

UDC 631.1:631.8:633.1

DOI: 10.15587/2313-8416.2018.127018

## THE EFFECT OF NITROGEN FERTILIZER APPLICATION TIME ON THE YIELD, QUALITY AND FRACTIONAL COMPOSITION OF WINTER WHEAT GRAIN AFTER DIFFERENT PRECURSORS UNDER CONDITIONS OF THE SOUTHERN STEPPE OF UKRAINE

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*Наведені результати застосування позакореневого підживлення пшениці озимої різними нормами азотних добрив, що вирощуються після попередників чорного пару, гороху і ріпаку озимого та їх вплив на урожайність, якість і фракційний склад зерна. Показано, що термін весняного підживлення мало впливає на якість зерна при вирощуванні пшениці по чорному пару і гороху; по попереднику ріпак озимий підживлення слід проводити з фази масового трубкування*

**Ключові слова:** пшениця озима, підживлення, карбамід, якість, урожай, білок, клейковина, фракція, кореляція

### 1. Introduction

Within the structure of agroindustrial production, in the field of plant cultivation, at planting grain crops, Ukrainian economies specialize in two directions: in seed production and planting food grain. Requirements to the quality of a caryopsis are different at that. In seeds it is desirable that caryopses are big, with a great mass. In food grain, on the contrary, it must not obligatory have a high mass, but the higher protein content, the better quality, the higher price, the more profit.

Production of high-quality winter wheat grain is the most problem of agriculture of Ukraine. Complicated economic conditions of the period of establishing the statehood resulted in the abrupt worsening of quality parameters, even in the steppe zone, traditionally considered as a production zone of strong and high-value grain. During the last years food grain, produced in Ukraine mainly (67–75 %) didn't correspond to requirements of quality of the third and higher classes, when the gluten content  $\geq 18,0$  %, and protein concentration in grain is higher than 11,0 %. Fodder grain (sixth quality class, protein content no less than 10,5 %) stably forms a third of total volumes, delivered to bread-receiving stations. For Odessa region, I–III class grain volumes vary within 52,3...24,5 % by years [1].

At the same time the high quality of grain is a guarantee of the economic growth and indicator of a condition of a state and country in whole, because it gives a possibility to come at international markets. The internal market doesn't give to agricultural enterprises a possibility to raise profitability of the grain economy because of disparity of prices for grain realization that grew only by 42 % during the last decade and cost price of the production that grew in 2,9 times during the same period

at the expanse of increased prices for energy sources, fertilizers, means of plants protection. At the world market the demand for high-quality grain grows continuously and leaves supply essentially behind, so high quality grain it is an important export article that gives an important positive contribution in the state economy.

The quality of products depends on many factors, the most important among them are systems of plant nutrition, climatic conditions of their cultivation and level of soil yield. Without organizing the effective mineral nutrition and correct nitrogen feeding, winter wheat cultivation is low-profitable, doesn't cover expenditures for seeds, fertilizers, pesticides, agrotechnique and so on [2].

### 2. Literary review

Application of fertilizers taking into account biological peculiarities of a crop itself and soil-climatic conditions is a necessary component of a complex of arrangements, directed on improving the grain quality and winter wheat yield [3]. The high exactingness of this grain crop to nutrition is explained by the fact that its root system is characterized with a low ability to assimilate nutrition elements of hardly soluble soil compounds [4]. Determination of optimal doses and terms of introducing fertilizers, first of all, nitrogen, – is the main condition of their successful use, but discordances in research results are observed just in this question. Thus, the experiments demonstrated that under dry conditions the term of using nitrogen fertilizers almost didn't influence the profitability of winter wheat cultivation, and their effectiveness depended on precipitation and soil humidity [5]. Determination of a strategy of using nitrogen fertilizers on grain crops has the important value for raising their yield and production quality [6], moreover the pro-

tein content in winter wheat grain directly depends on the application norm [7].

The experiments, conducted at the Mykolaiv SAES (southern steppe) indicate the necessity of three-time feeding: for increasing the yield by 3–4 c/he –  $N_{35-45}$  in frozen-melted soil +  $N_{30}$  before plants outgoing in a tube, the third one with the norm  $N_{10-20}$  – from heading to milk ripeness – favors the increase of the protein content by 0,9–1,2 % and gluten – by 3–7 % [8]. In other experiments of the same zone, at the intensive technology that provided the main application of  $N_{30}P_{60}$  and additional fertilizer  $N_{40}$  – renovation of spring vegetation (RSV) +  $N_{30}$  at the beginning of outgoing in a tube +  $N_{30}$  in the phase of milk ripeness, there was obtained the increase of productivity after precursors in average in 1,7–2,1 times depending on variety [9].

