FORMATION OF THE BASIC BIOCHEMICAL INDICATORS OF WINTER WHEAT GRAIN QUALITY ON THE FERTILIZERS BACKGROUND AND PREDECESSORS

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Abstract: *According to the many years of research results in a stationary field experiment on southern chernozems, it has been shown that the systematic use of fertilizers for black and green fallow provides the production of winter wheat grains with protein and gluten that meets the requirements of the first class (protein is not ≤14.0%, gluten is not ≤28, 0%); for MBC corn, winter rapeseed and winter wheat - the requirements of the second class (protein content is not ≤12.5%, gluten is not ≤23.0%). For the zone of the Black Sea steppe of Ukraine, the payback options of an active substance unit of organic, mineral and organo-mineral fertilizers are determined by the growth of protein and gluten content in winter wheat grain.*

Keywords: *agriculture, fertilizers, sustainable development, winter wheat.*

Classification JEL: *Q Agricultural and Natural Resource Economics; Environmental and Ecological Economics. Q010 Sustainable Development.*

INTRODUCTION

The Black Sea steppe is one of the main regions of Ukraine, supplying winter wheat grain with a high content of protein and gluten. This is mainly due to the peculiarities of the climate: the presence of frequent and prolonged droughts, especially during the period of grain filling. However, even under the same weather conditions and within the same enterprise, quality indicators are not stable, since they are the product of not only weather conditions, but also the level of fertility of a particular field, as well as all parts of the cultivation technology: compliance with crop rotation, tillage, sowing dates, the fertilizers use, plant protection systems, etc. [1, 5, 6].

Fertilizers have the most effective and powerful effect on the winter wheat quality of [2-4]. And since cereal crops remain the main source of vegetable protein, it is important to establish which doses and elements ratios in the winter wheat fertilizer system will ensure their greatest payback not only by yield increases, but and an increase in quality, especially increases in the content of raw protein and gluten proteins.

MATERIALS AND METHODS

To achieve this research goal, the materials of a long-term stationary experiment with fertilizers, which was laid down in 1972 on the experimental field of the Odessa State Agricultural Experimental Station, were systematized and processed. Soil - southern low-humus chernozem clayey-loamy on the loess. Four rotations was fallow - grain - row-crop rotation took place, in which the predecessors of winter wheat were black fallow, peas and maize of milk-wax maturity, and two rotations of fallow - grain with predecessors were black fallow, winter rapeseed, green manure and winter wheat after green manure (i.e. stubble).

The experience scheme constantly includes 17 options. Of the first 4 rotations, 7 options (variants) are presented: 1- control without fertilizers, in which the nutrition background was formed due to crop rotation; 2 - the first organic (O1), where an average of 64 tons of manure per hectare of arable land was introduced; 3 - second organic (O2 - 80 t ha^{-1}); 4 - mineral (M - an average of 4 rotations for wheat was $N_{75}P_{52.5}K_{52.5}$; 5 - organo-mineral (O1 + M1 - O1 + $N_{50}P_{40}K_{35}$); 6 - organo-mineral (O2 + M1); 7- organo-mineral (O1 + M2 - O1 + $N_{75}P_{52,5}K_{52,5}$) and 8- organo-

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mineral (O2 + M2). The indicated norms of manure were introduced in two doses: for black fallow and for corn.

The passage of the following 2 rotations coincided with the period of reorganization of Ukraine as an independent state, which in the agricultural sector caused a sharp reduction in the number of livestock, and hence the yield of manure. Therefore, the introduction of manure was replaced by a green manure crop, the mass of which was planted into the soil during the budding phase - the beginning of flowering. Of the options for the 5-6th rotation, the following are presented: control; N_{60}; N_{120}; N_{180}; $N_{60}P_{30}K30$; $N_{120}P_{30}K_{30}$; $N_{180}P_{30}K_{30}$; $N_{60}P_{60}K_{60}$; $N_{120}P_{60}K_{60}$; $N_{180}P_{60}K_{60}$. As mineral fertilizers used ammonia nitrate, nitrogen-phosphate, superphosphate simple granular and potassium salt.

The experience is located in four permanent fields, entering the crop rotation is carried out in one field; 3-fold repetition in the experiment with the systematic placement of variants and repetitions. The total area of the plot is 240 m^2, accounting 88 m^2.

