The efficiency of the differentiated application of mineral fertilizers in the production technology of winter wheat cultivation

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D A Petukhov[1], A B Ivanov[1], E V Bondarenko[1], A V Trubnikov[2] and S A Semizorov[3]

[1]Novokubansk Affiliate of Russian Research Instittute of Information and Feasibility Study on Engineering Support of Agribusiness the Federal State Bugetary Scientific Institution, 15, Krasnaya Str., Krasnodar Region, Novokubansk, 352243, Russia
[2]LLC Agronote, territory of the Skolkovo Innovation Center, Bolshoy Boulevard, 42, p. 1, office 136, Moscow, 121205, Russia
[3]Northern Trans-Ural State Agricultural University, 7, Respublika Str., Tyumen, 625003, Russia

E-mail: dmitripet@mail.ru

Abstract. The article discusses the results of experimental studies of a field experiment on the differentiated application of granular mineral fertilizers, in comparison with their continuous application with an average economic dose in areas with different relative levels of soil fertility. The results of assessing the effect of fertilization methods on plant parameters and the efficiency of winter wheat cultivation are presented.

1. Introduction

Precision farming technology consists of a large number of elements and systems that can be applied both individually and in combination in the cultivation and harvesting of crops.

At present, precision farming cannot be carried out without conducting studies to study the effect of intra-field heterogeneity on crop yields, which indicate the effectiveness of the use of high-intensity agricultural technologies in conditions of heterogeneity [1-3]. It is known that one of the most important elements of precision farming technologies is the differentiated application of granular mineral fertilizers (GMF).

Differentiated application implies the distribution of GMF in optimal doses only in those areas of the field where it is needed. At the same time, the integrated use of navigation systems, digital mapping, parallel driving and differentiated fertilization allows you to save money by reducing the cost of fertilizers in low-productivity areas of the field and increasing yields due to their competent redistribution.

It has been established that data management, their mathematical processing and timeliness of information for precise (coordinate) farming increase the accuracy of operations and allow you to control the variability of fertility parameters within the field, while precision farming allows you to simulate the situation and ensure optimal growth for each plant while reducing production costs [4].

It should be noted that the application of fertilizers with field-averaged (fixed) doses does not meet the requirements of individual plants to the level of mineral nutrition, because the variation of different

agroecological conditions (relief, soil cover structure, moisture regime, etc.) within the field is very significant. Differences in soil fertility in different parts of the field can reach up to 300% [5]. When applying fixed doses of nitrogen, phosphorus and potassium fertilizers, more than 30% of plants receive insufficient or, conversely, excessive mineral nutrition with the ensuing consequences for the productivity of agricultural crops [6].

Research on precision farming technologies, carried out in Russia within the framework of the scientific programs of the Russian Agricultural Academy in various soil and climatic conditions, have shown the high efficiency of the differentiated application of granular mineral fertilizers for grain crops: the payback of nitrogen fertilizers increases by 1.5-1.8 times and the application rates are reduced fertilizers up to 30% [7].

Thus, the differentiated application of GMF is one of the most important economic and environmental aspects of precision farming.

The aim of the work is to study the effectiveness of the differentiated application of granular mineral fertilizers, in comparison with their continuous application with an average economic dose when growing winter wheat in the Krasnodar Territory.

2. Materials and methods

To achieve this goal, the following materials and methods were used:

- Spreader GMF Bogballe M2 base, equipped with the system "Agronavigator-ASUR-Batcher" with automatic control of fertilizer consumption to maintain a given dose at changes in speed and location on the field;
- Combine harvester Polesie GS-12, equipped with sensors and a yield mapping system Trimble YM, to determine the yield of winter wheat with a coordinate reference and create electronic maps of yield;
- The method of retrospective monitoring of the soil and land cover according to the Earth remote sensing data, to build a map of the zones of stable intra-field heterogeneity of the fertility of the experimental field (ASF-index);
- Method of field soil-landscape survey for verification and agroecological assessment of zones of stable intra-field heterogeneity of fertility of the experimental field;
- A method for developing task maps (prescription maps, prescriptions) in KML format for differentiated fertilizing of winter wheat;
- Comparative field experience on the differentiated application of GMF on top dressing of winter wheat in areas with different relative levels of productivity potential of agricultural crops.