Under conditions of the Southern steppe at cultivating winter wheat by the precursor black fallow, grain is not lower than the second quality is obtained at introducing nitrogen in total amount up to 90 kg/he at feeding, the effectiveness of increased doses of  $N_{120-150}$  was lower [10, 11].

Scientists of the Forest-Steppe of Ukraine studied the effectiveness of the one-time fertilizing on frozen-melting soil by the norms from  $N_{30}$  to  $N_{120}$  and considered  $N_{90}$  as an optimal norm (precursor – pea), that provided the yield increase by 9,8 % and gluten content at the level of requirements to the first quality class (28,9 %), although at  $N_{30}$  they obtained grain of the 2 class, but with unessential (by 1,4 %) productivity growth. The authors observed a tendency to decreasing the mass of 1000 grains and nature at feeding by the norms  $N_{90}$  and  $N_{120}$  [12].

Thus, the problem of the influence of norms and terms of feeding winter wheat by mineral nitrogen on the crop productivity and grain quality, especially in the section of soil-climatic zones remains debatable.

### 3. Aim and tasks of research

The aim of the research – is to optimize nitrogen nutrition of winter wheat under dry conditions of the Southern Steppe.

For achieving the aim, the following tasks were set:

1. To establish optimal terms and norms of adding nitrogen fertilizers at cultivating winter wheat after different precursors for conditions of the Southern Steppe.
2. To study changes of quality parameters depending on precursor, norms and terms of adding mineral nitrogen.

### 4. Material and methods of research

Field temporary experiments were conducted during 2009–2013 in the crop rotation on the experimental field of Odessa state agricultural experimental station of NAAS of Ukraine, placed in the Western suburbs of Odessa. The territory of lands relates to the first technological group by steepness of slopes.

Natural climatic zone – Steppe; agro-soil province – DS – 1: Dry Steppe near Black Steppe. Soil of experimental plot – southern chernozem, little-humus, hardly loam on the forest rock. The power of the humus horizon 50–55 cm. The arable layer of soil had the following agrochemical characteristic: humus content 2,95 %; pH of aqueous extract 7,8; content of easily-hydrolyzed nitro-

gen 11,3–13,8 mg for 100 g of soil; movable phosphorus and accessible potassium (extract by F. Chirikov) 11,4–13,1 and 10,0–11,1 mg for 100 g of soil, respectively.

The soil cultivation was mid-water, conventional for dry conditions of the Southern Steppe and was conducted corresponding to a precursor: black fallow [13], pea [14], winter rape [15]. The experiments were realized in three- and fourfold repeat. The area of the sowing plot is 144 m<sup>2</sup>, accounting – 80 m<sup>2</sup>. For nitrogen additional fertilizing, there was used ammoniac salt peter (34 %) and carbamide (46 %). Winter wheat of Knop variety, which precursors were black fallow, pea and winter rape, was sown out. Sowing was realized in the term, optimal for our zone (28–30 of September). The field experiments with fertilizers were conducted by recommendations of F. A. Yudin [16].

It was harvested by a combine “Sampo-500” along plots, selecting grain samples for the analysis; the grain mass was recalculated for the standard humidity and 100 % pureness.

Experimental schemes are presented at giving results.

The selection of experimental samples of grain and determination of quality parameters were realized according to standard methods: quantity and quality of gluten – SS 13586.1-68 [17], protein content – by the method of infrared spectroscopy on a device Spectran-119M – SS 4117:2007 [18], mass of 1000 seeds – SS 4138–2002 [19], nature of grain – SS 10840–64 [20], content of moisture by the thermo-gravimetric method – SS 13586.5–93 [21]. For determining the fraction composition, grain samples were sifted on sieves with orifices 3,2×20 mm, 2,6×20 mm, 2,4×20 mm, which product was considered as coarse grain, and products of the sieve with orifices 2,0×20 mm, 1,7×20 mm and 1,5×20 mm – as fine grain.

The statistical processing of the obtained results was realized by B.A. Dospekhov using the package of applied programs Excel and Statistika, by the methods of dispersion, correlation and regression analysis [22].

As to weather conditions, four of five years were favorable by humidity in spring and autumn in the active phases of growth (from March to May): there are 2009–2011 and 2013 years; 2012 year at the total amount of precipitation for vegetation as 448,1 mm that was 112,6 % of the average index of many years was remarkable for the intense drought of the first two months of autumn (ATF=0,42) and unfavorable by the precipitation distribution in spring. The absence of precipitation in first two decades of May of 2012 conditioned the development of the atmospheric and then soil drought and coincided with the critical period in the development of plants of winter crops; in the third decade there were 74,4 mm of precipitation that could be related to optimal ones, but 93 % were as a pouring rain and caused more damage than profit that was reflected on the level of yield and quality.

