The role of mineral fertilizers for controlling spring barley root rot development

A A Postovalov
Kurgan State Agricultural Academy named after T.S. Maltsev, Lesnikovo village, Ketovskiy district, Kurgan, 641300, Russia

E-mail: p_alex79@mail.ru

Abstract. The article presents data on the effect of mineral fertilizers on productivity and resistance of spring barley to root rot. When applying complex mineral fertilizers, root rot development decreased to 22.1%, the biological efficiency was 41.2%. On the epicotyl and stem base, the root rot development index decreased by 1.8–3.0 times. The spring barley root rot was affected by weather conditions, the share of this factor was maximum throughout the growing season and amounted to 23.5 to 86.9%, the share of the influence of mineral fertilizers varied from 6.5 to 33.3%. Under favorable hydrothermal conditions, the root rot development index decreased to 10%; with a decrease in the moistening regime, it increased to 40%. When applying nitrogen-phosphorus and complex mineral fertilizers, the yield increased by 53.7 and 63.8%. Under the favorable moistening regime, the yield increased, the dependence equation is \( y = 25.8 - 2.6x \). With an increase in the susceptibility to root rot, productivity decreased, the regression equation is \( y = 45.58 - 0.84x \).

1. Introduction
Mineral fertilizers have a complex effect on all components of agroecosystems and their interaction with each other – plants, soil microorganisms, phytopathogenic organisms [1–3]. Under the influence of mineral fertilizers, the agrochemical soil characteristics change, which affects components of the soil-biotic system, namely, the viability and survival of phytopathogens [4].

Under the influence of mineral fertilizers, plants become more resistant to adverse environmental factors, diseases. They accelerate development and maturation of seeds, and limit the number of phytopathogens [5–7]. The balanced mineral nutrition reduces the long-term dynamics of soil infections, which include root rot pathogens, improves phytosanitary conditions of soil and crops, increases soil suppression and limits the use of fungicides [8, 9].

The purpose of the research is to evaluate the effect of mineral fertilizers on productivity of spring barley and resistance to root rot.

2. Research object and methods
Field experiments were conducted on the experimental field of Kurgan State Agricultural Academy. The effect of mineral fertilizers on root rot susceptibility was studied on spring barley Prairie. There were the following options: control (without fertilizing); \( N_{60} \) (urea); \( P_{60} \) (superphosphate double); \( N_{60}P_{60} \) (nitroammophosphate); \( N_{60}P_{60}K_{60} \) (nitrophosphate).

Soil of the experimental plot was low-power, low humus, medium loamy leached chernozem. The agricultural technology was common for the zone.
Sowing, monitoring of plant development, and harvesting were carried out according to the method developed by the State department of agricultural crop variety testing [10].

The account of root rot was carried out differentially using the method suggested by V.A. Chulkina [3]. Before harvesting, we kept records of elements of the crop structure.

The results obtained during the observations were processed according to the algorithms proposed by B.A. Dospekhov.

3. Results

When applying mineral fertilizers in the tillering phase, the barley root rot development index decreased several times. When applying complex mineral fertilizers, it was 1.5 times lower on the root system and epicotyl. When applying nitrogen, the degree of root rot development was 11.6 % on the root system. On the epicotyl and stem base, it was higher than in the control option (Figure 1).

![Figure 1. The effect of mineral fertilizers on the root rot development index in the tillering phase of spring barley, %](image)

The situation changes by the harvesting period. In the control option, the disease development index did not exceed 69.7 %, and in options with fertilizers, it was much lower. The index of disease development in options with fertilizers is significantly lower than in the control option, indicating improvements in the phytosanitary situation throughout the growing season. When applying nitrogen-phosphorus and complex mineral fertilizers, the disease development index decreased to 22.1 %, the biological effectiveness was 41.2 %. On the epicotyl and stem base, the index of root rot development decreased by 1.8–3.0 (Figure 2).

The spring barley root rot development was affected by weather conditions, the share of this factor was maximum throughout the growing season and amounted to 23.5 to 86.9 %. The share of the influence of mineral fertilizers was lower and varied from 6.5 to 33.3 % (Table 1).

| Table 1. The influence of weather conditions and mineral fertilizers on the root rot development index for spring barley, % |
|---|---|---|---|
| Factor | Root system | Epicotyl | Stem base |
| Tillering phase | Weather conditions | 78.9 | 55.7 | 23.1 |
| | Mineral fertilizers | 8.1 | 7.8 | 14.9 |
| Before harvesting | Weather conditions | 86.9 | 85.1 | 37.5 |
| | Mineral fertilizers | 7.8 | 6.5 | 33.3 |
Under favorable hydrothermal conditions, root rot development decreased to 10 %, with a decrease in the moistening regime, it increased to 40 % (Figure 3). The regression equation is \( y = 38.2 - 13.8x \).

Under the favorable humidification regime, the yield of spring barley increased, a regression analysis made it possible to solve the equation of dependence of productivity on hydrothermal conditions: \( y = 25.8 - 2.6x \) (Figure 4).

