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Productivity of winter barley depending on its predecessors in Transcarpathia of Ukraine

Abstract. Winter barley is a valuable food, fodder, and technical crop. The purpose of the study is the establishing and developing of an economically and energetically feasible, adequate bioresource potential for the yield of winter barley grain, depending on its predecessors in Transcarpathia of Ukraine. Studies and calculations of the balance of available moisture in the soil showed that in the conditions of Transcarpathia, it is negative and ranges from 250 to 1210 t/ha, or 25-121 mm. The accumulation and effective use of available moisture in the soil depends on the amount of precipitation and its frequency, the alternation of crops in crop rotation (predecessors), the system of tillage, fertilisation, and the extent of how weeded the fields are. The largest reserves of available moisture in the soil during the sowing period of winter barley were after winter rapeseed and buckwheat, the smallest – after sunflower and, especially, corn for grain. During the autumn-winter period, the reserves of available moisture in the meter-deep soil layer were replenished by 21-35%, but the pattern, according to its predecessors, was preserved. The critical period of winter barley in terms of moisture occurs during earing – grain ripening. Predecessors of early harvesting periods (winter rapeseed and buckwheat) have a positive effect on the accumulation and preservation of moisture in the soil. Predecessors of late harvesting periods (corn for grain and sunflower) reduce the content of available moisture and its reserves by up to 18% compared to crops of early harvesting. On average, for three years,

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the highest yield of winter barley was after buckwheat and amounted to 5.9 t/ha, the lowest – after corn for grain and was at the level of 4.9 t/ha, which is 0.8 t/ha lower than the control option

Keywords: available moisture content, winter barley, predecessor, yield

RELEVANCE

Winter barley is a valuable food, fodder, and technical crop. According to FAO, 48% of the barley grain produced goes to industrial processing, 36% – to mixed feed, and 16% – to food purposes. It is proved that the productivity of this crop depends on providing plants with all the necessary factors of life in the optimal amount and optimal proportions. (Wicket & Yaloha, 2011; Moisienko & Podolsky, 2019; Sokolovskaya & Al-Brud, 2010).

Ultimately, the investigation of the features of the establishment of productivity of winter barley and the degree of reproduction of soil fertility elements, depending on the optimisation of elements of cultivation technology, is now relevant and has led to the choice of a research algorithm.

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

The main task of modern agriculture is to ensure food security of the country by producing the quantity and quality of products necessary for society (Tanchyk, 2009). When growing winter barley, an important task is to increase grain production and yields, effectively use mineral and organic fertilisers, the best precursors, and the preserving soil treatment. (Sinchenko & Tanchik, 2018; Tanchik & Babenko, 2015)

The intensification of agriculture is accompanied by the degradation and depletion of soils, contamination with chemical and biological impurities, a drop in fertility, and a decrease in the yield of cultivated crops. (Tanchik, 2009). In modern conditions of agricultural development, the role of crop rotations as the most effective environment and ensuring high, stable, environmentally, economically, and energetically adequate winter barley yields is growing. Along with this, modern technologies for growing this crop have quite a few reserves of improvement, considering not only the selection of varieties adapted to the soil and climatic conditions of a particular region, optimising the placement of winter barley in crop rotations (of various specialisations), but also the choice of effective methods and depth of the main tillage to ensure maximum crop productivity and cost recovery (Tanchyk, 2009; Melnik & Govorun, 2014; Gamayunova & Litovchenko, 2017).

The purpose of the study consists in determining and developing regularities in the establishment of economically and energetically expedient, adequate to the bioclimatic potential of the winter barley grain yield zone, depending on its predecessors in Transcarpathia of Ukraine. It was planned to solve the following tasks to achieve this goal: establish the influence of various precursors on the content of available moisture in the soil, phytosanitary condition, and productivity of winter barley. Provide an economic and energy assessment of crop cultivation under different predecessors.

MATERIALS AND METHODS

Experimental studies on the influence of precursors on winter barley were conducted during 2018-2020 in the experimental crop rotation of the separated subdivision "Mukachevo Agricultural College of the National University of Life and Environmental Sciences of Ukraine" of the Transcarpathian region. The soils of the experimental field are podzolic gumbo turf, which contain an average of 2.6% humus in the humus horizon. With depth, the amount of humus decreases gradually and at a depth of 100-130 cm it reaches 1.0-1.7%. Formation on carbonate-free parent rocks and the influence of the podzolic process of soil formation caused a high active and potential acidity of soils, the pH of salt extract ranges between 5.0-6.0.

The soil under study, according to the agrochemical analysis of the initial samples, contains available forms of nitrogen – 35-45 mg/kg, mobile phosphorus (according to Kirsanov) – 130-160 mg/kg, mobile potassium (according to Kirsanov) – 120-170 mg/kg. The soil is typical for the area of the studies and is moderately provided with mobile forms of phosphorus, potassium, and nitrogen. A qualitative assessment of the surveyed soils showed that the soil requires constant use of organic and mineral fertilisers, liming, and the introduction of crop rotations.