### 5. Research results

In the first series of the experiments there was studied the effectiveness of one-time spring fertilizing of winter wheat crops with the norm  $N_{60}$  in the phase from outgoing in a tube to heading. In average during three

years (Table 1) the essential increment of yield was obtained at fertilizing at the beginning of tubing and at appearing a flag-like leaf at cultivating on black fallow (rise was 11,3 and 11,6 %); by pea – yield increment was 26,6–18,6 % at adding mineral nitrogen from the beginning of tubing to appearing a flag-like leaf; by winter

rape – during the tubing phase (+14,4–13,5 % to the control variant).

In separated years there was obtained the reliable increase of yield at fertilizing and in other phases of wheat plants development, but in the aforesaid periods – practically stably during all years.

Table 1

Effectiveness of spring fertilizing of winter wheat crops on the background of different precursors  
(yield at introducing  $N_{60}$ , t/he)

Phase of introduction	Year			among	± to control	
	2009	2010	2011		t/he	%
Precursor – black fallow						
control without adding nitrogen	6,09	6,66	6,31	6,36	0	0
beginning of outgoing in a tube	7,14	7,66	6,45	7,08	0,72	11,3
tubing	6,95	7,39	6,56	6,97	0,61	9,6
appearance of a flag-like leaf	7,34	7,50	6,45	7,10	0,74	11,6
beginning of heading	6,47	6,78	6,38	6,54	0,18	2,8
heading	6,04	6,94	6,22	6,40	0,04	0,6
LED <sub>0,95</sub>	0,18	0,12	0,16	0,69		
Precursor – pea						
control without adding nitrogen	4,43	4,44	4,53	4,47	0	0
beginning of outgoing in a tube	5,84	6,61	6,03	6,16	1,69	26,6
tubing	5,61	6,13	5,72	5,82	1,35	21,2
appearance of a flag-like leaf	5,69	5,40	5,86	5,65	1,18	18,6
beginning of heading	5,07	5,13	4,25	4,82	0,35	5,5
heading	4,57	5,02	4,08	4,56	0,09	1,4
LED <sub>0,95</sub>	0,12	0,13	0,12	0,67		
Precursor – winter rape						
control without adding nitrogen	5,58	6,29	5,68	5,85	0	0
beginning of outgoing in a tube	6,28	7,92	5,87	6,69	0,84	14,4
tubing	6,14	7,78	6,01	6,64	0,79	13,5
appearance of a flag-like leaf	5,76	6,78	5,78	6,11	0,26	4,4
beginning of heading	5,88	6,84	6,00	6,24	0,39	6,7
heading	5,28	6,84	5,69	5,94	0,09	1,5
LED <sub>0,95</sub>	0,22	0,27	0,19	0,62		

By protein and gluten content of such precursors as black fallow and pea, grain corresponded to the requirements of the third class of quality, despite the term of spring additional fertilizing, by winter rape – from the phase of mass tubing, at that there was observed no difference between precursors from appearing a flag-like leaf (Table 2). The main mass of grain was formed by the

share more than 2,5 mm: in the control variant it varied within 82,8–85,5 % depending on a precursor, and in the experimental ones – 75,2–87,3 %. The minimal content of this fraction at wheat cultivating on black fallow was observed at adding nitrogen in norm 60 kg/he in the phase of heading beginning, by pea and winter rape – appearance of a flag-like leaf (78,6 and 69,9 %, respectively).

Table 2

Fraction share >2,5 mm (product of sieves with orifices 2,6×20 mm and 3,05×20 mm) and quality of winter wheat grain depending on the term of adding mineral nitrogen ( $N_{60}$ ) and precursor

Phase of adding nitrogen	Parameter								
	Fraction output >2,5 mm, %			Protein content, % for dry substance			Gluten content, %		
precursor	black fallow	pea	winter rape	black fallow	pea	winter rape	black fallow	pea	winter rape
control	84,4	85,5	82,8	11,19	10,61	9,10	18,5	17,5	17,0
beginning of outgoing in a tube	83,8	83,9	76,7	11,74	11,65	10,88	22,0	20,3	18,4
mass tubing	87,1	82,5	72,0	12,23	11,65	11,33	21,7	21,4	19,5
appearance of a flag-like leaf	87,3	78,6	69,9	12,52	12,06	12,23	22,7	22,0	20,6
heading beginning	75,2	81,1	76,2	12,15	12,23	12,20	21,8	22,0	21,3
heading	83,1	83,8	76,8	12,27	12,09	12,40	22,7	22,5	22,8

As to the mass of 1000 grains, the highest indices were in the fraction more than 3,0 mm – 48,3–51,4 g, grain fraction 2,5...3,0 mm – 38,8–41,6 g and 2,0...2,5 mm – 27,9–28,7 g, the reliable difference by periods of fertilizing and precursors is absent within each fraction (Fig. 1).

