

## FEATURES OF ACCUMULATION AND CONSUMPTION OF SOLUBLE CARBOHYDRATES BY PLANTS OF SOFT WINTER WHEAT VARIETIES.

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The results of three-year research (2016–2019) conducted in the fields of the State Enterprise Experimental Farm "Dnipro" of the SE Institute of Grain Crops of NAAS of Ukraine with soft winter wheat was presented. The soft winter wheat was placed on black fallow (on background of  $N_{30}P_{60}K_{30}$ ) and after sunflower (on background of  $N_{60}P_{60}K_{60}$ ). It was found that winter wheat plants had a not the same ability to accumulate soluble carbohydrates in years with different weather conditions. The analysis of plant samples showed that the largest number of these substances had synthesized in the autumn 2017. It was found that in the plots with black fallow during the period from November 20, 2017 to January 10, 2018, the amount of soluble carbohydrates (total amount of monosaccharides and disaccharides) in the tillering nodes of winter wheat plants of Uzhynok variety decreased from 41.2 % to 34.7 % (by 6.5 %), Nyva odeska variety – from 43.9 % to 32.7 % (by 11.2 %), Kokhanka variety – from 45.0 % to 42.6 % (only by 2.4 %). From January 10 until the growth resumption in the spring, the carbohydrates were consumed most intensively by plants of the Uzhynok and Kokhanka varieties.

It was found that the winter wheat plants accumulated more soluble carbohydrates in all years after black fallow despite the lower doses of mineral fertilizers applied to pre-sowing cultivation than after sunflower. On average for three years of research, the highest consumption of sugars during the winter both in leaves and in tillering nodes, regardless of the predecessor, was observed in plants of the Uzhynok variety. It was found that the winter wheat plants of Kokhanka variety consumed soluble carbohydrates more economically than the Uzhynok and Nyva odeska varieties, and grew more intensively in early spring. The content of sugars in the tillering nodes of Kokhanka variety during resumption of spring growing season was 28.4 % for black fallow and 25.9 % after non-fallow predecessor.

**Key words:** *winter wheat, variety, soluble carbohydrates, predecessor, background of nutrition.*

Many studies conducted in different soil and climatic conditions are devoted to the problem of increasing resistance of winter crops to adverse factors of the winter period. [1–7]. It is known that frost and winter hardiness is an adaptive property of winter crops, which is constantly changing depending on the age of plants, growing conditions and temperature effects. Prolonged growing season at high temperatures leads to a decrease in winter hardiness, and at low temperatures – to its increase. Winter hardiness of plants especially increases at the average daily air temperature makes about 0 °C. At the same time, growth processes are slowed down, and accumulation of organic substances and reduction of their consumption for respiration occurs in tillering nodes [8, 9]. Soluble carbohydrates accumulated in plant tissues during hardening perform a protective function and determine the level of frost resistance [10, 11].

Most of the sugars accumulate in the till-

ering nodes, and this process is significantly affected by agronomic measures and weather conditions. The largest amount of reserve substances was accumulated by plants of optimal sowing dates (autumn growing season – 50–55 days), which formed 3–4 stems. The effective temperature sum for this period reached 300–350 °C [12–14]. But now, due to global warming, there is a need to clarify the optimal sowing dates of winter crops, in particular winter wheat (*Triticum aestivum* L.) for each zone. The existing ideas about the patterns of accumulation of soluble carbohydrates depending on the sowing dates change with the introduction of new generation varieties [15].

According to a data of researchers, in recent years the winter and early spring periods have become more favorable for overwintering winter crops and regrowth of plants in the spring. The plant resistance to adverse conditions, especially low temperatures, determines

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by economical consumption of carbohydrates by plants during the winter. This is one of the indicators of increased winter hardiness of winter wheat varieties. It should be noted that the probability of growth resumption for 2–3 weeks earlier increased compared to long-time dates, and the winter dormancy period of plants decreased. In addition, plants partially restored growth with warming during overwintering [16–18]. Against the background of such changes, the theoretical and practical importance of research aimed at establishing patterns of accumulation and consumption of soluble carbohydrates in the winter enhanced.