The climate of the area is moderate with unstable humidity. The average long-term precipitation rate for the year is 618.0 mm. Over the years of the studies, the amount of precipitation for the year was: 2018 – 568.3 mm, 2019 – 558.1, and 2020 – 513.1 mm, which is 10-13% less than normal. The following precursors were studied for the cultivation of winter barley: soy (control), winter rapeseed, buckwheat, corn for grain, and sunflower. The repetition rate of the experiment is fourfold, the total area of one plot is 240 m^2, accounting plot – 150 m^2. Land plot placement is randomised.

The content of available moisture in the soil was determined by the thermostatic-weight method according to DSTU ISO 16586 : 2005; actual contamination with weeds in the phase of germination of cultivated plants and spring restoration of vegetation was determined by quantitative, and the earing phase – by quantitative-weight method. Crop accounting was conducted by direct combining.

RESULTS AND DISCUSSION

Available moisture in the soil is one of the main terrestrial factors of plant life. Many studies, including this one, have established that in recent years in Ukrainian agriculture, moisture is a limiting factor that negatively affects seed germination, the dissolution of mineral and organic substances in the soil, the maintenance of cellular turgor, transpiration, the vital activity of microorganisms, and, ultimately, their productivity.

The study established that the initial reserves of available moisture in the soil and its accumulation in the autumn-winter and growing seasons depend on the amount of precipitation and predecessors. Thus, during the sowing period of winter barley, the largest moisture reserves in 0-30 cm and a meter layer of soil were 30.0 and 121.0 mm after winter rapeseed, respectively (Table 1). The smallest ones are after corn for grain (25.0 and 109.0 mm, respectively). This depends on the morphobiological and ecological characteristics of the culture.

Table 1. Content of available moisture in 0-100 cm of the soil layer in winter barley crops, depending on the predecessor, mm (average for 2018-2020)

Predecessor	Soil layer, cm	Sampling period (phase)			
		Sowing	Spring vegetation restoration	Earing	Harvest period
Soy (control)	0-30	26	32	24	21
	0-100	115	148	127	107
Winter rapeseed	0-30	30	33	27	23
	0-100	121	147	129	111
Buckwheat	0-30	29	32	25	22
	0-100	119	144	128	113
Corn for grain	0-30	25	29	23	20
	0-100	109	133	113	99

Table 1, Continued

Predecessor	Soil layer, cm	Sampling period (phase)			
		Sowing	Spring vegetation restoration	Earing	Harvest period
Sunflower	0-30	27	30	24	22
	0-100	112	140	119	109

Winter rapeseed begins the spring restoration of vegetation in Transcarpathia of Ukraine, in most cases, in the first half of April. The full growing season ends in late June and early July. This creates conditions for the economical use of moisture by the crop, early releasing of the field and promoting the accumulation and preservation of moisture for the next crop – winter barley.

Corn for grain develops a powerful root system that intensively uses moisture and nutrients dissolved in it throughout the growing season. With the appearance of panicles, the need for corn moisture increases sharply and reaches its maximum from the beginning of flowering to the beginning of milk ripeness. This study proved that during this period, corn uses approximately 70% of the total amount of moisture consumed. All this leads to intensive consumption of moisture from the soil and reduces its reserves, which negatively affects the growth, development, and productivity of the subsequent crop – winter barley.

Buckwheat is one of the hygrophilous plants. The transpiration coefficient of buckwheat is 500-600. Buckwheat plants absorb the greatest amount of moisture during mass flowering – fruit formation. This period in buckwheat is critical in terms of moisture. Nevertheless, buckwheat is one of the precocious field crops, the duration of the growing season is in the range of 70-80 days. All this contributes to the economical use of moisture from the soil, its accumulation, and preservation of it for subsequent crops of crop rotation.

Soy is a hygrophilous short-day plant. After sowing, soybean seeds consume at least 130-160% volume of moisture compared to their own mass. It is necessary to have a reserve of moisture in the soil of about 30 mm in a soil layer of 0-20 cm to get full shoots. The critical period of soybeans in terms of moisture is the period of flowering – the formation and development of beans. Hence, soybeans most intensively use moisture from the soil in the second half of the growing season. This usage is incurred by soybean plants for transpiration and photosynthesis, and soil evaporation, especially during the ripening period of the crop.

Thus, soy, as a legume crop, has preserved the properties of the legume plant to increase soil fertility, especially the fixation of biological nitrogen. However, soybeans are not a moisture accumulator and in dry years do not provide full shoots of winter barley, which leads to a decrease in its yield.

