European Proceedings of
Social and Behavioural Sciences
EpSBS

www.europeanproceedings.com
e-ISSN: 2357-1330

DOI: 10.15405/epsbs.2021.05.164

ISCKMC 2020

International Scientific Congress «KNOWLEDGE, MAN AND CIVILIZATION»

MINERAL FERTILIZERS INFLUENCE ON SOME CHARACTERISTICS OF WINTER WHEAT

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Abstract

The article presents materials on the influence of the calculated doses of mineral fertilizers on the degree of development, the prevalence of diseases (root rot, powdery mildew, pyrenophorosis) and the yield of winter wheat on leached chernozem in 2016–2018. As a result of the research, it was found that the degree of development and the prevalence of root rot of Fusarium etiology depended on the resistance of the variety and the dose of fertilizers. In all periods of accounting, the calculated doses of fertilizers by 7.5 and 10 t/ha increased the prevalence and degree of development of the disease relative to control. When the doses of $N_{186}P_{95}K_{45}$ and $N_{248}P_{133}K_{60}$ were applied, the prevalence of powdery mildew exceeded the control by 8.7–6.0 %, and pyrenophorosis — by 8.9–10.9 %. Variety Dolya proved to be more resistant to root rot and pyrenoforosis compared to other varieties, variety Vassa – to pyrenophorosis and powdery mildew. On all varieties of winter wheat, on average for 2016–2018, the calculated doses of mineral fertilizers relative to the control increased the yield by 1.6–5.36 t/ha. The planned yield level of 5.0 and 7.5 t/ha was achieved for all varieties, the planned yield level of 10.0 t/ha was not achieved.

Keywords: Mineral fertilizers, degree of development and prevalence of diseases, winter wheat, productivity, leached chernozem

https://doi.org/10.15405/epsbs.2021.05.164
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Selection and peer-review under responsibility of the Organizing Committee of the conference
eISSN: 2357-1330

1. Introduction

Plant protection from diseases is an urgent problem of increasing the productivity of all agricultural crops in many regions of the world. Losses of crop production from harmful organisms are, depending on the culture and technology elements, 12–28 % (Shutko et al., 2018). Balanced application of fertilizers contributes to an increase in physiological resistance and endurance of winter wheat to infections (Perederieva et al., 2017; Shutko, 2018).

2. Problem Statement

It is important that the effectiveness of mineral fertilizers depends on their ratio. Phosphorus and potash fertilizers contribute to plant resistance to diseases; excessive and uneven application of nitrogen fertilizers causes loosening of plant tissues, which directly contributes to the development of diseases. In addition, the elements that make up fertilizers can directly inhibit the development of fungal pathogens (Golosnoy et al., 2019; Właśniewski et al., 2019). To obtain a high yield of winter wheat, it is necessary to strictly control the amount of applied mineral fertilizers (Al-Saidan et al., 2019; Grechishkina et al., 2019; Korostylev et al., 2019).

3. Research Questions

In this regard, the goal of our research was to determine the calculated doses of mineral fertilizers for the degree of development, the prevalence of diseases and the yield of winter wheat.

4. Purpose of the Study

The experiment was carried out on the land use of the agricultural experimental station of the Stavropol SAU in the period from 2015 to 2018.

The soil cover of the research site is represented by leached, thick, low-humus, heavy loamy chernozem. In the course of the agrochemical survey prior to setting up the experiment, it was revealed that the soils are provided with an average of organic matter (5.1–5.4 %), N-NO3 (16–30 mg/kg); P2O5 (20–25 mg/kg), K2O (220-270 mg/kg) and mobile forms of manganese (16.1–17.0 mg/kg), have a low supply of zinc (0.5–0.6 mg/kg) and copper (0.12–0.18 mg/kg), the reaction of the soil solution is neutral (6.1–6.5 units).

The territory of the experimental agricultural station is located in the zone of insufficient moisture in the Stavropol Territory and is characterized by unstable climate indicators, which are primarily expressed in the unevenness of precipitation throughout the year.

