УДК:633.11 https://doi.org/10.31867/2523-4544/0161

INFLUENCE OF FERTILIZER SYSTEMS ON SPRING BARLEY YIELD IN CONDITIONS OF THE RIGHT BANK FOREST STEPPE.

H. P. Voitova
Khmelnytskyi State Agricultural Experimental Station of the Institute of Feed and Agriculture of Podillia of NAAS, Samchyky village, Starokostiantyniv district, Khmelnytskyi region, 31182, Ukraine

We have presented the research results on the influence of fertilization systems on spring barley productivity in the Right-Bank Forest Steppe. The traditionally fertilized backgrounds were studied: mineral, organic and organomineral (with half rate of fertilizers on previous backgrounds), and the alternative to organic matter was cereal straw and biomass of green manure crops. The best backgrounds and optimal fertilizer systems for high level of grain yield were determined.

The main factors that formed the productive stem density of spring barley were the rates and types of fertilizers. The plant nutrition was improved due to application of organic and mineral fertilizers that allowed to increase the productive stem density in the agrocenosis and the competitiveness of plants, and decreased the weed infestation in crops.

The fertilizer type have influenced to the grain yield of spring barley. Based on the research results, it was found that the combination of traditional fertilization with the application of alternative types of organic matter has increased the grain yield of barley spring compared to the control variant on mineral background within 1.61–2.04 t/ha, organic – 1.69–2.14 t/ha, organomineral – 1.79–2.19 t/ha, accordingly, the grain yield was: 4.86–5.29, 4.94–5.39 and 5.04–5.44 t/ha.

The highest yield of spring barley was provided by a combined fertilizer system with half rate both mineral fertilizer and manure against the background of the predecessor straw afteraction with compensatory dose of N_{10}/t and green manure biomass of white mustard as organic fertilizer, and equaled of 5.44 t/ha (yield gain was 2.19 t/ha compared to control).

The optimal fertilizer systems to increase of spring barley yield in conditions of the Right Bank Forest Steppe are combined mineral, organic and organomineral fertilizer systems, which include the traditional fertilization: the action of mineral fertilizers and the afteraction of manure, as well as alternative fertilizers – the straw of pre-predecessor with a compensatory dose of N_{10}/t in combination with the green manure biomass of white mustard.

Keywords*: spring barley, predecessor by-products, mineral fertilizers, yield, fertilizer systems, grain quality.*

In Ukraine, spring barley is mostly grown (*Hordeum vulgare* L.) [1]. Stabilization of spring barley grain production is inextricably linked with provision a reliable balance of food and feed grain in the field of domestic agro-industrial production. The important role of barley is not only to increase livestock productivity, but also to improve the efficiency of grain farming in whole. However, Ukraine is inferior to Western European countries in terms of average annual barley grain yield [2]. Therefore, existing and improved cultivation technologies of this grain crop should be aimed to fully implement the genetic potential of varieties at intensive cultivation [3, 4]. One of the important elements of technology is the optimization of the fertilizer system. One of the most effective means to increase the spring barley grain productivity is fertilizers. However, implementation of the maximum potential productivity demands a rational fertilizer system that would properly meet the requirements of plant growing conditions [5]. If this condition is complied, grain yield increases by 50 % or more [6, 7]. Therefore, research on the fertilizer systems impact on spring barley productivity is important to optimize the plant nutrition.

Aim. The research was aimed to determine optimal fertilizer systems in order to increase the spring barley yield in the conditions of the Right-Bank Forest-Steppe.

Author information:
Halyna P. Voitova, *Researcher,* e-mail: test96079@gmail.com, http://orcid.org/0000-0001-6152-5677

Materials and Methods. Subject of research was features of spring barley yield changes (Sviatohor variety) under the influence of different fertilizer systems for 2013–2015. The research was conducted in the stationary field trial of the Khmelnytskyi State Agricultural Research Station of the Institute of Feed Research and Agriculture of Podillia NAAS.

The traditionally fertilized backgrounds were studied: mineral, organic and organomineral (with half rate of fertilizers on previous backgrounds), and the alternative to organic matter was cereal straw and biomass of green manure crops. The spring barley cultivation technology is generally accepted for the Right-Bank Forest-Steppe. In the years of research, the hydrothermal regime was typical for this zone.

The soil in the experimental field was medium loamy podzolic chernozem. There was accounting area of the plot – 40 m^2; replication was three times; systematic location of plots. Humus content according to Tiurin's method was 3.64 %, pH 5.7–6.7; easily hydrolysable nitrogen per 1 kg of absolutely dry soil according to Cornfield's method – 171–199 mg; mobile phosphorus – 114–178 mg and potassium 83–86 mg according to Chyrykov's method.

