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Formation Of Photosynthetic And Grain Yield Of Soft Winter Wheat (Triticum aestivum L.) Depending On Varietal Characteristics And Optimization Of Nutrition.

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ABSTRACT

The article presents the results of studies about the effectiveness of winter wheat crop cultivation with modern growth-regulating preparations in the background of mineral fertilizers carried out in 2011-2016yrs on the southern black soils in the Ukrainian Steppe. It was studied the effects of varietal characteristics of winter wheat and nutrition options on the photosynthetic activity of crops. It was determined that for growing winter wheat after peas it should be done under presowing cultivation of mineral fertilizer dose $N_{30}P_{30}$ (background) and use of foliar application crops at the beginning of the restoration of spring growing season and beginning of plant stoolingwith complex organic fertilizers Escort-bioas the favorable conditions would established for the formation of maximum leafe area of plants and in accordance to the highest value of photosynthetic capacity and net photosynthesis productivity of crops of studied varieties. Thus, on average, over the years of research, in this variant of nutrition the largest values of the area of the plant's leaf surface of winter wheat reached in the ear staining – 53.1 – 55.0 thousand m^2/ha depending on the variety. The maximum photosynthetic potential of crops was determined in the background application of $N_{30}P_{30}$ and subsequent fertilization of crops with Organic D2. Thus, on average, over the years of research, in the interphase period of tillering – plant stooling the photosynthetic potential of the Kol'chuga variety was 0.82 million m^2/ha x days, and the photosynthetic potential of the Zamozhnist' variety was 0.91 million m^2/ha x days, which respectively exceeded control by 29.3% and 28.6% respectively. The same trend was observed in the interphase period asplant stooling - earing. On average, during the years of research, the value of the index of pure productivity of photosynthesis in plant varieties in the control in the interphase period of tillering–plant stooling varied within 2,01 - 2,34 g/m^2 per day, the output of plants in the period of plant stooling - earing varied within 5, 38 - 5.92 g/m^2 per day and depending on the variety. After the application of mineral fertilizers under pre-sowing cultivation at a dose of $N_{30}P_{30}$ and subsequent nutrition of plants with the preparation Organic D2, the value of NPF in Kol'chuga and Zamozhnist' varieties increased by 29.4 - 34.7 and 21.2 - 39.3 % respectively depending on the interphase period of plant growth and development. It should be considered that the best variety of all investigated varieties of winter wheat according to their complex of indicators was the variety Zamozhnist'.

Keywords: winter wheat, variety, plant nutrition, growth-regulating preparations, leaf area surface, photosynthetic potential, pure photosynthesis productivity.

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INTRODUCTION

The demand for organic products has a steady tendency to increase throughout the world [1; 2; 3; 4]. With the adoption of the primary legislative framework, there was a certain impetus to the development of this trend in Ukraine, which in recent years had been included in 10 countries with the largest area of organic grain crops, including soft winter wheat. In world organic production of grain crops, wheat occupies 36% of all crop acreage, and in Ukraine it ranks first among all agricultural crops, occupying in crop rotation up to 50% [5; 6].

The transition from intensive technologies to organic farming ones, including winter wheat, would be a rather long process, which could last from 2 to 5 years, as a sharp transition to organic farming leads to significant depletion of the soil, deterioration of its physical and chemical properties, reduced yields and the deterioration of the quality of agricultural crops and it requires the achievement of a deficit-free balance of organic matter and basic nutrients [1; 7; 8].

Therefore, in the process of improving the technology of growing soft winter wheat in conditions of insufficient and unstable moisturing, it was appeared the matter of payback and ecological and energy efficiency of introducing low doses of mineral fertilizers and reducing the cost of production due to the combination of the application of the calculated doses of mineral fertilizers and extra-root nutrition with integrated organic fertilizers.

The main objective of organic technology of winter wheat cultivation is the realization of potential yields of varieties by rational use of natural factors of productivity. In each region, it would be necessary to select such varieties, which bioecological features fully correspond to the natural conditions of the area [9; 10; 11]. Modern varieties of winter wheat are characterized by high ecological plasticity, resistance to diseases and grain quality [10; 11; 12; 13].