5. Research Methods

The average annual precipitation according to long-term data is 551 mm, the sum of active temperatures is in the range of 3000–3200 °C, the hydrothermal index is 1.1–1.3. All three agricultural

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years of the experiments were characterized by an increased temperature regime: the difference with the average long-term norm was – in 2015–2016. – 1.9 °C, in 2016–2017. – 0.2 °C and in 2017–2018. – 2.2 °C.

The optimal distribution of precipitation was 2015–2016 agricultural year, and the amount of precipitation (643 mm) exceeded the multiyear norm by 92 mm. In 2016–2017, this indicator was 110.3 mm higher than the average long-term value, but the extremely uneven distribution of precipitation during the growing season of plants created unfavorable conditions for the growth and development of plants. The smallest amount of precipitation during the years of research was noted in 2017–2018 agricultural year – 518 mm, which was 33 mm below the norm.

The experiment was repeated 3 times, placement of plots by the method of randomized repetitions, width – 3.6 m, length 5 m, total plot S – 18 m2. Two-factor experience, represented by the following factors: factor A – calculated doses of mineral fertilizers for the planned level of winter wheat yield 5.0, 7.5 and 10.0 t/ha; factor B – winter wheat varieties Dolya, Vassa, Grom.

Experiment scheme: 1. Control – N63P52; 2. Planned yield 5.0 t/ha – N124P72K30; 3. Planned yield of 7.5 t/ha – N186P95K45; 4. Planned yield 10.0 t/ha – N248P133K60. On the control, the recommended dose was applied, and for the planned yield level of 5.0, 7.5 and 10.0 t/ha, the doses of mineral fertilizers were calculated according to Ageeva and Esaulko (2011). The rates, ratios and calculated doses of mineral fertilizers were established based on the results of soil analyzes in accordance with the level of the planned yield and were updated annually.

The use of mineral fertilizers provided for two methods of application: pre-sowing (for the main cultivation of the soil) and 3 additional fertilizing in the phases of tillering, stemming, and heading. Ammophos, potassium chloride, ammonium nitrate, and urea were used as fertilizers in the experiment. The predecessor in the experiment is peas. Phytosanitary monitoring of the state of crops was carried out according to the VIZR methods. Counting of the yield was carried out by the method of mechanized harvesting with subsequent recalculation to standard moisture and purity according to the method of state variety testing of agricultural product cultures of 1989.

6. Findings

The data presented in Table 1 indicate that in the phase of the end of tillering – the beginning of emergence into the tube, the prevalence of root rot according to the variants of the experiment reached 50 %, and the degree of development did not exceed the threshold of harmfulness (2.4–8.6 %). The least resistant variety was the Dolya – on variants of this variety, the degree of development was 2.4–5.7 %.

The maximum level of root rot development was observed in the Vassa variety – 8.6 %. This is due to the fact that the winter hardiness of this variety is below average. As a result, additional stress during the overwintering period created favorable conditions for the development of the disease. In addition, the low level of development is associated with the fact that a high-quality fungicidal dressing agent Lamandor Pro with three active ingredients (prothioconazole + tebuconazole + fluopyram) was used, which reliably protects cereals from a wide range of pathogens transmitted with seeds. But, unfortunately, the dressing agent does not completely solve the problem of protecting crops from root rot.

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The next count was carried out at the beginning of the earing phase. There was an increase in root rot infection (Table 2). However, due to its increased drought resistance and heat resistance, the Dolya variety better withstood the development of the disease. The prevalence of the disease by varieties reached 70.0 %, but the development of the disease did not exceed the economic threshold of 4.8-12.1 %.

Table 1. Infestation of winter wheat varieties with root rot of Fusarium etiology, depending on the doses of mineral fertilizers, the phase of the end of tillering – the beginning of tube emergence (average for 2016–2018)

Fertilizer dose	Vassa		Grom		Dolya	
	prevalence, %	degree of development, %	prevalence, %	degree of development, %	prevalence, %	degree of development, %
$N_{63}P_{52}$ (Control)	47,0	5,2	40,1	4,2	35,0	3,1
$N_{124}P_{72}K_{30}$ (5,0 t/ha)	46,5	3,9	42,0	3,1	30,0	2,4
$N_{186}P_{95}K_{45}$ (7,5 t/ha)	48,5	5,3	44,3	5,4	41,2	3,8
$N_{248}P_{133}K_{60}$ (10,0 t/ha)	50,0	8,6	47,0	7,9	44,0	5,7

