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INTERACTIONS BETWEEN AGRO-LANDSCAPE AND WINTER WHEAT AGRONOMICAL-VALUE TRAITS

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Abstract: *The objectives of our investigations are to describe the limits of variability of the main agricultural types of modern Ukrainian winter wheat varieties in order to their relations with difference growth conditions. Our investigations confirmed statements about relations between content of nutrient elements in winter wheat plants, their uptaking from soil, type of relief, wheat variety genotype and limits of adaptable for difference conditions. We recommended varieties Kolos Mironovschiny, Sonechko, Favoritka for growing under these conditions by grain productivity and varieties Lasunya by grain protein content and protein composition.*

Keywords: *relief, landscape, winter wheat, variety.*

1. Introduction

With the annual production of about 757 million tons (in 2017) [19], bread wheat (*Triticum aestivum* L.) is one of the world's most important crops. Winter wheat is the world's leading cereal grain and the most important food crop, occupying commanding position in Ukraine Agriculture take 48% area under cereals and contributing 38% of the total food grain production in the country [12]. Until the end of the 19th century, cultivars were mainly landraces that were well suitable to their regional conditions. Since the beginning of the 20th century, as breeding methods have developed, landraces have been used as a source of variability in creating modern cultivars by classical breeding methods [2]. In the last 60 years intensive plant breeding programs led to the total replacement of landraces by modern semi-dwarf and high-yielding varieties, correlating with a decrease in wheat genetic diversity and

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needs in special requirements for realization their potential higher grain productivity and protein quality [9 -11].

In the past wheat researches was more tried to improve grain productivity of the crop, but winter wheat breeders ignored the importance of wheat growth conditions on different reliefs. By conditions it means the relief of lands for cultivation and exposition of slopes land which determine the properties of wheat yield and the quality of grains [6]. These agricultural-value traits in interaction actually determine the overall varieties of wheat whether good or poor for farming [7]. Winter wheat yield has the most important and complex character affected directly or indirectly by gens systems present in plant as well as interaction with environment [14]. This has been in response to the pressure for an adequate food supply caused by constantly increasing population in Ukraine and the world as a whole [16]. Therefore, ecological estimation of new wheat varieties with high yield genetic potential under difference condition, it`s components and quality traits [8] has become a permanent purpose in the plant farming and breeding programs [13].

Disequilibrium in influence of different nature-agricultural factors and their interactions of region determine distinguishes in land using. High-level of lands tillage, complicated landscape and high amount of technical cultivars lead to soil degradation. Erosion of slope soils is one of the main components of this problem [1]. Due to this fact we investigated varieties requirements under different types of slopes. One of the main nature factors for evaluation is a land relief, content of macro- and microelements in the soils after erosion, plants and soil interactions, climate and hydrometeorology conditions, mutual influence between wheat plants and type of relief. They determined balance of moisture, character of winter wheat growth and development, differences in season’s conditions, intensively of water erosion [5].

Focused on only yield traits we have to understand that any high yield has no sense without proper quality for food and fodder demands. Grain storage proteins (mostly gliadins and glutenins) include about 60–80% of the total protein in wheat grains and metabolic proteins, remaining part consists of the albumins and globulins (15–20%) [5], [15]. The two main grain storage proteins fractions are glutenins and gliadins in mix together with water perform the rheological and bread-making qualities of wheat dough. These proteins, more certainly, are mainly responsible for the viscoelastic qualities of dough [3].

For proper protein complex formation we need in availability of N and S in the soil, which highly influences on quality and quantity characteristics. N supply increases the rate and duration of protein accumulation and so increases the proportion of S-poor grain storage proteins in mature grain [4, 18].

The objectives of our investigations are to describe the phenotypic variation of the main groups of modern winter wheat varieties due to their interactions with environmental conditions.

2. Material and Methods

Experiments were carried out on the experimental fields of Dnipro State Agrarian and Economic University. The field`s geographic coordinates are: 48°30'N lat. and 35°15' E long. The experimental field is lied on 245 meters above the sea level. The air temperature during winter wheat growing season (September - July) is 8 – 11 °C, the average rainfall is about 350 – 550 mm in similar vegetation season. The research fields occupy an area of 60 hectares and it is crossed out three types of landscapes. One of them is of 30 m depth with a slope of > 7°, the other two have the slopes up to 3° Investigation was performed on flat (full-height normal soil), on the northern exposition slope (low eroded soil), on the southern exposure slope (middle level of erosion). Special attention was paid to the distinguishes with several traits (grain yield, protein and main protein components content in grains, assimilation of main macro- and microelements).

The recommended intensive agronomic practice was followed. Evaluation of total grain yield per plot was calculated from 2015 to 2017 years. The trial was set up at a randomized block design method with three replications and with a plot size of 20 m^2 in 3 replications.