3. Results

As a result of the study, using the method of retrospective monitoring [8-9], an electronic map of stable intra-field heterogeneity of fertility (ASF-index) of the experimental field 11/1 of the validation polygon of the Novokuban branch of the Federal State Budgetary Scientific Institution "Rosinformagrotech" KubNIITiM was created (figure 1). It was found that the maps of stable intra-field heterogeneity, obtained using the technology of retrospective monitoring of the soil and land cover using dozens of remote sensing data (ERS) from Landsat and Sentinel satellites, are the most informative for the technology of differentiated fertilization [10-12].

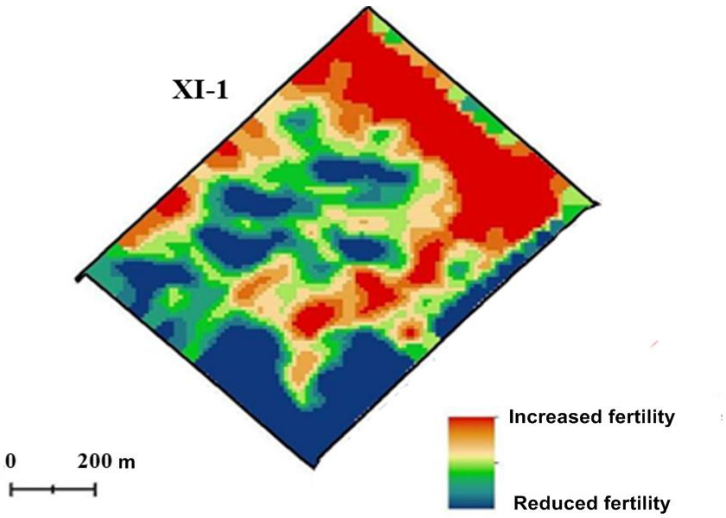

Figure 1. Map of stable intra-field heterogeneity of fertility of the experimental field 11/1, 72 hectares (crop - winter wheat, predecessor - corn for grain).

A digital map-task for a field experiment with a differentiated introduction of HMOs according to zones of stable in-field heterogeneity (IHI) of soil and land cover fertility (figure 2) was developed in the ArcGIS program, as follows:

- Vectorized a raster map with a grid of 10x10 meters, taking into account the results of a field soil and landscape survey with generalization of the initial 9 zones into 3 zones of the map-task for fertilizing in the north-western half of the field and highlighted on the map the southeastern half of the field for a continuous norms;
- Then, for each cell, data on the cell number and the given dose of fertilization were entered;
- After this operation, we saved the task map file in the KML format “pk_field number.kml” and loaded it into the on-board computer of the “Agronavigator ASUR-Batcher” system connected to the servo drive installed on the fertilizer spreader.

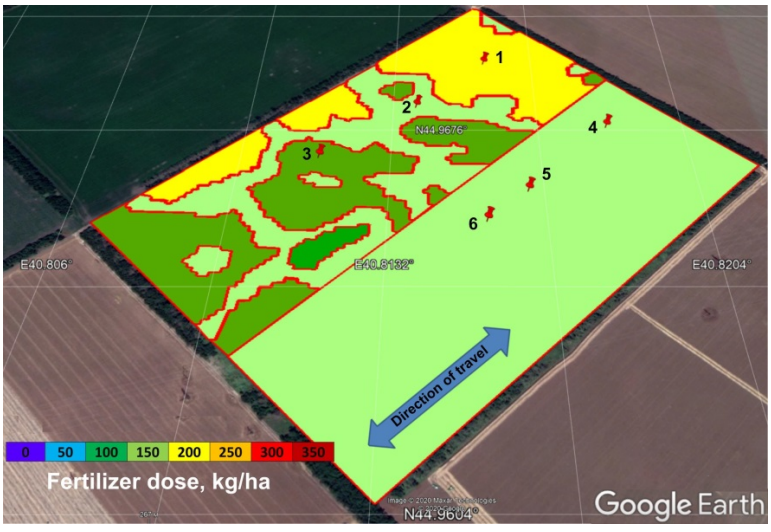

Figure 2. Task map for the first and second differentiated fertilizing of winter wheat with ammonium nitrate for field 11/1.