To protect winter wheat crops from diseases and pests, an integrated method of protection was used, combined soil cultivation generally accepted for the cultivation zone. Harvesting and harvesting were carried out using the Sampo-500 combine.

Grain sampling and determination of quality indicators were carried out by standard methods: the quantity and quality of gluten — Ukrainian national standardization system 13586.1-68 [7], the protein content — by infrared spectroscopy on a Spectran-119M instrument — Ukrainian national standardization system 4117: 2007 [8]. Mathematical processing of the results was carried out using the Excel and Statistic software package, using the methods of variance and correlation - regression analyzes [9].

RESULTS AND DISCUSSIONS

A generalization of long-term data showed that the food properties of wheat grains are determined not only by fertilizers, but also by the quality of the precursor (Table 1).

Table1 – The influence of predecessors on grain quality

Predecessors	Years	Protein, %		Gluten, %		Gluten quality	
		K*	Y*	K	Y	K	Y
Black fallow	1973-2017	12.20	14.18	22.3	29.0	83.6	86.0
Green fallow	2011-2019	11.90	14.16	20.6	28.8	79.9	82.8
Peas	1976-2005	11.31	13.48	20.2	27.2	88.3	86.2
Corn	1978-2007	10.93	12.55	18.7	24.9	87.1	86.2
Winter rape	2009-2019	10.62	13.02	16.9	23.9	87.7	81.9
Winter wheat	2012-2016	11.97	13.82	19.9	25.8	80.5	78.4

**K– control; *Y – average for fertilizer options*

In the control variant, the grain quality was ensured by the level of natural fertility, a background of nutrition due to crop rotation and a specific predecessor. Thus, the protein content in the dry matter of winter wheat grain during the transition from fallow to winter rapeseed naturally decreased from 12.20% to 10.62%, gluten content - from 22.3% to 16.9%. With the systematic use of fertilizers, these parameters are higher, but a similar trend persists: the protein content of the grain decreases from 14.18% to 13.02%, the gluten content - from 29.0% to 23.9%. The overall picture on the stubble predecessor is slightly disturbed, perhaps this is due, firstly, to a sample for a relatively small period (5 years) and, secondly, with the fact that almost all five years differed in extremely arid conditions during the period of grain filling. It is known that under such conditions a grain with a high protein content is formed [3, 10]. For the other predecessors, there were longer observation periods, in which there was still an alternation of favorable and varying degrees of arid conditions of the spring-summer vegetation of the culture.

The correlation and regression analysis showed a high degree of influence of the precursor on the process of protein and gluten formation in winter wheat grain: on unfertilized variants 98% and 96%, for fertilizer options, 75.7% and 92.2%, respectively (when calculating paired correlation coefficients). The influence of the precursor on the quality of gluten is much lower and amounts to only 13.0%. With an increase in the dose of fertilizer application, the protein content of wheat grain also increases, which is well illustrated by Figure 1 and 2. On average for 5-6 rotations, the protein content in the grain of the control variant was 11.68%, with N_{60} - 12.76%; N120 - 14.02% and N_{180} -14.84%. Despite significant fluctuations over the years, within each year, the protein content in fertilized variants is higher than the control.

Figure 1 - Protein content in the grain of winter wheat, depending on the dose of mineral nitrogen precursor black steam, % (5-6 rotation)