In different years, many scientists worked on the definition of the main groups of soluble carbohydrates in plants by various methods [19–21]. And at present, interest in these issues is not diminishing. To increase the objectivity of such searches, traditional and new methods of studying the sugar content are constantly being improved, especially in the tissues of winter cereals [22–24].

**Aim.** To establish the characteristics of the accumulation of soluble carbohydrates in the plant tissues of different varieties of soft winter wheat, which were grown on black fallow and after sunflower, and to determine the level of sugar consumption by the plant during the winter.

**Materials and Methods.** The research was carried out during the growing seasons of 2016–2017 and 2018–2019 in the fields of the State Enterprise Experimental Farm "Dnipro" of the State Enterprise Institute of Grain Crops of NAAS in accordance with the generally accepted methods of field experiment and guidelines for field experiments with cereals [25, 26]. Predecessor of winter wheat was black fallow (for pre-sowing cultivation was applied  $N_{30}P_{60}K_{30}$ ), and sunflower (on background of  $N_{60}P_{60}K_{60}$ , respectively). The soil cover of the experimental plots was represented by ordinary low-humus full-profile and slightly eroded chernozems. Researched varieties such as Kokhanka (SE Institute of Grain Crops NAAS), Nyva odeska and Uzhynok (Plant Breeding and Genetics Institute NAAS) related to soft wheat variety of *erythrospermum* are characterized by increased drought and heat resistance, plasticity to the predecessor and agrophone. Nyva odeska and Uzhynok varieties belong to the group of strong

wheat, Kokhanka – to valuable wheat in terms of grain quality. Crops of the Nyva odeska variety are pointed out, as a rule, by higher plant stand in comparison with other studied samples.

The sowing rate was 5.0 million seeds/ha, the depth of sowing – 5–6 cm. Sowing winter wheat was carried out on September 20 with a mounted driller SN-16.

To determine the amount of soluble carbohydrates, plants were selected annually in four replications in two terms: at the time of growth arrest in the autumn and growth resumption in the spring from each variant of the experiment. Samples were separately formed from leaves and tillering nodes placed in a drying chamber heated to 105 °C and kept for 30 minutes, then the temperature was reduced to 40–60 °C to obtain completely dry samples. After that, the plant material was crushed and analyzed for the monosaccharide and disaccharides content according to general accepted methods [18].

The pre-sowing period in 2016–2018 was marked by a deficit of precipitation in August and a long dry period. But with the rains in September, the conditions for sowing winter crops and sprout emergence improved significantly. The autumn period was mostly favorable for winter wheat in all years of research. Despite the fact that the early decrease in air temperature was observed in October 2016, but in the first ten-days of November there was again warming. In the years of research, the autumn growing season stopped a little earlier than the long-term average: November 11, 2016, November 15, 2017, and November 6, 2018. In general, the average temperature was lower for the autumn in 2016 than in the next two years and amounted to 8.0 °C. While it reached 10.0 °C in 2017, and 10.2 °C in 2018 at the climate normal of 8.7 °C in the place of field experiments.

It should be noted that in December and early January 2017–2018 of the growing season due to a significant increase in air temperature, resumption of vital processes in winter wheat plants was observed, i.e. the slow development of the root system and aboveground part.

