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MODERN UKRAINIAN WINTER WHEAT VARIETIES GRAIN PRODUCTIVITY AND QUALITY AT ECOLOGICAL EXAM

SUMMARY

The objectives of our investigations are to describe the variation of the main groups of modern winter wheat varieties (19 varieties, check is a national standard by grain productivity, Podolyanka) due to their interactions with environmental conditions by agronomic-value traits like as general grain productivity, components of one, protein and gluten content, developing relations between once (correlation relations), which determining wheat quality and yield in a complex. Second our purpose to estimate asset of winter wheat accessions and appear a useful diversity in comparison of modern varieties. Nineteen winter wheat genotypes have been investigated under regional conditions. Only one genotype surpassed standard in by agronomic-value traits on higher value and only one too have shown its traits in complex on standard level. Regarding to our investigations, ecological exam is necessarily to clarify true adaptability and suitability of winter wheat variety for regional conditions.

Keywords: winter wheat, variety, grain productivity, quality, ecological exam.

INTRODUCTION

With the annual production of about 757 million tons (in 2017) (USDA, 2018), bread wheat (Triticum aestivum L.) is one of the world’s most important cereal crops. Winter wheat is the world’s leading cereal grain and the most important food crop, occupying commanding position in Ukraine. Ukrainian agriculture takes about 48% area under cereals and contributing 38% of the total food grain production in the country (Nazarenko, 2015). Until the end of the 19th century, cultivars were mainly landraces that were well suitable to their regional ecological 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 (Bordes et al, 2008). 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

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decrease in wheat genetic diversity and needs in special requirements for realization their potential higher grain productivity and protein quality (Nazarenko and Kharitonov, 2016, Nazarenko, 2017). But in spite of increasing total grain productivity tolerance to the special ecological demands of new varieties have been decreased, what, consequently, influencing on the future adaptability and special interactions with environment of winter wheat (Nazarenko and Lykholat, 2018).

In the past wheat researches was more tried to improve general grain productivity of the crop, last twenty years focused more on grain quality, but winter wheat breeders ignored special adaptability fore regional specific conditions (like as Northern Steppe of Ukraine). By conditions in terms of our investigations we mean the special combination of insufficient of water in critical growing stages which combined with high temperature and hard winter conditions. These combinations determine the properties of wheat yield and the quality of grains (Dawson et al, 2011). These agricultural-value traits in interaction actually determine the overall varieties of wheat whether good or poor for farming (Gepts, Hancock, 2006). Winter wheat yield has the most important and complex character affected directly or indirectly by gens systems present in plant (Rangare et al, 2010) as well as interaction with environment (Tester and Langridge, 2010; Serpolay et al, 2011). 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 (Martynov and Dobrotvorskaya, 2006; Mba et al, 2012). Therefore, ecological estimation of new wheat varieties with high yield genetic potential under regional conditions, it`s components and quality traits (Slafer and Andrade, 1993) has become a permanent purpose in the plant farming and breeding programs (Reif et al, 2005; Tuberosa and Salvi, 2006, Nazarenko and Lykholat, 2018).

Disequilibrium in influence of different nature-agricultural factors and their interactions of region determine distinguishes summarized in different genotypes grain productivity and quality (Kharytonov et all, 2017). Due to this fact we investigated varieties main agricultural-value traits under regional conditions. They determined balance of moisture, character of winter wheat growth and development, differences in seasons conditions, interaction between types of variety development (terms and specify of development stages) (Andrusevich et al, 2018).

Focused on only yield traits we have to understand that any high yield has no sense without proper quality for food and fodder demands. In mature grain, 10–15% of the dry mass is protein. 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%) (Dai et al, 2015). Grain storage proteins actively produce by plants during the effective filling phase of plant development (Shewry et al., 2012, Bonnot et al, 2017). Thus, the grain storage proteins of winter wheat determines its economics value.

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 by agronomic-value traits like as general grain productivity, components of one, protein and gluten content. The most target objects are developing relations between once (correlation relations), which determining wheat quality and yield in a complex. Second our purpose to estimate asset of winter wheat accessions and appear a useful diversity in comparison of modern varieties. To appreciate the interest of researches in the vast geographical representation of wheat varieties, we compared the diversity of several directions of winter wheat breeding in Ukraine from difference regions of the country with great discrepancy in natural conditions and selection purposes in breeding process. All varieties in our investigation were harvested in a location suited to growing wheat, recommended to North Steppe district as suitable for agriculture in this region. Main agronomic-value traits were determined and analyzed.