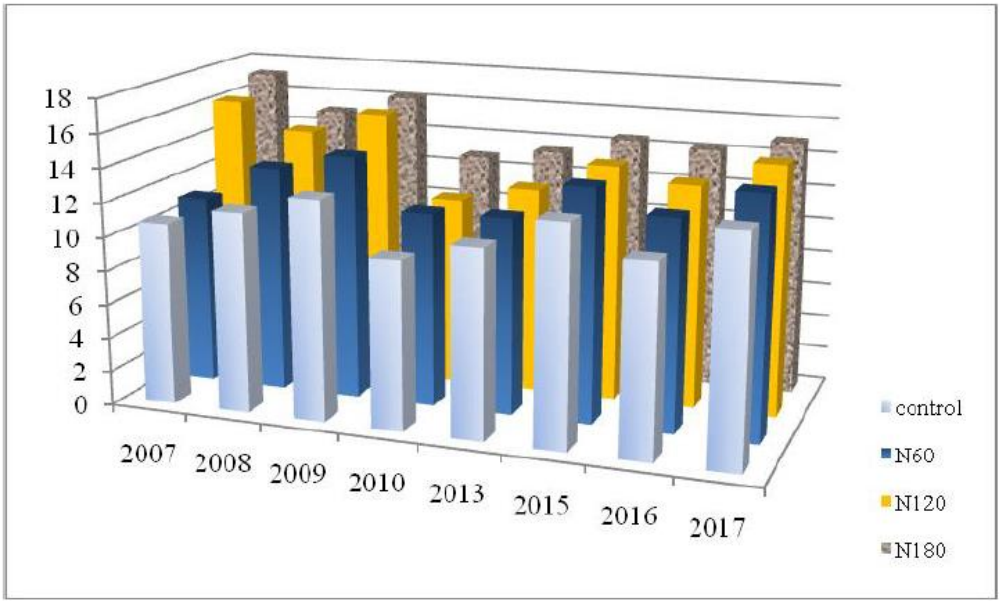
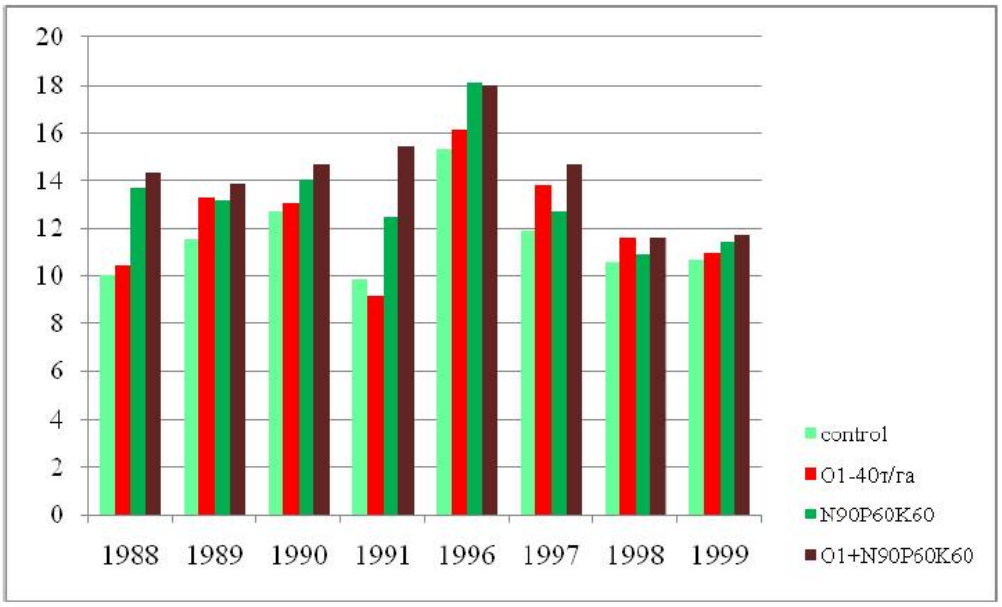


Figure 2 - The influence of fertilizer systems on the protein content in the grain of winter wheat on the precursor of corn, % (application doses are given in 2-3 rotations)



A similar situation is observed when growing winter wheat in maize for silage (Fig. 2). As an example, data are given for years of observations in the second and third rotations for four nutritional backgrounds: zero, where the average protein content in winter wheat was 11.58%, at the aftereffect of manure application at a rate of 40 t ha^{-1} - 12.30%, for the mineral fertilizer system -

13.30% and the organo-mineral - 14.30%. Similar results were obtained, for example, on the typical chernozems by S.I. Popov et al. [11], Yu.I. Krivda and others in the conditions of the Right Bank of the Central Dnipro [12].

One of the important indicators of the effectiveness of fertilizers on winter wheat crops is their payback by the growth of grain and gluten. According to the precursor of maize (Figure 3, 4), the highest payback of fertilizers by increments in protein (14.2 and 19.2 mg) and gluten (48.0 and 62.2 mg) was observed when using organo-mineral fertilizer systems, where, on average, they were applied by background O1 and O2 $N_{50}P_{40}K_{35}$.