The nitrogen and phosphorus concentration in plant samples was estimated using Kjeldahl method. Total P concentrations of the applied residues were determined by sulfuric acid digestion [17]. Potassium was determined with flame photometry. Trace elements were determined with method of atomic absorption spectrophotometry.

The protein content and contents of gliadin and glutenin were identified on CNS Model Flash EA 1112 (for protein content) and RP-HPLS (for gliadins and glutenins).

Mathematical processing of the results was performed by the method of analysis of variance, factor analyses was conducted by module ANOVA (Statistica 8.0).

3. Results and Discussion

As we can see from the Tables 1 and 2 winter wheat was responded with statistics reliability on growth condition (relief of cultivated territory), which has been shown in yield and exploited of main mineral elements from soil. Efficiency in utilization of mineral macroelements are depended on next factors, such as variety ($F = 41.17$; $F_{critical} = 3.94$; p-level 0.01), type of landscape ($F = 53.17$; $F_{critical} = 4.40$; p-level 0.01) and quantity of mineral sources ($F = 18.82$; $F_{critical} = 3.43$; p-level 0.02) enabled for plants utilization. Due to our dates from the same table higher grain yield winter wheat was produced on slope of north exposition, especially for varieties Kolos Mironovschiny, Kalinova, Favoritka and Sonechko. All of these varieties are corresponded to intensive type, which required higher level of nitrogen fertilization than semiintensive type (such as Podolyanka in our investigations, according to breeding classification with lower requirements to nitrogen and level of agrotechnology).

After analyze by the peculiarities of macroelements losses from soil with harvest of winter wheat plants and quantities which need for obtaining 1 ton of grain had been conducted we determined that demands of main nutrient elements are directly depended on winter wheat varieties special abilities in high grain yield performance. Nitrogen utilization by winter wheat plants on flat interfluves waved from 259.5 to 334.1 kg/ha, phosphorus 80.0 – 110.1 kg/ha, potassium 188.8 – 249 kg/ha during three years. We can see difference in demands for different elements which based on winter wheat varieties peculiarities. Some of the varieties (intensive) need more all of elements, but sometimes proportion between different elements changed (as for example – need more phosphorus for grains formation). On the north exposition slope difference in grain productivity amid varieties is more that on the flat. The nitrogen losses from soil with yield were 252.0 – 382,3 kg/ha, phosphorus 75,6 – 118.8 kg/ha, potassium 201.5 – 260.1 kg/ha. Mineral elements loses from soil with yield on south exposition were considerably less: nitrogen was 215.8–255.8 kg/ha, phosphorus was 75,6 – 118.8 kg/ha, potassium was 201.5 – 260.1 kg/ha. The order by grain productivity under conditions of north exposition was the same as for flat, but for south exposition other situation has been observed. Intensive varieties were less productivity and semiintensive variety Voloshkova took over first place. Variety Favoritka gave us statistically lower yield than standard.

Table 1

Yield and utilization of main nutrient macroelements

Variety	Yield, t/he	Uptake from soil kg/he			For 1 ton of grain, kg		
		N	P	K	N	P	K
Flat							
Podolyanka	8.8	273.7	83.6	213.0	31.1	9.5	24.2
Kolos Mironovschiny	9.6*	334.1	101.8	246.5	34.8	10.6	25.7
Kalinova	9.4	322.4	101.6	236.8	34.3	10.8	25.2
Voloshkova	8.9	275.9	81.5	207.0	31.5	9.2	23.3
Sonechko	10.1*	360.5	110.1	249.0	35.7	10.9	24.7
Favoritka	9.5*	332.5	100.7	242.0	35.0	10.6	25.5
Hurtovina	8.3	259.4	80.0	188.8	31.3	9.6	22.8
Lasunya	9.1	279.2	85.3	217.2	30.7	9.4	23.9
Line 418	8.2	262.7	80.3	204.4	32.0	9.8	24.9
Average	9.1	300.0	91.7	222.7	32.9	10.0	24.5