According to the developed task map, the first differentiated fertilizing of winter wheat with ammonium nitrate (February 27, 2020) and the second fertilization with ammonium nitrate (March 24, 2020) were carried out. The comparative experience provided for the differentiated application of GMF on an area of 36 hectares, by redistributing fertilizers according to the task map, taking into account the ASF index: an average (economic dose) of 150 kg / ha was introduced into zones with a

normal level of productivity potential for one feeding, in zones with a reduced the level of 100 kg / ha of ammonium nitrate, the remaining 50 kg / ha, were redistributed to zones with increased productivity potential of 50 + 150 kg / ha, in total - 200 kg / ha. On the rest of the field of 36 hectares, a basic (economic) variant was laid, with a continuous application of 150 kg / ha for one top dressing throughout the site.

To create a digital map of the yield, the entire experimental field was mapped in the optimal agro technical terms for harvesting winter wheat with one combine. Before mapping the yield, the system was calibrated according to the instructions and recommendations of Trimble specialists. In the process of mapping, to control the accuracy of the Trimble YM system, the loading parameters of the bunker (weight of harvested grain and average grain moisture) were re-measured at the weighing point.

The mapping process for winter wheat yields is shown in figure 3.

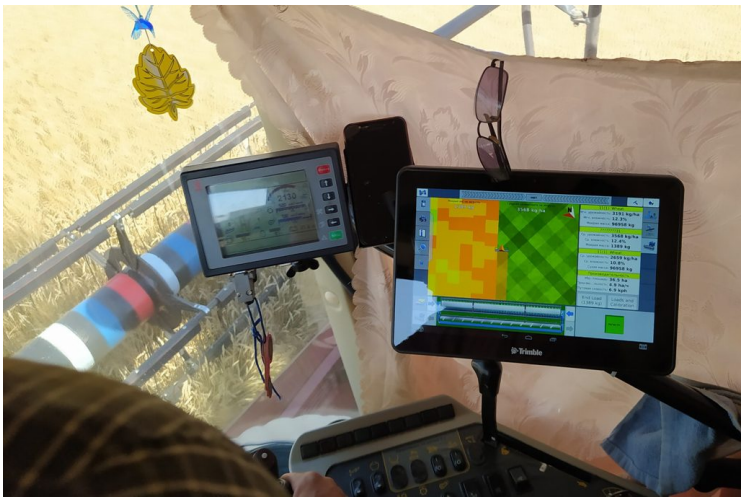

Figure 3. General view of the Trimble TMX-2050 monitor in the cab of the Polesie GS-12 combine harvester when mapping the winter wheat yield on test field 11/1.

Before harvesting the experimental field 11/1 of winter wheat, to determine the structure of the biological yield according to the variants of the experiment, pre-harvesting of sheaves was carried out from 18 sites, 6 points, 3 replicates each, in high, medium and low fertility zones, in the areas shown in figure 2 with differentiated (1, 2, 3) and continuous (4, 5, 6) application of nitrogen fertilizers.

The harvesting conditions were typical: soil moisture in the 0-10 cm layer averaged from 12.8 to 14.5%, soil hardness ranged from 0.3 to 1.2 MPa, plants were in full ripeness in all variants of the experiment. , grain moisture varied from 10.3 to 11.9%, which corresponded to the technological requirements for harvesting winter wheat.

The structure of the biological yield of winter wheat after manual parsing of the sheaves and the yield indicators obtained after mapping and processing in the Trimble AG Software software are presented in table 1.