Figure 3 - Payback of a fertilizer unit with protein growth, mg % per 1 kg (t)
(average for 1973-2007)

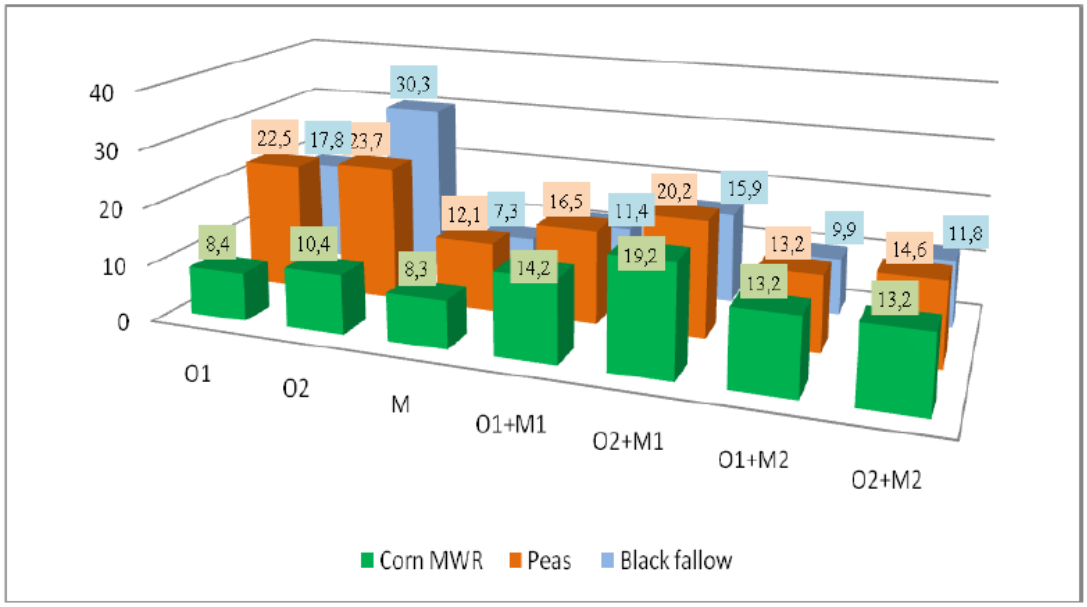
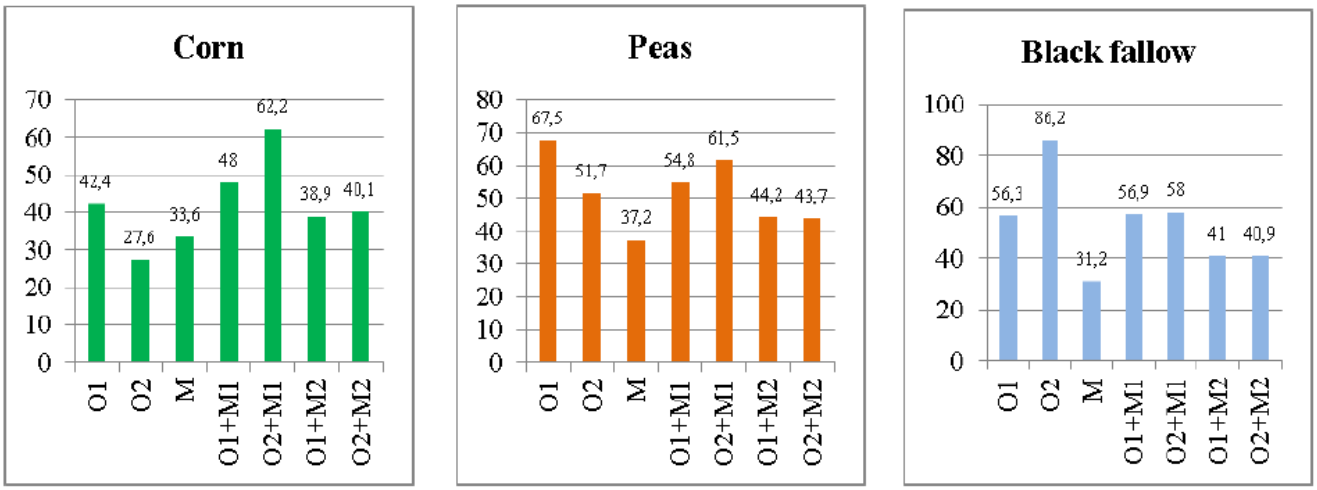


