DEPÓSITO LEGAL ZU2020000153
ISSN 0041-8811
E-ISSN 2665-0428

Revista de la Universidad del Zulia

Fundada en 1947
por el Dr. Jesús Enrique Lossada

Ciencias Exactas, Naturales y de la Salud

75
ANIVERSARIO

Año 13 N° 37
Mayo - Agosto 2022
Tercera Época
Maracaibo-Venezuela

REVISTA DE LA UNIVERSIDAD DEL ZULIA. 3ª época. Año 13 N° 37, 2022
Oleksander O. Vinyukov et al. /// Agrotechnical methods of increasing drought resistance... 244-261
DOI: http://dx.doi.org/10.46925//rdluz.37.16

Agrotechnical methods of increasing drought resistance of spring barley

Oleksander O. Vinyukov *
Anatoliy D. Gyrka **
Oksana M. Korobova ***
Olha B. Bondareva ****
Hanna A. Chuhrii *****

ABSTRACT

Studies were conducted in the Northern Steppe of Ukraine with the aim to increase the drought resistance of spring barley through such agrotechnical methods as: selection of new adaptive varieties, as well as improving the fertilizer system through the use of new nutrient complexes. New promising drought-resistant varieties of spring barley such as Stepovyk, Avers, Pryazovskyi 9, Chudovyi, Donetsk 14 are intended for cultivation in the Northern Steppe of Ukraine. It is established that the use of the new Nutrient Complex 3 increases the yield with the mineral fertilizer system by 1.37 t/ha, with the organo-mineral fertilizer system — by 2.08 t/ha, and Nutrient Complex 1 with the biological fertilizer system — by 1.6 t/ha, compared with control sample without the use of nutrient complexes.

KEYWORDS: biopreparation, plant growth regulators, spring barley, drought resistance, nutritional complex.

*Senior Researcher of Donetsk State Agricultural Science Station of National academy of agrarian sciences of Ukraine, Pokrovsk, Ukraine. ORCID: https://orcid.org/0000-0002-2957-5487. E-mail: olgafast43@gmail.com

**Professor of The Institute of Grain Crops of National Academy of Agrarian Sciences of Ukraine, Dnipro, Ukraine. ORCID: https://orcid.org/0000-0002-2521-502X. E-mail: adgurka1@gmail.com

***Head of the department of selection and seed production of grain and fodder crops of Donetsk State Agricultural Science Station National Academy of Agrarian Sciences of Ukraine, Pokrovsk, Ukraine. E-mail: oksy.korobov22@ukr.net

****Candidate of Technical Sciences, Senior Researcher of Donetsk State Agricultural Science Station National Academy of Agrarian Sciences of Ukraine, Pokrovsk, Ukraine. ORCID: https://orcid.org/0000-0002-8128-8485. E-mail: olbraum51gm87@gmail.com

*****Head of the Department of Agricultural Production Technologies of Donetsk State Agricultural Science Station National Academy of Agrarian Sciences of Ukraine, Pokrovsk, Ukraine. ORCID: https://orcid.org/0000-0002-0250-2456.

Recibido: 04/02/2022 Aceptado: 30/03/2022

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Métodos agrotécnicos para aumentar la resistencia a la sequía de la cebada de primavera

RESUMEN

Se realizaron estudios en la estepa septentrional de Ucrania con el objetivo de aumentar la resistencia a la sequía de la cebada de primavera a través de métodos agrotécnicos como: selección de nuevas variedades adaptativas, así como mejorar el sistema de fertilización mediante el uso de nuevos complejos de nutrientes. Las nuevas variedades prometedoras de cebada de primavera resistentes a la sequía, como Stepovyk, Avers, Pryazovskyi 9, Chudovyi, Donetsk 14, están destinadas al cultivo en la estepa septentrional de Ucrania. Se establece que el uso del nuevo Complejo de nutrientes 3 aumenta el rendimiento con el sistema de fertilizantes minerales en 1,37 t / ha, con el sistema de fertilizantes organominerales - en 2,08 t / ha, y el Complejo de nutrientes 1 con el sistema de fertilizantes biológicos - en 1,6 t / ha, en comparación con la muestra de control sin el uso de complejos de nutrientes.

PALABRAS CLAVE: biopreparado, reguladores del crecimiento vegetal, cebada primaveral, resistencia a la sequía, complejo nutricional.

