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PHOTOMETRIC DIAGNOSTICS AS AN EVALUATION ELEMENT OF THE EFFECTIVENESS OF ORGANIC AND MINERAL FERTILIZERS

VALERIY K. TOKHTAR*, PAVEL I. SOLNTSEV, YULIA V. KHOROSHILOVA AND MIKHAIL YU. TRETYAKOV

Belgorod State National Research University, 85, Pobedy Str., Belgorod, 308015, Russia [VKT, PIS, YVK, MYT].

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ABSTRACT

The article presents data on the change in the accumulation level of the sum of chlorophyll a + b, flavonoids and the nitrogen status of plants in a five-field grain-coupled crop rotation with different doses of organic, organomineral and mineral fertilizers. The revealed patterns of changes in the level of nitrogen nutrition of plants allow us to conclude about the positive effect of the aftereffect of organic fertilizers only in soft winter wheat and corn in the Belgorod region. The difference between the doses of mineral and organic fertilizers is significant only in the case of wheat. Increased doses of mineral fertilizers lead to a cumulative accumulation of nitrogen in the soil and, as a result, a decrease in nitrogen status in plants.

Keywords: Nitrogenous nutrition; wheat; sugar beet; barley; corn; chlorophyll; flavonoids; photometric express diagnostics; five-field crop rotation.

INTRODUCTION

Diagnostics of nitrogenous nutrition of crops is one of the urgent tasks of agriculture in general, but especially of the conditions of accurate (coordinate) farming [1,2]. Nitrogen, along with phosphorus and potassium, is one of the three main elements of plant and soil microflora nutrition [3]. The accuracy of the dosages and types of nitrogen-containing fertilizers for different crops and the methods of their cultivation [4], largely depends on the timely and correct diagnosis of the need of plants in nitrogen in specific soil, weather and other conditions prevailing at the time of nitrogen application [5].

Most often, operational diagnostics of nitrogenous nutrition of field crops is carried out on the basis of chemical methods. At the same time, the individual parts (indicator organs) are sampled from the crops and tested in the laboratory settings

(stems, leaves, leaf petioles - depending on the characteristics of the crop) [6]. As a diagnostic indicator, as a rule, the content in indicator organs of total (gross) (GOST 26889-86 [7]) or nitrate nitrogen (GOST 13496.19-93 [8]) is determined, which, if compared with the reference (optimal) content given in special tables, serves the basis for the conclusion about the level of nitrogen nutrition and, accordingly, the need to introduce nitrogen fertilizers to increase productivity or improve product quality.

Currently, photometric rapid diagnostic methods are increasingly being used, which are based on the determination of the intensity of the green color of plants or the fluorescence of chlorophyll [9]. This approach is due to the fact that the quantitative content of chlorophyll is directly proportional to the level of nitrogenous nutrition and productivity, although there is evidence that there is no relationship between these indicators [10].

At the same time, French researchers (FORCE-A) reported that polyphenols, in particular flavonoids, are indicators of the nitrogen status of plants. Under favorable conditions, the plant uses the main metabolism and synthesizes proteins (nitrogen-containing molecules), the main component of which is chlorophyll. In the case of nitrogen deficiency, the plant enhances the synthesis of flavonoids [11].

The nitrogenous nutrition metering device of French developers is based on the principle of comparing the lengths of the fluorescent wave excited in ultraviolet (UV) rays and in red light. Both waves cause chlorophyll fluorescence, but only the presence of flavonoids will influence the UV wave [12].

The difference in chlorophyll fluorescence is measured in the infrared range. This difference is directly proportional to the amount of flavonoids present in the epidermis. Using the difference between the two wavelengths, DUALEX® SCIENIFIC gives a numerical value associated with the chlorophyll contained in the measured samples. The patented FORCE-A indicator, called NBI® is the nitrogen balance index of plants, which represents the ratio of the amount of chlorophyll and flavonoids (nitrogen/carbohydrate) and provides the most accurate information on the nitrogen nutrition of crops [13,14,15].

The objective of research is to analyze the nitrogen status of winter wheat, sugar beets, barley and corn with different backgrounds of nitrogenous nutrition in a five-field grain-crop rotation. This is important because winter wheat, sugar beet, barley and corn are abundant in the study area, on the other hand, nitrogenous nutrition of crops is in great demand in the study area and it is very important to study new methods and new compounds to prepare it to meet this need.

MATERIALS AND METHODS

The studies were carried out in a long-term stationary field experiment in grain-crop row rotation: 1) autumn fallow; 2) winter wheat; 3) sugar beets; 4) barley; 5) grain corn. Each introduction of organic and mineral fertilizers involved 20 measurements of different plants. Statistical data processing was performed in Microsoft office Excel with calculation of arithmetic mean, standard deviation and confidence interval.

The ground conditions were considered the same for all crops, so that the soil of the experimental plot is a typical heavy loamy poorly washed low-humus chernozem; salt extract pH – 5.8-6.0; with an average and high content of mobile phosphorus and exchange potassium (according to Chirikov) – respectively.

