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FEATURES OF FERTILIZING DINKEL WHEAT BY NITROGEN FERTILIZERS

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The features of fertilizing dinkel wheat by nitrogen fertilizers in Right-Bank Forest-Steppe of Ukraine are investigated. Different fertilizers doses and terms of their application are studied. During the experiment a variety of spelt Zorya Ukrainy was grown. The content dynamics of mobile compounds of phosphorus and potassium in the soil, at the different fertilizing in the layer 0 – 40 cm, and reserves of mineral compounds nitrogen ($N\text{-}NO3^{-}$ + $N\text{-}NH4^{+}$) in the soil layer 0 – 100 cm was determined.

In modern conditions of reformation of agricultural complex with its low level of resources and quality of winter wheat grain significantly, increases the role and importance of technology of its cultivation, which is aimed primarily at creating optimal conditions for plant growth and development under appropriate soil and climatic conditions. The technology of growing winter wheat provides a sequence of technological measures, including a significant role of the nutrition background, sowing terms, variety [1 – 3].

Spelt can grow in poor soils, cold-resistant and very winter-hardy, resistant to excessive moisture, has a high tillering and is less affected by diseases [4 – 6].

Among cereals, winter wheat is the most demanding to nutrition conditions [7]. The high demands of this culture on nutrition is explained by the fact that its root system is characterized by a low capacity to absorb the nutrition elements from hard soluble compounds of the soil. At the same time carrying out the nutrition by the harvest 40 kg / ha is high and is 110 – 130 kg / ha of nitrogen, 50 – 70 – P_2O_2, 70 – 90 kg / ha K_2O [8, 9]. The use of fertilizers is one of the most important measures in winter wheat cultivation technology that enhances yield and grain quality. Proper identification of doses of fertilizing, especially nitrogen – is the main condition for their successful usage [10, 11]. In the system of application of nitrogen fertilizers are important not only doses but also terms of their introduction [7, 12].

Spelt is unexplored variety, including new variety Zorya Ukrainy. It is a high-protein crop. The demand for high-quality wheat, both on domestic and foreign markets is large enough [13] and grown in Ukraine wheat of high quality don’t cover the needs of even the domestic market. So studying of the question how to optimize nutrition and fertilization of spelt considering varietal and genetic features is important.

The purpose of research. The purpose – is to establish the optimal terms, doses and norms of application of nitrogen fertilizers for spelt in Right-Bank Forest-Steppe of Ukraine.

The methodology of the research. The study was conducted at the experimental field of Uman NUH during 2011 – 2012.

The objective of the study was to determine the optimal rules and time limits for nitrogen fertilizers on the background $P_{60}K_{60}$ under spelt on black soil of Right-Bank Forest-Steppe.

Subject of the study – is the optimization of nitrogen nutrition of spelt on podzolized black soil of the Right-Bank Forest-Steppe of Ukraine, use of different norms, terms and methods of application of nitrogen fertilizers.

In the experiment was grown variety of spelt Zorya Ukrainy. The predecessor was peas. Variants in the experiment were placed sequentially, repetition of the experiment is triple. Research field area – 72 m^2, accounting field – 40 m^2. According to the scheme of the experiment were applied ammonium nitrate (34% N, GOST 2-85) granulated superphosphate (19,5% P_2O_5, GOST 5956-78), potassium chloride (60% K_2O, GOST 4568-95) and urea (46% $(NH_2)_2CO$, GOST 2081-92). Phosphate and potash fertilizers were applied under primary tillage and nitrogen – due to the experiment schemes: under pre-sowing cultivation, in early spring feeding, in tillering phases, in the tube and also foliar fertilizing by urea.

According to ISO 4362:2004 Soil quality. Indicators of soils quality, podzolized balck soil had a high content of humus, content of nitrogen alkaline hydrolytic compounds – low, medium – of mobile phosphorus and potassium compounds, the reaction of soil solution – weak acidic. Weather conditions during the study were different, which influenced the yield and quality of spelt. In 2011, conditions were favorable during the vegetation, and in 2012 – dry for the growth and development of plants.