Introduction

Ukraine is an important supplier of grain crops in the world. According to the US Department of Agriculture, Ukraine ranked second in the supply of barley to world markets in 2020 (Radio "Svoboda", 2021). Thus, the need for barley grain production in our country is growing every year, which encourages to increase its production in all climatic zones of Ukraine. It is especially reasonable to grow spring barley in the Northern Steppe zone of Ukraine due to high potential productivity, low energy and resource consumption (Timofeyev et al., 2016). Under the conditions of observance of scientifically substantiated technologies, the bioclimatic potential of the Steppe zone allows obtaining the yield of spring barley at the level of 8.0-9.0 and more than 10.0 t/ha (Adamenko, 2004, 2006; Diduh, 2009). However, agrotechnologies for growing spring barley do not take into account the peculiarities of new varieties, climate change, which brings frequent droughts and dry winds in the steppe zone of Ukraine, the use of new biopreparations and growth regulators, so its yield in this area is quite low in the range of 1.8–2.5 t/ha (Laman et al., 1991; Lipinskiy et al., 2003; Pashtenko et al., 2010; Yurkevich et al., 2011).

DOI: http://dx.doi.org/10.46925//rdluz.37.16

So, solving the problem of increasing the yield and drought resistance of spring barley requires improving existing agrotechnical methods of its cultivation, taking into account the agrobiological characteristics of new adaptive varieties and improving the fertilizer system using biopreparations and plant growth regulators. Therefore, research on the selection of varieties and improvement of the fertilizer system through the use of biopreparations, plant growth regulators, biofertilizers is urgent (Abay and Bjørnstad, 2009; Sallam et al., 2018).

1. Materials and Methods

The research was conducted in 2011–2018 on the research field of the Donetsk State Agricultural Research Station of the National Academy of Agrarian Sciences of Ukraine, which is located in the central part of the Donetsk region. The crop area is 80.0 m2. There was a triple repetition in experiments. The placement of crop areas is systematic. Soil — ordinary low humic, heavy loamy chernozem. Gross content of basic nutrients: N — 0.28-0.31%, P2O5 — 0.16-0.18%, K2O — 1.8-2.0%, humus content in the arable layer — 4.5%, soil pH — 6.9. The experiment involved 37 sown varieties of spring barley of different breeding centers. The technology of growing spring barley is generally accepted for the region. The sowing rate is 4.5 million/ha of similar seeds. The crop was harvested with a Sampo-130 combine in sections.

The coenotic composition of crops by plant productivity rank was studied When determining the adaptive potential of varieties to maintain ontogenetic homeostasis: zero rank (0) — plants without seeds, first rank (1) — plants with one fertile tiller, second rank (2) — plants with two fertile tillers and so on for the third and fourth ranks.

Research was also conducted to study the effectiveness of new nutrient complexes, which included biopreparations, plant growth regulators for growth and development of spring barley. There were three fertilizing backgrounds: Background 1 — N30P30K30, Background 2 — N15P15K15 + biohumus (250 kg/ha), Background 3 — biohumus (250 kg/ha). Microbiological complex of biopreparations — a mixture of Phosphoenterin (133.3 g/t), Diazophyte (133.3 g/t) and Biopolycid (133.3 g/t). The design of the experiment consisted of the following options:

Background 1 – N30P30K30: Control — without seed treatment and crop spraying; chemical protection of crops — seed treatment with Vitavax 200FF (3 l/t) and crop spraying

DOI: http://dx.doi.org/10.46925//rdluz.37.16

with Borey insecticide (0.1 l/ha) and Falkon fungicide (0.6 l/ha); biological crop protection — inoculation of seeds with a microbiological complex (400 g/t); Complex 1*: seed treatment with Rost-forte (0.5 l/t) in a mixture with a complex of amino acids, spraying of plants in the tillering and earing phases with a mixture of Rost-concentrate 15.7.7 (1 l/ha) + amino acid complex + Khelatin (2 l/ha) + microbiological complex (400 g/ha); Complex 2**: seed treatment with Aidar (2 l/t), spraying of plants in the tillering and earing phases with a mixture of Aidar (2 l/ha) and microbiological complex (400 g/ha); Complex 3***: seed treatment with Sizam (250 g/t) in a mixture with a microbiological complex (400 g/t), spraying of plants in the tillering phase with a mixture of Sizam (250 g/ha) and microbiological complex (400 g/ha).

Background 2 – N15P15K15 + biohumus (250 kg/ha). Control — without seed treatment and spraying; Chemical crop protection — seed treatment with Vitavax 200FF (3 l/t) and spraying of crops with Borey insecticide (0.1 l/ha) and Falkon fungicide (0.6 l/ha). Biological crop protection — seed inoculation with microbiological complex (400 g/t); Complex 1*: seed treatment with Rost-forte (0.5 l/t) in a mixture with amino acid complex, spraying of plants in the tillering and earing phases with a mixture of Rost-concentrate 15.7.7 (1 l/ha) + amino acid complex + Khelatin (2 l/ha) + microbiological complex (400 g/ha); Complex 2**: seed treatment with Aidar (2 l/t), spraying of plants in the tillering and earing phases with a mixture of Aidar (2 l/ha) and microbiological complex (400 g/ha). Complex 3***: seed treatment with Sizam (250 g/t) in a mixture with a microbiological complex (400 g/t), spraying of plants in the tillering phase with a mixture of Sizam (250 g/ha) and a microbiological complex (400 g/ha).