MATERIAL AND METHODS

Experiments were carried out on the experimental fields of Dnipropetrovsk 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 field station of Dnipropetrovsk State Agrarian and Economic University use for many years (start from 60th years of twenty century) as an area for intensive agricultural farming and researches (Kharytonov et.al, 2017). It is located far away from the city Dnipro (about 30 km) enough to avoid industrial or town airpollution effects.

Winter wheat seeds were procured form department of breeding and seed farming of DSAEU. The recommended intensive agronomic practice was followed. Evaluation of total grain yield per plot was calculated from 2017 to 2018 years. The trial at ecological winter wheat varieties exam was set up at a randomized block design method with three replications and with a plot size of 10 m^2 in 3 replications. The controls were national standard by productivity ‘Podolyanka’ and initial variety. Data on yield structure components (plant height, number of productive culms, number of grain per spike, grain weight per spike and plant, 1,000 grains weight) were taken from 50 randomly selected plants of each line representing properly morphological traits for this variety.

Wheat samples were held at room condition at 18 - 20 for several days before grinding. Each sample of 30 g weigh was separately ground on a laboratory cyclone grinder (LMT-1, PLAUN LLC, Russia).

Mathematical processing of the results was performed by the method of analysis of variance, the variability of the mean difference was evaluated by Student's t-test, cluster and correlation analyses was conducted by module ANOVA. In all cases standard tools of the program Statistica 8.0 were used.

RESULTS AND DISCUSSION

Analysis of grain productivity and its structure

Under field conditions, measurements were recorded grain yield, main components of grain productivity such as number of productive culms, number of grains, grains weight of 1000 kernels, weight of grains from one main spike, weight of grains from m^2 (table 1 – 2). Standard error (±SE) values of these varieties like as average mean and standard deviation are at tables too.

Table 1. Components of winter wheat grain productive structure

Number	Variety	Number		Weight of grains		
		Number of productive culms, pcs.	Number of grains, pcs.	Weight of 1000 grains	From 1 spike, g.	From m^2, g.
1	Voloshkova	463	32*	34,2	1,09	505
2	Novosmuglyanka	555	17	48,6*	0,82	455
3	Smuglyanka	531	17	46,8	0,79	422
4	Spivanka	440	27*	47,2*	1,27*	560
5	Podolyanka, st	580	22	42,6	1,00	580
6	Komerciyna	391	26	47,2	1,22*	476
7	Ednist	505	26	36,6	0,94	476
8	Spasivka	368	26	48,8*	1,27*	467
9	Bogdana	460	19	48,4*	0,91	420
10	Kolyadka	515	25	44,2	1,12	578
11	Lodizhinka	416	23	43,6	1,02	425
12	Gorodnicya	470	22	49,4*	0.89	417
13	Garantiya	401	26	48,0*	1,23*	495
14	Melodiya	373	25	44,6	1,12	418
15	Zluka	440	22	48,0*	1,06	468
16	Gileya	400	24	53,0*	1,27*	510
17	Mudrist	420	29*	47,8*	1,39*	582
18	Svitanok	412	26	43,4	1,12	462
19	Selevita	507	24	45,2	1,09	553
	Average	455	24	45,7	1,09	488
	Std. deviation	62	4	4,4	0,17	58

* - difference is statistically significance from check at $P_{0.05}$

The results on number of productive culms, number of grains, grains weight of 1000 kernels, weight of grains from one main spike, weight of grains from m^2 derived from varieties and compared with national standard Podolyanka (line 5 at table) are tabulated (Table 1). Next genotypes have been developed by these traits due to high its level (more than standard) – varieties Voloshkova, Spivanka, Mudrist by number of grains from main spike (first and third varieties are corresponded to Forrest-Steppe type, which adapted to most humid conditions, Spivanka is corresponded to direct Steppe type), by weight of 1000 grains varieties Novosmuglyanka, Spivanka, Spasivka, Bogdana, Gorodnicya, Garantiya, Zluka, Gileya, Mudrist (varieties Spivanka, Garantiya are Steppe ecotype, other to Forrest-Steppe), by weight of grains from main spike varieties Spivanka, Spasivka, Garantiya, Gileya, Mudrist (varieties Spivanka, Garantiya are Steppe ecotype, other to Forrest-Steppe), weight of grains from m^2 we can find only genotypes on level of standard, but not higher.

