Effect of different Agromeliorants on Yield and Quality of Spring Wheat

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Received October 08, 2021; Accepted December 25, 2021
ISSN: 1735-188X
DOI: 10.14704/WEB/V19I1/WEB19375

Abstract

The task of this work wass to assess the impact of new organo-mineral complex based on peat Gumiton, enriched with trace elements (B, Mo, Mn), on the yield and quality of spring wheat,

including under conditions of technogenic soil pollution. In a series of field experiments on various types of soils of the Kaluga Region and the Republic of Tatarstan of Russia in farms of various forms of ownership, it was shown that the treatment of spring wheat crops of various varieties with Gumiton in various phases of plant development contributed to an increase in yield by 15-25%. Under the conditions of the growing experiment on soddy-podzolic sandy loam soil, double Gumiton treatment of spring wheat crops of Rima variety increases the B content in the grain to 1.4; Mo-by 1.3 times relative to the variants without the use of the drug. Gumiton reduces the accumulation of Cd in grain up to 1.2 times and improves zootechnical indicators of grain-increases the protein content by 0.9%, fat - up to 0.6%. Gumiton is a highly effective complex for use in spring wheat cultivation technologies, which increases the yield and quality of grain and reduces the accumulation of pollutants (heavy metals).

Keywords

Soil, Spring Wheat, Gumiton, Grain Yield, Cd, Trace Elements, Quality.

Introduction

Cereals in the Russian Federation occupy the first place in the gross harvest, of which wheat is the most widespread. In 2019, 74.335 thousand tons of winter and spring wheat grain were harvested, 20.459 - winter and spring barley, and 4403 thousand tons of oats with an average yield of 2.70 t/ha, 2.4 and 1.82 t/ha, respectively [1]. Spring wheat is the most demanding to the conditions of cultivation. Therefore, for normal growth and development, it is necessary to introduce not only the basic elements of nutrition, but also microfertilizers (B, Mo, Zn, Cu, Mn, etc.), which contribute to improving growth and development, increase plant resistance, activating physiological processes [2, 3]. This issue is most acute in the case of heavy metal (HM) contamination of agricultural land, which in the Russian Federation is mainly caused by emissions from industrial, energy, and chemical enterprises, as well as the abnormal use of chemical plant protection products against pests and diseases and sewage sludge. The area of HM contamination of agricultural soils is more than 3.6 million hectares, of which more than 1 million hectares are particularly toxic elements (hazard class I – Cd, Hg, Pb, Zn) and about 2.3 million hectares are toxic (hazard class II-Co Ni, Cu, Cr, etc.) [4]. In this regard, as modern research shows, great importance is given to the development of technologies for the cultivation of agricultural crops, especially in conditions of man-made pollution with the use of new types of organo-mineral complexes, which are among the most important factors regulating the growth processes at all stages of plant development [5-8]. One of such complexes is Gumiton [9] - a highly effective preparation based on biologically

active components of peat with the content (%): N-10-12; P_2O_5-20-24; K_2O-27-30; Ca-0.5; Mg-0.2; B-0.2; Mo-0.1; Mn-0.1, organic matter 18-20, water-soluble potassium humates 11-14% [10-12]. The preparation is used for non-root treatment of vegetative plants by spraying and processing of seed and planting material.

Materials and Methods

The research was conducted in 2019-2020 in field experiments. On the basis of Kaluga Research Agriculture Institute Branch of Russian Potato Research Centre on gray forest medium loamy soil, the effect of a single treatment with Gumiton of spring wheat crops of the Lubava variety in the tillering phase on yield was studied. Before starting the experiment, the 20-cm soil layer contained 2.3-2.9% humus, P_2O_5 and K_2O - 180-214 and 131-150 mg/kg of soil, respectively, pH_{KCl} 5.6-6.1. On the basis of Limited Liability Company (LLC) "Rodina" Maloyaroslavetsky district of Kaluga region on loamy soddy-podzolic soil was evaluated the effect of a single treatment Gumiton of spring wheat variety Lubava in the phase of stem elongation to the grain yield. Agrochemical characteristics of the soil: humus content-2.15%, pH_{KCl} 5.3, hydrolytic acidity - 1.98 mmol (eq)/100 g of soil, P_2O_5 – 183 and K_2O - 84 mg/kg of soil, respectively. On the basis of LLC "Berezovsky Zori" Bavlinsky district of the Republic of Tatarstan on the ordinary chernozem medium loamy evaluated the effect of single use Gumiton on grain yield of spring wheat variety Hercules.