Numerous studies of scientists in the world found that the use of complex organic fertilizers, composite growth bioregulators, inoculants, nanopreparations, biogenic elements would contribute to the regulation of growth and development of plants, their resistance to stress through increased plant immunity, activation of biological processes, synthesis of organic substances, increase the leaf area surface, the increase in the net productivity of photosynthesis and the yield of crops [14; 15; 16; 17; 18]. However, today, the market presents a very wide range of biologics as it complicates the choice, and scientific evidence of the influence of these drugs on the productivity of winter wheat in the world scientific literature is still not significant.

Taking into account the acuity of the problem, it is necessary to study the influence of modern certified biological products Organic D2 and Escort-bio on the productivity of wheat of winter varieties of Kol'chuga and Zamozhnist, as it involves the partial replacement of mineral fertilizers and chemical pesticides in order to increase the net productivity of photosynthesis, yield and quality of grain, and the creation the most favorable conditions for the restoration of soil fertility. The relevance of such study increases with the globalization of the influence of anthropo-technological load on the natural environment and the growth of the rate of depletion of natural ecosystems.

MATERIALS AND METHODS

Experimental researches were carried out during 2011 – 2016yrs on the experimental field of Mykolaiv National Agrarian University. The object of research was winter wheat of varieties of Kol'chuga and Zamozhnist'. The technology of their cultivation, with the exception of the investigated factors, was generally accepted due to existing zonal recommendations for the southern Steppe of Ukraine. The territory of the farm is located in the third agro-climatic region and belongs to the subzone of the southern steppe of Ukraine. The climate here is temperate-continental, warm, dry, with unstable snow cover. Weather conditions for hydrothermal indices during the research years varied, which gave an opportunity to obtain objective results, but in general, they were typical for the location of the farm.

The soil of experimental sites was represented by southern black soil, residual-weakly solonchack heavyclay loamon the loess. The reaction of the soil solution was neutral (pH 6,8). The content of humus in the

layer 0 - 30 cm was 3.3%. Movable forms of nutrients in the arable layer of soil on average contained of: nitrates (by Grandval Liag) were 18 mg / kg, mobile phosphorus (by Machigin) was 49 mg / kg, exchangeable potassium (on a flame photometer) was 295 mg / kg of soil.

The total land area was of 80 m^2, the accounting area was 30 m^2, the repetition was three times.

The scheme of experience included the following options:

Factor A as variety such as: 1. Kol'chuga; 2. Zamozhnist'.

Factor B as nutrition such as: 1. Control (without fertilizers); 2. $N_{30}P_{30}$ - for presowing cultivation-background; 3. Background + Urea K1 (1 l/ha); 4. Background + Urea K2 (1 l/ha); 5. Background + Escort-bio (0.5 l/ha); 6. Background + Urea K1 + Urea K2 (0.5 l/ha); 7. Background + Organic D2 (1 l/ha). The norm of the working solution was 200 l/ha. Fertilization of crops with modern growth-regulating preparations was carried out at the beginning of the resumption of spring vegetation and at the beginning of the winter wheat stooling. Plants of the control variant were sprayed with the tap water into the specified phases of growth and development.

Preparations used for foliar application of winter wheat crops were included in the List of pesticides and agrochemicals authorized for use in Ukraine. Preparations of Urea K1 and Urea K2 were registered as fertilizers containing respectively N about 11-13%, P_2O_5about 0,1-0,3%, K_2O about 0,05-0,15%, micronutrients about 0,1%, amberic acid about 0.1% and N about 9-11%, P_2O_5about 0.5-0.7%, K_2O about 0.05-0.15%, sodium humate about 3 g / l, potassium humate about 1 g / l , trace elements about 1 g / l. Organic D2 is a organo-mineral fertilizer containing N about 2,0 - 3,0%, P_2O_5about 1,7-2,8%, K_2O about 1,3-2,0%, total calcium about 2,0 - 6,0%, organic matter about 65 - 70% (in terms of carbon). Escort-bio - is a natural microbial complex that contains strains of microorganisms of genera Azotobacter, Pseudomonas, Rhizobium, Lactobacillus, Bacillus and biologically active substances produced by them (BAS).

For determining the phytometric indices (mass of dry and raw matter of plants, leaf area), plants were taken by frame method from 1 m^2 in three non-adjoining repeats in stages of growth and development. During the growing season, the area of the plant leaf surface was determined by the method of carving, the net productivity of photosynthesis (NFP) was determined as the growth of the mass of dry matter per unit time of the leaf area, the index of the leaf surface (PI) was determined as the ratio of the total leaf area to the unit area of the plantings.