Background 3 — biohumus (250 kg/ha). Control — without seed treatment and crop spraying; chemical protection of crops — seed treatment with Vitavax 200FF (3 l/t) and spraying of crops with Borey insecticide (0.1 l/ha) and Falkon fungicide (0.6 l/ha); biological protection of crops — inoculation of seeds with microbiological complex (400 g/t). Complex 1*: seed treatment with Rost-forte (0.5 l/t) in a mixture with amino acid complex, spraying of plants in the tillering and earing phases with a mixture of Rost-concentrate 15.7.7. (1 l/ha) + amino acid complex + Khelatin (2 l/ha) + microbiological complex (400 g/ha). Complex 2**: seed treatment with Aidar (2 l/t), spraying of plants in the tillering and earing phases with a mixture of Aidar (2 l/ha) and microbiological complex (400 g/ha). Complex 3***: seed

DOI: http://dx.doi.org/10.46925//rdluz.37.16

treatment with Sizam (250 g/t) in a mixture with a microbiological complex (400 g/t), spraying of plants in the tillering phase with a mixture of Sizam (250 g/ha) and microbiological complex (400 g/ha).

2. Results

Comparative analysis of the coenotic structure of varietal crops allows differentiating varieties by adaptive capacity to maintain ontogenetic homeostasis under stress of the factor "productive moisture reserves in the soil" and identifying the most adapted varieties for specific adverse growing conditions (Table 1).

The varieties Stepovyk, Avers, Pryazovskyi 9, Chudovyi, which demonstrated high adaptability and ecological plasticity on average over the years of research, are distinguished in the experiment according to the above-mentioned qualities.

The largest percentage was occupied by the first productivity rank (from 58.6% to 61.8%), followed by the second productivity rank (from 22.4% to 28.9%). These varieties also had the third productivity rank (from 2.5% to 4.1%), and the varieties Avers and Pryazovskyi 9 had the fourth rank of productivity of 0.2% and 0.3%, respectively.

Intensive-type varieties — Kazkovyi, Vodohrai, Vakula, Tokada under unfavourable growing conditions were significantly inferior in terms of coenotic structure of experimental crops to varieties of adaptive type. These varieties increased the zero rank of plant productivity, the share of which reached 30% or more in both favourable and droughty years. Plants with the first productivity rank had the largest proportion — from 47.4% to 60.9%, and with the second — only from 5.2% to 10.5%.

A comparative analysis of plant productivity elements for two productivity ranks (first — second, first — third) is a sufficiently informative means of determining the economic value of varieties. Therefore, we will give an example of such an analysis based on the results of varietal research in the conditions of hyperarid 2015, which is typical for the conditions of the Donetsk region in terms of moisture supply.

We will make an analysis based on the results of biometric data, where the indicators of quantitative indicators of ears for plants of the second rank of productivity were calculated as the sum of indicators of the main and secondary ear and considered them as characteristics of one conditional ear (Table 2).

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Table 1. Indicators of coenotic structure of crops of the spring barley varieties of ecological crop variety testing of the Donetsk State Agricultural Research Station of the National Academy of Agrarian Sciences of Ukraine, average for 2011-2015.

Variety name	Shoots, pcs/m^2	Number of plants before harvesting						Productive stems, pcs/m^2	Productive shoots, pcs per 1 plant
		Total, pcs/m^2	Including by productivity rank						
			0	1	2	3	4		
Stalker	470	466	15.9	71.8	11.4	0.9	-	460	0.99
Donetskyi 12	436	423	10.9	73.7	14.6	0.8	-	449	1.1
Hetman	406	390	24.7	59.3	14.6	1.2	0.2	362	0.93
Kazkovyi	364	330	40.6	48.1	10.5	0.8	-	233	0.71
Chudovyi	398	388	12.3	61.2	22.4	4.1	-	441	1.14
Vodohrai	402	372	36.2	56.9	6.8	0.1	-	263	0.71
Adapt	400	385	18.6	72.2	9.2	-	-	349	0.91
Vakula	396	345	33.7	60.9	5.2	0.2	-	249	0.72
Helios	441	387	30.6	64.4	4.9	0.1	-	288	0.74
Komandor	405	400	30.0	59.8	9.4	0.8	-	324	0.81
Halaktyk	370	365	31.0	56.2	12.6	0.2	-	300	0.82
Pivdennyi	510	503	27.0	67.7	5.3	-	-	394	0.78
Charivnyi	423	395	33.8	51.5	13.2	1.5	-	327	0.83
Enei	490	477	20.3	69.1	9.7	0.8	0.1	435	0.91
Vsesvit	510	502	24.9	70.5	4.4	0.2	-	402	0.80
Annabel	387	365	285	58.8	11.8	0.9	-	310	0.85
Danuta	448	415	12.7	67.7	18.1	1.4	0.1	455	1.1
Tokada	404	365	44.3	47.7	7.1	0.8	-	235	0.64
Donetskyi 14	442	410	12.5	66.1	20.2	1.2	-	450	1.1
Donetskyi 15	352	326	15.1	61.9	20.0	2.7	0.3	361	1.1
Partner	496	488	13.5	73.8	12.2	0.5	-	485	1.0
Skhidnyi	413	400	12.1	73.2	14.0	0.7	-	425	1.06