In a vegetation experiment based on RIRAE on soddy-podzolic sandy loam soil, the effect of Gumiton on the productivity of spring wheat of Rima variety, quality indicators and Cd accumulation in the grain were studied. Agrochemical parameters of the soil: pH_{KCl} 4.30, humus content - 1.18%, Ca - 1.66 mmol (eq)/100 g, Mg-0.17 mmol (eq)/100 g, P_2O5 and K_2O - 86 and 75 mg / kg of soil, content of mobile forms of trace elements: Cu - 3.9, Zn - 2.0, B - 0.59, Mo - 0.30, Mn - 87.4 mg/kg of soil, respectively. Experience scheme: 1. Control – (soil without fertilizers). 2. Cd_6 (mg/kg of soil). 3. Azofoska, 0.94 g/kg of soil. 4. Azofoska + Cd_6. 5. Soil without fertilizers + Gumiton. 6. Cd_6 + Gumiton. 7. Azofoska + Gumiton. 8. Azofoska + Cd_6 + Gumiton. The vessel contained 5.5 kg of soil. Cd was introduced as a solution of $3CdSO_4$ x $8H_2O$ salt. The repetition of the experience is 3 times. In each vessel, 15 plants were grown. Treatment Gumiton vegetative plants was carried out twice: at the tillering stage and in the phase of elongation. After harvesting, the content of HM and zootechnical indicators of grain (protein, fat, ash) were determined in wheat grain. Planning of experiments, analysis of the structure of the crop after harvesting wheat was carried out according to Dospekhov [13]. Mathematical processing of

experimental data was carried out using the MS Exel 2007 program with a 95% level of significance of the results.

The Results of the Research

According to the results of studies on gray forest medium loamy soil, a single treatment with Gumiton of spring wheat crops of the Lubava variety in the tillering phase contributed to an increase in the grain yield from 2.02 to 2.46t/ ha, or by 21.8% in relation to the control (farm technology). Similar results were obtained on soddy-podzolic medium loamy soil, where a single treatment with Gumiton of spring wheat Lubava variety in the phase of entering the tube increased the crop yield from 2.30 to 2.70 t/ha, or by 17.4% compared to the control. On ordinary medium-loamy chernozem, a single application of Gumiton on crops increased the grain yield of spring wheat of the Hercules variety from 3,35 to 3,84 t / ha, or by 14.6%.

In the vegetation experiment in the conditions of 2020, it was shown that the introduction of Cd in the soddy-podzolic sandy loam soil at a concentration of 6 mg/kg of soil did not affect the biometric parameters of wheat plants of Rima variety. The weight of wheat grain and straw in the control (in the soil without fertilizers) was very low – 4.53 and 9.88 g/vessel. The mass of 1000 grains was only 20.9 g (table 1).

Table 1 Effect of mineral fertilizers and Gumiton on the structure of spring wheat yield on soddy-podzolic sandy loam soil containing Cd. Vegetation experience 2020

Variant	**Grain weight, g/vessel**	**Straw weight, g/vessel**	**Weight of 1000 grains, g**
Soil without fertilizers - control	4,53	9,88	20,9
Soil without fertilizers + Gumiton	5,44	11,30	24,5
Azofoska	10,79	19,99	35,5
Azofoska + + Gumiton	13,58	22,02	37,7
Soil without fertilizers + Cd_6	4,94	9,81	24,0
Soil without fertilizers + Cd_6 + Gumiton	5,56	10,27	26,5
Azofoska + Cd_6	12,66	19,70	39,1
Azofoska + Cd_6 + Gumiton	13,48	22,18	43,3
LSD_{05}	0,90	2,00	2,46

Making azofoska in soil that does not contain Cd_6 contributed: significant increase in grain weight of wheat by 6.26 g/vessel (or 138%); increasing fineness of grain (weight of 1000 grains was bigger by 14.6 g or 70%); the increase in weight of straw by 10.11 g/vessel, or 102%, compared to benchmarks. Gumiton treatment of wheat plants on fertilized azophoska soil that does not contain Cd_6 contributed to a significant increase in

grain weight by 2.79 g/vessel or 26%, straw weight-by 2.03 g/vessel or 10%, relative to the variant without an organo-mineral complex, respectively. The use of Gumiton on fertilized soddy-podzolic soil containing Cd_6 increased the weight of 1000 wheat grains by 4.2 g or 11%, respectively. On the soil without fertilizers, which does not contain Cd_6, Gumiton treatment increased grain size (the weight of 1000 wheat grains was 3.6 g or 17% more), relative to the control.

The introduction of Cd into soddy-podzolic soil at a dose of 6 mg/kg (12 Approximate Permissible Concentrations (APC) for sandy and sandy loam soils) significantly increased the metal content in wheat grain by 1.97 mg/kg (or 18.9 times relative to the control) on soil without fertilizers, and by 2.77 mg/kg (26.2 times) on soil containing azofoska. Double treatment of vegetative plants with Gumiton on the background without fertilizers reduced the accumulation of Cd by wheat grain by 0.35 mg/kg (or 1.2 times), relative to the option without the use of an organo-mineral complex. A similar pattern was preserved with the Azofoska + Cd_6 + Gumiton variant - the decrease in the indicator value was 0.25 mg/kg. Nevertheless, the concentration of Cd in wheat grain on Cd_6-contaminated soil, even after the use of Gumiton, significantly (by 5.8-8.8 times) exceeded the existing standards for the content of Cd in grain and grain fodder (table 2).