RESULTS AND DISCUSSION

The top of plants plays an important role in the life of plants, as they mobilize carbohydrates and nitrogen-containing substances to form a productive part of the crop. Particularly the important role of the top of plants is provided in the south of Ukraine, where until the period of filling of the grain the significant part of the leaf apparatus dies.

On average, over the years of research, plants of the Variety Zamozhnist' (Table 1) accumulated somewhat higher amounts of crude on dry over ground masses. Thus, in the control version of the investigating of raw biomass of plants of the Zamozhnist' variety, the productivity in the phase of the plant stooling accumulated 1595 g/m^2, and the ear staining phase it accumulated 2083 g/m^2, which was 84 - 107 g / m^2 or 5.1 - 5.3% more in comparison with the raw weight of plants of the Kol'chuga variety. The same trend was observed in other variants of the experiment.

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Table 1: The growth of crude and dry overground mass of winter wheat plants depending on the variety features and nutrition optimization (average for 2012 - 2016 gg.), g/m²

Nutrition variant	Crude overground mass			Dry mass of plants		
	Phase of plant development					
	spring tillering	plant stooling	earing	spring tillering	plant stooling	earing
variety Kol'chuga						
Control	807	1511	1976	163	276	642
$N_{30}P_{30}$ (background)	857	1618	2107	180	301	700
Background + Urea K1	1050	1854	3031	220	352	1043
Background + Urea K2	1090	1941	3112	246	410	1099
Background + Urea K1 + Urea K2	1124	2045	3327	249	462	1214
Background + Escort-bio	1190	2181	3455	297	540	1332
Background + Organic D2	1150	2088	3365	261	467	1214
variety Zamozhnist'						
Control	865	1595	2083	177	324	675
$N_{30}P_{30}$ (background)	952	1730	2261	203	368	731
Background + Urea K1	1151	1978	3144	251	408	1103
Background + Urea K2	1194	2025	3227	285	454	1155
Background + Urea K1 + Urea K2	1260	2162	3412	286	499	1291
Background + Escort-bio	1347	2300	3581	332	592	1400
Background + Organic D2	1270	2205	3458	280	529	1265

It should be noted that the use of foliar fertilization of plants during the growing season with modern growth-regulating preparations Organic D2 and Escort-bio in the background of the application of a moderate dose of mineral fertilizers contributed to the accumulation of somewhat higher amount of crude over ground weight of plants of both investigated varieties of winter wheat. Thus, on average, over the years of research and by factor variety, in the phase of spring tillering it was formed 1210-1269 g/m^2, in the phase of plants stooling it was formed 2147 - 2241 g/m^2, in the phase of earing it was formed 3412 - 3518 g/m^2, it was exceeded the indicators of the control variant at 374 - 433; 594 - 688 and 1382 - 1488 g/m^2, or 30.9 - 34.1; 27.7 - 30.7 and 40.5 - 42.3% respectively.

The dynamics of accumulation of dry matter during the winter wheat growth in our studies had practically the same tendencies that were found during the formation of the crude over ground mass. In the tillering phase, the process of accumulation of dry matter by plants was slow, and the difference between the studied variants was only 17 - 134 g/m^2 for the Kol'chuga variety and it was 26 - 155 g/m^2 for the Zamozhnist' variety. However, already from the phase of plant stoolingit was traced a significant difference depending on the nutrition of plants and varieties at 8.3 - 48.9 and 12.0 - 45.3% with the advantage of the option background + Escort-bio.

Formation of a high yield of agricultural plants is the result of photosynthesis, in the process of which from simple substances it would be formed rich in energy complex and diverse in chemical composition of organic compounds. As known, the intensity of accumulation of organic matter depends on the size of the leaf surface, which is determined by the biometric parameters of plants and to a large extent it depends on the mode of their nutrition, as well as the duration of the productive activity of the leaves. The capacity of the assimilation apparatus and the duration of its work is a decisive factor in the productivity of photosynthesis, which determines the quantitative and qualitative indices of the crop. Our research found that the use of foliar fertilization of winter wheat crops contributed to the increase in the leaf surface area of plants from the phase of spring tillering to earing, after which in all years of the research a significant decrease was observed in this

indicator as it was related to the culture of biology, namely, the fading of the leaf apparatus and the outflow of nutrients from the leaves to the generative organs, although the processes of plant development were still ongoing. Thus, on average, over the years of research, during the entire vegetation season in fertilized plants, the leaf surface area was greater than of non-fertilized ones (table 2).