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Stepovyk	423	410	10.0	61.6	24.5	3.9	-	505	1.23
Avers	412	407	6.6	61.8	28.9	2.5	0.2	519	1.27
Shchedryk	424	411	12.4	63.7	21.5	2.4	-	462	1.12
Pryazovskyi 9	425	411	12.6	58.6	25.3	3.2	0.3	492	1.20
Zernohradskyi 813	461	421	26.2	60.4	12.8	0.3	-	367	0.87
Pryklad	462	446	29.0	62.3	8.5	0.2	-	335	0.80
Zdobutok	420	417	26.1	68.3	5.4	0.2	-	332	0.80
Parnas	482	475	22.5	68.4	8.8	0.3	-	412	0.87
Inklusyv	464	446	29.0	62.0	8.8	0.2	-	359	0.80
Vzirets	490	480	26.2	61.6	11.2	1.0	-	417	0.80
Etyket	400	392	23.4	62.9	12.9	0.8	-	356	0.91
Vyklyk	371	345	31.7	58.0	10.0	0.3	-	272	0.80
Zadum	360	353	25.7	53.0	19.2	2.0	0.1	341	0.97
Dokaz	418	396	20.5	62.4	15.8	1.3	-	387	1.0

Comparative analysis for two ranks of plant productivity allowed to evaluate varieties for agroecological plasticity, which is largely due to the fact that the transition of plants to a higher level of individual productivity is accompanied by a weak competition between productive shoots in the distribution of plastic substances and as a result of optimal synchronicity of their development by length, grain size and weight of ears.

According to the multiplicity of growth of plant productivity indicators of the second rank, the variety Donetsk 14 was distinguished among the varieties of spring barley studied in 2015, which can be objectively defined as a variety with a high level of agroecological plasticity.

The Donetsk Agricultural Research Station of the National Academy of Agrarian Sciences of Ukraine obtained the highest yield from the new variety —Skhidnyi — at the level of 3.47 t/ha among the studied varieties of spring barley. Thus, this variety was selected for further research to study the effects of new nutrient complexes, which included

DOI: http://dx.doi.org/10.46925//rdluz.37.16

biofertilizers, biopreparations and plant growth regulators on growth and development of spring barley.

Table 2. Elements of plant productivity in spring barley varieties of ecological crop variety testing, 2015 (for two productivity ranks)

Variety name	Plant productivity rank	Development of quantitative indicators of productivity							
		Plant height, cm	Seeding rate, adjusted, pcs	Ear length, cm	The number of grains in the main ear, pcs	Ear weight, g	Grain weight, g	Economic efficiency, %	Ear unit weight, mg/cm
Stalker	1	40.7	1.6	5.4	11.8	0.59	0.67	0.92	108
	2	38.6	2.9	8.3	14.0	0.74	1.13	0.68	89
	n*	-1.05	1.81	1.53	1.18	1.25	1.68	-1.35	-1.21
Chudovyi	1	43.0	1.4	5.2	11.2	0.57	0.62	0.91	104
	2	44.7	2.0	9.8	19.7	0.90	1.01	0.92	93
	n	1.03	1.42	1.88	1.75	1.57	1.62	1.01	-1.12
Selenit	1	40.3	3.3	6.4	9.4	0.46	0.96	0.51	71
	2	42.3	4.1	11.9	17.7	0.83	1.38	0.63	70
	n	1.04	1.24	1.85	1.88	1.8	1.43	1.23	-1.01
Vodohrai	1	39.4	2.8	7.0	10.6	0.57	0.97	0.67	84
	2	40.6	3.4	12.1	19.8	1.01	1.37	0.77	82
	n	1.03	1.21	1.72	1.87	1.77	1.41	1.14	-1.02
Kazkovyi	1	36.1	2.5	6.0	9.8	0.49	0.86	0.61	83
	2	37.3	2.8	11.4	14.9	0.79	1.17	0.71	74
	n	1.03	1.12	1.90	1.52	1.61	1.36	1.16	-1.12