In other series of experiments winter wheat was planted by the precursor winter rape, nitrogen fertilizers N<sub>60</sub> were introduced from sprouting to mass growing in spring. Essential increments of yield (from 0,30 to 0,97 t/he) were received at feeding practically in all terms, except mass growing (Table 3).

Protein concentration in grain at introducing nitrogen in norm 60 kg/he in the autumn development period and in December was lower or on the limit of the third quality class (it is necessary to have 11,0, and factually 10,57–11,10 %); at feeding from December to the mass growing – it stably was the third class (11,56–11,70 % against 9,10 on the variant without fertilizers). The mass of 1000 seeds little differed by feeding terms and depended only on a grain fraction.

In the chain of crop rotation black fallow – winter wheat and pea – winter wheat both the decrease of the feeding norm to N<sub>90</sub> and N<sub>120</sub> and application separately in two steps are ineffective from the aspect of yield: it doesn't essentially grow comparing with one-time feeding by the norm N<sub>90</sub>, but has advantages only comparing with the control sample (sample 2). If to take into account the grain quality (Table 4, 5), the use of N<sub>90</sub> dose in two phases gives a possibility to get food grain of the second class, in which the protein content exceeds 12,5 %, and gluten 23,0 %, at adding N<sub>30</sub> on sprouts and N<sub>60</sub> in the period from mass tubing to heading at cultivating on black fallow, and by the pea precursor – the second feeding must be conducted at heading.

At increasing the norm of feeding by retail to N<sub>120</sub> high-quality grain was obtained at all combinations of fertilizing (Fig. 2).

The correlation-regression analysis of the whole volume of obtained data allowed to reveal the influence of factors for formation of yield and quality of grain (Table 6).

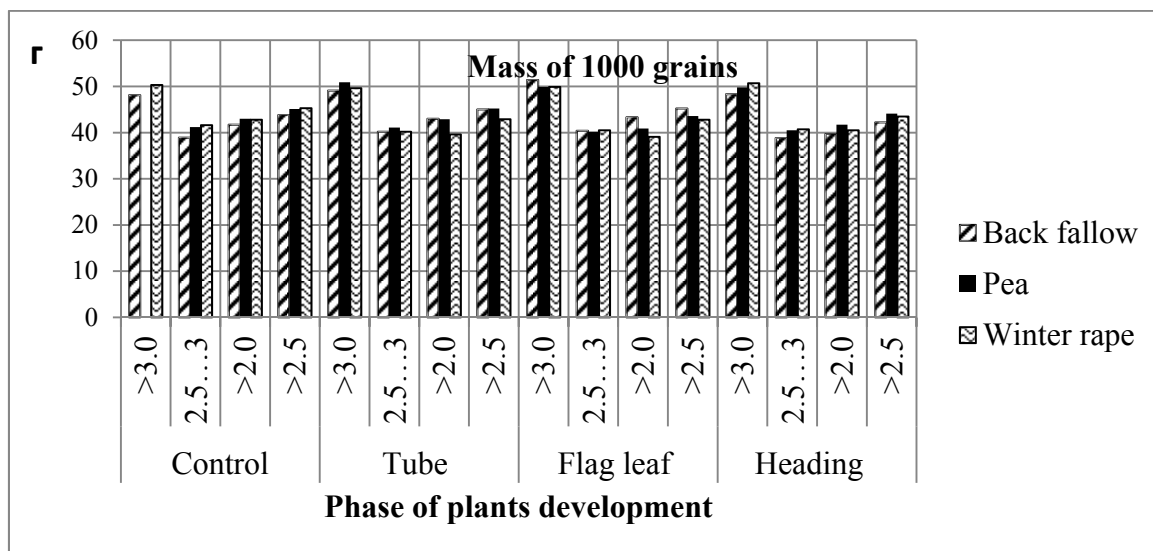


Fig. 1. Mass of 1000 seeds y fractions at spring feeding by the norm N<sub>60</sub> (average for three years)

Table 3

The influence of autumn-winter and early spring feeding by mineral nitrogen on yield, fraction composition and quality of grain of winter wheat (precursor – winter rape)