Table 2: Photosynthetic activity of winter wheat crops depending on varietal characteristics and optimization of nutrition (average for 2012 - 2016 gg.)

Plant nutrtion	Leaf index m^2/m^2			The net productivity of photosynthesis, g/m^2 per day		
	Phase of plant development			Interphase periods		
	spring tillering	Plantstooling	earing	tillering - stooling	stooling - earing	tillering – earing
variety Kol'chuga						
Control	1,20	2,34	3,51	2,01	5,92	3,75
$N_{30}P_{30}$ (background)	1,33	2,56	4,67	2,15	8,85	5,05
Background + Urea K1	1,42	2,77	5,00	2,44	8,38	4,89
Background + Urea K2	1,46	3,15	5,05	2,91	8,98	5,53
Background + Urea K1 + Urea K2	1,64	3,42	5,31	2,30	7,66	4,71
Background + Escort-bio	1,55	3,25	5,15	2,68	9,44	5,37
Background + Organic D2	1,62	3,38	5,27	3,08	8,38	5,60
variety Zamozhnist'						
Control	1,25	2,59	3,62	2,34	5,38	3,66
$N_{30}P_{30}$ (background)	1,42	2,81	4,79	2,25	8,25	4,87
Background + Urea K1	1,55	3,03	5,16	2,24	7,82	4,64
Background + Urea K2	1,62	3,32	5,18	2,64	9,00	5,37
Background + Urea K1 + Urea K2	1,80	3,65	5,50	2,76	6,64	4,50
Background + Escort-bio	1,67	3,44	5,28	2,54	8,34	5,12
Background + Organic D2	1,78	3,58	5,42	2,97	8,87	5,37

So, for the cultivation of winter wheat of the Kol'chuga variety from the beginning of spring tillering and till the earing phase in variants with a moderate dose of mineral fertilizers, the index of the area of the leaf surface increased up to 4.67 m^2/m^2, while for cultivating the Zamozhnist' variety, it in creased up to 4.79 m^2/m^2 .

The foliar fertilization of crops in the main periods of winter wheat plants vegetation with modern growth-regulating preparations in combination with the main application of the $N_{30}P_{30}$ provided for the growth of the index of the leaf surface of plants of the Kol'chuga variety in the earing phase up to 5,00 - 5,27 m^2/m^2, and the index of the Zamozhnist' variety increased up to 5.16-5, 50 m^2 / m^2 depending on the plant nutrition.

It should be noted that on average, in the years of research and in terms of nutrition factor, the index of leaf area of plants of winter wheat Zamozhnist' variety was slightly higher compared to Kol'chuga variety: in the tillering period it was higher by 7.6%, in the stooling it was higher by 6.9%, and in the earing it was higher by 2.8%

According to the results of our researches it was found that during vegetation the work of the leaf apparatus of plants was determined by the net productivity of photosynthesis (NFP). It was determined that this index depended on the investigated factors such as biological characteristics of the studied varieties of winter wheat, the background of nutrition, and on the phases of growth and development of plants. Thus, on average, over the years of research, in the experimental variants, where only the background fertilizer $N_{30}P_{30}$ was introduced, the Kolchuga variety in the interphase period of tillering - stooling, this index was 2.15 g/m^2 per day, during the interphase period, stooling - earing it was 8.85 g/m^2 per day. For the cultivation of

Zamozhnist' winter wheat, the yields were slightly higher compared to the Kol'chuga variety and they were 2.25 and 8.25 g/m^2 per day respectively.

The application of mineral fertilizers under pre-sowing cultivation in a dose of N30P30 with subsequent recharge at the beginning of the restoration of spring vegetation and at the beginning of winter wheat plants stooling with Urea K1 and Urea K2 provided an increase in this index of the Kol'chuga variety compared to the control in the interphase period of tillering - stooling was 21.4 and 44.8%, respectively, while in the interphase period, stooling - earing it was by 41.6 and 51.7%. The same trend was observed in the Zamozhnist' variety.