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Zadonskyi 8	1	44.4	2.7	6.7	11.6	0.62	0.98	0.63	97
	2	45.3	2.8	12.4	19.9	1.03	1.45	0.71	85
	n	1.02	1.03	1.85	1.71	1.66	1.47	1.12	-1.14
Donetskyi 12	1	42.9	1.7	5.1	10.5	0.48	0.67	0.73	94
	2	45.9	2.0	9.7	18.0	0.87	1.02	0.85	90
	n	1.05	1.17	1.90	1.71	1.81	1.52	1.16	-1.04
Donetskyi 14	1	41.0	2.7	5.2	8.1	0.42	0.91	0.47	79
	2	44.9	2.7	10.2	16.7	0.88	1.27	0.71	84
	n	1.09	1.00	1.96	2.06	2.09	1.39	1.51	1.06
Donetskyi 15	1	39.4	2.4	5.6	11.0	0.55	0.87	0.66	99
	2	39.0	2.4	10.4	18.5	0.92	1.16	0.79	87
	n	-1.01	1.00	1.85	1.68	1.67	1.33	1.19	-1.13
Partner	1	43.9	2.0	5.4	10.0	0.50	0.67	0.79	93
	2	44.4	2.5	10.0	18.2	0.91	1.18	0.78	89
	n	1.01	1.25	1.85	1.82	1.82	1.76	-1.01	-1.04

Note: n* – the multiplicity of growth of quantitative indicator in the transition of plants to a higher productivity level

The results of studies on the density of spring barley of Skhidnyi variety in the full maturity phase depending on the nutrient complex and nutritional background showed that the highest increase in total tillering compared to the control on the mineral nutritional background was observed when using microbiological preparations — +0.41 compared to control (Table 3).

The study of the productive tillering coefficient showed an increase for all options of the experiment compared with the control. The largest increase was observed in the use of microbiological drugs to stimulate growth processes and protect plants from pests and diseases.

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Table 3. The density of spring barley of Skhidnyi variety in the full maturity phase depending on the nutrient complex and the nutritional background, average for 2014–2018

Option	Number of stems, pcs/m^2		Tillering rate	
	total	productive	total	productive
Background 1 – $N_{30}P_{30}K_{30}$				
Control	1,007.5	563.0	2.24	1.25
Chemical protection of crops	1,185.0	651.5	2.63	1.45
Biological protection of crops	1,193.5	661.0	2.65	1.47
Complex 1*	1,146.0	584.0	2.55	1.30
Complex 2**	1,171.0	628.0	2.60	1.40
Complex 3***	1,169.0	654.0	2.60	1.45
Background 2 – $N_{15}P_{15}K_{15}$ + biohumus (250 kg/ha)				
Control	998.5	430.5	2.22	0.96
Chemical protection of crops	1,177.5	603.0	2.62	1.34
Biological protection of crops	1150.0	586.0	2.56	1.30
Complex 1*	1,190.0	526.0	2.64	1.17
Complex 2**	1,164.0	661.5	2.59	1.47
Complex 3***	1,173.0	647.7	2.61	1.44
Background 3 – biohumus (250 kg/ha)				
Control	804.0	432.5	1.79	0.96
Chemical protection of crops	978.5	495.0	2.17	1.10
Biological protection of crops	921.0	533.5	2.05	1.19
Complex 1*	967.0	588.5	2.15	1.31
Complex 2**	992.5	571.0	2.21	1.27
Complex 3***	997.8	579.0	2.22	1.29

The smallest increase in the total and productive tillering coefficients compared to the control on the mineral nutritional background was observed when using Nutrient Complex 1 (+0.31 and +0.05, respectively).

DOI: http://dx.doi.org/10.46925//rdluz.37.16

In case of the organo-mineral background, the use of Nutrient Complex 1 contributed to an increase in the total number of stems compared to the control by 174.5 pcs/m2. This is the best option on this background. And the largest number of productive stems was formed by plants using Nutrient Complex 2 (+231 pcs/m2 compared to the control).

On the organic background, the use of nutrient complexes showed an increase in both total and productive tillering coefficients, compared with the control. The highest total tillering coefficient was obtained for the option of application of Nutrient Complex 3 (2.22), and the productive tillering coefficient — nutrient complex 1 (1.31).

Comparing the three nutritional backgrounds, we can conclude that the greatest impact of the nutrient complexes studied was when using an organic background. That is, the highest increases in the total and productive tillering coefficients compared to the control were obtained on this background. The study of the effect of nutrient complexes on the yield structure of spring barley Skhidnyi found that on the mineral nutritional background the best results were obtained with the use of Nutrient Complex 3 — the ear length increased compared to the control by 1.7 cm, the number of grains in the ear — by 2.1 pieces, the weight of 1,000 grains — by 2.8 g (Table 4).

A similar situation was observed on the organo-mineral background, and the organic nutritional background contributed to obtaining the best indicators of yield structure when using Nutrient Complex 2. Thus, the ear length increased by 2.4 cm compared to the control, the number of grains in the ear — by 2.4 pieces, weight of 1,000 grains — by 2.9 g.