Variants of experiment terms of adding the nitrogen fertilizer	Indices of studied factors													
	Mass share of grains in harvest, %					Mass of 1000, gramsm					Yield of grain t/he at 14 % humidity		Raw protein	Gluten
	>3 mm	2,5-3 mm	2-2,5 mm	1,7-2 mm	<1,7 mm	>3 mm	2,5-3 mm	2-2,5 mm	>2 mm	>2,5mm	Total-ly	>2,5 mm	%	
control N <sub>0</sub>	32,6	50,2	14,2	2,2	0,8	50,9	41,6	28,7	42,8	45,3	5,83	4,82	9,10	17,0
sprouts N <sub>60</sub>	29,7	48,1	17,9	3,2	1,1	48,8	39,4	27,4	40,1	43,0	6,13	4,77	10,57	18,2
autumn tillering N <sub>60</sub>	27,7	50,4	18,2	2,8	0,9	48,5	39,8	27,7	40,0	42,9	6,20	4,84	11,03	19,4
November N <sub>60</sub>	26,1	52,5	17,5	2,9	1,0	47,7	38,6	27,4	39,1	41,6	6,24	4,90	10,92	19,0
December N <sub>60</sub>	25,2	54,7	17,2	2,2	0,7	48,2	39,6	27,6	39,7	42,3	6,80	5,43	11,10	19,5
January N <sub>60</sub>	27,3	54,2	19,1	2,4	0,6	48,5	39,3	28,0	39,3	42,1	6,00	4,67	11,70	20,2
February N <sub>60</sub>	23,0	55,5	18,3	2,4	0,8	49,2	40,1	28,4	40,1	42,8	6,36	4,99	11,56	19,4
RSV N <sub>60</sub>	22,4	55,1	19,1	2,5	0,9	49,4	39,9	28,3	39,8	42,7	6,20	4,80	11,55	20,2
mass growing N <sub>60</sub>	21,7	54,3	20,0	2,9	1,1	49,5	39,2	27,9	39,1	42,1	5,98	4,54	11,77	20,6

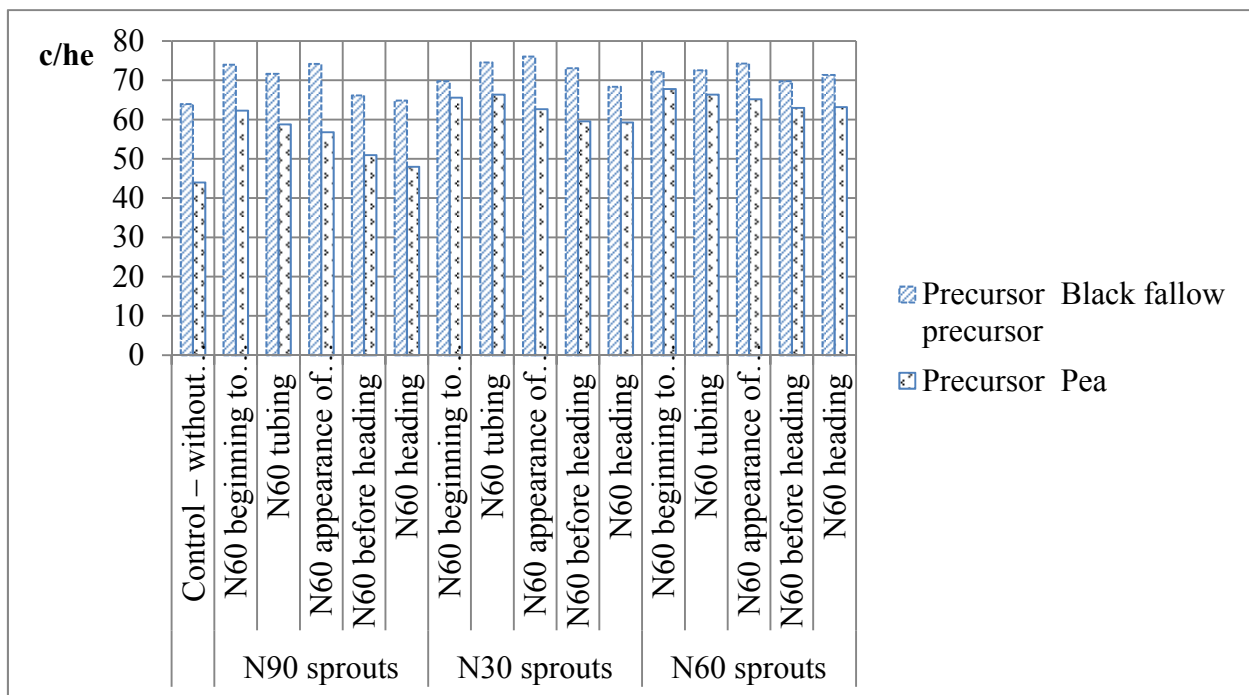


Fig. 2. Influence of terms and norms of application of nitrogen fertilizers on yield of wheat grain after black fallow and pea