The largest net photosynthesis activity was determined in the background application of N30P30 and subsequent application of crops with Organic D2 and Escort Bio. Thus, in the middle of the year, in the years of research, in the interphase period of tillering –plant stooling, the net productivity of the photosynthesis of the Kol'chuga variety was 2.68 - 3.08 g/m^2 per day, and the net productivity of the photosynthesis of the Zamozhnist' variety was 2.54 - 2.97 g/m^2 per day, which exceeded control by 33.3 - 53.2 and 8.5 - 26.9%, respectively. The same trend was observed in the interphase period such asstooling - earing.

It should be noted that, on average, over the years of research and on the factor of plant nutrition, somewhat higher indices of pure productivity of photosynthesis were for the cultivation of the Kol'chuga variety. Thus, in the interphase period of tillering - earing, the net productivity of the photosynthesis of this variety exceeded this index of the variety Zamozhnist' by 0.2 g/m^2 per day or by 4.2%.

Consequently, the intensification of growth processes in winter wheat plants caused by the influence of modern organo-mineral and mineral fertilizers resulted in the formation of a larger over ground mass of plants, a more powerful leaf apparatus and it increased the net productivity of photosynthesis. Such anatomical and morphological changes positively influenced on the productivity of winter wheat varieties (Table 3).

Table 3: Performance of winter wheat, depending on varietal characteristics and optimization of nutrition (average for 2012 - 2016 gg.)

Variety	Plant nutrition	Number of grains in the ear, pc.	Weight of corn grain, g	Grain yield, t/ha
Kol'chuga	Control	24,9	0,88	2,89
	$N_{30}P_{30}$ (background)	27,0	1,00	3,44
	Background + Urea K1	28,0	1,08	4,23
	Background + Urea K2	28,2	1,11	4,33
	Background + Urea K1 + Urea K2	28,7	1,15	4,38
	Background + Escort-bio	29,8	1,25	4,48
	Background + Organic D2	29,3	1,19	4,42
Zamozhnist'	Control	27,5	1,02	3,05
	$N_{30}P_{30}$ (background)	29,5	1,15	3,58
	Background + Urea K1	30,2	1,23	4,64
	Background + Urea K2	30,5	1,26	4,83
	Background + Urea K1 + Urea K2	31,2	1,31	4,95
	Background + Escort-bio	31,7	1,35	4,99
	Background + Organic D2	31,3	1,32	4,96

Thus, on average, over the years of research, nutrition options to some extent influenced on the number of grains in the ear of investigated winter wheat varieties. So, if without fertilizers the ear of the wheat Kol'chuga variety contained of 24.9 grains, and the ear of the wheat Zamozhnist' variety contained of 27.5 grains, The pre-planting application of mineral fertilizers provided an increase of this index in terms of the varieties taken for studying at 6.8 - 7.8% , while for the fertilization of foliar nutrition it increased at 11.1 - 16.4% for the cultivation of the Kol'chuga variety and for the cultivation of the Zamozhnist' variety it increased for 8.9% - 13.2%.

In all years of the research somewhat larger number of grains in the ear was formed by plants of the Zamozhnist' variety. So, on average, over the years of research on the nutrition factor, they formed 30.3 grains, which exceeded the number of grains of the Kol'chuga variety by 2.3 grains or 7.6%.

It was found that, on average, over the years of research, varieties and variants of nutrition affected on the mass of grain from one ear. So, for the application of the background recommended dose of mineral fertilizers for the winter wheat Kol'chuga variety, the weight of grain from the ear was increased by 12.0% compared to unchecked control, and it was increased by 11.3% for the Zamozhnist' variety. Conducting of extra root nutrition on the background of mineral fertilizers increased the specified index of yield structure by 18.5 - 29.6 and 17.1 - 24.4% compared to control respectively.

In average, over the years of research, the most optimal parameters of the structure of winter wheat yield and the grain yield level were distinguished by the Zamozhnist' variety compared to the Kol'chuga variety. Thus, on average, over the years of research and on the factor of nutrition, the yield of the winter wheat Zamozhnist' variety was higher than the yield of the Kol'chuga variety by 0,41 t/ha or 10.2%.

Increasing of grain yield of the winter wheat Zamozhnist' variety on the application of N30P30 to control was 0.53 t/ha or 17.4%. On the background of the application of $N_{30}P_{30}$ the application of the growth-regulating preparations provided an increase in the grain yield of winter wheat about 1.59 - 1.94 t/ha or 52.1 - 63.6% depending on the preparation.