When comparing the two options for plant protection against pests and diseases, it was found that regardless of the nutritional background, the best indicators of yield structure were achieved using biological crop protection (the use of microbiological drugs for seed inoculation and crop spraying). Thus, on the mineral nutritional background with biological protection of crops, the ear length was greater than the option of chemical protection by 0.1 cm, the number of grains in the ear increased by 0.3 pcs, weight of 1,000 grains — by 0,8 g.

On the organo-mineral nutritional background, biological protection of crops provided elongation of the ear compared to chemical protection by 0.4 cm, the number of grains in the ear increased by 0.6 pieces, and the weight of 1,000 grains — by 1 g.

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Table 4. Indicators of the yield structure of spring barley Skhidnyi depending on the nutritional complex and the background (average for 2014-2018)

Option	Plant height, cm	Ear length, cm	Number of grains in the ear, pcs	Mass of 1000 grains, g	Grain unit, g/l
Background 1 – $N_{30}P_{30}K_{30}$					
Control	59.6	8.4	13.0	43.1	586.0
Chemical protection of crops	62.1	8.9	13.6	44.9	586.7
Biological protection of crops	63.5	9.0	13.9	45.7	587.4
Complex 1*	63.6	9.8	14.7	45.5	587.3
Complex 2**	63.4	9.9	14.9	45.4	589.5
Complex 3***	64.3	10.1	15.1	45.9	588.4
$HIP_{0.5}$	0.2-0.5	0.3-0.6	0.7-0.9	0.5-0.9	0.7-1.5
Background 2 – $N_{15}P_{15}K_{15}$ + biohumus (250 kg/ha)					
Control	60.9	8.0	12.5	42.1	579.5
Chemical protection of crops	63.1	9.3	12.9	43.4	581.7
Biological protection of crops	62.5	9.7	13.5	44.4	579.5
Complex 1*	63.2	10.1	14.7	44.9	581.3
Complex 2**	62.9	10.7	13.9	44.7	565.1
Complex 3***	63.6	11.0	14.9	45.0	573.0
$HIP_{0.5}$	0.6-0.9	0.1-0.4	0.6-0.9	0.3-0.5	0.4-1.3
Background 3 – biohumus (250 kg/ha)					
Control	58.0	7.5	12.1	41.9	556.2

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Chemical protection of crops	61.8	8.7	13.9	42.2	588.7
Biological protection of crops	61.5	8.9	13.7	43.5	567.9
Complex 1*	62.7	9.5	14.0	44.5	571.0
Complex 2**	62.2	9.9	14.5	44.8	562.4
Complex 3***	62.8	9.7	13.9	44.2	569.5
$HIP_{0.5}$ for: experiment option	0.7–0.9	0.1–0.2	0.1–0.2	1.3–1.4	1.7–1.9
nutritional background	0.5–0.6	0.1–0.2	0.1–0.2	1.0–1.1	2.6–3.1
interaction	1.0–1.2	0.2–0.3	0.2–0.3	1.6–1.8	3.7–4.2

Comparison of food backgrounds shows that the highest indicators of the yield structure were obtained when using the mineral background, regardless of the options studied. At the same time, organic and organo-mineral backgrounds contributed to obtaining the highest indicators of yield structure compared to control. When determining the effectiveness of these complexes on the level of grain yield of spring barley Skhidnyi, it was found that the use of Nutrient Complex 3 on a mineral nutritional background provided an increase in grain yield of 1.37 t/ha, or 51.9% compared with control (Table 5).

Organo-mineral nutritional background in combination with Nutrient Complex 3 contributed to a yield increase of 2.08 t/ha before control. On the organic nutritional background, the highest increase in yield (1.60 t/ha) was provided by the use of Nutrient Complex 1.

A detailed analysis of the impact of new nutrient complexes in combination with organic and organo-mineral nutrition on the yield of spring barley showed that their use promotes active growth and development of plants during the growing season, as well as improves the yield structure of spring barley Skhidnyi in the Eastern parts of the Northern Steppe.

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Table 5. Yield of spring barley depending on the application of the nutrient complex and nutritional background (average for 2014–2018), t/ha

Option	Yield, t/ha	Yield increase	
		t/ha	%
Background 1 – $N_{30}P_{30}K_{30}$			
Control	2.63	-	-
Chemical protection of crops	3.01	0.43	16.16
Biological protection of crops	3.81	1.18	44.68
Complex 1	3.46	0.83	31.56
Complex 2	3.71	1.08	41.06
Complex 3	3.99	1.37	51.90
Background 2 – $N_{15}P_{15}K_{15}$ + biohumus (250 kg/ha)			
Control	1.78	-	-
Chemical protection of crops	2.88	1.10	61.80
Biological protection of crops	3.04	1.26	70.79
Complex 1	3.01	1.23	69.10
Complex 2	3.61	1.83	102.81
Complex 3	3.86	2.08	116.85
Background 3 – biohumus (250 kg/ha)			
Control	1.65	-	-
Chemical protection of crops	2.43	0.78	47.27
Biological protection of crops	2.68	1.03	62.42
Complex 1	3.25	1.60	96.97
Complex 2	3.21	1.56	94.55
Complex 3	3.05	1.40	84.85
$HIP_{0.5}$, t/ha for: A – 0.09–0.13; B – 0.11–0.17; AB – 0.18–1.29			

