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Efficiency of barley foliar feeding under conditions of leached chernozem fertility heterogeneity

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Abstract. The article presents the results of studies conducted on the effectiveness of barley foliar feeding under field experiment conditions. The studies were carried out in a field stationary experiment in a grain-vapor-tilled crop rotation system with the following rotation: green-manured fallow - spring wheat - barley - maize - spring wheat. The object of the research was leached chernozem. Rotation cropping was sown on two degrees of ground fertilization – without fertilizer and with fertilizer. Urea (carbamide) was added as barley foliar feeding. Spring wheat that was sown on rape plant green-manured fallow served as the forecrop to the barley. Soil fertility heterogeneity was determined by examining barley crops during the tillering period (biomass scanning). Unmanned aerial vehicles manufactured by Krasaeroskan were used for this purpose. The results of NDVI index determination in the field experiment formed the basis for determining the mineral nitrogen fertilizer doses. Such doses were refined by tissue diagnostics. It was established that foliar feeding with mineral nitrogen fertilizers (urea) contributed to an increase in barley productivity.

1. Introduction

As is known [1], the soil mantle of the agricultural part of the Krasnoyarsk Territory is very heterogeneous, characterized by a complex structure and heterogeneous composition, a phenomenon that is explained by the specificity of the hydrothermal conditions of soil formation [2]. It is possible to find several types, subtypes, and varieties of soil on one land plot. These soil varieties differ significantly in a number of soil fertility parameters. At the same time, the soil agrochemical parameters within a separate land plot may have a very high level of variation. Researches of several authors establish a similar fact. According to [3], the maximum degree of variation is typical for such parameters as productive moisture, nitrate and ammonium nitrogen, labile phosphorus, exchangeable potassium. At



the same time, the most stable parameter was the soil solution reaction, the spatial variation of which only slightly depended on external factors.

The presence of such a significant heterogeneity of soil fertility inhibits realizing the productivity potential of cultivated crop varieties in full. Eliminating the negative impact of the land plot heterogeneity on soil fertility is possible only by applying geoinformational technologies. Applying such technologies allows processing quite a large array of information that includes data on the terrestrial factors of plant life. Detailed analysis of the data allows developing modern technologies for field crop cultivation that will take into account the state of the soil fertility of this land plot's individual elementary areas.

Introducing such agricultural crop cultivation technologies is very important in the long term, as it allows not only increasing their yield, thus ensuring environmentally-safe and high-quality crop production, but also significantly reducing the material and technical costs of production per unit [4].

Thus, according to [5], the differential application of nitrogen and potash fertilizers was the most promising in the western zone of the Orenburg Region. At the same time, the saving of ammophos was 1.7 tons and of potassium chloride –20.0 tons on the 112-hectare plot. According to [6], the differential application of mineral fertilizers ensures obtaining cultivated crop harvests and the preservation of soil fertility parameters at the continuous application level, while fertilizer loss is reduced by 10-15%.

Differential application of mineral fertilizers forms the basis of a systematic approach in the cultivation of crops and soil fertility management. It is known [7] that the share of mineral fertilizers in the modern world may be up to 30% of total costs.

However, such an economically efficient element of the precision agriculture system as the differential application of mineral fertilizers is not applied at all in the industrial agriculture system of the Krasnoyarsk Territory.

Such technologies are of particular relevance under the conditions of the agricultural part of the Krasnoyarsk Territory, since the same conditions for growth and development are created for all plants on the field.

However, soil heterogeneity in fertility must be established to be able to introduce the technology for the differential application of fertilizers. According to [8, 9, 3], even the most leveled field is heterogeneous in terms of soil characteristics and, accordingly, in terms of potential yield in its individual elementary areas.

In this regard, the studies were aimed at testing individual elements of resource-saving technology of grain crops cultivation through the introduction of the technology of differential application of mineral fertilizers in the form of barley foliar feeding.

For this purpose, the following tasks must be solved:

- evaluation of the soil heterogeneity of experimental field using the remote sensing method;
- evaluation of the reflection spectrum of agricultural plants (biomass scanning) by using unmanned aerial vehicles in the tillering stage of grain crops;
- testing of the barley foliar feeding method during the tillering period under conditions of heterogeneous soil cover in fertility on the leached chernozem of the Krasnoyarsk forest-steppe.

The scientific novelty lies in the fact that studies to assess the efficacy of foliar feeding with mineral nitrogen fertilizers based on the variability of soil fertility parameters were conducted for the first time in the conditions of the Krasnoyarsk forest-steppe.

2. Research methods

The research object was the leached chernozem of the Krasnoyarsk forest-steppe.

One of the fairly common methods for determining soil heterogeneity in fertility is the survey of crops during the growing season (biomass scanning).

For this purpose, the NDVI index (normalize difference vegetation index) is used. It is most widely used in remote sensing for analyzing vegetation states on the earth's surface.

A land plot that is typical for this agricultural zone was chosen for benchmarking and carrying out a long-term field experiment. For this purpose, the field was digitized. A field experiment with a total area of 10 hectares was subsequently laid out on it (figure 1).



Figure 1. Land plot on which long-term field experiment was laid out on the work-study unit of Minderlinskoye.