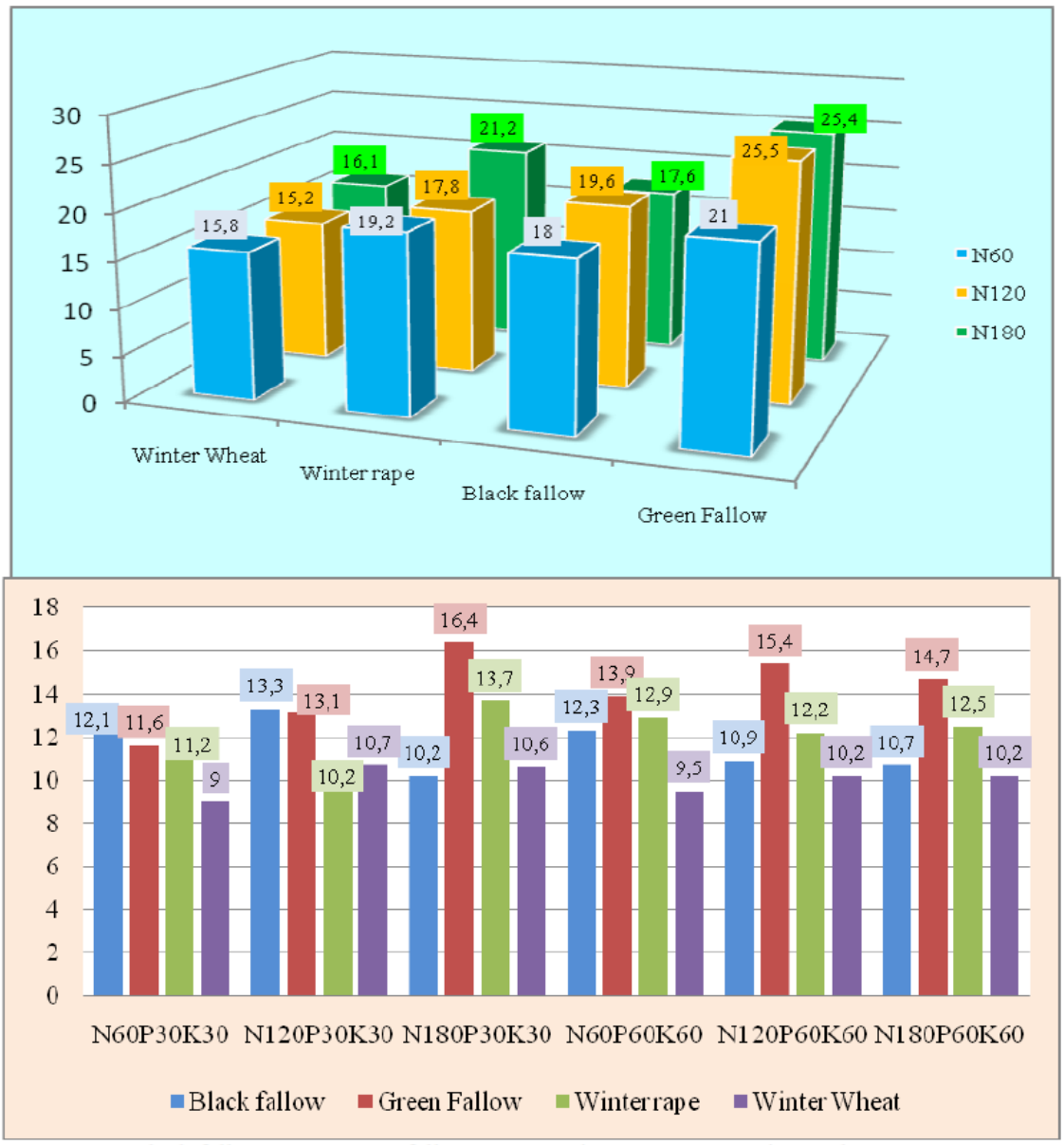
Figure 4 - Payback of a fertilizer unit with gluten growth, mg% per 1 kg (t)
(average for 1973-2007)



When growing winter wheat with peas, the maximum payback with protein (22.5–23.7 mg) was due to the addition of organic matter (O1 and O2), and gluten (67.5 mg) was a consequence of adding 32.0 t ha^{-1} of manure and when using background O2 mineral fertilizer $N_{50}P_{40}K_{35}$ (61.5 mg). According to the precursor, black fallow has the most effective effect on increasing the protein content (+30.3 mg) and gluten (+86.2 mg), an organic fertilizer system was allocated, where 40 t ha^{-1} of manure was introduced under the precursor; organo-mineral systems also had a positive effect on gluten growth: O1 + M1 (+56.9 mg), O2 + M1 (+58.0 mg).