In nature of soils, in contradistinction to nitrogen, there are no rich in phosphorus. The main source of phosphorus during the pedogenesis is the maternal material, but due to the plants, it accumulates in the upper horizons, root systems of which absorb phosphorus from the lower layers and transfer to the top by profile. By its chemical properties, phosphorus has a complex nature of interaction of the various components of the soil that determine many different forms, reactions, compounds and complexes, in the form of which it can be in the soil. This greatly complicates the assessment of phosphorus content in soil in terms of its availability for plant nutrition [14, 15]. The absorption of phosphorus is determined not only by their availability, but also by efficient of functioning of plants absorption that use phosphorus of organic phosphate after enzymatic mineralization [16].

Research results. Our research found that fertilizing contributed to a higher content of mobile phosphorus in the soil (Table 1).

Thus, on average for two years of research during plants tillering, in the control variant content of mobile phosphorus in the soil layer of 0 – 20 cm was 98 mg / kg, 20 – 40 cm – 94 mg / kg soil. While in the variants woth application of R60K60 this index was higher in the soil layer 0 – 20 cm on average 11 mg/kg, and 20 – 40 cm – 5 mg / kg soil.

During the growing season was spelled wheat absorption of phosphate from the soil. It should be noted that the most intensive use of mobile phosphorus plants was during the phase of tillering to heading stage of wheat spelled. On average, two years on fertilized plots decrease its content was 5 mg / kg in soil layer 0 – 20 cm and 3 mg / kg in the 20 – 40 cm layer.

1. Dynamics of the content of mobile phosphorus in soil under spelt by different fertilizing (2011 - 2012), mg / kg

Experiment variant	Phase of plant growth and development				
	Sprouts	Tillering	Output in the tube	Earing	Full ripeness
without fertilizers (control)	94* / 97	94 / 94	94 / 93	93 / 92	94 / 92
$P_{60}K_{60}$ – background	107 / 100	103 / 97	101 / 95	100 / 94	100 / 95
background + N_{30} before sowing	105 / 100	102 / 98	100 / 95	98 / 94	98 / 94
background + N_{30}	108 / 100	103 / 97	96 / 96	96 / 93	96 / 92
background + N_{60}	102 / 101	103 / 97	101 / 94	100 / 94	99 / 94
background + N_{90}	106 / 100	103 / 98	101 / 95	100 / 95	98 / 96
background + N_{120}	108 / 100	105 / 97	103 / 95	101 / 94	100 / 95
background + N_0 + N_{30}	101 / 98	102 / 97	100 / 94	99 / 93	99 / 94
background + N_0 + N_{60}	107 / 100	104 / 98	102 / 96	100 / 94	100 / 94
background + N_{30} + N_{30}	108 / 98	105 / 96	102 / 94	99 / 93	100 / 93
background + N_{60} + N_{30}	103 / 100	104 / 98	101 / 96	98 / 95	99 / 95
background + N_{30} + N_{60}	106 / 100	104 / 97	102 / 96	100 / 94	99 / 94
background + N_{60} + N_{60}	106 / 98	103 / 96	101 / 94	100 / 93	98 / 93
background + N_{30} + N_{30} + N_{30}	107 / 99	105 / 97	103 / 96	100 / 95	100 / 94
background + N_{30} + N_{60} + N_{30}	106 / 100	105 / 98	103 / 95	101 / 95	100 / 96
background + N_{60} + N_{30} + N_{30}	109 / 101	104 / 98	102 / 96	100 / 94	99 / 95
LSD_{05} 2011	*7 / 6*	*7 / 6*	*6 / 6*	*6 / 6*	*6 / 5*
LSD_{05} 2012	*8 / 7*	*7 / 6*	*6 / 6*	*6 / 6*	*6 / 5*

Note. * Above the dash – in the 0-20 cm soil layer, under the dash - 20-40 cm

Potassium helps wintering plants, regulates in them physiological processes such as colloidal physical condition of tissues, water balance, photosynthesis, protein synthesis. It is of particular importance for synthesis, metabolism, transformation and movement of carbohydrates from the leaf surface to the reproductive organs of cereal plants. It positively affects plant resistance to drought, low temperature [17]. Potassium is involved in the formation of cell walls, strengthens stems and increase plant resistance to lodging, especially against the background of high doses of nitrogen fertilizers which cause excessive growth of vegetative mass. In addition, potassium stimulates the accumulation of proteins in plants, significantly increasing the efficiency of applying nitrogen fertilizer [18].