Table 4  
Influence of retail application of mineral nitrogen on the fraction composition and quality of winter wheat grain (precursor –black fallow)

Terms and doses of adding nitrogen fertilizer	Share of grains in yield, %					Mass of 1000 grains of separate fractions, g					%		
	>3 mm	2,5-3 mm	2-2,5 mm	1,7-2 mm	<1,7 mm	>3 mm	2,5-3 mm	2-2,5 mm	>2 mm	>2,5 mm	protein	gluten	Fraction output >2,5 mm
Control – without fertilizers	42,1	42,3	13,0	1,8	0,8	48,8	38,9	28,1	41,7	43,8	11,19	19,5	84,4
N <sub>60</sub> on sprouts	16,5	58,2	21,5	2,9	0,9	46,1	36,9	27,0	36,3	38,9	12,27	21,8	74,7
N <sub>30</sub> sprouts N <sub>60</sub> beginning of outgoing in a tube	19,7	56,4	20,2	2,8	0,9	47,6	38,0	27,3	37,7	40,5	12,02	22,7	76,1
N <sub>30</sub> -sprouts N <sub>60</sub> -tubing	29,8	50,7	15,9	2,4	1,2	49,7	38,3	28,5	40,2	42,5	12,85	24,3	80,5
N <sub>30</sub> -sprouts N <sub>60</sub> -appearance of a flag-like leaf	41,3	44,3	12,0	1,6	0,8	48,7	38,2	28,1	41,4	43,3	13,00	25,1	85,6
N <sub>30</sub> -sprouts N <sub>60</sub> -before heading	43,4	42,9	11,2	1,7	0,8	48,1	39,3	27,7	41,9	43,7	13,20	25,1	86,3
N <sub>30</sub> -sprouts N <sub>60</sub> -heading	20,5	54,7	20,6	3,1	1,1	47,1	38,0	27,6	37,7	40,5	12,90	24,2	75,2
N <sub>60</sub> -sprouts N <sub>60</sub> -beginning of outgoing in a tube	19,4	57,8	19,4	2,6	0,8	46,5	36,7	27,2	36,8	39,2	14,10	26,0	77,2
N <sub>60</sub> -sprouts N <sub>60</sub> -tubing	25,6	53,6	17,3	2,5	1,0	46,9	37,8	27,5	38,4	40,7	14,80	24,6	79,2
N <sub>60</sub> -sprouts N <sub>60</sub> -appearing of a flag-like leaf	38,3	45,4	13,4	1,9	1,0	48,0	38,1	28,1	40,6	42,6	13,09	24,2	83,7
N <sub>60</sub> -sprouts N <sub>60</sub> -before heading	48,1	39,1	10,4	1,6	0,8	48,2	38,4	27,9	42,1	43,8	12,63	23,6	87,2
N <sub>60</sub> -sprouts N <sub>60</sub> -heading	46,9	39,2	11,2	1,8	0,9	49,2	39,5	28,0	42,9	44,8	12,75	23,0	86,1

Table 5

Influence of retail application of mineral nitrogen on the fraction composition and quality of winter wheat grain (precursor – pea)