Sunflower is one of the controversial precursors of winter crops, including winter barley, in Ukraine. This study established that sunflower seeds takes approximately 250 kg of NPK per 1 ton of dry matter. During the growing season, the root system penetrates the soil to a depth of 1.5-2.0 m or more. In the initial periods (before the formation of 5-6 leaves), moisture and nutrients of the sunflower plant are used from a soil layer of up to 40 cm. During the period of basket formation and flowering, the root system penetrates to a depth of more than 2.0 meters. It was identified that at the beginning of the growing season, the most active root system of sunflowers is in the upper layer of the soil, while in the second half of the growing season – in the lower layers. Hence, the most active soil factors of plant life in the first half of the growing season are used from the upper layers of the soil, which are renewed due to the introduction of mineral and organic fertilisers for the main, pre-sowing treatment and plant care, and moisture is renewed due to spring-summer precipitation.

In the second half of the growing season, the most active root system of sunflowers is at a depth of 60 cm and deeper. Hence, sunflower plants intensively use the life factors of the soil, especially moisture and nutrients. During this period, due to precipitation, the application of mineral fertilisers during plant care, the high activity of microorganisms, etc., the soil factors of plant life of the upper 0-40 cm of the soil layer are restored.

Consequently, sunflower seeds use nutrients and moisture more actively from the lower layers during the growing season than from the upper ones. Due to this, sunflower is not a critically negative precursor of winter barley.

Table 2. Yield of winter barley depending on its predecessors in Transcarpathia of Ukraine, t/ha

Predecessor	Years			Average for 2018-2020	Deviation	
	2018	2019	2020		t/ha	%
Soy (control)	6.2	5.7	5.3	5.7	0	0
Winter rapeseed	6.0	5.8	5.4	5.7	0	0
Buckwheat	6.3	5.8	5.7	5.9	+0.2	+3.5
Corn for grain	5.0	4.9	4.8	4.9	-0.8	-14.1
Sunflower	5.4	5.2	5.0	5.2	-0.5	-8.8
$HIP_{0,5}$, %				1.9		

Thus, the accumulation of moisture in the soil and its effective use is influenced by many factors – the amount of precipitation, the introduction of crop rotations, tillage, fertilisation, etc. The correct strategy and tactics for managing the reserves of available soil moisture allow for reducing unproductive costs to a minimum.

An intensive indicator of the effectiveness of various predecessors for growing spring barley is its productivity. The highest yield of winter barley, on average for three years, was after buckwheat and amounted to 5.9 t/ha, the lowest – after corn for grain and was at the level of 4.9 t/ha, which is 0.8 t/ha lower than the control option (Table 2).

CONCLUSIONS

In Transcarpathia of Ukraine, on turf-podzolic winter soils, barley sown after buckwheat, soybeans, and winter rapeseed had the best indicators of available moisture throughout the growing season. The crop spent it most economically and efficiently during the growing season compared to the predecessors of late harvesting periods – sunflower and corn for grain.

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Продуктивність ячменю озимого залежно від попередників в умовах Закарпаття України

Анотація. Ячмінь озимий – цінна продовольча, кормова та технічна культура. Метою дослідження є встановлення та розробка економічно та енергетично обґрунтованого, достатнього біоресурсного потенціалу врожайності зерна ячменю озимого залежно від попередників в умовах Закарпаття України. Дослідження та розрахунки балансу доступної вологи в ґрунті показали, що в умовах Закарпаття він від'ємний і коливається від 250 до 1210 т/га, або 25-121 мм. Накопичення та ефективне використання доступної вологи в ґрунті залежить від кількості опадів та їх періодичності, чергування культур у сівозміні (попередників), системи обробітку ґрунту, удобрення, а також від ступеня забур'яненості полів. Найбільші запаси доступної вологи в ґрунті на період сівби озимого ячменю були після озимого ріпаку та гречки, найменші – після соняшнику і, особливо, кукурудзи на зерно. За осінньо-зимовий період запаси доступної вологи в метровому шарі ґрунту поповнилися на 21-35%, але закономірність по попередниках збереглася. Критичний період озимого ячменю за вологозабезпеченістю припадає на період колосіння - дозрівання зерна. Попередники ранніх строків збирання (озимий ріпак та гречка) позитивно впливають на накопичення та збереження вологи в ґрунті. Попередники пізніх строків збирання (кукурудза на зерно та соняшник) знижують вміст доступної вологи та її запаси до 18% порівняно з культурами ранніх строків збирання. В середньому за три роки найвища врожайність ячменю озимого була після гречки і становила 5,9 т/га, найнижча – після кукурудзи на зерно і була на рівні 4,9 т/га, що на 0,8 т/га нижче контрольного варіанту

Ключові слова: вміст доступної вологи, ячмінь озимий, попередник, урожайність