As mineral fertilizer, nitrogen-phosphorus-potassium fertilizer (16:16:16) was used. It is semi-rotted cattle litter (cattle). Mineral fertilizers were applied in autumn before the main tillage (plowing to a depth of 25-27 cm). Manure was introduced in the crop rotation for winter wheat. For Photometric diagnostics the following steps were taken:

1- Photometric diagnostics of Sintetik soft winter wheat plants was carried out using the following fertilizer options: 1. Control (without fertilizers); 2. Manure - manure 40

t/ha - background; 3. Background + $N_{60}P_{60}K_{60}$; 4. Background + $N_{90}P_{90}K_{90}$; 5. $N_{60}P_{60}K_{60}$; 6. $N_{90}P_{90}K_{90}$.

2- Photometric diagnostics of Kaskad sugar beet hybrid was carried out using the following fertilizer options: 1. Control (without fertilizers); 2. Manure - manure 40 t/ha (residual effect - 1 year) - background; 3. Background + $N_{120}P_{120}K_{120}$; 4. Background + $N_{180}P_{180}K_{180}$; 5. $N_{120}P_{120}K_{120}$; 6. $N_{180}P_{180}K_{180}$.

3- Photometric diagnostics of Khadzhibei barley plants was carried out using the following fertilizer options: 1. Control (without fertilizers); 2. Manure - manure 40 t/ha (residual effect - 2 years) - background; 3. Background + $N_{60}P_{60}K_{60}$; 4. Background + $N_{90}P_{90}K_{90}$; 5. $N_{60}P_{60}K_{60}$; 6. $N_{90}P_{90}K_{90}$.

4- Photometric diagnostics of Belkorn 250 MV grain corn plants was carried out using the following fertilizer options: 1. Control (without fertilizers); 2. Manure - manure 40 t/ha (residual effect - 3 years) - background; 3. Background + $N_{60}P_{60}K_{60}$; 4. Background + $N_{120}P_{120}K_{120}$; 5. $N_{60}P_{60}K_{60}$; 6. $N_{120}P_{120}K_{120}$.

RESULTS AND DISCUSSION

The studies found that the level of accumulation of the amount of chlorophyll a + b significantly increases with the introduction of nitrogen fertilizers in mineral form, and the effect of the introduction of organic fertilizers is not reliable (Figs. 1, 2, 3, 4). The difference in the accumulation of the sum of chlorophyll a + b at different doses of mineral fertilizers is insignificant, and in the case of barley and corn (Figs. 3, 4) even the arithmetic mean for higher application doses is lower. The effect of applying only organic fertilizers is insignificantly higher in all crops except corn (Fig. 4). This effect is due to the high degree of responsiveness of corn to organic fertilizers (Gray). The combined action of mineral and organic fertilizers significantly increases the synthesis of chlorophyll a + b compared to mineral fertilizers only in wheat (Fig. 1). The obtained effect of the action of organomineral fertilizers only in wheat is explained by the previous autumn fallow, which leads to an increase in the biological absorption of nutrients (in particular, nitrogen), as well as the prevention of its leaching from the soil (Eremin & Dunchev, 2019; [16]).

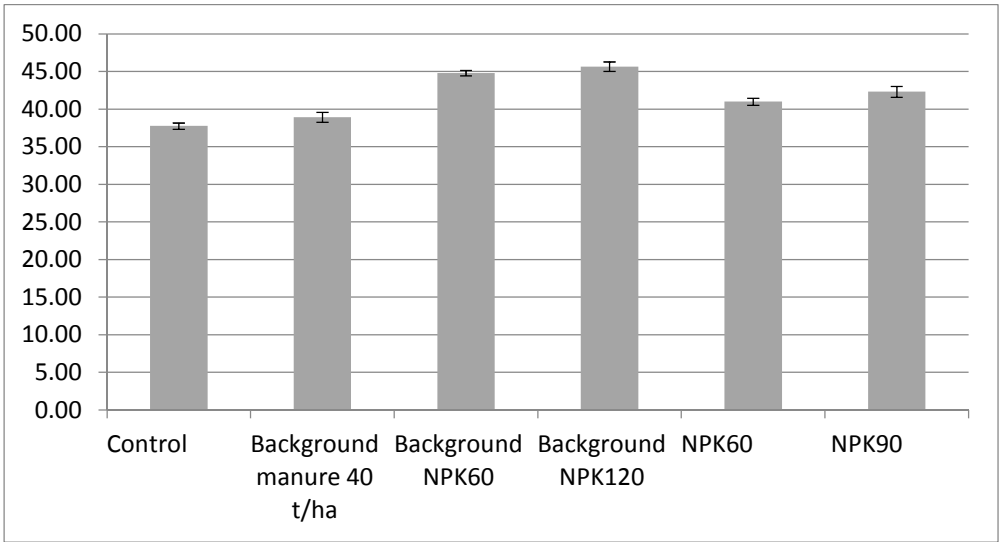

Fig. 1. The level of chlorophyll accumulation under different conditions of nitrogen nutrition of soft winter wheat cultivar 'Synthetic' (axis Y mg/cm^2 of chlorophyll a+b)