4. Discussion

From the given table 1 it can be seen that in winter wheat plants in the zone with a low level of productivity potential, the height of plants with differential application of granular mineral fertilizers with a total dose of 200 kg / ha was 47.4 cm, which is 0.4 cm higher than with economic application with a total dose of 300 kg / ha. The spike length in the low zone is 6.8 and 7.0 cm, the grain moisture is 10.3% and 10.8%, the weight of 1000 grains is 36.6 and 38.5 g, the average ratio of grain weight to straw weight is 1: 1.7 and 1: 2.1, respectively, with differentiated and economic introduction of GMF.

In the zone with an average level of fertility, with the differentiated application of granular mineral fertilizers with a total dose of 300 kg / ha, the plant height was obtained - 51.1 cm, and with economic application with a total dose of 300 kg / ha, it was 47.0 cm , which is 4.1 cm higher.The ear length in the middle zone is 6.7 and 7.2 cm, grain moisture 11.9% and 10.8%, 1000 grain weight - 38.7 and 39.5

g, average the ratio of grain mass to straw mass is 1: 2 and 1: 2.1, respectively, with differentiated and economic introduction of GMF.

Table 1. Average parameters of winter wheat plants according to the doses of mineral fertilizers in different fertility zones on field 11/1.

Point number	Productivity potential zone (ASF-index)	Average plant height, cm	The ratio of grain weight to straw weight	Grain weight from the site 1 m^2, g	Straw weight from the site 1 m^2, g	Average ear length, cm	Grain moisture,%	Weight of 1000 grains, g	Harvesting yield, according to data from the combine, centners / ha	Productivity in terms of standard moisture content, centners / ha	The total dose of fertilizing fertilizers, kg / ha
1	high	51.3	1:1.8	441.2	792	7.7	11.0	43.0	44.1	45.7	400
2	average	51.1	1:2.0	377.2	769.6	6.7	11.9	38.7	37.7	38.6	300
3	low	47.4	1:1.7	325.2	546.8	6.8	10.3	36.6	32.5	33.9	200
4	high	49.6	1:2.0	381.1	770.4	7.4	11.0	40.8	38.1	39.4	300
5	average	47.0	1:2.1	368.0	757.2	7.2	10.8	39.5	36.8	38.2	300
6	low	47.0	1:2.1	328.0	675.8	7.0	10.8	38.5	32.8	34.0	300

In an area with a high level of fertility, with the differentiated application of granular mineral fertilizers with a total dose of 400 kg / ha, the plant height was obtained - 51.3 cm, and with an economic application with a total dose of 300 kg / ha, it was 49.6 cm , which is 0.7 cm higher. The ear length in the high zone is 7.7 and 7.4 cm, the grain moisture is the same - 11.0%, the weight of 1000 grains according to the options is 43.0 g, differentiated application and 40.8 g continuous application. The average ratio of grain mass to straw mass is 1: 1.8 and 1: 2, respectively, with differentiated and economic introduction of GMF.

A comparative analysis of the productivity of winter wheat plants by fertility zones showed that with a differentiated application of GMF, an increase in the dose of fertilizers from 200 to 400 kg / ha leads to an increase in the yield from 33.9 to 45.7 centners / ha, and with an economic application with a dose of 300 kg / ha increases in the middle and high zone to 38.2 and 39.4 centners / ha, respectively.

5. Conclusion

As a result of the study, the following conclusions can be drawn:

- The highest yield index with differentiated application - 45.7 centners / ha, was obtained at control plots with a total fertilizer application rate of 400 kg / ha in areas with a high level of productivity potential;
- Gross grain harvest with differentiated application of nitrogen fertilizing from an area of 36 hectares was - 143.64 tons, the average yield was 39.9 centners / ha, and with economic fertilization from an area of 36 hectares, the gross grain harvest was 135.0 tons, average yield - 37.5 centners / ha;
- Additional income received from an increase in yield of 2.4 centners / ha, with the same amount of GMF applied at two spring fertilizing of winter wheat, due to the differentiated redistribution of a part of fertilizers from zones with a low level of soil fertility to zones with

medium and high levels, with the selling price of winter wheat grain - 0.11 EUR / kg, amounted to - 26.43 EUR / ha;

- Additional income from the differentiated application of fertilizers from a plot of the experimental field with an area of 36 hectares was 951.61 EUR.

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