Researches have shown that the content of mobile potassium compounds depends on the fertilizer (Table 2). Compared to the control, the greatest decrease in mobile connections was observed during the growing – tillering. On average for 2011 – 2012 content of mobile compounds of potassium in the soil layer 0 – 20 cm was 116 mg / kg compared to the control - 104 mg / kg, respectively, in layer 20 - 40 cm – 103 and 98 mg/kg. Slightly lower was observed during the beginning of the outlet in tube and heading. Thus, in the soil layer 0 – 20 cm content amounted on average for two years 99 mg / kg, and the control – 91 mg / kg, and in the layer 20 – 40 cm this index was 93 and 86 mg / kg. The content of mobile potassium compounds during the growing season of spelt decreased as a result of its assimilation by plants, and the transition to non-exchange form.

It is known that the efficiency of nitrogen fertilizers application under winter wheat is in inverse dependence on supplies of mineral nitrogen in the soil layer with roots. The problem of optimization of nitrogen nutrition involves the optimal division of certain norm of fertilizers on several terms of application and development of methods of establishment of the optimal dose of nitrogen based on soil and climatic conditions, precursors and varietal characteristics. Regardless of soil and climatic conditions, the average standard stock of nitrogen mineral compounds in the spring in the soil of layer 0 – 60 cm under winter wheat is 110 – 130 kg / ha. The increase in reserves of mineral nitrogen compounds in the soil above the specified value does not contribute to the yield of wheat, but slightly improves its quality. Therefore, the dose of nitrogen fertilizer for further fertilizings can be calculated from the balance calculations, taking into account the overall need of winter wheat in nitrogen for the planned harvest, the dose of nitrogen applied in the spring and reserves of nitrogen of mineral compounds in the soil [7].

Research has established that the application of nitrogen fertilizers influenced on the content of nitrogen of mineral compounds in the 0 – 100 cm soil layer (Table 3). According to ISO 4362:2004 soil had a low content of nitrogen mineral compounds. In meter layer of soil reserves of mineral forms of nitrogen in the not fertilized areas on average for two years amounted 66 kg / ha and increased to 234 kg / ha in the variant with application of the biggest norm of nitrogen fertilizer. Humectation conditions in 2011 were favorable compared to the weather conditions in 2012, which contributed to a better passing of processes of mineralization of soil organic matters and increase of its stocks in the 0 – 100 cm soil layer. Most of plants used nitrogen from tillering stage to the earing.