The yield of spring barley decreased with an increase in root rot susceptibility, the regression equation is \( y = 45.58 - 0.84x \). An inverse close correlation between the productivity and the disease development index was observed. Depending on the year, it varied from -0.83 to -0.88.
Figure 4. Dependence of the spring barley yield on hydrothermal conditions of the vegetation period

Figure 5. Dependence of the spring barley yield on the root rot development index

Table 2. Yield and spring barley crop structure when applying mineral fertilizers

| Option          | Productivity, c/ha | Number of productive stems per 1 m², pcs. | Number of grains per ear, pcs. | Mass of 1000 grains, g |
|-----------------|--------------------|------------------------------------------|--------------------------------|------------------------|
| Control         | 22.9               | 381.7                                    | 13.8                           | 46.8                   |
| N₆₀             | 30.6               | 417.0                                    | 15.6                           | 50.7                   |
| P₆₀             | 30.3               | 415.7                                    | 16.3                           | 48.4                   |
| N₆₀P₆₀          | 35.2               | 448.7                                    | 16.5                           | 52.4                   |
| N₆₀P₆₀K₆₀      | 37.5               | 443.7                                    | 16.7                           | 55.7                   |
| LSD(0.05)       | 2.0                | 12.1                                     | 0.9                            | 3.7                    |

The maximum yield of spring barley was obtained when applying nitrogen-phosphorus and complex mineral fertilizers. It was 12.3 and 14.6 kg/ha or 53.7 and 63.8 % higher than in the control option. This yield was obtained by increasing the number of productive crop stems per 1 m² to 448 pieces, the number of grains per ear was 17 pieces, and the weight of 1000 grains was 55.7 g (Table 2).
The application of nitrogen and phosphorus fertilizers increased the number of productive stems by 9.2 and 8.9 % and spike grains up to 16, but the grain was finer – 50.7 and 48.4 g, compared with the one when applying complex mineral fertilizers.

Productivity of spring barley increased under the favorable moisture regime, the influence of this factor on productivity and crop elements ranged from 45.6 to 72.1 %. The influence of mineral fertilizers was 2.4–4.2 times lower than the influence of weather conditions, since humidity is the main limiting factor for the yield (Table 3).

| Factor                          | Yield, c/ha | Number of productive stems per 1 m², pcs. | Mass of 1000 grains, g |
|--------------------------------|-------------|------------------------------------------|------------------------|
| Weather conditions             | 72.1        | 71.2                                     | 45.6                   |
| Mineral fertilizers            | 22.1        | 16.9                                     | 18.4                   |

4. Conclusion
When applying complex mineral fertilizers, development of diseases of the root system of spring barley decreased to 22.1 %, the biological efficiency was 41.2 %. On the epicotyl and the stem base, the root rot development index decreased by 1.8–3.0. Under favorable hydrothermal conditions, root rot development decreased to 10 %; with a decreasing moistening regime, development of diseases increased up to 40 %.

When applying nitrogen-phosphorus and full mineral fertilizers the yield of spring barley increased by 53.7 and 63.8 %. It was achieved by increasing the number of productive crop stems per 1 m² to 448 pieces, the number of grains per ear was 17 pieces and the weight of 1000 grains was 55.7 g. Under the favorable moistening regime, the yield increased, the equation of dependence of the yield on hydrothermal conditions is $y = 25.8 – 2.6x$.

The yield of spring barley decreased with increasing susceptibility to root rot; the regression equation is $y = 45.58 – 0.84x$. There was an inverse close correlation between productivity and the disease development index, which ranged from –0.83 to –0.88.

References
[1] Durymina E P and Velikanov L L 1984 Soil Phytopathogenic Fungi (Moscow: Moscow State University) 104 p
[2] Chulkina V A, Toropova E Yu, Stetsov G Ya, Medvedchikov V M et al 2004 The agrotechnical method is the fundamental basis of phytosanitary measures Plant Protect. and Quarantine 5 18–24 (in Russian)
[3] Chulkina V A and Toropova E Yu 2004 Root rot Plant Protect. and Quarantine 2 16–18 (in Russian)
[4] Glinushkin A P, Sokolov M S and Toropova E Yu 2016 Phytosanitary and Hygienic Requirements for Healthy Soil (Moscow: Agrorus) 288 p
[5] Karpachev V V, Savenkov V P, Chesnokova L D et al 2014 Development of innovative technology of advanced macro- and microfertilizers application on spring rape using new (nano) materials Sci. Israel – Technol. Advantages 16(3) 84–91
[6] Postovalov A A 2018 The reaction of microorganisms of the rhizosphere of spring barley to mineral fertilizers and biological products Bull. of the Kurgan State Agriculture Acad. 4(28) 39–45
[7] Postovalov A A 2019 Pathogenic micromycetes feed crop rhizoplanes IOP: Earth and Environmental Sci. 341 012158
[8] Toropova E Yu, Selyuk M P, Kazakova O A et al 2017 Induction factors of soil suppressiveness of agrocenoses Agrochemistry 4 51–64 (in Russian)
[9] Toropova E Yu, Sokolov M S and Glinushkin A P 2016 Soil suppression induction as the most
important factor reducing harmfulness of root infections *Agrochemistry* 8 44–55 (in Russian)

[10] Fedin M A et al 1989 Methodology of state variety testing of agricultural crops, in: *Cereals, legumes, corn and forage crops* vol 2 (Moscow) 194 p