Table 2. Nfestation of winter wheat varieties by root rot of Fusarium etiology depending on the doses of mineral fertilizers, heading phase (average for 2016–2018)

Fertilizer dose	Vassa		Grom		Dolya	
	prevalence, %	degree of development, %	prevalence, %	degree of development, %	prevalence, %	degree of development, %
$N_{63}P_{52}$ (Control)	68,3	7,9	67,1	6,2	57,1	5,4
$N_{124}P_{72}K_{30}$ (5,0 t/ha)	66,0	6,5	65,0	5,4	55,0	4,8
$N_{186}P_{95}K_{45}$ (7,5 t/ha)	69,0	8,9	68,3	7,6	58,3	6,7
$N_{248}P_{133}K_{60}$ (10,0 t/ha)	70,0	12,1	69,2	9,6	60,0	8,0

Comparison of varieties showed that the use of calculated doses of mineral fertilizers contributed to a change in the degree of development of fungi of the genus Fusarium. The minimum infestation by root rot was noted on the variety Dolya when N124P72K30 was applied with a planned yield of 5.0 t/ha. A similar dose of mineral fertilizers for all varieties shows the smallest degree of disease development from 4.8 to 8.0 % (table 2).

The analysis of the results showed that in the phase of the end of tillering – the beginning of emergence into the tube, the introduction of calculated doses of mineral fertilizers for the planned yield of 7.5, 10.0 t/ha increased the prevalence of root rot in the Dolya variety relative to the control – by 6.2–9 %, in the Vassa variety – by 1.5–3 %. The application of a dose of N124P72K30 to the planned yield of 5.0 t/ha on varieties Vassa and Dolya reduced the prevalence of root rot relative to the control by 0.5–5 %, but in variety Grom there was an increase of 1.9 %. The dose of N124P72K30 for the planned yield of 5.0 t/ha reduced, relative to the control, the degree of development in varieties Vassa by 1.3 %, Grom by

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eISSN: 2357-1330

1.1 % and Dolya by 0.7 %. Doses of N186P95K45 and N248P133K60 in all varieties increased the degree of root rot development.

In the heading phase on all studied varieties, the decrease in the prevalence and degree of development of root rot was facilitated only by the dose of N124P72K30 for the planned yield of 5.0 t/ha. It increased in other variants with the introduction of calculated doses of mineral fertilizers in these indicators. High doses contribute to an increase in the density of the stalk, thickening of crops, it creates a microclimate favorable for the development of phytopathogens, facilitates the transfer of the mycelium of pathogens from one plant to another, so they are more affected by root rot and other diseases. Thus, it is required to carefully phytosanitary monitor winter wheat crops and timely use chemical crop protection products.

On average, according to the experiment, the variety Dolya turned out to be the most resistant to root rot, in the phase of the end of tillering – the beginning of stemming, regardless of the variant of the experiment, the degree of development was 3.75 %, which turned out to be 2.0 % lower than that of the Vassa variety; Grom – by 1.4 %.

In the heading phase, the Dolya variety, regardless of the variant of the experiment, had a degree of development of 6.2 %, which is 2.65 % lower than that of the Vassa variety, and 1.0 % for the Grom variety.

The prevalence of powdery mildew on variants of the experiment ranged from 1.0–15 %, the degree of development was 0.1 %. In the control variant, powdery mildew was not detected on all studied varieties; when the calculated dose of N124P72K30 was applied to the planned yield of 5.0 t/ha, the prevalence of this disease was found only on the Dolya variety and amounted to 1.0 % with a degree of development of 0 % (Table 3).

Table 3. Infestation (%) of varieties of winter wheat with powdery mildew, depending on the doses of mineral fertilizers, the phase of the end of tillering – the beginning of stemming (average for 2016–2018).