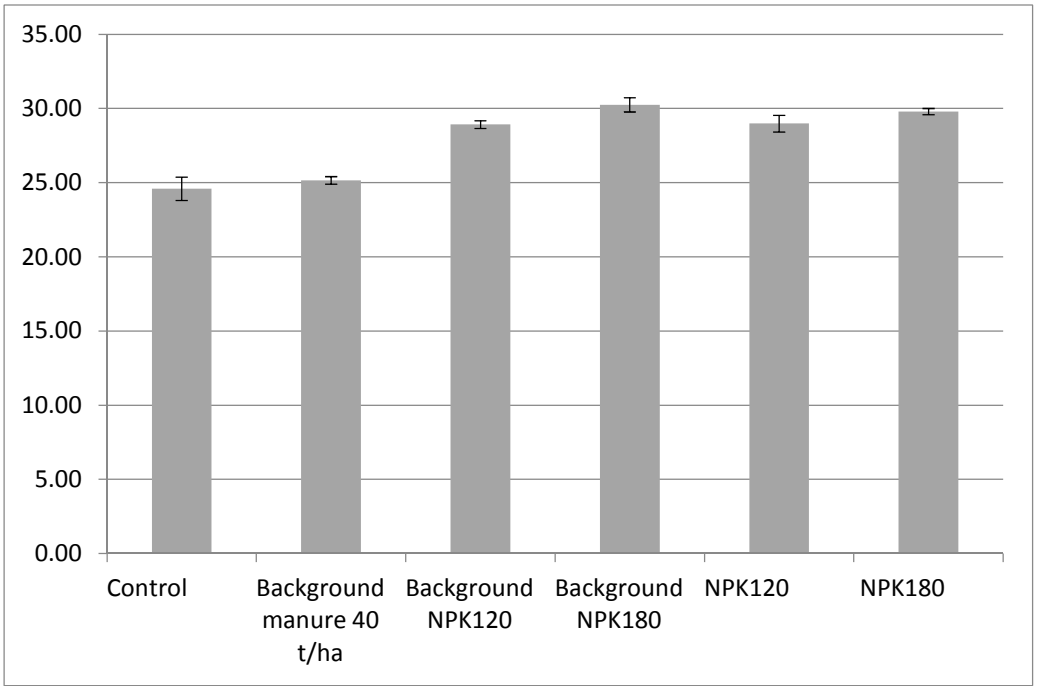

Fig. 2. The level of chlorophyll accumulation under different conditions of nitrogen supply of sugar beet of the Cascade hybrid (Y axis mg/cm^2 of chlorophyll a+b)

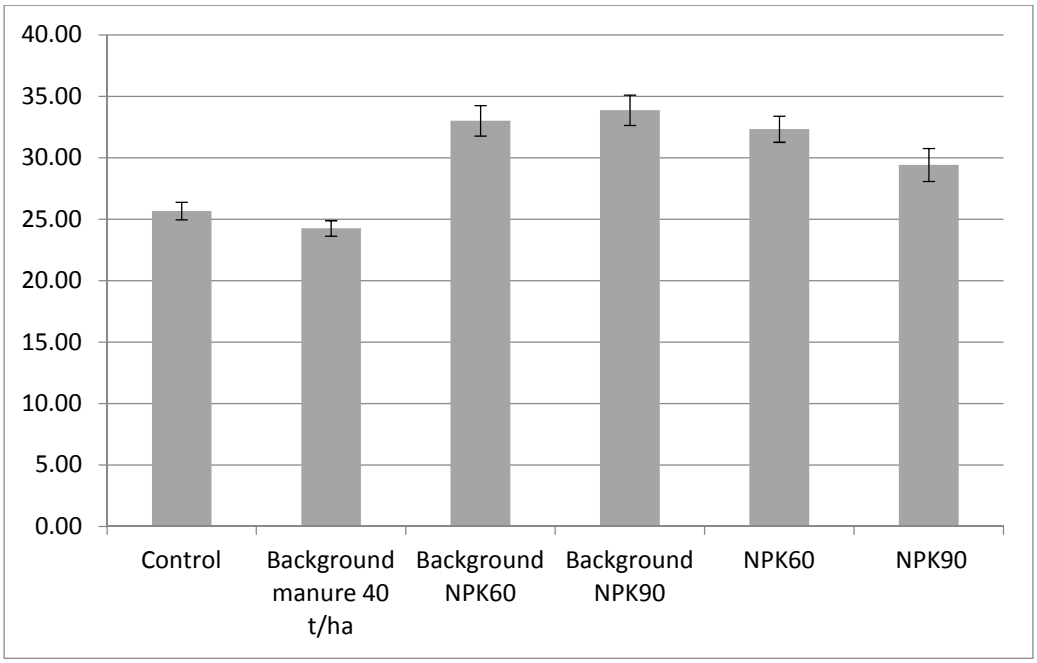

Fig. 3. The level of chlorophyll accumulation under different conditions of nitrogen nutrition of spring barley of the 'Hadzhibey' variety (Y axis mg/cm^2 of chlorophyll a+b)