3. Discussion

The selection of varieties is a very important problem for most regions of Ukraine in the agrotechnology of spring barley cultivation, as climate change leads to decreased rainfalls

DOI: http://dx.doi.org/10.46925//rdluz.37.16

and increased droughts and dry winds, especially in the southern regions of our country. This is not only a problem of Ukraine, but also a global problem, as evidenced by studies (Cammarano et al., 2020; Carter et al., 2019; Sallam et al., 2019; Solonechnyi et al., 2015; Toymetov and Maryina-Chermnykh, 2020; Yurkevich et al., 2011) . The increased droughts in the south of Ukraine leads to the fact that intensive varieties of spring barley cannot use their full potential, resulting in a significant yield reduction (Vinyukov et al., 2016).

Our proposed method of selecting the varieties with the help of coenotic composition of crops according to the plant productivity rank is patented in Ukraine and has no analogues in the world. Our research has shown that this method of selecting adaptive varieties of spring barley is quite promising in terms of ranking plants by the number of productive shoots and determining the most adapted varieties for growing in specific climatic conditions (Krček et al., 2008).

As for this agrotechnical method of fertilizer system using biopreparations and plant growth regulators, studies in Western and Eastern Europe show that the treatment of crops with a complex of plant growth regulators increases the productivity of these crops by 15-30% (Rassokhina et al., 2020; Toymetov and Maryina-Chermnykh, 2020). This is influenced by such factors as: reducing the incidence of plant root rot, increasing the leaf surface of barley plants resulting from increased photosynthetic activity, reduced negative effects of stress, increased drought resistance of plants, etc. (Bidnyna et al., 2013; Gerasimenko, 1981; Kadyrov et al., 1984; Kasatkina and Gamayunova, 2018; Vinyukov et al., 2014). In our studies of new nutrient complexes consisting of biopreparations, biofertilizers, plant growth regulators, the yield increase ranged from 16 to 116%. The yield increase through the use of nutrient complexes indicates that their use reduces such negative effects as the lack of sufficient moisture in the soil, and thus helps to increase the drought resistance of spring barley plants.

Conclusion

According to the comparative analysis of coenotic structure of varietal crops, it was found that the most drought-resistant for growing in agro-climatic conditions of the eastern part of the Northern Steppe of Ukraine were the following varieties: Stepovyk, Avers, Pryazovskyi 9, Chudovyi, which have high adaptability and ecological plasticity. As for the productivity of plants of the second rank, Donetsk 14 should be noted, which can be described as a variety with a high level of agroecological plasticity. It was found that such an agrotechnical method as the use of new nutrient complexes on different fertilizer backgrounds in the cultivation of spring barley contributed to the good development of plants throughout the growing season and allowed to obtain a yield that significantly exceeded the control sample.

In particular, with the introduction of N30P30K30, grain yield from the use of Nutrient Complex 3 (seed treatment with Sizam (250 g/t) in a mixture with a microbiological complex (400 g/t), spraying plants in the tillering phase with a mixture of Sizam (250 g/ha)) and microbiological complex (400 g/ha)) compared to the control increased by 1.37 t/ha, while on the organo-mineral background (N15P15K15 + biohumus, 250 kg/ha) the same Nutrient Complex 3 — 2.08 t/ha, and on an organic nutritional background (biohumus, 250 kg/ha), Nutrient Complex 1 (seed treatment with Rost-forte) (0.5 l/t) in a mixture with amino acid complex, spraying of plants in the tillering and earing phases with a mixture of Rost-concentrate 15.7.7. (1 l/ha) + amino acid complex + Khelatin (2 l/ha) + microbiological complex (400 g/ha)) — 1.60 t/ha.

References

Abay, F., & Bjørnstad, A. (2009). Specific adaptation of barley varieties in different locations in Ethiopia. *Euphytica, 167*, 181–195.

Adamenko, T. I. (2004). *Change of agroclimatic conditions and their influence on grain economy of Ukraine. Weather and grain economy of Ukraine: materials of the meeting-seminar*. Kyiv, Ukrainian hydrometeorological center.

Adamenko, T. I. (2006). Influence of soil-climatic and weather conditions on the formation of grain quality. *Grain Storage and Processing, 5*, 39–42.

Bidnyna, I. O., Vlashtuk, O. S., Kozyrev, V. V., & Tomnytskiy, A. V. (2013). The effectiveness of the joint use of fertilizers and microbial preparations in the cultivation of crops in southern Ukraine. *Irrigated Farming, 60*, 54-56.