Variety	Yield, t/he	Uptake from soil kg/he			For 1 ton of grain, kg		
		N	P	K	N	P	K
Slope of noth exposition							
Podolyanka	8.4	252.0	75.6	201.6	30.0	9.0	24.0
Kolos Mironovschiny	10.2*	356.0	111.2	260.1	34.9	10.9	25.5
Kalinova	9.6*	324.5	102.7	243.8	33.8	10.7	25.4
Voloshkova	8.8	262.2	79.2	206.8	29.8	9.0	23.5
Sonechko	10.4*	373.4	116.5	255.8	35.9	11,2	24.6
Favoritka	10.8*	382.3	118.8	272.2	35.4	11.0	25.2
Hurtovina	8.8	279.8	86.2	201.5	31.8	9,8	22.9
Lasunya	9.3	293.9	89.3	216.7	31.6	9.6	23.3
Line 418	8.8	291.3	87.1	216.5	33.1	9.9	24.6
Average	9.5	312.8	96.3	230.6	32.9	10.1	24.3
Slope of south exposition							
Podolyanka	7.2	222,5	66,2	172,8	30,9	9,2	24
Kolos Mironovschiny	7.1	244,9	72,4	181,1	34,5	10,2	25,5
Kalinova	7.5	255,8	77,3	188,3	34,1	10,3	25,1
Voloshkova	7.8*	241,8	70,2	177,5	31,0	9,0	22,8
Sonechko	6.9	242,2	73,1	169,1	35,1	10,6	24,5
Favoritka	6.4	225.3	66.6	161.9	35.2	10.4	25.3
Hurtovina	7.0	220.5	67.9	161.0	31.5	9.7	23.0
Lasunya	7.1	215.8	66.0	168.3	30.4	9.3	23.7
Line 418	6.9	218.0	64.86	168.4	31.6	9.4	24.4
Average	7.1	231.9	69.4	172.1	32.7	9.8	24.3

* statistically significant differences from standard at $t_{0.05}$

As we can found from the table 1 winter wheat require considerably quantity of nitrogen for producing 1 ton of grain 30.7-35.7 kg (under flat conditions). This variation is explained with genotype difference of varieties. Sonechko carried out 35.8 кg of nitrogen while Lasunya 30.7 kg for 1 ton of grain, but, as we can see later, both varieties demonstrated high grain quality. On the other way variety Voloshkova with less expenditure in nitrogen (31.0 kg) under south exposition conditions gave us greater yield than Sonechko or Kolos Mironovschiny. Losses of phosphorus for wheat growth waved from 9.2 to 10.9 kg under flat conditions. Least was for variety Volochkova and peak for Sonechko (just the same as nitrogen). The potassium uptake varied less in limits 22.8 – 25,7 kg and fewer variables. Under north exposition slope conditions all varieties have been shown the similar situation as for other conditions in case of macroelemens utilization for 1 ton of grain, but not for grain productivity and semiintensive varieties were more efficiency in mineral sources exploited.

Generally, dates at Table 1 shows as that more productive varieties took from soil more total nitrogen and phosphorus spent more for producing 1 ton of grains at all cases (Kolos Mironovschiny, Kalinova, Favoritka and Sonechko). As for our opinion its depends on the genotype peculiars in nitrogen utilization, intensive short stem varieties are not so efficiency in more limited conditions. Under these conditions semiintensive varieties are more suitable. Slope of north exposition was more preferable by growth conditions and gave a possibility to produce higher yield. Grain productivity of intensive genotypes more depends from relief conditions them extensive and under conditions of south slope difference with standard was not statistically significance or yield decreased.

Assaying average uptake of nutrient substances from soil we are able to conclude about joint influence on this parameter either slope exposition and variety features (Table 2). We can conclude that more measured quantity of nutrient elements in slope of south exposition winter wheat plant exploited at higher level than other. It has been shown us wide limits in winter wheat adaptation. Results of general uptake of microelements calculation are at the Tables 3 and 4.

So, we can see that the grain of wheat contains more microelements than straw. At the same time the lead and nickel uptake was more in the straw samples. It was one of the natural mechanisms for avoiding concentration of unappreciable elements in reproductive organs of plants. We cannot observe statistically reliable influence of relief on microelements and heavy metals content. Dates were contradictory. On the other hand we have to regard decreasing of some microelements (Zn, Mn, Fe) in straw on the slopes and valley floor. When we determined uptake of microelements from soil (Table 4) with winter wheat yield we observed that meaningful quantity of iron (2016.6 – 6659.9 g/ha), zinc (1036,7 – 1395,3 g/ha), manganese (1170.2 – 2555.0g/ha) take out with winter wheat and wasted out of the field. Uptake of copper was 256.6 – 433.2 g/ha, lead 201.9 – 265.0 g/he, nickel 141.9 – 346.9 g/ha. Losses of microelements on the south exposition slopes were considerably less than on flat interfluves and slope of north exposition.

High protein content has been identified in grains of the varieties Kolos Mironovschiny, Sonechko, Favoritka and Lasunya (Table 5).