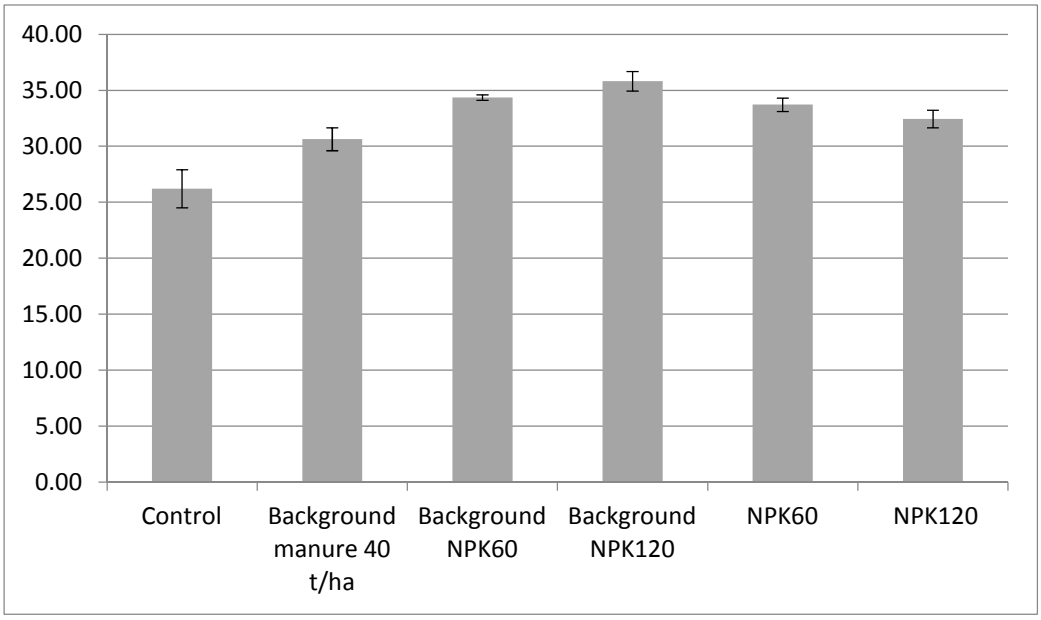

Fig. 4. The level of accumulation of chlorophyll under different conditions of nitrogen nutrition of maize hybrid 'Belkorn 250' (axis Y mg/cm^2 of chlorophyll a+b)

The intensity of accumulation of flavonoids in the leaves was determined by the introduction of organic and mineral fertilizers. It was inversely related to chlorophyll a + b and was reliably confirmed for all crop rotation crops (Figs. 5, 6, 7, 8). However, for spring barley of the Khadzhibei variety, the aftereffect of organic fertilizers is not reliable (Fig. 8).

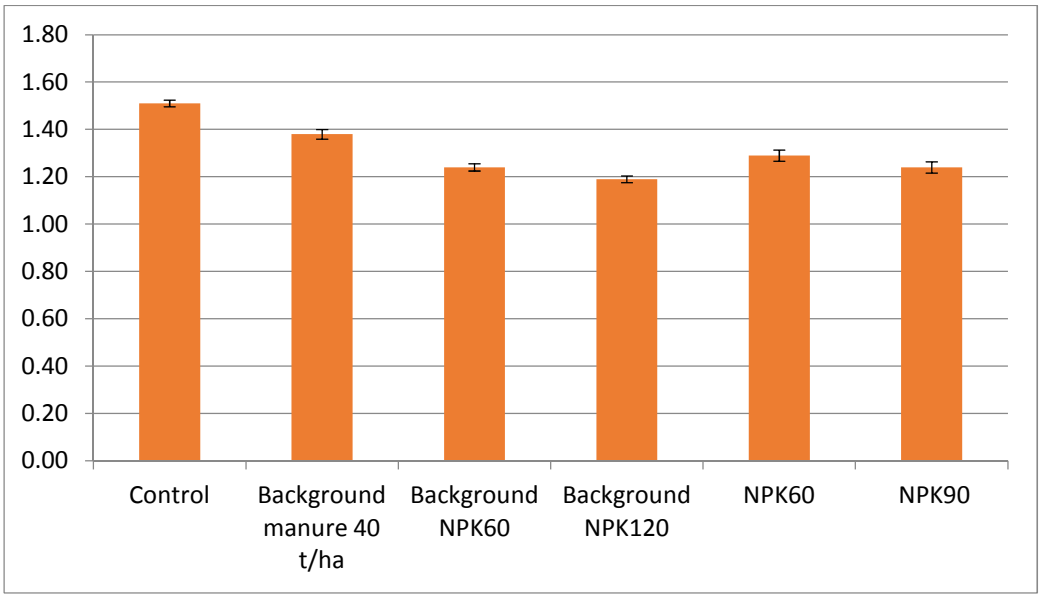

Fig. 5. The level of accumulation of flavonoids under different conditions of nitrogen nutrition of soft winter wheat cultivar 'Synthetic' (Y axis mg/cm^2)