Cammarano, D., Holland, J., & Ronga, D. (2020). Spatial and temporal variability of spring barley yield and quality quantified by crop simulation model. *Agronomy, 10*(3), 393. https://doi.org/10.3390/agronomy10030393

Carter, A. Y., Hawes, M. C., & Ottman, M. J. (2019). Drought-tolerant barley: i. field observations of growth and development. *Agronomy, 9*(5), 221.

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Diduh, Ya. P. (2009). Environmental aspects of global climate change: causes, consequences, actions. *The Bulletin of the National Academy of Science of Ukraine*, *2*, 34–44.

Gerasimenko, V. F. (1981). Preliminary estimation of selection material according to the parameters of ecological plasticity. *Agricultural Biology*, *6*, 938-941.

Kadyrov, M. A., Grib, S. I., & Baturo, F. N. (1984). Some aspects of selection of varieties with wide agroecological adaptation. *Plant Breeding and Seed Production*, *7*, 8–11.

Kasatkina, T. O., & Gamayunova, V. V. (2018). Prospects and features of growing spring barley in the South of Ukraine. *Scientific Horizons*, *7-8*(70), 131-138.

Krček, M., Slamka, P., Olšovská, K., Brestič, M., & Benčíková, M. (2008). Reduction of drought stress effect in spring barley (Hordeum vulgare L.) by nitrogen fertilization. *Plant Soil and Environment*, *54*(1), 7-13.

Laman, N. A., Pevnev, A. M., & Makarova, N. A. (1991). Modern technologies of grain cultivation abroad. *Grain Crops*, *1*, 37-38.

Lipinskiy, V. M, Dyachuk, V. A., & Babichenko, V. M. (2003). *Climate of Ukraine*. Kyiv, Rayevskiy's publishing.

Pashtenko, Yu. M., Rybka, V. S., & Shevchenko, M. S. (2010). Intensification of grain production. Agroecological and socio-economic essence. *Exclusive Technology*, *3*(8), 22–27.

Radio "Svoboda". (2021). Ukraine took the second place in the world for crop export according to the Ministry of Economy. Retrieved from https://www.radiosvoboda.org/a/news-eksport-zernovykh/31064060.html

Rassokhina, I. I., Platonov, A. V., Laptev, G. Y., & Bolshakov, V. N. (2020). Morphophysical reaction of Hordeum vulgare to the influence of microbial preparations. *Regulatory Mechanisms in Biosystems*, *11*(2), 220-225. https://doi.org/10.15421/022032

Sallam, A., Alqudah, A. M., A., Dawood, M. F. A., Baenziger, S. P., & Börner, A. (2019). Drought stress tolerance in wheat and barley: advances in physiology, breeding and genetics research. *International Journal of Molecular Sciences*, *20*(13), 3137. https://doi.org/10.3390/ijms20133137

Sallam, A., Amro, A., EL-Akhdar, A., Dawood, M. F. A., Kumamaru, T., & Baenziger, S. P. (2018). Genetic diversity and genetic variation in morpho-physiological traits to improve heat tolerance in Spring barley. *Molecular Biology Reports*, *45*, 2441–2453.

Solonechnyi, P., Vasko, N., Naumov, O., Solonechnaya, O., Vazhenina, O., Bondareva, O., & Logvinenko, Yu. (2015). GGE biplot analysis of genotype by environment interaction of spring barley varieties. *Zemdirbyste-Agriculture*, *102*(4), 431–436.

DOI: http://dx.doi.org/10.46925//rdluz.37.16

Timofeyev, M. M., Vinyukov, O. O., & Bondareva, O. B. (2016). Biogenic systems of agriculture in the aspect of formation of sustainable agrobiogeocenoses. *Bulletin of the Center for Scientific Support of APV Kharkiv Region, 20*, 68–74.

Toymetov, M. E., & Maryina-Chermnykh, O. G. (2020). Influence of biological drugs on phytosanitary condition of seeds of spring barley. *2020 IOP Conference Series: Earth and Environmental Science, 421*(2).

Vinyukov, O. O., Bondareva, O. B., & Korobova, O. M. (2016). Ecological plasticity of new varieties of spring barley to stress factors. *Plant Breeding and Seed Production, 110*, 29–35.

Vinyukov, O. O., Mamedova, E. I., Sipun, O. L., & Solovyanova, K. V. (2014). The effect of Sizam on the productivity of spring barley depending on the background of nutrition. *The Bulletin of the Institute of Agriculture of the Steppe Zone of Ukraine of the NAAS of Ukraine, 6*, 65–69.

Yurkevich, E. O., Kovalenko, N. P., & Bakuma, A. V. (2011). *Agrobiological bases of crop rotations of the Steppe of Ukraine: monograph*. Odesa, VMV Publishing.