016 – 225.4, and in 2017 – 247.4 mm (norm – 233 mm).

The treatment of seeds and plants was performed with ORMISS (organo-mineral stimulating compositions). These preparations contain microelements in chelate and organic form. In addition to microelements and growth stimulants, the mixture includes the most important macroelements – nitrogen and sulfur.

The treatment of seeds and vegetating plants was carried out with two organo-mineral stimulating compositions recommended for pulse crops:
• ORMISS Cu/B contains copper – 33-38, boron – 27-30, nitrogen – 70-73, sulphur – 17-20 g/l;
• ORMISS Cu/Mo contains copper – 33-38, molybdenum – 10-14, nitrogen – 70-73, sulphur – 17-20 g/l.

The dosage of agents for the treatment of pea seeds and plants, respectively, was 2 l/t, 2 l/ha.

Experimental design:
1. Without processing – control (C).
2. Presowing treatment of seeds (TS).
3. Seed treatment + treatment of plants in 3-5 leaf phase (TS + TP₁).
4. Seed treatment + treatment of plants in flowering phase (TS + TP₂).
5. Treatment of plants in 3-5 leaf phase (TP₁).
6. Treatment of plants in flowering phase (TP2).
7. Treatment of plants in the 3-5 leaf phase + in the flowering phase (TP1 + TP2).

The experiments and statistical processing of data were carried out according to the method of field experiment proposed by B.A. Dospekhov. The accounting area of plots – 25 m$^2$. The plots were placed in a standard way, in quadruple tier. Two-factor experiment: factor A – variety, factor B – processing option. The economic costs were determined according to the process planning and operations for pea cultivation.

3. Research results
Yield is the main characteristic of the variety value.

The use of organo-mineral stimulating compositions with both boron and molybdenum on the studied peas contributed to an increase in yield, as evidenced by the obtained experimental data. The studies established that pea varieties were more responsive to double treatments with these agents than to single ones. In this regard, the paper provides data and their analysis only for various options of double treatment.

Thus, on average over 2015-2017 the yield of seeds in the Aksaysky usatyi 5 variety under control was 2.44 t/ha, in experimental options – 3.03-3.60 t/ha. The yield of this variety significantly exceeded the control by 0.86-0.90 t/ha when treated with ORMIS Cu/B in variants TS+TP1 and TP1+TP2. (Table 1). The use of ORMIS Cu/Mo on vegetating plants (TP1+TP2) ensured the highest yield and gain of 3.60 and 1.16 t/ha respectively to control (Table 2).

### Table 1. Alterations in yield of pea seeds induced by ORMIS Cu/B, t/ha (2015-2017)

| Experiment option | Aksaysky usatyi 5 | Alliance | Ataman |
|-------------------|------------------|----------|--------|
|                   | yield ± C        | yield ± C| yield ± C|
| Control           | 2.44             | 2.59     | 2.73   |
| TS+TP1            | 3.30 (0.86)      | 3.45 (0.86) | 3.03 (0.30) |
| TS+TP2            | 3.03 (0.59)      | 3.16 (0.57) | 3.16 (0.43) |
| TP1+TP2           | 3.34 (0.90)      | 3.23 (0.64) | 3.68 (0.95) |

|                  |                  |          |        |
|-------------------|------------------|----------|--------|
|                  | HCP<sub>05</sub> | 0.26     |        |
|                  | HCP<sub>A</sub> | 0.10     |        |
|                  | HCP<sub>B</sub> | 0.21     |        |

### Table 2. Alterations in yield of pea seeds induced by ORMIS Cu/Mo, t/ha (2015-2017)

| Experiment option | Aksaysky usatyi 5 | Alliance | Ataman |
|-------------------|------------------|----------|--------|
|                   | yield ± C        | yield ± C| yield ± C|
| Control           | 2.44             | 2.59     | 2.73   |
| TS+TP1            | 3.11 (0.67)      | 3.49 (0.90) | 3.34 (0.61) |
| TS+TP2            | 3.29 (0.85)      | 3.23 (0.64) | 3.25 (0.52) |
| TP1+TP2           | 3.60 (1.16)      | 3.44 (0.85) | 3.31 (0.58) |

|                  |                  |          |        |
|-------------------|------------------|----------|--------|
|                  | HCP<sub>05</sub> | 0.26     |        |
|                  | HCP<sub>A</sub> | 0.10     |        |
|                  | HCP<sub>B</sub> | 0.21     |        |

In the Alliance variety, the average yield over 3 years was 2.59 t/ha under control, in experimental options 3.16-3.49 t/ha. When treated with ORMIS Cu/B this variety had the maximum yield in the option TS+TP1 (3.45 t/ha), ORMIS Cu/Mo in the options TS+TP1 (3.49 t/ha) and TP1+TP2 (3.44 t/ha), the gain to control was 0.85-0.90 t/ha.

In the Ataman variety, the average yield over the years of study was 2.73 t/ha, in experimental variants – 3.16-3.68 t/ha. A twofold out-root treatment with ORMIS Cu/B (TP1+TP2) provided the highest yield and gain to control – 3.68 and 0.95 t/ha respectively. In case of double treatment with
ORMISS Cu/Mo, the yield almost did not differ in all options (3.25-3.34 t/ha), and the gain to control made 0.58-0.61 t/ha.