The studies were carried out in crop rotation links. Such crop rotation is deployed in time and across the fields. Each link included forecrops and the first and repeated sowing of grain crops placed after it. The following crop alternation was used in the crop rotation: green-manured fallow – spring wheat – barley – maize – spring wheat.

In the experiment, spring wheat of the Novosibirsk 15 variety and barley of the Acha variety were sown.

The experimental design included soil tillage types presented below.

- Moldboard soil treatment (plowing on 20-22 cm).
- Non-moldboard treatment (subsurface plowing on 20-22 cm).
- Minimal treatment (disk plowing on 8-10 cm).
- Without basic soil treatment (zero treatment).

The total area of the field experiment is 10 hectares.

The term for sowing of spring wheat and barley is the third decade of May.

The area of the experimental plots in the field experiment was 5000 m². The experiment has a fourfold replication. The location of the plots is two-storeyed, systematic.

Forecrops and crops were cultivated as per the generally accepted technologies. The main and pre-sowing tillage was carried out as per the zonal recommendations.

As is known, the principle of determination of the elementary plots area characterized by different growing conditions of agricultural plants is the basis for the differential application of mineral fertilizers.

Aerial vehicles manufactured by JSC Geoscan were used for NDVI index determination. Elementary areas differing in the value of the NDVI index were distinguished based on the obtained plans.

The rate of mineral nitrogen fertilizers application based on plant availability with mineral nitrogen from the results obtained with tissue diagnostics was determined on the selected elementary areas by the plant diagnostics. Fertilizer limiting element introduction rates were calculated on the basis of elementary areas.

Foliar feeding was carried out using a ground sprayer. The control type was formed for an objective assessment of the foliar feeding effectiveness on the same field land.

The total area of experiment with barley crops was 2 hectares.

The growing period of 2018 was distinguished by an extremely unequal distribution of atmospheric precipitation and increased average monthly air temperature in June and August. All this led to a weak growth of grain crops. In general, the growing season in 2018 was characterized as unfavorable for crops cultivation.

3. Results of the study

The results of NDVI index determination in the field experiment using an unmanned aerial vehicle in the tillering stage of grain crops are presented in the figure 2.

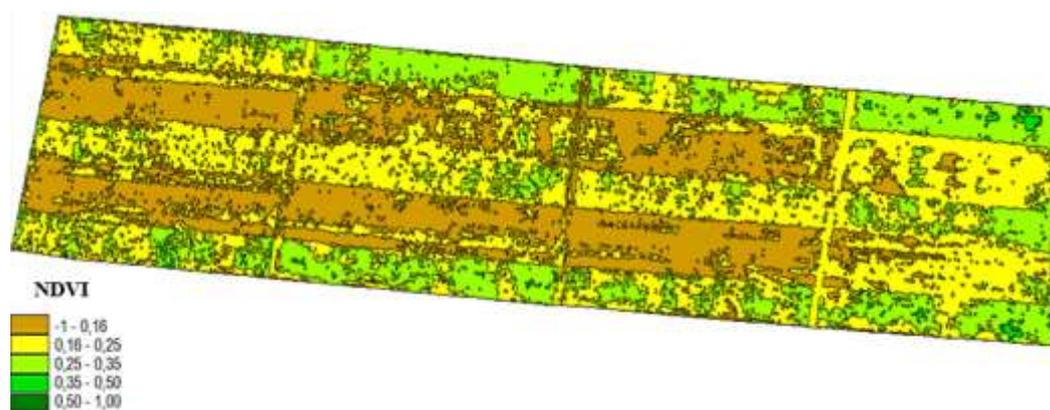


Figure 2. The results of NDVI index determination using an unmanned aerial vehicle on the crops of the grain-vapor-tilled rotation.

Tissue diagnostics was used to clarify the mineral fertilizer rates. Such diagnostics allows to correct the mineral nutrition of plants during the growth and development of cultivated plants. It is based on a chemical analysis of whole plants or their individual parts [10]. Numerous studies have shown that the availability of soil nutrients can be assessed only by a plant. Therefore, plant diagnostics clarifies the soil agrochemical characteristics. As an objective control of the crop condition, such diagnostics solves the issue of the reasonable use of mineral fertilizers of agricultural crops. The positive effect of foliar feeding on the agroecosystem productivity and the quality of agricultural products was noted in various regions of the country.

The optimal dose of mineral nitrogen, in kg/ha, was calculated as per the tissue diagnostics results.

The results of barley harvest assessment indicate that foliar feeding of barley crops with mineral nitrogen fertilizers for all the studied soil tillage types led to an increase in barley grain yield from 4.0% (no basic soil treatment type) to 24.7% (surface tillage type) compared to the type without fertilizers.

Thus, determination of the NDVI index using an unmanned aerial vehicle adequately reflects the heterogeneity of soil fertility on the leached chernozem of the Krasnoyarsk forest-steppe.

Foliar feeding with mineral nitrogen fertilizers (urea) on the basis of soil fertility heterogeneity in the tillering stage of barley led to an increase in the productivity and profitability level of this crop cultivation compared to the unfertilized cultivation.

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