In the trial, we calculated rates of mineral fertilizers to obtain the planned yield of spring barley of 4.5 t/ha. Considering that the mobile phosphorus content in the soil is medium and high, it was studied the possibility to reduce the rate of phosphate fertilizers to a minimum – P_{10} per crop. In view of the above, the full fertilizer rate on the mineral background was $N_{45}P_{10}K_{90}$, and half rate of $N_{23}P_{10}K_{45}$ was on the organomineral background. Manure was applied under the pre-predecessor and autumn plowing on organic background in rate of 40 t/ha and organomineral – 20 t/ha. In the variants with straw (under the pre-predecessor), before plowing it, nitrogen at the rate of N_{10} per 1 ton of straw was additionally applied to the soil. White mustard of Podolianka variety was sown on green manure (under the pre-predecessor). Predecessor – sugar beet. The sowing rate was 4.0 million germinable seeds/ha. Granstar Pro 75 WG herbicide was applied to protect the sown area against weeds at 15 g/ha dose with working solution of 300 l/ha. In the course of the research, we guided by the B. O. Dospekhov's method of field experimentation (1985).

Results. Over the years of research, it was established that the spring barley plants, which were grown in a five-field grain-beet crop rotation (winter wheat – sugar beet – spring barley – maize for silage – peas), had underdeveloped root system, low level of nutrients assimilation, they better used of direct action and afteraction of fertilizers.

The main factors that effected to form the productive stem density of spring barley were the rates and types of fertilizers. We studied the fertilizer backgrounds, and identified that the slightly more plants with productive stems were formed under application of the mineral and organic fertilizers; considering a nonsignificant difference in tillering plants and its preservation, the percentage of unproductive stems was the lowest compared to the background of natural soil fertility (Table 1).

1. Density of spring barley plants on different fertilizer backgrounds (average for 2013–2015)

Fertilizer background	Plant density, thousand pcs/ha		Productive stem density, thousand/ha	Coefficient of productive tillering	Number of unproductive stems, thousand/ha	Preservation of plants, %
	sprouts	harvest				
Control (natural fertility of soil)	3314	2893	5646	1.95	11	87
Mineral ($N_{45}P_{10}K_{90}$)	3293	3082	6099	1.98	8	94
Organic (manure, 40 t/ha)	3350	3051	6162	2.02	7	91
Organomineral ($N_{23}P_{10}K_{45}$ + manure, 20 t/ha)	3358	3057	6204	2.03	7	91

The natural fertility of the soil without fertilization resulted in the poor growth and development of barley plants and suppression theirs by weeds. Indicators of plant density and preservation were the lowest due to high weed infestation, at the sprout emergence stage (before herb-

icide application), there were 217 weeds per 1 m^2 of sown area, and at the end of the growing season – 11 weeds with their fresh weight 77, 7 g (Table 2). Application of organic and mineral fertilizers improved the plant nutrition and led to increase the productive stem density in the agrocenosis, to increase the competitiveness of spring barley plants and to reduce the number of segetal plants by 20–39 % at emergence stage and weeds by 28–34 % at the end of the growing season in comparison with natural soil fertility.

2. Weed infestation of spring barley area on different fertilizer backgrounds, pcs/m^2 (average for 2013–2015)

Group of weeds	Fertilizer background			
	natural fertility	mineral ($N_{45}P_{10}K_{90}$)	organic (manure, 40 t/ha)	organomineral ($N_{23}P_{10}K_{45}$ + manure, 20 t/ha)
Number of weeds at the beginning of the growing season, pcs/m^2				
Annual	216	170	192	182
Perennial	1	0	0	0
Total	217	170	192	182
Number of weeds at the end of the growing season, pcs/m^2				
Annual	10	6	9	7
Perennial	1	0	1	1
Total	11	6	10	8
Weight of weeds at the end of the growing season, g/m^2				
Annual	74.9	53.3	56.1	54.1
Perennial	2.8	-	1.5	1.9
Total	77.7	53.3	57.6	56.0

3. Spring barley yield in depending on fertilization system (average for 2013–2015), t/ha

Fertilizer background	Alternative fertilizers (under pre-predecessor)	Average yield for 2013–2015	The increase in grain yield, ±					
			to control variant		to background		factor interaction	
			t/ha	%	t/ha	%	t/ha	%
Control (natural fertility of soil)	-	3.25	0	0	0	0	0	0
	straw + N_{10}/t	3.43	0.18	6	0.18	6	0	0
	green manure	3.59	0.34	11	0.34	11	0	0
	straw + N_{10}/t + green manure	3.81	0.56	17	0.56	17	0	0
mineral ($N_{45}P_{10}K_{90}$)	-	4.73	1.48	46	0	0	1.48	46
	straw + N_{10}/t	4.86	1.61	50	0.13	3	1.43	42
	green manure	5.06	1.81	56	0.33	7	1.47	41
	straw + N_{10}/t + green manure	5.29	2.04	63	0.56	12	1.48	39
organic (manure, 40 t/ha)	-	4.80	1.55	48	0	0	1.55	48
	straw + N_{10}/t	4.94	1.69	52	0.14	3	1.51	44
	green manure	5.14	1.89	58	0.34	7	1.55	43
	straw + N_{10}/t + green manure	5.39	2.14	66	0.59	12	1.58	42
organomineral ($N_{23}P_{10}K_{45}$ + manure, 20 t/ha)	-	4.87	1.62	50	0	0	1.62	50
	straw + N_{10}/t	5.04	1.79	55	0.17	4	1.61	47
	green manure	5.27	2.02	62	0.40	8	1.68	47
	straw + N_{10}/t + green manure	5.44	2.19	67	0.57	12	1.63	43
$LSD_{0,05}$	2013		0.04		0.10		0.15	
	2014		0.05		0.15		0.21	
	2015		0.06		0.09		0.17	