Thus, Aksaysky usatyi 5 and Ataman were more responsive to the double treatment of vegetating plants: Aksaysky usatyi 5 with ORMISS Cu/Mo, and Ataman – with ORMISS Cu/B. The Alliance responded better to pre-treatment of seeds with both ORMISS Cu/B and ORMISS Cu/Mo in combination with out-root treatment in the 3-5 leaf phase.

To objectively assess the feasibility of treating pea varieties with the above organomineral stimulating mixtures, the indicators of their economic efficiency were used. When calculating the cost-effectiveness of ORMISS, such values as the cost of gross output, the size of production costs, notional net profit and the economic effect of the use of the studied microfertilizer per unit area were used.

The basis for determining production costs were process charts, which include a complete list of cultivated varieties, agrotechnical requirements, standards and terms of work, rational compositions of units and maintenance personnel, production standards, fuel and lubricants consumption, etc. The calculations were carried out on the basis of the standards applied in Rostov Region valid from 2015 to 2017.

The cost of gross production was calculated based on the average sale price of pea seeds of 15 rubles per 1 kg, which developed in the conditions of Rostov Region for the period of 2015-2017.

To assess the economic effect, the conditionally net profit of the studied varieties was compared under control and experimental conditions. The assessment revealed that despite the increase in costs, double treatments were more economically profitable than single ones.

In case of Aksaysky usatyi 5 variety, the conditional net profit compared to the control for an average of 3 years amounted to 18450 rubles/ha. The largest profit was obtained in the option TP1+TP2 (30504 rub/ha) when feeding ORMISS Cu/B, the economic effect relative to control was 12054 rub/ha (Table 3). When treated with ORMISS Cu/Mo, the highest conditionally net profit was also obtained in the option TP1+TP2 (34070 rub/ha), the economic effect relative to control was 15620 rub/ha (Table 4). Double feeding with molybdenum was more effective than with boron.

### Table 3. Cost-effectiveness of pea varieties cultivation when treated with ORMISS Cu/B (2015-2017)

| Experiment option | Aksaysky usatyi 5 | Alliance | Ataman |
|-------------------|-------------------|----------|--------|
|                   | Net profit, rub/ha| Economic effect, rub/ha | Net profit, rub/ha | Economic effect, rub/ha | Net profit, rub/ha | Economic effect, rub/ha |
| Control           | 18450             | –         | 20890  | –         | 22510             | –         |
| TS+TP1            | 29925             | 11475    | 32344  | 11454    | 25844             | 3334     |
| TS+TP2            | 25983             | 7533     | 27730  | 6840     | 27729             | 5219     |
| TP1+TP2           | 30504             | 12054    | 29154  | 8264     | 32269             | 9759     |

### Table 4. Cost-effectiveness of pea varieties cultivation when treated with Cu/Mo ORMISS (2015-2017)

| Experiment option | Aksaysky usatyi 5 | Alliance | Ataman |
|-------------------|-------------------|----------|--------|
|                   | Net profit, rub/ha| Economic effect, rub/ha | Net profit, rub/ha | Economic effect, rub/ha | Net profit, rub/ha | Economic effect, rub/ha |
| Control           | 18450             | –         | 20890  | –         | 22510             | –         |
| TS+TP1            | 26965             | 11125    | 32740  | 11850    | 30155             | 7645     |
| TS+TP2            | 29575             | 8515     | 32740  | 11850    | 30155             | 7645     |
| TP1+TP2           | 34070             | 15620    | 32015  | 11125    | 30320             | 7810     |

Regarding the Alliance variety, the net profit compared to the control for an average of 3 years
amounted to 2089 rubles/ha. It was the maximum in the TS+TP₁ option both when treated with ORMISS Cu/B and ORMISS Cu/Mo, respectively, 32344 and 32740 rubles/ha, and the economic effect relative to the control was 11454 and 11850 rubles/ha respectively. The best treatment was with ORMISS Cu/Mo.

Concerning the Ataman variety, the conditionally net profit compared to the control over the years of study averaged 22,510 rubles/ha. The maximum profit was obtained in the option T₁+T₂ both when treated with ORMISS Cu/B and ORMISS Cu/Mo, 32269 and 30320 rub/ha, respectively. The economic effect relative to control was 9759 and 7810 rubles/ha, respectively. The best was the double feeding with ORMISS Cu/Mo.

A comparative assessment of the effect of the studied organomineral stimulating complexes showed that for pea varieties Aksaysky usatyi 5 and Alliance ORM ISS Cu/Mo was the most effective, and for Ataman variety – ORM ISS Cu/B.

4. Conclusion
Along with traditional effective agro- and phytosanitary techniques, it is advisable to use organomineral stimulating compositions when cultivating peas.

The studies revealed that all studied pea varieties were responsive to treatment with ORM ISS containing copper-boron and copper-molybdenum complexes. The greatest responsiveness of these varieties was noted with double treatment.

The maximum yield and reliable increase relative to the control was established when treating Aksaysky usatyi 5 for vegetating plants and Alliance with ORM ISS Cu/Mo when combining seed treatment with plant treatment in the 3-5 leaf phase, when treating Ataman variety with ORM ISS Cu/B – in the option of double out-root treatment.

The highest economic impact from the use of the given ORM ISS on the studied pea varieties was obtained in the above double treatments.

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