Table 2. Winter wheat varieties grain productivity

Number	Variety	Percent of grains in total productivity	Yield, t/he (average, 2017 – 2018)	Number of cluster by grain yield
1	Voloshkova	37,9	5,05	2
2	Novosmuglyanka	27,9	4,55	2
3	Smuglyanka	29,4	4,22	3
4	Spivanka	41,5	5,60*	1
5	Podolyanka, st	42,7	5,80	1
6	Komerciyna	38,7	4,76	2
7	Ednist	42,0	4,76	2
8	Spasivka	38,9	4,67	2
9	Bogdana	38,8	4,20	3
10	Kolyadka	40,3	5,78*	1
11	Lodizhinka	32,7	4,25	3
12	Gorodnicya	36,8	4,17	3
13	Garantiya	40,1	4,95	2
14	Melodiya	40,5	4,18	3
15	Zluka	35,1	4,68	2
16	Gileya	40,3	5,10	2
17	Mudrist	38,8	5,82	1
18	Svitanok	36,0	4,62	2
19	Selevita	36,9	5,30*	1
	Average	37,7	4,81	--
	Std. deviation	4,0	0,54	--

* - difference is statistically significance from check at $P_{0.05}$

Summarized these dates next varieties have been identified as more perspective by these traits in complex Spivanka, Garantiya (Steppe ecotype, breeding special for Steppe conditions), Spasivka, Gileya, Mudrist (Forrest-Steppe ecotype). Differences of ecotypes are characterised by plant architecture and terms of several stages (date of critical stages like as evidence of spike are earlier than for other types and more suitable for higher quantity of water). We cannot see valuable forms by so key for yield characteristics as number of productive culms and grain weight from m^2. Grain productivity and percent of grains weight in a total productivity (on other way – coefficient of yield efficiency) are represented at table 2.

As we can see from the table, we could not develop genotypes with general grain productivity more than for standard Podolyanka. After cluster analyse we can subdivided all varieties on three type: 1 cluster for forms which productivity on a level of standard with stable meaning (Spivanka, Kolyadka, Mudrist, Selevita), 2 cluster for forms with grain productivity significantly lower than Podolyanka (and cluster 1 at general), but with possibility in some years be on this level (Voloshkova, Novosmuglyanka, Komerciyna, Ednist, Spasivka, Bogdana, Garantiya, Zluka, Gileya, Svitanok), 3 cluster for forms with grain productivity significantly lower than Podolyanka (and cluster 1 at general) under any year's conditions. As we can see, this classification cannot dependent from coefficient of yield efficiency and this parameter isn't important for ecological estimation. Regarding to the cluster classification we can recommended first cluster for Northern Steppe conditions and, partly, second cluster for some years or fore farmers, which placed under river's valley conditions, more humidly. As we can see no one components of grain productivity cannot use as reliable for yield forecasting.

Grain quality and relations with traits of grain productivity. At table 3 we represent dates of the results of next parameters analyzed: grain moisture, protein content and gluten content. Standard error (± SE) values of the treated variants are shown at table 3 too.

Table 3. Parameters of winter wheat grain quality.

Number	Variety	Moisture, %	Protein content, %	Gluten, %
1	Voloshkova	17,90±0,06	13,77±0,04	26,60±0,17
2	Novosmuglyanka	18,44±0,02	13,60±0,21	25,41±0,12
3	Smuglyanka	17,10±0,03	14,40±0,05	27,33±0,17*
4	Spivanka	16,20±0,04	14,20±0,02	26,9±0,09
5	Podolyanka, st	14,90±0,04	13,73±0,03	25,20±0,08
6	Komerciyna	15,90±0,19	13,50±0,02	24,60±0,02
7	Ednist	16,60±0,05	14,30±0,01	26,40±0,05
8	Spasivka	15,90±0,01	11,70±0,04	19,34±0,08
9	Bogdana	16,70±0,03	14,13±0,02	25,30±0,12
10	Kolyadka	14,22±0,51	12,30±0,06	25,54±0,21
11	Lodizhinka	14,22±0,01	14,00±0,10	25,72±0,26
12	Gorodnicya	16,90±0,01	13,50±0,05	23,72±0,16
13	Garantiya	16,00±0,05	14,70±0,05*	27,40±0,12*
14	Melodiya	16,34±0,02	13,32±0,04	24,80±0,12
15	Zluka	15,71±0,02	13,70±0,15	25,00±0,30
16	Gileya	16,80±0,05	14,81±0,05*	27,05±0,19
17	Mudrist	16,94±0,06	15,24±0,04*	28,83±0,20*
18	Svitanok	14,80±0,03	14,70±0,05*	27,40±0,19*
19	Selevita	14,80±0,02	13,54±0,05	24,34±0,24
	Average	16,12	13,85	25,63
	Std. deviation	1,16	0,84	2,00