Our research also found that the grain yield of spring barley varied depending on the fertilizer type. The lowest yield was 3.25 t/ha on the background of natural soil fertility (Table 3).

The afteraction of alternative fertilizers increased crop yield on this background. The increase in grain yield reached 0.18 t/ha due to leaving straw as organic fertilizer, 0.34 t/ha – after plowing green manure, and 0.56 t/ha at combination of these operations. The productive stem density increased by 9 % due to biologization of the natural soil fertility that led to increase barley grain yield. However, against this background, there was the lowest grain weight per one spike relative to plots with traditional fertilization.

Higher barley yields (from 4.73 to 4.87 t/ha) with a grain yield gain from 46 to 50 % compared to natural soil fertility (without fertilizers) were obtained by applying mineral fertilizers and afteraction of manure, as the productive stem density increased by 9 %, and the grain weight per one spike – on average by 34 %. At $N_{45}P_{10}K_{90}$ application, the increase in grain yield was 1.48 t/ha, afteraction of manure (with rate of 40 t/ha) – 1.55 t/ha, with half of application rates of these fertilizers ($N_{23}P_{10}K_{45}$ + 20 t/ha) – 1.62 t/ha.

When traditional fertilizers were combined with the application of alternative types of organic fertilizers, an increase in the spring barley grain yield on a mineral background was 1.61–2.04 t/ha, on organic – 1.69–2.14 t/ha, on organomineral – 1.79–2.19 t/ha compared with the control. The grain yield varied within: 4.86–5.29; 4.94–5.39; 5.04–5.44 t/ha, respectively. Over the years of research, the productive stem density increased by 5 % and the weight of grain per one spike – by almost 3 % due to alternative fertilizer.

The combined fertilizer system provided the highest yield of spring barley of 5.44 t/ha, the increase in grain yield was 2.19 t/ha compared to control. The combined system included both half norms of mineral fertilizer and manure against the background of the afteraction of prepredecessor straw with $N_{10/t}$ compensation and green manure biomass of white mustard as organic fertilizer. Under such fertilization system, spring barley formed heavy stem density and the weight of grain per one spike averaged 0.89 g.

Conclusions.

We think that to increase the spring barley yield in the Right-Bank Forest-Steppe, the optimal combined systems of mineral, organic and organomineral fertilizers should be introduced, including traditional fertilizers: action of mineral fertilizers, afteraction of manure, as well as alternative fertilizers such as prepredecessor straw with N_{10}/t compensation in combination with green manure biomass of white mustard.

References

1. Bel'diy, N., Zahynaylo, M., Nosulya, A. (2012). [Barley is a profitable crop]. *Propozytsya* [Proposal], 12–14. [in Ukrainian]
2. Stepanenko, T. (2005). Ukraine grain. *Propozytsya* [Proposal], *819*, 28–32. [in Ukrainian]
3. Romanyuk, V. I. Porivnyal'na otsinka konkurentospromozhnosti tekhnolohiy vyroshchuvannya yachmenyu yaroho na zerno v umovakh pravoberezhnoho Lisostepu. DOI: http://dx.doi.org/10.31548/dopovidi 2019.02.016. [in Ukrainian]
4. Moysiyenko, V. V., Podol's'kyy O. M. Produktyvnist' ozymoho yachmenyu sortu Khaylayt zalezhno vid elementiv tekhnolohiyi vyroshchuvannya. Doi: 10/ 33249/2663-2144-2019-83-10-13-19. [in Ukrainian]
5. Drozd, M. O. (2015). Efficiency of elements of spring wheat cultivation technology in the Northern Forest-Steppe. *Zbirnyk naukovykh prats' NNTs IZ UAAN*. [Collection of scientific works of NSC IZ UAAS]. Kyiv: NNTs IZ UAAN, *4*, 53–57. [in Ukrainian]
6. Pol'ovyy, V. M. (2007). *Optymizatsiya system udobrennya u suchasnomu zemlerobstvi* [Optimization of fertilizer systems in modern agriculture]. Rivne: Volyns'ki oberehy. 320 p. [in Ukrainian]
7. Lisovyy, M. V. (1991). *Pidvyshchennya efektyvnosti mineral'nykh dobryv* [Improving the efficiency of mineral fertilizers]. Kyiv: Urozhay. 120 p. [in Ukrainian]