Over the studied years, agrometeorological conditions of the winter for winter cereals were quite satisfactory. The spring of 2017 and 2019 was early, the steady transition of the average daily air temperature through 5 °C towards the

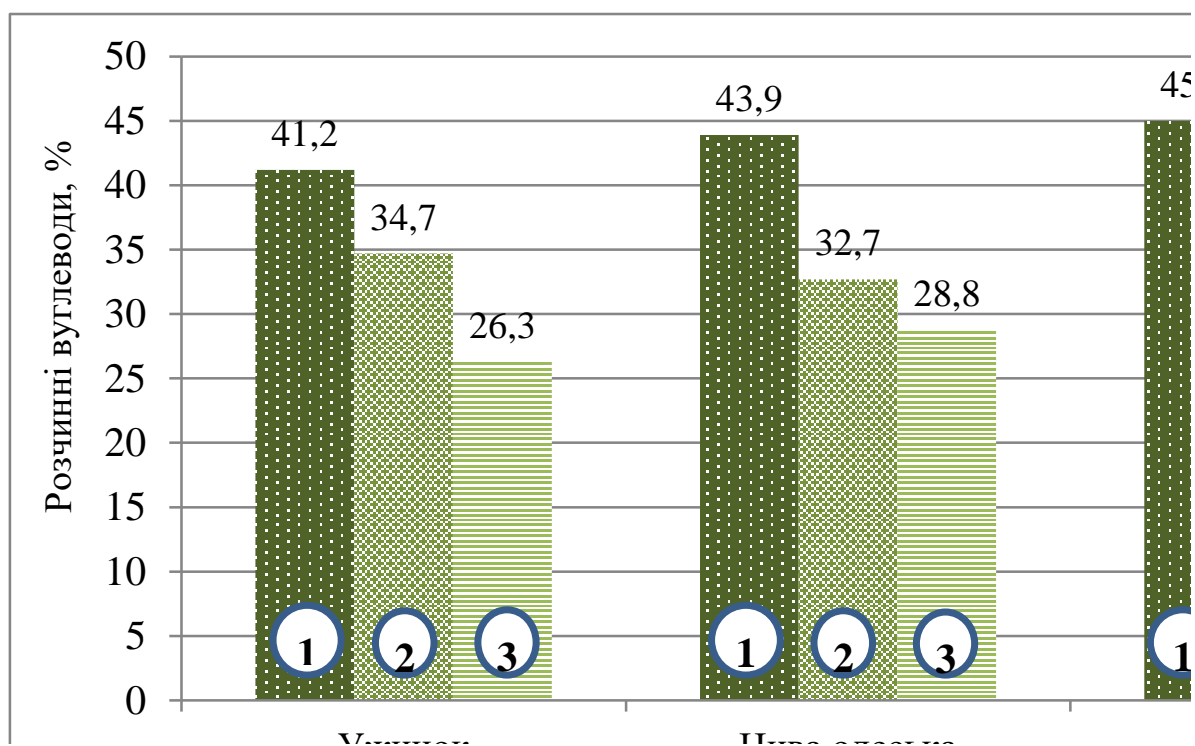
increase was noted in the beginning of March. The spring of 2018 was late and short.

**Results.** Observations show that winter wheat plants have a different ability to accumulate soluble carbohydrates in different weather conditions. Analysis of plant samples showed that the largest number of these substances was synthesized in the autumn of 2017. Due to the fact that the weather was abnormally warm in December and early January 2017–2018, winter wheat plants temporarily restored growth, which was accompanied by increased respiration and other metabolic processes. Therefore, there was a need to determine the sugar content in plants selected at the end of the first ten-days of January, and to compare the results with the amount of carbohydrates at growth arrest in the autumn.

It was found that the amount of soluble carbohydrates (total amount of monosaccharides and disaccharides) in the tillering nodes of Uzhynek winter wheat varieties decreased from 41.2 to 34.7 % (by 6.5 %), Nyva odeska – from 43.9 to 32.7 % (by 11.2 %), Kokhanka – from 45.0 to 42.6 (only 2.4 %) in plots after black fallow for the period from November 20, 2017

to January 10, 2018. At the growth resumption in the spring, the sugar content in the plant ranged from 26.3 to 32.4 % depending on the variety, the maximum value of this indicator was in the Kokhanka variety. It was found that the carbohydrates were consumed most intensively by Nyva odeska plants from the growth arrest in the autumn to the second term of plant sampling (January 10), and Uzhynek and Kokhanka varieties – from January 10 until the growth resumption in the spring. The lowest consumption of sugars during the winter of 2017–2018 was observed in the tillering nodes of Kokhanka variety plants (Fig. 1).