Foliar fertilization of the winter wheat Kol'chuga also positively affected on grain yield. Thus, on average, over the years of research, such agronomic technique contributed up to 1.34-1.59 t/ha or 46.4-55.0% increase in the yield compared to control.

The yield of both varieties naturally grew on variants of carrying out of foliar fertilization on the background of mineral fertilizer application. At the same time, the more significant increments of grain were formed in the variants of carrying on their background the fertilization of crops with the preparations Organic D2 and Escort-bio. Their application contributed to the increase in the grain yield of the winter wheat Kol'chuga by 1.53 - 1.59 t/ha or 52.9 - 55.02%, the grain yield of the winter wheat Zamozhnist' increased by 1.91 - 1.94 t/ha or 62.6 - 63.6% respectively.

CONCLUSION

In southern Ukraine, on average, over the years of research, the application of mineral fertilizers at a dose of $N_{30}P_{30}$ under pre-sowing cultivation and the application of extra-root crop cultivation at the beginning of the restoration of spring vegetation and early plant stooling and the application of fertilizers Organic D2 and Escort-bio contributed to the accumulation of somewhat more raw and dry overground mass of plants of both investigated varieties of winter wheat. Thus, on average, over the years of research and by factor variety, in the phase of spring tillering, 1210-1269 g/m^2 of crude overground mass was formed, in the phase of plant stoolingit was formed 2147 - 2241 g/m^2, in the phase of earing it was formed 3412 - 3518 g/m^2 , which, respectively, exceeded the indicators of the control variant at 374 - 433; 594 - 688 and 1382 - 1488 g/m^2, or 30.9 - 34.1; 27.7 - 30.7 and 40.5 - 42.3%.

The root-crop fertilization of crops in the main periods of vegetation of winter wheat plants with modern growth-regulating preparations in combination with the main application of the $N_{30}P_{30}$ provided for the growth of the index of the leaf surface of plants of the Kol'chuga variety in the earing phase up to 5,00 - 5,27 m^2/m^2, and the growth of the index of the Zamozhnist' variety - to 5.16-5, 50 m^2/m^2 depending on the plant nutrition. Drinking with Escort-Bio and Organic D2 supplies the highest yields of the crop structure. Thus, according to the data of the plant nutrition, on the average over the years of research, the number of grains in the ear and the grain weight of one ear in the Kol'chuga variety amounted to 29.3 - 29.8 pcs respectively. and 1.19 - 1.25 g, depending on the preparation, and the number of grains in the ear and the grain weight of one ear in the Zamozhnist' variety amounted to 31.3 - 31.7 pcs. and 1.32-1.35 g. In this regard, irrespective of the year of cultivation, the significantly higher yield of winter wheat yields provides the cultivation of Zamozhnist' variety on the application of moderate recommended dose of mineral fertilizers on the background and to carry out foliar nutrition of the plants by Escort-bio.

REFERENCES

[1] Pattanapant, A. and Ganesh Prasad Shivakoti. Factors influencing the adoption of organic agriculture in Chiang Mai Province, Thailand. Journal of Nutrition, Agriculture & Environment, Vol.12 (1), January 2014. Pp. 132-139. doi: https://doi.org/10.1234/4.2014.4152

[2] Yamamoto, D., Engelsted, A. K. (2014) World Wide Opportunities on Organic Farms (WWOOF) inthe United States: locations and motivations of volunteer tourism host farms. Journal of sustainable tourism, 22(6), 964-982. doi:10.1080/09669582.2014.894519.

[3] Muneret, L., Thiery, D., Joubard, B. (2017)Deployment of organic farming at a landscape scale maintains low pest infestation and high crop productivity levels in vineyards. Journal of applied ecology, 55(3), 1516-1525.doi:10.1111/1365-2664.13034

[4] Lee, T. H., Chen, Y. Y., Chen, M. H. (2018) Assessing a sustainable development model for organic agriculture: the example of leisure farms in Taiwan. Environmental engineering and management journal, 17(3), 675-684. doi: 10.30638/eemj.2018.068.