2. The content of mobile compounds of potassium in the soil under spelt by different fertilizing (2011 - 2012), mg / kg

Experiment variant	Phase of plant growth and development				
	Sprouts	Tillering	Output in the tube	Earing	Full ripeness
Without fertilizers (control)	107* / 98	101 / 93	92 / 87	88 / 83	85 / 76
$P_{60}K_{60}$ – background	118 / 108	115 / 103	106 / 100	102 / 95	98 / 92
background + N_{30} before sowing	119 / 106	114 / 102	107 / 97	101 / 94	94 / 91
background + N_{30}	119 / 117	114 / 103	106 / 96	101 / 91	99 / 86
background + N_{60}	119 / 107	113 / 102	104 / 94	99 / 91	96 / 85
background + N_{90}	118 / 104	114 / 101	104 / 93	101 / 90	95 / 86
background + N_{120}	118 / 105	112 / 102	106 / 94	101 / 92	98 / 87
background + N_0 + N_{30}	120 / 111	114 / 105	107 / 99	104 / 93	99 / 89
background + N_0 + N_{60}	119 / 107	112 / 102	105 / 95	100 / 90	96 / 87
background + N_{30} + N_{30}	119 / 105	113 / 101	107 / 94	103 / 91	99 / 88
background + N_{60} + N_{30}	119 / 107	113 / 101	106 / 94	102 / 91	101 / 87
background + N_{30} + N_{60}	118 / 105	113 / 99	107 / 93	100 / 90	97 / 87
background + N_{60} + N_{60}	120 / 108	114 / 103	107 / 96	102 / 93	98 / 89
background + N_{30} + N_{30} + N_{30}	119 / 106	113 / 102	106 / 95	102 / 92	98 / 88
background + N_{30} + N_{60} + N_{30}	121 / 107	115 / 103	107 / 97	102 / 92	99 / 87
background + N_{60} + N_{30} + N_{30}	120 / 109	114 / 104	105 / 96	100 / 93	98 / 89
LSD_{05} 2011	*8 / 7*	*7 / 7*	*7 / 6*	*6 / 5*	*6 / 5*
LSD_{05} 2012	*7 / 7*	*7 / 6*	*6 / 6*	*6 / 5*	*6 / 5*

Note. * Above the dash – in the 0-20 cm soil layer, under the dash - 20-40 cm.

3. Stock dynamics of nitrogen of mineral compounds (N-NO3⁻ + N-NH4⁺) in the soil layer 0 – 100 cm under spelt, kg / ha

Experiment variant	Phase of plant growth and development									
	Sprouts		Tillering		Output in the tube		Earing		Full ripeness	
	1*	2	1	2	1	2	1	2	1	2
Without fertilizers (control)	79	83	81	70	64	59	59	54	57	51
$P_{60}K_{60}$ – background	89	93	79	75	67	57	60	53	59	52
background + N_{30} before sowing	121	115	89	77	71	65	62	57	58	50
background + N_{30}	76	79	126	111	84	73	65	60	58	54
background + N_{60}	82	75	168	134	117	112	84	76	60	55
background + N_{90}	80	90	196	157	135	124	98	89	63	57
background + N_{120}	78	81	237	195	154	149	107	102	64	58
background + N_0 + N_{30}	81	76	83	70	119	107	82	76	57	53
background + N_0 + N_{60}	75	85	80	78	162	128	103	94	61	54
background + N_{30} + N_{30}	82	78	123	108	158	135	95	98	62	55
background + N_{60} + N_{30}	79	91	165	140	184	163	99	102	64	58
background + N_{30} + N_{60}	83	85	127	115	172	159	101	97	63	58
background + N_{60} + N_{60}	77	76	165	134	234	179	115	121	67	62
background + N_{30} + N_{30} + N_{30}	82	85	129	110	165	161	109	115	64	59
background + N_{30} + N_{60} + N_{30}	80	86	128	112	186	164	116	124	69	64
background + N_{60} + N_{30} + N_{30}	79	92	167	141	181	169	119	127	70	65

Note. * 1 – 2011, 2 – 2012.

Our research found that the yield of spelt influenced weather conditions and norms and time limits of applying nitrogen fertilizers (Table 4). The largest increase in yield (12,1 h / ha) on average for two years compared to the control was obtained in the variant where was applied N_{60} in early spring, N_{30}– in the tillering stage and N_{30} during the appearance of the apical leaf. There were the best conditions of nitrogen nutrition of wheat plants. Applying N_{30} in early spring on average for two years gave the yield increase in 2,8 kg / ha, N_{60} – 7,4; N_{90} – 8,9; N_{120} – 10,3 h / ha. In areas without fertilizers spelt yields on average for two years was only 19 kg / ha and raised after the introduction of phosphate and potash (variant $P_{60}K_{60}$) in 3,3 kg / ha or

17%. Application of nitrogen fertilizers in dose of 30 kg / ha during pre-sowing cultivation did not give significant yield increase that can be explained by sufficient supply of nitrogen plants during sowing after peas, and favorable weather conditions for the formation of nitrogen of mineral compounds in the soil.