Terms and doses of adding nitrogen fertilizer	Fraction of grains in yield, %					Mass of 1000 grains of separate fractions, g					%	
	>3 mm	2,5-3,0 mm	2-2,5 mm	1,7-2 mm	<1,7 mm	>3 mm	2,5-3 mm	2-2,5 mm	>2 mm	>2,5 mm	pro-tein	glu-ten
Control – without fertilizers	38,1	47,4	11,9	1,9	0,7	49,9	41,2	28,3	43,0	45,1	10,61	19,1
N <sub>60</sub> on sprouts	30,9	52,3	14,0	2,0	0,8	48,4	39,6	27,5	40,6	42,9	11,30	20,5
N <sub>30</sub> sprouts N <sub>60</sub> beginning of outgoing in a tube	39,5	47,1	10,8	2,0	0,6	48,0	39,8	27,5	41,8	43,5	11,60	20,7
N <sub>30</sub> -sprouts N <sub>60</sub> -tubing	32,3	51,0	14,0	2,0	0,7	47,8	40,1	28,1	40,9	43,1	12,10	21,6
N <sub>30</sub> -sprouts N <sub>60</sub> -appearance of a flag-like leaf	22,8	53,0	19,2	3,5	1,4	47,8	39,5	27,5	39,1	42,0	12,25	22,2
N <sub>30</sub> -sprouts N <sub>60</sub> -before heading	22,9	55,2	18,0	2,9	1,0	48,5	39,8	27,7	38,6	42,3	12,54	24,4
N <sub>30</sub> -sprouts N <sub>60</sub> -heading	28,4	51,8	16,4	2,5	0,9	49,2	40,1	27,7	40,7	43,3	13,02	24,2
N <sub>60</sub> -sprouts N <sub>60</sub> -beginning of outgoing in a tube	26,4	53,8	16,5	2,4	0,9	47,9	39,2	27,2	39,5	42,1	12,51	23,0
N <sub>60</sub> -sprouts N <sub>60</sub> -tubing	19,9	55,9	20,2	3,0	1,0	47,8	38,9	27,2	38,3	41,2	13,51	24,3
N <sub>60</sub> -sprouts N <sub>60</sub> -appearing of flag-like leaf	15,5	57,8	22,2	3,4	1,1	48,4	39,2	27,4	38,0	41,2	12,10	24,5
N <sub>60</sub> -sprouts N <sub>60</sub> -before heading	17,8	56,9	21,3	3,0	1,0	48,4	39,3	28,2	38,5	41,5	12,85	23,7
N <sub>60</sub> -sprouts N <sub>60</sub> -heading	24,6	53,0	18,0	3,2	1,2	48,9	39,8	27,1	39,7	42,7	12,81	23,6

Table 6

Pair coefficients of correlation and determination

Precursor	Norm of application of mineral nitrogen			Share of fractions of fine grain – protein content		Share of fractions of coarse grain – protein content		Share of fractions of coarse grain – gluten content		Protein-gluten	
	yield	Content									
		r	protein	gluten	r	r <sup>2</sup>	r	r <sup>2</sup>	r	r <sup>2</sup>	r
Black fallow	0,26	0,92	0,98	0,01	0	-0,35	0,12	-0,04	0,002	0,73	0,53
pea	0,52	0,64	0,50	0,52	0,25	-0,63	0,40	-0,57	0,37	0,95	0,90
winter rape	0,80	0,57	0,50	0,73	0,53	-0,69	0,48	-0,42	0,18	0,92	0,85

It is known, that pair correlation coefficients testify to the close connection between two variables: at module values more than 0,7 – strong connection, at  $r \geq 0,5$  and  $< 0,7$  – middle and at  $r$  less than 0,5 – weak. According to the correlation-regression analysis, the influence of the norm of application of mineral nitrogen grows with decreasing the precursor's quality: if the yield level for black fallow was determined by the norm of nitrogen feeding by 6,8 %, for pea – by 27,0 %, and by winter rape – by 64 %; at that pair coefficients of correlation between the norm of nitrogen fertilizers in feeding and protein and gluten content for black fallow are the highest (0,92–0,98), that testify to the high degree of connection, and for pea and winter rape – middle degree ( $r=0,64$  and 0,50 and 0,57 and 0,50).

At cultivating winter wheat on black fallow, there was revealed the weak reverse connection between the share of coarse grain fraction and protein content ( $r=-0,35$ ); at cultivating on pea or winter rape, the influence direction is the same (increase of the coarse fraction share results in decreasing the protein

concentration), but the influence degree is middle. The influence of the big size of grain on the gluten content repeats the previous scenario at the comparatively less closeness of connection. The share of fine grain and protein content are in the direct connection of the middle degree:  $r=0,52$  at cultivating on the precursor pea and  $r=0,73$  – on winter rape).

Summarizing the obtained data, we can say that the terms and ways (one-time or retail) of nitrogen application in feeding must be chosen taking into account the production direction. For example, at cultivating winter wheat for seeds it is more rational to fertilize additionally by nitrogen fertilizers N<sub>60</sub> in the phase of appearance of a flag-like leaf. Such feeding provides the high yield of grain as 7,10 t/ha that is by 0,74 t/he higher than in the control, and almost at the same level with the yield at using N<sub>90</sub> and N<sub>120</sub> fertilizers as feeding at retail application – on sprouts and at growing a flag-like leaf (7,46–7,34 t/he). At the same time the highest output of grain is left on a sieve with orifices 3,0 mm and high percent of the output of the seed fraction with the

diameter more than 2,5 mm (87,7 %). At cultivating food grain, it is reasonable to include feeding by the scheme  $N_{60}$  on wheat sprouts from autumn and  $N_{60}$  during the tubing phase in the technology. At that the yield forms at the level 6,73–6,75 t/he, grain has a less size and mass, but the gluten and protein contents are high 14,1–14,8 % and 26,0–24,6 %, respectively, that relates to the second class by gluten (gluten in grain of the first class must not be lower than 28,0 %), and protein concentration corresponds to requirements of 1-st class (not lower than 14,0 %); such grain may be used for improving quality parameters of other grain fractions and as a raw material for macaroni products.