Fertilizer dose	Vassa		Grom		Dolya	
	prevalence, %	degree of development, %	prevalence, %	degree of development, %	prevalence, %	degree of development, %
$N_{63}P_{52}$ (Control)	–	–	–	–	–	–
$N_{124}P_{72}K_{30}$ (5,0 t/ha)	–	–	–	–	1,0	–
$N_{186}P_{95}K_{45}$ (7,5 t/ha)	1,0	–	10,0	0,1	15,0	0,1
$N_{248}P_{133}K_{60}$ (10,0 t/ha)	1,0	–	5,0	0,1	12,0	0,1

With increasing doses of mineral fertilizers, the prevalence and degree of development of powdery mildew increased. So, when N186P95K45 was applied to the planned yield of 7.5 t/ha, the prevalence in the Vassa variety was 1.0 %, in the Grom variety – 10.0 %, in the Dolya variety it reached 15.0 %. At the same time, the degree of development was found only in the variety Grom and Dolya – 0.1 %.

In the variant with the introduction of a dose of N248P133K60 for the planned yield of 10.0 t/ha, the degree of development, as well as in the variant with a dose of N186P95K45, is 0.1 %, but the

https://doi.org/10.15405/epsbs.2021.05.164
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eISSN: 2357-1330

prevalence decreases in the variety Grom by 5.0 %, in the variety Dolya – by 3.0 %. The prevalence in the Vassa variety is 1.0 %, but the degree of development is absent.

The most resistant to powdery mildew is the Vassa winter wheat variety. In the variants with the introduction of calculated doses for the planned yield of 7.5 and 10.0 t/ha, the prevalence was only 1.0 %, the degree of development was absent. In all studied variants, the development of the disease did not exceed the economic threshold of harmfulness.

Studies have shown that the prevalence of pyrenophorosis ranged from 35.1–69.2 %, while the degree of development ranged from 1.3 to 8.1 %. All the calculated doses of mineral fertilizers for the planned yield of 5.0, 7.5 and 10.0 t/ha decreased the prevalence of pyrenophorosis relative to the control in the Dolya variety relative to the control, from 0.6 to 20.7 %, but increased the degree of development by 0.2–0.6 % (table 4).

Table 4. Infestation (%) of winter wheat varieties with pyrenophorosis, depending on the doses of mineral fertilizers, the phase of the end of tillering – the beginning of stemming (average for 2016–2018).

Fertilizer dose	Vassa		Grom		Dolya	
	prevalence, %	degree of development, %	prevalence, %	degree of development, %	prevalence, %	degree of development, %
$N_{63}P_{52}$ (Control)	63,5	1,6	35,1	1,5	58,3	1,5
$N_{124}P_{72}K_{30}$ (5,0 t/ha)	42,5	1,3	62,2	7,0	37,6	1,7
$N_{186}P_{95}K_{45}$ (7,5 t/ha)	61,7	1,5	65,9	7,8	56,1	1,9
$N_{248}P_{133}K_{60}$ (10,0 t/ha)	62,8	1,5	69,2	8,1	57,7	2,1

In the Vassa variety, a similar relationship was observed, with the introduction of the calculated doses of mineral fertilizers, the prevalence decreased relative to the control from 0.7 to 21 %, but the degree of development did not increase, as in the Dolya variety, but decreased by 0.1–0.3 %.

In the Grom variety, an increase in the doses of mineral fertilizers provoked an increase in the prevalence by 27.1–34.1 % and the development of the disease by 5.5–6.6 %.

In all studied variants, the development of the disease did not exceed the economic threshold of harmfulness. The cultivars Vassa and Dolya were the most resistant to pyrenophorosis in the experimental variants under study.

In the Vassa variety, the calculated doses of mineral fertilizers for the planned yield of 5.0, 7.5 and 10.0 t/ha reduced the prevalence by 0.7–21 % and the degree of development by 0.1–0.3 %.