4. Spelt wheat yield depending on the nitrogen nutrition conditions, kg / ha

Experiment variant	2011	2012	Average for two years
Without fertilizers (control)	20,7	17,3	19,0
$P_{60}K_{60}$ – background	24,4	20,1	22,3
background + N_{30} before sowing	25,5	20,9	23,2
background + N_{30}	27,4	21,6	24,5
background + N_{30} + N_{30} outside the root	27,8	21,9	24,9
background + N_{60}	29,5	23,2	26,4
background + N_{90}	31,1	24,7	27,9
background + N_{120}	32,5	26,1	29,3
background + N_0 + N_{30}	27,6	21,1	24,4
background + N_0 + N_{60}	29,4	22,8	26,1
background + N_{30} + N_{30}	29,9	23,6	26,8
background + N_{30} + N_{30}+ N_{30} outside the root	30,3	24,0	27,2
background + N_{60} + N_{30}	31,7	25,3	28,5
background + N_{30} + N_{60}	31,9	25,1	28,5
background n + N_{60} + N_{60}	33,7	26,9	30,3
background + N_{60} + N_{60} + N_{30} outside the root	34,1	27,2	30,7
background + N_{30} + N_{30} + N_{30}	32,1	25,8	29,0
background + N_{30} + N_{60} + N_{30}	34,0	27,3	30,7
background + N_{60} + N_{30} + N_{30}	33,8	27,7	30,8
background + N_{60} + N_{30} + N_{30} + N_{30} outside the root	34,2	28,0	31,1
LSD_{05}	*1,5*	*1,3*	–

By a single application of nitrogen fertilizers in early spring in 2011 the best dose was 90 kg / ha, and in 2012 – 120 kg / ha.

Transfer of terms of nitrogen fertilizers application on the tillering phases of plants (variants background – N_{30} and background – N_{60}) although it gave reliable increase grain yield compared to phosphorus-potassium background (respectively 2,1 and 3,8 kg / ha on average for two years) but had no advantage over recharge with the same dose in early spring.

Among the variants with different combinations of double fertilizing (in early spring and in the tillering stage, better on average for two years of research was variant background + N_{60} + N_{60}. Increase in yield to phosphorus-potassium background was 8,0 kg / ha, or 34%, and return of 1 kg of nitrogen fertilizer was 6,7 kg of grain. Transfer of part of nitrogen fertilizer norms (90 – 150 kg / ha) in the third (during the appearance of the apical leaf) and fourth (in the phase of gold ripeness of grain) feeding did not give significant increase in yield of spelt.

Conclusion. Spelt reacts well on the application of fertilizers. Increase of productivity in the variant of experience $P_{60}K_{60}$ + N_{60} + N_{60} compared to the control (without fertilizers) was 11,3 kg/ha, or 59%. The greatest increase in yield provides nitrogen component of complete mineral fertilizer. As a result of two years of research on the influence on grain yield most effective was double fertilization of plants: in early spring by the dose N_{60} and in tillering stage also by the dose N_{60}.

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The features of spelt wheat fertilizing by nitrogen fertilizers on the Right-Bank Forest-Steppe of Ukraine were investigated. Studied different doses and terms of fertilizer application. In the experiment a cultivar of spelt wheat - Dawn of Ukraine was grown. The dynamics of content of motile compounds of phosphorus and potassium in the soil, with different fertilizers in the layer 0 – 40 cm and reserves of mineral nitrogen compounds ($N–NO_3^-$ *+* $N–NH_4^+$*) in the soil layer 0 – 100 cm was determined. Effect of foliar fertilization on protein content of gluten in grains. It was found that the yield of wheat spelt was influenced by weather conditions and norms and time limits of nitrogen fertilizers. Spelt wheat is tolerant to the introduction of high rate of nitrogen fertilizers in early spring.*

Keywords*: spelt wheat, nitrogen fertilizers, phosphorus, potassium, protein, gluten.*