At planting winter wheat after the precursor pea for seeds it is most rational to use the following system of additional fertilizing: to apply nitrogen in the norm  $N_{90}$  by retail ( $N_{30}$  on sprouts before the tillering phase, and  $N_{60}$  in spring at the beginning of outgoing in a tube). Such variant of feeding provides the high yield of grain 6,46 t/he that is by 1,99 t/he (44,5 %) higher than the control, the share of seeds with the diameter more than 2,5 mm is 86,5 % and has the mass of 1000 seeds as 43,5 grams. For obtaining high-quality food grain, it is necessary to conduct the nitrogen feeding in two times, namely  $N_{60}$  in autumn on sprouts and  $N_{60}$  at tubing. At that the yield of 6,82 t/he is a bit lower than at application at the beginning of outgoing of plants of winter wheat in a tube, grain is fine, but has the most protein content (13,1 %) and gluten one 24,3 % comparing with other variants that corresponds to the quality parameter of the third class.

After the precursor winter rape the highest yield of seeds 6,80 t/he and the share of a seed fraction with the diameter more than 2,5 mm – 5,43 t/he was provided by adding  $N_{60}$  in December, before finishing the spring vegetation. The protein content in seeds is not very high 11,1 %, gluten – 19,5 %.

The optimal term of application and the norm of the nitrogen fertilizer must be considered as  $N_{60}$  in the phase of wheat tubing. At that the yield is at the level of 6,64 t/he, protein content – 11,33 %, gluten – 19,5 %. According to SSU 3768:2010, such grain relates to the third food class. Grain with the higher protein content (12,23–12,40 %) and gluten content (20,6–22,8 %) forms at feeding by the norm  $N_{60}$  in the period from appearing a flag-like leaf to heading phase, but at that the tendency to decreasing the yield by 0,40–0,70 t/he comparing with  $N_{60}$  in the tubing phase is observed.

At that, it must be taken into account, that these results are obtained at cultivating winter wheat at plots, where the arable soil layer had the middle degree of provision with accessible nutrition elements.

## 6. Conclusions

Thus, based on the conducted studies on southern, little-humus, hard-loamy soil with the middle level of provision with accessible nutrition elements it was established:

1. At cultivating winter wheat for seeds and food grain, the optimal terms and norms of application of nitrogen fertilizers in feeding are different: on the precursor black fallow at cultivating fallow wheat for seeds it is more rational to conduct the feeding by nitrogen fertilizers  $N_{60}$  in the phase of appearing a flag-like leaf; for obtaining high-quality food grain it is rational to apply  $N_{60}$  on wheat sprouts from autumn +  $N_{60}$  during the tubing phase.

At cultivating winter wheat after the precursor pea for seeds – the nitrogen fertilizer must be applied in the norm  $N_{90}$  by retail ( $N_{30}$  on sprouts before beginning the tillering phase, and  $N_{60}$  in spring at the stage of outgoing in a tube); for obtaining high-quality food grain it is necessary to conduct the nitrogen fertilizing also in two terms, namely  $N_{60}$  in autumn on sprouts and  $N_{60}$  at tubing;

After the precursor winter rape, the most yield of seeds 6,80 t/he and share of seeds fraction with the diameter more than 2,5 mm – 5,43 t/he is provided by introducing  $N_{60}$  in December, before ending the autumn vegetation. The optimal term for applying the nitrogen fertilizer for obtaining food grain with the quality parameters of the third class –  $N_{60}$  is in the wheat tubing phase. Delay of the feeding term results in decreasing the yield on the background of the quality increase, but within requirements to the third class.

2. The term of the spring feeding little influences the grain quality at cultivating wheat on black fallow and pea: by the protein and gluten contents it corresponds to requirements of the third quality class; for obtaining grain of the high class with the protein content no less than 11–12 % and gluten 18–23 %, the feeding of winter wheat crops on the precursor winter rape by the nitrogen fertilizer must be conducted from the mass tubing phase. At later one, the high quality of grain is not determined by the precursor, but depends only on the norm of the nitrogen fertilizer.

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*Рекомендовано до публікації д-р с.-г. наук Січкарь В. І.  
Дата надходження рукопису 28.02.2018*

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