Table 2 Effect of mineral fertilizers and Gumiton on the content of Cd and trace elements in the grain of spring wheat of the Rima variety. Vegetation experience 2020

Variant	Content in grain, mg/kg					
	Cd	**B**	**Mo**	**Mn**	**Cu**	**Zn**
Soil without fertilizers - control	0,11	3,06	0,34	28,30	11,66	26,93
Soil without fertilizers + Gumiton	0,09	3,21	0,39	31,96	11,67	25,95
Azofoska	0,14	3,20	0,47	40,31	10,52	36,61
Azofoska + + Gumiton	0,10	3,47	0,60	44,99	10,41	35,30
Soil without fertilizers + Cd_6	2,08	2,50	0,33	22,93	10,97	34,99
Soil without fertilizers + Cd_6 + Gumiton	1,73	3,43	0,38	24,79	9,55	30,33
Azofoska + Cd_6	2,88	3,23	0,45	37,80	9,65	45,88
Azofoska + Cd_6 + Gumiton	2,63	3,34	0,54	39,87	8,29	41,23
LSD_{05}	0,21	0,44	0,06	3,81	0,66	3,59

The results showed that in the variant of Cd_6 application to the soil without fertilizers, the B content in wheat grain decreased by 0.56 mg / kg or 1.2 times. In the Soil without fertilizers + Cd6 + Gumiton variant, the amount of this trace element in the grain increased by 0.93 mg/kg (1.4 times), compared to the Soil without fertilizers + Cd_6 variant. Azofoska contributed to an increase in the Mo content in wheat grain by 0.13 mg / kg or 1.3 times compared to the control. Treatment of plants with Gumiton led to an increase in the content of trace elements in the grain by 0.13 mg/kg (1.3 times). The introduction of azofoska into the soil as a fertilizer contributed to an increase in the Mn

content in wheat grain by 12.01 mg/kg by 1.4 times compared to the control variant. The use of Gumiton based on the azofoska background on Cd-free soil increased the Mn content in grain products by 4.68 mg/kg or 1.1 times compared to the azofoska variant. Azofoska reduced the Cu content in the grain by 1.1 times (by 9.8%) in the soil without Cd and by 1.2 times (by 17.2%) in the soil containing Cd_6, compared to the control. Treatment with Gumiton did not significantly affect the intake of Cu in the grain in any of the variants of the growing experiment with wheat. The use of azofoska increased the Zn content in the grain by 9.68 mg/kg, or 1.4 times compared to the control. Double treatment of vegetative wheat plants with Gumiton reduced the metal intake in grain products, according to the background without fertilizers and Cd_6 application to the soil, by 1.15 times (by 13.3% compared to the variant without the use of the drug), and by 1.1 times (by 10.1%) when applying azofoska to the soil, respectively. The protein content in the grain when using azofoska increased by 2.10%. The introduction of Cd_6 reduced the protein content in wheat grain in the variant with azofoska by 0.93%.

Treatment of plants with Gumiton positively affected the zootechnical indicators of grain. The use of the drug on wheat crops contributed to a significant increase in the protein content in the grain by 0.91% in the Azofoska variant and by 0.89% in the Azofoska + Cd6 variant, respectively. The ash content in grain during the treatment of plants with Gumiton significantly increased by 0.23-0.34%, the fat content by 0.32-0.62% in absolute figures, depending on the agrophone relative to options without the use of drug.

Conclusions

1. On the basis of experimental studies have shown the effectiveness of the use of organo-mineral complex Gumiton containing micronutrients (B, Mo, Mn) in spring wheat crops, to increase yields, improve grain quality and reduce the accumulation of pollutants (HM).
2. Treatment Gumiton of spring wheat in different soil and climatic conditions contributes to the increase of grain yield by 15-25%, depending on the variety, multiplicity and phase of treatment.
3. In the conditions of the growing experiment on soddy-podzolic sandy loam soil contaminated with Cd at a concentration of 6 mg/kg, double treatment of spring wheat plants of the Rima variety with Gumiton contributed to a decrease in metal accumulation by grain by 17% or up to 1.2 times, compared with the options without the use of the drug. The content of trace elements increased: B - up to 1.4; Mo-1.3 times, respectively.

4. Treatment of wheat plants with Gumiton had a positive impact on zootechnical indicators of grain. The use of Gumiton contributed to a significant increase in the protein content in the grain by 0.9%. The ash content when using Gumiton increased by 0.23-0.34%, fat-by 0.32-0.62% in absolute numbers, depending on the agrophone, relative to options without the use of the drug.

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