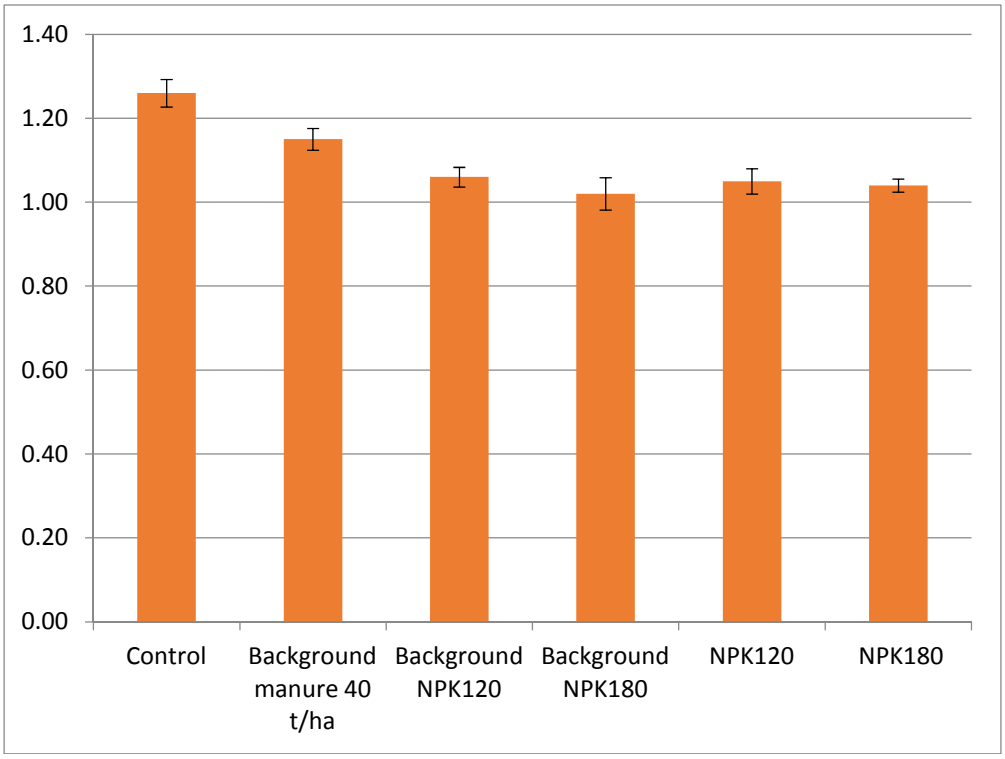

Fig. 6. The level of accumulation of flavonoids in different conditions of nitrogen nutrition of sugar beet of the hybrid 'Cascade' (Y axis mg/cm^2)

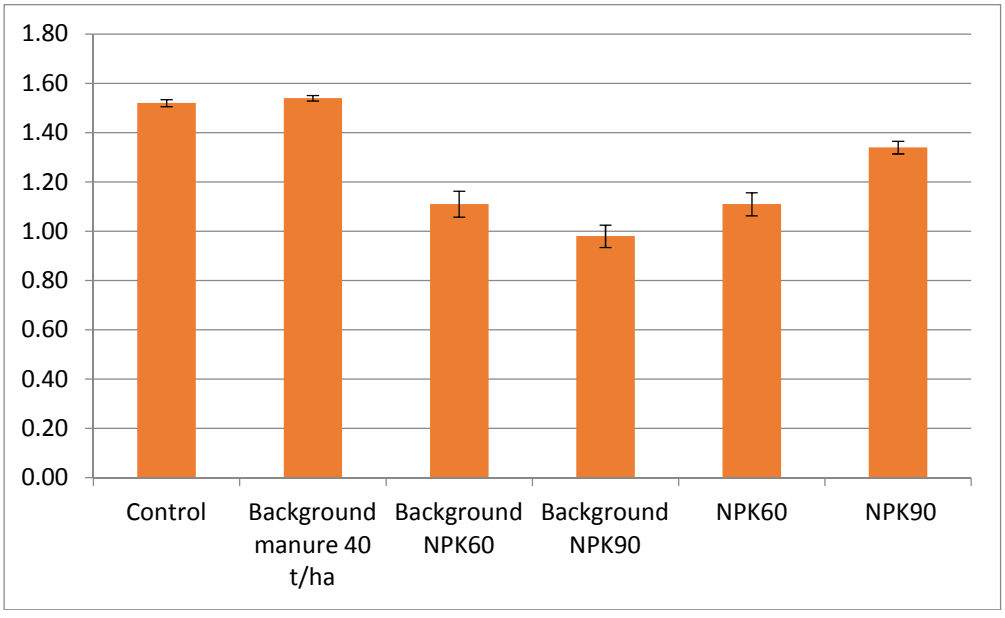

Fig. 7. The level of accumulation of flavonoids in different conditions of nitrogen nutrition of spring barley of the 'Hadzhibey' variety (Y axis mg/cm^2)