On average over three years of research, it was found that plants of all varieties at the time of growth arrest were marked by a slightly higher content of soluble carbohydrates in plots under black fallow than after sunflower. Thus, the amount of sugars in the leaves and tillering nodes in of winter wheat after black fallow varied depending on the variety from 25.5 to 27.1 and from 39.2 to 41.9 %, after sunflower from 23.1 to 25.9 % and from 38.1 to 39.0 %, respectively (Table 1).



**Fig. 1.** Dynamics of soluble carbohydrates in the tillering nodes of winter wheat plants after black fallow, % per on dry matter (2017–2018).

During the research years, thermal conditions in the winter contributed to the high intake of soluble carbohydrates in all parts of the plant.

Moreover, the most intense decrease in the amount of sugars was observed in plants of Uzhynek and Nyva odeska varieties. Thus, the

**Table 1. Content and consumption of soluble carbohydrates by plants of different varieties of winter wheat during the winter, % per absolute dry matter (2016/17–2018/19)**

Predecessor	Variety	Growth arrest in autumn	Growth resumption in spring	Consumption for the winter
In leaves				
Black fallow (on background of N <sub>30</sub> P <sub>60</sub> K <sub>30</sub> )	Uzhynok	25,5	14,3	11,2 (43,9 %)
	Nyva odeska	27,1	15,6	11,5 (42,4 %)
	Kokhanka	27,1	17,9	9,2 (33,9 %)
Sunflower (on background of N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> )	Uzhynok	23,1	13,3	9,8 (42,4 %)
	Nyva odeska	25,9	15,9	10,0 (38,6 %)
	Kokhanka	25,2	18,0	7,2 (28,6 %)
In tillering nodes				
Black fallow (on background of N <sub>30</sub> P <sub>60</sub> K <sub>30</sub> )	Uzhynok	39,2	22,2	17,0 (43,4 %)
	Nyva odeska	40,7	24,3	16,4 (40,3 %)
	Kokhanka	41,9	28,4	13,5 (32,2 %)
Sunflower (on background of N <sub>60</sub> P <sub>60</sub> K <sub>60</sub> )	Uzhynok	39,0	21,7	17,3 (44,4 %)
	Nyva odeska	38,1	25,2	12,9 (33,9 %)
	Kokhanka	38,4	25,9	12,5 (32,6 %)

consumption of carbohydrates in the leaves was 43.9 and 42.4 % of the total amount in autumn after black fallow, and after sunflower – 42.4 and 38.6 %. In the tillering nodes of plants after black fallow the values of similar indicators were 43.4 and 40.3%, after sunflower – 44.4 and 33.9 %, respectively.

On average over three years of research, less soluble carbohydrates were consumed during overwintering of Kokhanka varieties. At the time of growth resumption in the spring, the highest content of sugars was observed in the plant tissues of this variety (in the leaves – 17.9 % after black fallow and 18.0 % – after sunflower, and in the tillering nodes – 28.4 and 25.9 %, respectively). The consumption of carbohydrates in the leaves of the total amount was 33.9 % after black fallow and 28.6 % after non-fallow predecessor, in tillering nodes – 32.2 and

32.6 %, respectively. More economical consumption of carbohydrates led to better and more intensive regrowth of Kokhanka plants in early spring and intensification of regeneration processes.

**Conclusions.** Three years of research have shown that the winter wheat plants accumulate more soluble carbohydrates after black fallow despite lower doses of mineral fertilizers applied under pre-sowing cultivation than after sunflower. During the winter, the highest consumption of sugars in the leaves and in the tillering nodes was observed in the Uzhynok variety plants regardless of the predecessor. It was found that winter wheat plants of the Kokhanka variety more economically consumed soluble carbohydrates than the Uzhynok and Nyva odeska varieties, and more intensively regrew in early spring.

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