Uptake of microelements and heavy metals, mg/kg Table 3

Relief element	Zn	Mn	Cu	Pb	Ni	Fe
Grain						
Flat	22.1	22.2	3.8	2.1	3.0	43.1
Slope of noth exposition	20.6	28.3	4.8	2.1	1.4	41.3
Slope of south exposition	23.9	23.4	4.1	2.1	2.4	31.2
Straw						
Flat	4.2	17.3	3.2	2.8	3.1	72.0
Slope of noth exposition	2.7	15.3	2.7	2.7	1.8	19.1
Slope of south exposition	1.8	5.3	2.3	2.5	1.0	16.1

Table 4

General uptake of microelements and heavy metals, g/ha

Relief element	**Fe**	**Zn**	**Mn**	**Cu**	**Ni**	**Pb**
Flat interfluve	6659.9	1395.3	2555.0	433.2	346.9	265.0
Slope of noth exposition	3438.2	1293.3	1549.9	388.0	187.1	292.3
Slope of south exposition	2016.6	1036.7	1170.2	256.6	141.9	201.9
Average	4038.2	1241.7	1758.4	359.3	225.4	253.1
Cv, %	58.9	14.9	40.7	25.5	47.8	18.3

Table 5

Protein content in winter wheat grains(%), gliadins and glutenins (g)

Variety	**Flat**			**Slope of noth exposition**			**Slope of south exposition**		
	protein	**gliadin**	**glutenin**	**protein**	**gliadin**	**glutenin**	**protein**	**gliadin**	**glutenin**
Podolyanka	13.5	0.024	0.61	13.7	0.020	0.62	13.8	0.021	0.63
Kolos Mironovschiny	14.4*	0.021	0.64	14.3	0.020	0.63	14.3	0.022	0.64
Kalinova	14.0*	0.023	0.67	14.0	0.024	0.66	14.1	0.022	0.66
Voloshkova	13.8	0.022	0.67	14.0	0.023	0.68	13.9	0.022	0.67
Sonechko	14.6*	0.028	0.78	14.5	0.028	0.77	14.5	0.027	0.77
Favoritka	14.5*	0.030	0.71	14.5	0.031	0.73	14.3	0.029	0.72
Hurtovina	13.8	0.023	0.57	13.9	0.024	0.56	13.7	0.025	0.57
Lasunya	14.7*	0.032	0.77	14.6	0.031	0.76	14.5	0.030	0.77
Line 418	14.0*	0.025	0.71	14.0	0.022	0.72	13.9	0.024	0.70
Average	14.1*	0.030	0.68	14.2	0.020	0.68	14.1	0.020	0.68
Cv, %	2.8	15.0	10.2	2.2	17.2	10.3	2.1	13.4	9.7

* significant differences from standard at $t_{0.05}$

We cannot see great difference between relief conditions and we have to conclude it's depended only on genotype, not from the growth conditions in our investigations. Only variety Lasunya has a good composition of protein under any conditions (and good quality of protein). Varieties Sonechko and Favoritka have been identified as prevalent due to glutenins content. As we can see, they show us the good amount or these protein components under any conditions and protein quality didn't depend on relief conditions. As for our opinion, in unappreciated conditions high-quality varieties lose their grain for the first time, but keep quality traits.

4. Conclusions

Studies on winter wheat grain productive and quality traits are usually limited to a few types of landscapes and measured number of varieties (without any record of variety type by special demands for realized of potential yield). Further analyses are needed in providing evaluation under more types of reliefs and climate's conditions with wider number of varieties, which covered all types of varieties agrotechnologies. One of the key moment for further investigation is including determined of sulfur content in soil under different in our investigations, because the availability of sulfur in the soil highly influences on the grain storage proteins (gliadins and glutenins in our investigations) composition of winter wheat grain.

Our investigations confirmed existing of relations between concentration of nutrient substances in plants, their loss from soil and peculiarities of landscape, which influenced on wheat agroecosystem productivity (but not quality), variety genotype and limits of adaptable. Generally, north exposition gives winter wheat more preferable conditions for growth and development. We recommended varieties Kolos Mironovschiny, Sonechko, Favoritka, partly Kalinova for growing under these conditions by grain productivity and varieties Lasunya by grain protein content and protein composition (but in every case only for one of components. Variability of grain productivity between varieties was higher under slope conditions than on flat. All genotypes were depended on grows conditions by grain yield on high level, but protein content and proteins composition depended only on genotype. Variety with genetically-performed high grain quality under unsusceptible conditions losed in yield but preserved their quality. The useful variability in agricultural traits for modern Ukrainian winter wheat varieties can be found in the difference of reactions on environmental conditions influence, illustrating the need to provide such investigations for improving some components of varieties agrotechnologies for difference agroecological conditions, which not account up to now. Yield of intensive varieties more power related with growth conditions than extensive.

We established that wheat grains contain more microelements than straw. Thereby, winter wheat plant has a teacher to avoid heavy metals in process of grains formation.

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