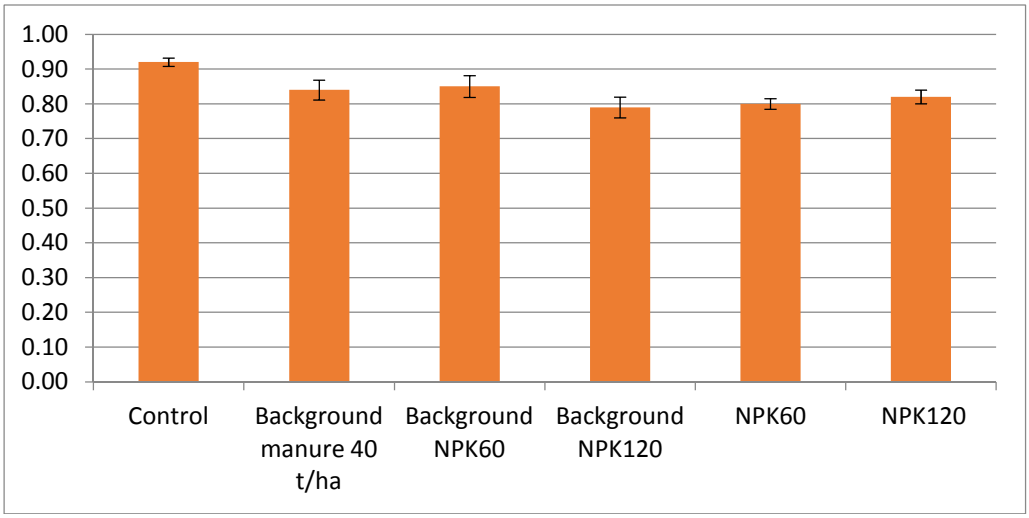

Fig. 8. The level of accumulation of flavonoids in different conditions of nitrogen nutrition of maize hybrid 'Belkorn 250' (Y axis mg/cm^2)

Based on the NBI index proposed for assessing the level of nitrogen nutrition, we found a significant high degree of nitrogen status in soft winter wheat in the crop rotation, both when applying organic, organic-mineral and mineral fertilizers. For other crop rotations, the difference between different doses of organic and mineral and mineral fertilizers was not reliable, and for barley, only mineral fertilizers at a dose of 90 kg/ha gave even lower values than at a dose of 60 kg/ha. The effect of manure is visible in wheat only. In the rest of the crops, the increase in nitrogen status was not significant (Figs. 9, 10, 11, 12).

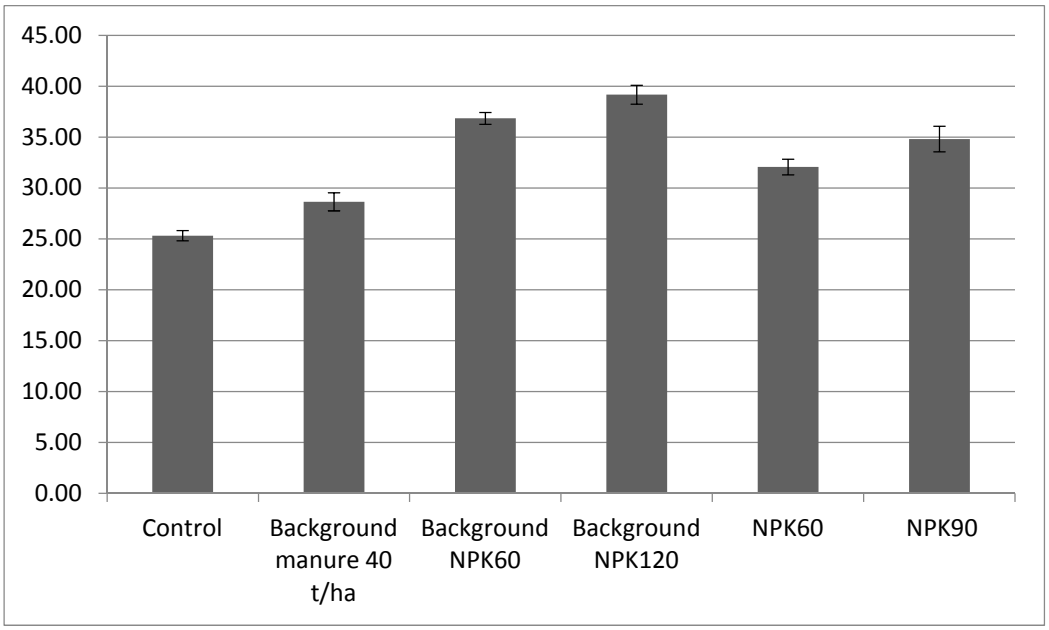

Fig. 9. The level of nitrogen nutrition in different conditions of nitrogen nutrition of soft winter wheat cultivar 'Synthetic' (Y axis in units of dualex)