[5] Bondar, V. (2016) Organic grain production market of Ukraine: prospects and trends. Baltic journal of economic studies, 2(3), 17-22. doi:http://dx.doi.org/10.30525/2256-0742/2016-2-3-17-22

[6] Bezus, R, Bilotkach, I. (2018) Development of organic farmers' cooperatives: the USA, the EU, andUkraine. Baltic journal of economic studies, 4(2), 24-31. doi: 10.30525/2256-0742/2018-4-2-24-31

[7] Stappen, V. F, Loriers, A., Mathot, M., Planchon, V., Stilmant, D., Debode, F. (2015) Organic versus conventional farming: the case of wheatproduction in Wallonia (Belgium). Agriculture and Agricultural Science Procedia, 7, 272-279. doi:10.1016/j.aaspro.2015.12.047

[8] Morvan, X., Verbeke, L., Laratte, S. (2018) Impact of recent conversion to organic farming on physical properties and their consequences on runoff, erosion and crusting in a silty soil. Catena, 165, 398-407. doi:10.1016/j.catena.2018.02.024

[9] Hrabovska, T. O., Melnyk, H. H. (2017) Vplyv biopreparativ na produktyvnist pshenytsi ozymoi za orhanichnoho vyrobnytstva. Ahrobiolohiia, V 1, 85.

[10] Kiseleva, M. I., Kolomiets, T.M., Pakholkova, E.V., Zhemchuzhina, N.S., Lubich, V. V. (2016) The differentiation of winter wheat (Triticum aestivum L.) cultivars for resistance to the most harmful fungal pathogen. Sel'skokhozyaistvennaya Biologiya, 3, 299-309. doi: 10.15389/agrobiology.2016.3.299rus http://www.agrobiology.ru/3-2016kiseleva.html

[11] Moskalets, V., Moskalets, T. Z., Vasylkivskyi, S. P., Grynyk, I. V., Vovkohon, A. G., Lobova, O. V., Shevchuk, O. A. Knyazyuk, O. V. (2016) Common wheat: ecological plasticity by biological and technological marker. Biological Bulletin of Bogdan Chmelnitskiy Melitopol State Pedagogical University, 6 (3), 311–318. doi:http://dx.doi.org/10.15421/2016100

[12] Montesinos-López, O. A., Baenziger, P. S., Eskridge, K. M., Little, R. S., Martínez-Crúz, E., Franco-Perez, E. (2018) Analysis of genotype-by-environment interaction in winter wheat growth in organic production system. Emirates Journal of Nutrition and Agriculture, 30(3), 212-223. doi: 10.9755/ejfa.2018.v30.i3.1643.

[13] Babenko, L. M., Hospodarenko, H. M., Rozhkov, R. V., Pariy, Y. F., Pariy, M. F, Babenko, A. V., Kosakivska, I. V. (2018) Triticum spelta Origin, biological characteristics and perspectives for use in breeding and agriculture. Regulatory Mechanisms in Biosystems, 9(2), 250–257. doi: 10.15421/021837

[14] Singh, G., Sharma, G., Sanchita, Kalra, P., Batish, D. R., Verma, V. (2018) Role of alkyl silatranes as plant growthregulators: comparative substitution effect on root and shoot development of wheat and maize. Journal of the science of nutrition and agriculture, 98(13), 5129-5133. doi: 10.1002/jsfa.9052

[15] Pestovsky, Y. S., Martinez-Antonio, A.(2017)The Use of Nanoparticles and Nanoformulations inAgriculture. Journal of nanoscience and nanotechnology, 17(12), 8699-8730. doi: 10.1166/jnn.2017.15041

[16] Piskaeva, A. I., Babich, O. O., Dolganyuk, V. F. (2017) Analysis of influence of biohumus onthe basis of consortium of effective microorganisms on the productivity of winter wheat. Nutritions and raw material, 5(1), 90-99.doi: 10.21179/2308-4057-2017-1-90-99.

[17] Wakchaure, G. C., Minhas, P. S., Ratnakumar, P., Choudhary, R. L. (2016) Effect of plant bioregulators on growth, yield and water production functions of sorghum [Sorghum bicolor (L.) Moench]. Agricultural water management, 177, 138-145. doi:10.1016/j.agwat.2016.07.020.

[18] Klein, J., Guimarães, V. F. (2018) Evaluation of the agronomic efficiency of liquid and peat inoculants of Azospirillum brasilense strains in wheat culture, associated with nitrogen fertilization. Journal of Nutrition, Agriculture & Environment, 16 (1), 41-48. doi:https://doi.org/10.1234/4.2018.5480