An analysis of the mineral fertilizer systems that were used during the fifth and sixth rotations according to the sideration background showed that for almost all doses of fertilizer application, their effectiveness was mathematically provable with respect to the zero variant and only when using $N_{60}P_{30}K_{30}$ for the green manure fallow - at the confidence level (Fig. 5).

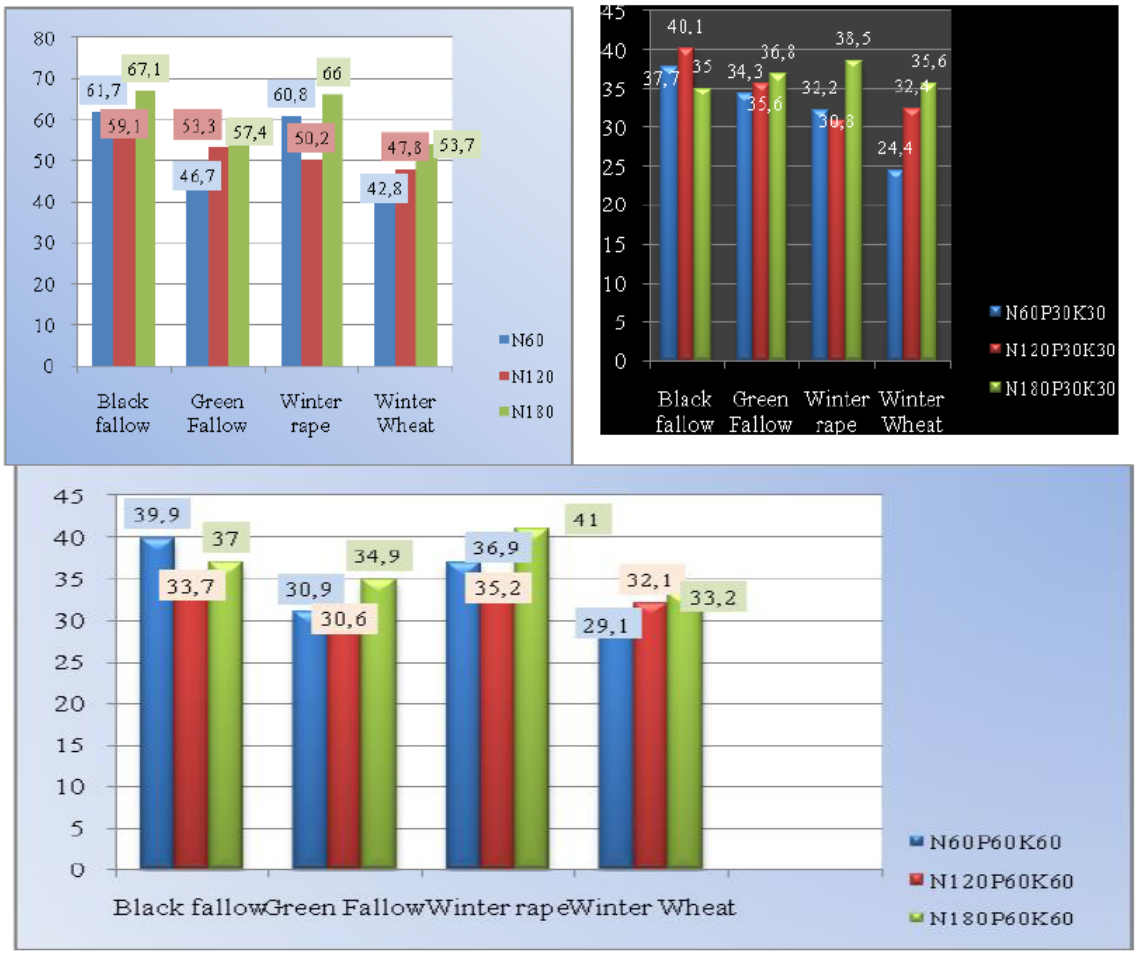
Figure 5 - Fluctuations in the growth of protein content in winter wheat grain depending on the doses of mineral fertilizers, mg kg^{-1} a.s. (average for 2002-2019)