* - difference is statistically significance from check at $P_{0.05}$

As we can see from table 3 in spite of grain productivity by protein content as key agronomic-value trait we can identify some more perspective than standard winter wheat varieties' like as Garantiya, Gileya, Mudrist, Svitanok. Only one of these varieties was corresponded to Steppe ecotype (Garantiya), other three for Forrest-Steppe, which characterized by higher protein content than the grains of first ecotype.

Regarding gluten content varieties Smuglyanka, Garantiya, Mudrist, Svitanok can be determined due to content hicher than standard. Only in one point (variety Smuglyanka) its distinguish from protein content parameter.

In complex (by quantity and quality traits) we can recommend variety Mudrist as full suitable by all parameters for Northern Steppe subzone (for our Dnipro region), other varieties are suitable only by yield or quality parameters, but variety Spivanka is also suitable on the level of standard by agronomic-value traits complex. At table 4 correlations between main yield and quality traits have been shown.

Table 4. Correlations between difference grain productive and quality traits

Correlation between	Weight of 1000 grains	Weight from 1 spike,	Weight from m^2	Percent of grains in total productivity	Yield	Protein content	Gluten
Weight of 1000 grains	--	-0,12	-0,13	-0,36*	-0,16	-0,23	-0,34*
From 1 spike, g.	-0,12	--	0,45*	0,52*	0,44*	-0,57*	-0,05
From m^2, g.	-0,13	0,45*	--	0,49*	0,99*	-0,20	0,25
Percent of grains in total productivity	-0,36*	0,52*	0,49*	--	0,52*	-0,19	-0,03
Yield	-,016	0,44*	0,99*	0,52*	--	-0,2	0,13
Protein content, %	-0,23	-0,57*	-0,20	-0,19	-0,2	--	0,79*
Gluten, %	-0,34*	-0,05	0,25	-0,03	0,13	0,79*	--

* - true strong relation.

Enough strong reliable correlations can be observed between such traits weight of 1000 grains and percent of grains in total productivity, gluten content (forward correlation), weight from 1 spike and grain weight from m^2, percent of grains in total productivity (direct correlation), protein content (forward correlation), weight from m^2 and yield (direct correlation). Generally, quality grain traits have strong forward correlation with productive traits and strong reliable direct correlations inside these groups.

Thus, we developed that in complex (by quantity and quality traits) we can recommend variety Mudrist as full suitable by all parameters for Northern Steppe subzone (for our Dnipro region), variety Spivanka is also suitable on the level of standard by agronomic-value traits complex..

Thereby, investigations in terms of ecological exam shows us, that general exam of winter wheat varieties isn't enough for detection suitability of winter wheat varieties for growth under regional conditions. Level of regional variability at climatic conditions is enough for significance discrepancies in genotype-environment reaction and, thus, for unsuccessful even for varieties obtaining in results of special breeding program for conditions of geographic zone (Steppe of Ukraine) and according to general variety model for this zone.

CONCLUSIONS

Due to results of our investigations our subzone has very specify requirements for winter wheat genotype grows and development. Only one genotype surpassed standard in by agronomic-value traits on higher value and only one too have shown its traits in complex on standard level.

Regarding to these statements, ecological exam is necessarily to clarify true adaptability and suitability of winter wheat variety for regional conditions. Sometimes even special breeding program for climatic zone is not enough for obtaining suitable forms. Moreover, under conditions of our exam variety Mudrist has a Forrest-Steppe ecotype and breeding not for these conditions at all.

Studies on winter wheat grain productive and quality traits are usually limited to a few types of climates (three zone for Ukraine) and measured number of varieties (without any record of variety type by special demands for realized of potential yield). Here the overall diversity of nineteen varieties in terms of many important indicators of wheat grain productivity and quality (content of protein and gluten) relating to growing, conditions was largely due to the diversity contributed by modern Ukrainian varieties. The wide phenotypic variability for the most of the agricultural-value traits investigated is indicative of the large diversity of the varieties and genotype-environment interactions, mutual influences of climatic conditions and genotype peculiarities.

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