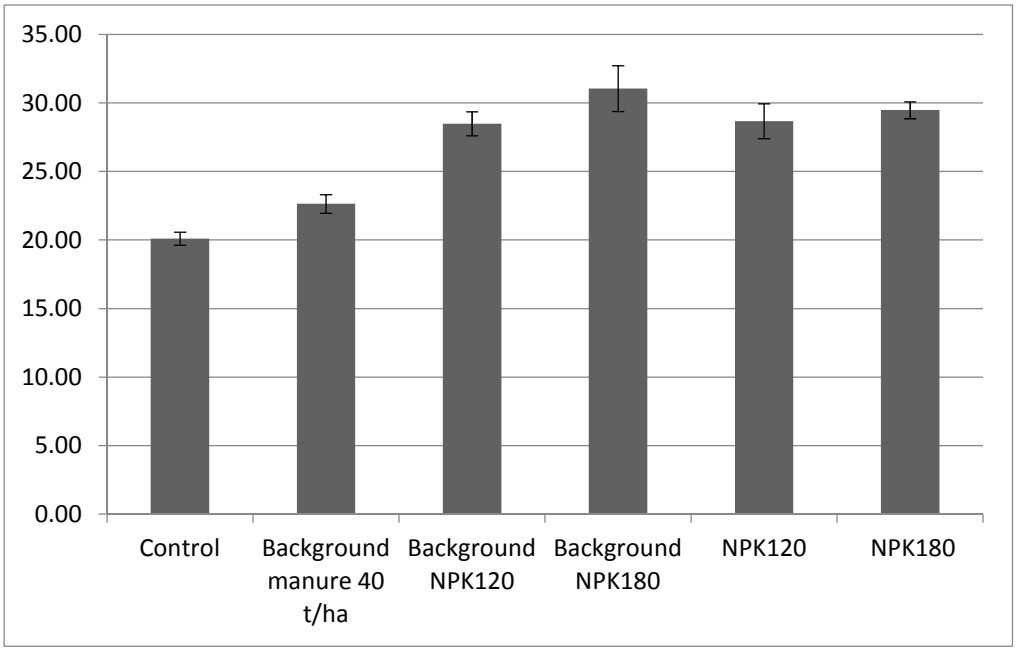

Fig. 10. The level of nitrogen nutrition in different conditions of nitrogen nutrition of sugar beet of the cascade hybrid (Y axis in dualex units)

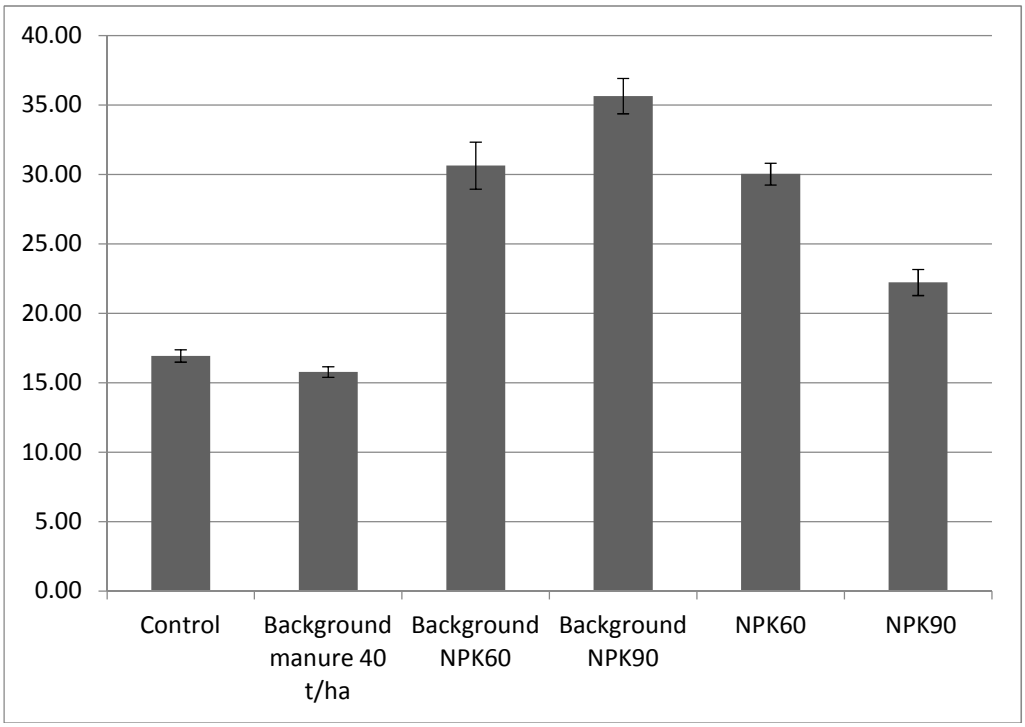

Fig. 11. The level of nitrogen nutrition in different conditions of nitrogen nutrition of spring barley of the 'Hadzhibey' variety (Y axis in dualex units)