Black fallow - 7.0; Green fallow - 11.5; Winter rape -7.1; Winter wheat -5.2

With increasing doses, the application of mineral nitrogen from 60 to 180 kg, the payback of 1 kg of the active substance increased, but the values did not differ from each other, which is also natural for the use of these doses of nitrogen as part of a complete mineral fertilizer, although the differences were clearer within the precursor. So, according to the precursor, $N_{120}P_{30}K_{30}$ - 13.3 mg kg^{-1}; for green manure and winter rapeseed $N_{180}P_{30}K_{30}$ - 16.4 mg kg^{-1} and 13.3 mg kg^{-1}, respectively; according to the stubble predecessor, they fluctuated in a rather narrow range: from 9.0 to 10.7 mg kg^{-1}, but nevertheless a large payback of 10.6 and 10.7 mg kg^{-1} was provided by the introduction of N_{120} and N_{180} according to the background of $P_{30}K_{30}$.

Figure 6 - Dependence of the payback of mineral fertilizers with gluten growth against the background of different doses and predecessors, mg kg^{-1} (average for 2002-2019)



Minimum difference 095: black fallow - 27.2; sidereal fallow - 23.4; winter rapeseed -21.2; winter wheat -12.2

The supply of a unit of mineral nitrogen with gluten growth was the highest when N_{180} was added and amounted to 67.1 mg for black fallow, 57.4 mg for sidereal fallow, 66.0 mg for winter rape and 53.7 mg for stubble (Fig. 6). The same nitrogen rate when applied both in the background of $P_{30}K_{30}$ and in the background of $P_{60}K_{60}$ showed greater efficiency with respect to lower doses of nitrogen in the composition of a complete mineral fertilizer for all precursors except black fallow. When growing wheat by black fallow, the maximum gluten gains per unit of active substance NPK were observed with the addition of $N_{120}P_{30}K_{30}$ (40.1 mg) and $N_{60}P_{60}K_{60}$ (39.9 mg). And although the differences in gluten growth by fertilizer options are not significant, it must be borne in mind that when applying N_{180}, $N_{180}P_{30}K_{30}$, $N_{180}P_{60}K_{60}$, the concentration of protein and gluten in the grain meets the requirements of the first class, regardless of the predecessor and weather conditions of the growing season; with a decrease in the dose of nitrogen to 120 kg ha^{-1}, the grain quality fluctuates between the first and second class, and at N_{60} in different combinations, between the second and third class.

If we return to the results of the study on the first four rotations, it should be noted that in general, the mineral and organo-mineral fertilizer systems for protein and gluten content ensured the production of Grade 2 grain (the actual gluten content was 24.5% compared to the required 23.0%, and protein 13.47-13.97% versus the required 12.5%), organic systems - according to the gluten content - are of the 2nd class, and protein is of a lower class (12.24%).

CONCLUSIONS

Based on the results of many years of field research, the following conclusions can be drawn:

- the systematic use of fertilizers for black and green manure fallow provides the production of winter wheat grains with protein and gluten content corresponding to the requirements of the first class (protein is not ≤14.0%, gluten is not ≤28.0%); for corn, winter rapeseed and winter wheat - the requirements of the second class (protein content is not ≤12.5%, gluten is not ≤23.0%);

- for the zone of the Black Sea steppe of Ukraine, the parameters for the payback of a unit of active substance of organic, mineral and organo-mineral fertilizers are determined by increments in the content of protein and gluten in winter wheat grain;

- the payback of a purely mineral fertilizer system at $N_{75}P_{52.5}K_{52.5}$ standards without the background introduction of manure and green manure below organic (64-80 tons of manure per 1 ha of arable land) and organo-mineral systems and, depending on the precursor, amounts to protein growth: 8.3 mg kg^{-1} a.s. (corn MVS), 12.1 mg kg^{-1} a.s. (peas), 17.3 mg kg^{-1} a.s. (black fallow); gluten growth - 33.6-37.2-31.2, respectively.

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