The lowest prevalence (42.5 %) and the degree of development (1.3 %) in the Vassa variety was provided by the dose of N124P72K30 for the planned yield of 5.0 t/ha. In the Dolya variety, the calculated doses of mineral fertilizers relative to the control reduced the prevalence of the disease by 0.6–20.7 %, but slightly increased the degree of development — by 0.2–0.6 %. The lowest prevalence and degree of development of pyrenophorosis was formed on the variant with a calculated dose for the planned yield level of 5.0 t/ha. The increase in the calculated doses of mineral fertilizers provoked the spread and development of the disease in the Grom variety.

https://doi.org/10.15405/epsbs.2021.05.164
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eISSN: 2357-1330

The planned yield level in 2016 of 5.0 t/ha with the application of a dose of N124P72K30 was achieved on the varieties Grom (5.32 t/ha) and Dolya (6.13 t/ha), the planned yield level of 7.5 t/ha s application of a dose of N186P95K45 was obtained on varieties Vassa (7.51 t/ha) and Dolya (8.39 t/ha), the planned yield level of 10.0 t/ha with a dose of N248P133K60 was recorded only in the variety Dolya (10.47 t/ha). The most responsive in the experience to increasing doses of mineral fertilizers in 2016 was the Dolya variety, which marked all levels of the planned yield.

Table 5. Productivity (t/ha) of winter wheat varieties depending on the calculated doses of mineral fertilizers (average for 2016–2018)

Fertilizer dose, A	Variety, B			A, HCP_{05} = 0,36
	Vassa	Grom	Dolya	
$N_{63}P_{52}$ (Control)	3.43	3.55	4.01	3.66
$N_{124}P_{72}K_{30}$ (5.0 t/ha)	5.06	5.16	5.57	5.26
$N_{186}P_{95}K_{45}$ (7.5 t/ha)	7.52	7.42	7.71	7.55
$N_{248}P_{133}K_{60}$ (10.0 t/ha)	8.70	9.13	9.23	9.02
B, HCP_{05} = 0.24	6.18	6.32	6.63	HCP_{05} = 0.50

In 2017, the planned yield level of 5.0 t/ha was obtained in two varieties: Vassa – 5.45 t/ha and Dolya – 5.23 t/ha, the planned level of 7.5 t/ha was formed only for the Vassa variety – 7.64 t/ha. In 2017, it was not possible to obtain a yield of 10.0 t/ha on any of the studied varieties. The Vassa variety during this period turned out to be the highest-yielding variety.

The planned yield of winter wheat of 5.0 t/ha in 2018 was obtained for all three studied varieties, 7.5 t/ha – only for varieties Grom (7.87 t/ha) and Dolya (7.94 t/ha) , yield of 10.0 t/ha was not achieved on any of the varieties. On average, according to experience, the highest-yielding variety in 2018 was the Dolya variety.

On all varieties of winter wheat, on average for 2016–2018, the calculated doses of mineral fertilizers relative to the control increased the yield by 1.6–5.36 t/ha. The planned yield level of 5.0 and 7.5 t/ha was achieved for all varieties, the planned yield level of 10.0 t/ha was not achieved. On average, the Dolya variety turned out to be the highest-yielding variety on all nutrition backgrounds (Table 5).

The maximum yield level was obtained when the dose of $N_{248}P_{133}K_{60}$ was applied to the planned yield of 10 t/ha for the mid-late variety Dolya – 9.23 t/ha and the mid-ripening variety Grom – 9.13 t/ha, which is significantly higher than the indicators of all experimental options.

When the calculated doses of mineral fertilizers were applied in all variants of the experiment, the economic threshold of harmfulness was not observed in 2015–2018. studies managed to obtain the planned yield of winter wheat varieties Dolya, Grom and Vassa 5.0 and 7.5 t/ha on leached chernozem after the predecessor peas, we can recommend the production of doses of mineral fertilizers $N_{124}P_{72}K_{30}$ and $N_{186}P_{95}K_{45}$, calculated by the method of Ageeva and Esaulko (2011).