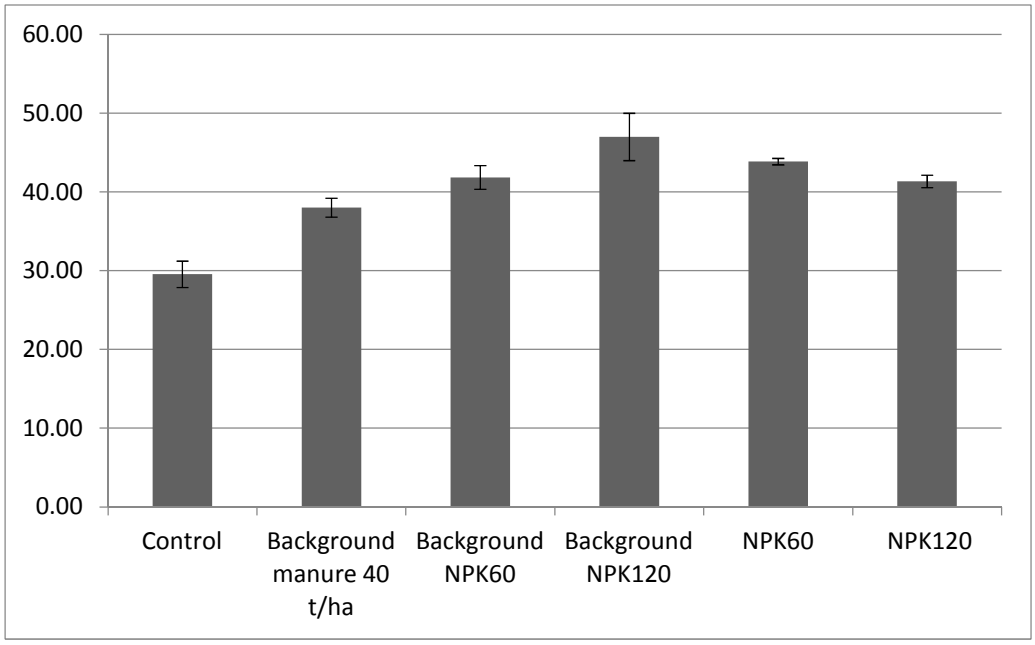

Fig. 12. The level of nitrogen nutrition in different conditions of nitrogen nutrition of maize hybrid 'Belkorn 250' (Y axis in units of dualex)

Secondary metabolites are organic compounds that are not directly involved in the growth or reproduction of a living organism. For many years, humanity has used this feature in medicinal plants in various industries such as industrial, pharmaceutical, health an Unlike primary metabolites, such as carbohydrates, proteins, and nucleic acids, the absence of secondary metabolites does not lead to immediate death, but may in the long run impair the survival, fertility, or appearance of the organism or may not cause any noticeable change.

These compounds often play an important role in the plant defense system against vegetarianism and other interstitial defense systems. Because plants are not mobile, they have evolved with a great deal of physiological flexibility to adapt to fluctuating external conditions. In addition, many plant species are dependent on animals for sexual reproduction and seed dispersal. Among the adaptive responses of plants to environmental stresses is the ability to synthesize many types of these chemical compounds.

Secondary metabolites are widely used in industrial products and are used in the manufacture of medicine, soap, essential oils, dyes, gums, resins, rubber, food seasonings and beverages, etc. These compounds in the plant itself have important functions such as the function of hormones and growth regulators, microbial contamination, absorption of pollinators and also repel herbivores and insects, which thus reduces the damage to animals and insects and help producing plants to Survive in their ecosystem. Plants use these compounds, which belong to different chemical families, including alkaloids and flavonoids, to protect themselves against microbial attacks, herbivores and ultraviolet radiation. Secondary metabolites also play a key role in the uptake of pollinating insects (especially anthocyanin pigments and terpenoids) and in other beneficial interactions with other organisms.

The general tendency to increase the synthesis of flavonoids at a low level of nitrogen supply to plants is explained by the stress response of plants [17]. Nitrogen status and the level of accumulation of chlorophyll depend strictly on crops. However, varietal or hybrid features should not be excluded to contribute to these values.

CONCLUSION

The study suggests that the application of organic fertilizers for chernozems of the Belgorod region significantly affects the level of nitrogenous nutrition in plants in a five-field crop rotation only in wheat, while mineral fertilizers lead to a significant increase in the nitrogen status in all crops. The lack of a significant increase in the level of nitrogen status of plants with increasing doses of applying only mineral fertilizers (except wheat), and even a decrease in the case of barley, may be due to high doses of fertilizers for sugar beets (preceding crops), which leads to moisture deficiency and decreased photosynthetic activity. Crops following wheat in a crop rotation have no need to introduce maximum doses of fertilizers, since this does not significantly increase the nitrogen status of plants. And in the case of barley, it even leads to the opposite effect.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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