7. Conclusion

In the phase of the end of tillering – the beginning of stemming in the variants with the introduction of calculated doses of mineral fertilizers for the planned yield of 7.5 (N186P95K45) and 10.0 (N248P133K60) t/ha, the prevalence and degree of development of root rot of fusarium entomology

https://doi.org/10.15405/epsbs.2021.05.164
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eISSN: 2357-1330

increased relative to the control variant. Thus, the prevalence of varieties Vassa increased by 1.5–3 %, Grom – by 3.3–6.9 % and Dolya – by 6.2–9 %, the degree of development – by 0.1–1.8 %; 1.2–3.7 % and 0.7–2.6 %. The calculated dose for the planned yield 5.0 t/ha (N124P72K30) on the Vassa and Dolya varieties reduced the prevalence of the disease by 0.5–5.0 % in relation to the control, on the Grom variety it slightly increased the studied indicator by 0.9 %, but the degree of development in all three studied varieties decreased in the Vassa variety by 1.3 %, Grom – by 1.1 %, and Dolya – by 0.7 %. A similar situation was observed in the study of plants in the heading phase, the calculated dose (N124P72K30) reduced the prevalence and degree of development of root rot both in relation to the control and in relation to the calculated doses of N186P95K45 and N248P133K60, and the difference was in prevalence in Vassa varieties – 2.3; 3.0; 4.0 %, Grom – 2.1; 3.3; 4.2 %, Dolya – 2.1; 3.3; 5.0 %, according to the degree of development in Vassa varieties – 1.4; 2.4; 5.6 %, Grom – 0.8; 2.2; 4.2 %, Dolya – 0.6; 1.9; 3.2 %.

The most resistant to root rot was the Dolya variety, depending on the phase of plant selection and the calculated doses of mineral fertilizers used in the experiment, the prevalence on this variety varied from 30 to 60 %, the degree of development – from 2.4 to 8 %, which turned out to be lower than in the Vassa variety by 10.0–16.5 % and 1.5–4.1 %, in the Grom variety – by 10.0–10.1 % and 0.7–1.6 %.

The prevalence and degree of development of powdery mildew in the control variant were not recorded. When the calculated dose of N124P72K30 was applied, only in the variety Dolya, a prevalence of 1 % was noted, with a zero degree of development. With an increase in the calculated doses, the prevalence and degree of development of the disease increased: in the Vassa variety, when applying doses of N186P95K45 and N248P133K60, a prevalence of 1.0 % with a zero degree of development was noted, in the variety Grom the prevalence was 10 and 5.0 % with a degree of development of 0.1 %, in the Dolya variety – 15.0 and 12.0 % with a degree of development of 0.1 %. The most resistant to powdery mildew was the Vassa variety, on which only the prevalence of the disease was recorded at 1.0 %.

The doses of mineral fertilizers studied in the experiment had a different effect on the prevalence and degree of development of pyrenophorosis. Thus, in the Vassa variety, all calculated doses of mineral fertilizers reduced the prevalence (0.7–21.0 %) and the degree of development (0.1–0.3 %) of pyrenophorosis. In the Grom variety, with increasing doses of mineral fertilizers, both the prevalence (by 27.1–34.1 %) and the degree of development (by 5.5–6.6 %) increased. In the Dolya variety, the calculated doses of mineral fertilizers reduced the prevalence from 0.6 to 20.7 % but increased the degree of pyrenophorosis development by 0.2–0.6 %.

The cultivars Vassa and Dolya were the most resistant to pyrenophorosis in the experimental variants under study. The Vassa variety had the lowest degree of development, from 1.3 to 1.6 %, while the Dolya variety had the lowest prevalence, from 37.6 to 58.3 %.

On all varieties of winter wheat, on average for 2016–2018, the calculated doses of mineral fertilizers relative to the control increased the yield by 1.6–5.36 t/ha. The planned yield level of 5.0 and 7.5 t/ha was achieved for all varieties, the planned yield level of 10.0 t/ha was not achieved. On average, the Dolya variety turned out to be the highest-yielding variety on all nutrition backgrounds. The maximum yield level was obtained when the dose of $N_{248}P_{133}K_{60}$ was applied to the planned yield of 10

t/ha for the mid-late variety Dolya – 9.23 t/ha and the mid-ripening variety Grom – 9.13 t/ha, which is significantly higher than the indicators of all experimental options.

Acknowledgments

This work was carried out with the support of FSBEI HE "Stavropol SAU".

The authors would like to thank their colleagues for their contribution and support to the research. They are also thankful to all the reviewers who gave their valuable inputs to the manuscript and helped in completing the paper.

The authors have no conflict of interest to declare.

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