showed that this trait is determined by one recessive gene. A number of genotypes have been identified, the weight of 1000 seeds of which exceeded 600 g. Collection forms of chickpea are important for breeding, combining a high level of seed productivity with a weight of 1000 seeds over 400 g. High-protein samples are recommended for use in hybridization to create varieties with increased protein amount per unit area. Significant genotypic variability of water absorption by chickpea seeds was established at different temperature conditions. This process was more intensive in the genotypes NEC 1838 (Chile) and the sample from Italy. In laboratory conditions 27 forms revealed a high level of tolerance against the fusarium, while possessing a valuable complex of economically valuable traits. The drought-resistant genotypes described in India turned out to be ultra-early maturing and undersized under our conditions, although they formed large seeds. A brief description of 12 varieties of chickpea obtained during the period of these studies is given.

Conclusions. As a result of the research carried out, donors and sources of the main economically valuable traits of chickpea have been identified and characterized, and those have been identified that have especially valuable complexes.

The presence of genotypes from different geographic zones and genetic centers will allow more targeted breeding, especially in the creation of disease-resistant forms. The forms of chickpea described by us can be used in breeding by other scientific institutions in our country and abroad.

Key words: *chickpea, collection samples, protein content, disease tolerance, productivity.*

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A METHOD OF SELECTING INITIAL BREEDING MATERIAL OF TRITICALE BASED ON THE GRANULOMETRIC COMPOSITION OF GRAIN STARCH

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To create triticale varieties for different purposes, it is important to improve methods of evaluation and selection of breeding material based on of appropriate qualitaty parameters. In order to increase the effectiveness of starch quality-oriented selection of triticale breeding material, a method based on characterization of accessions in terms of starch granulometric structure. To accomplish this, we used light microscopy and a USB camera with subsequent processing of the obtained images in the ImageJ program. This method can be used to analyze a large batch of accessions; the analysis requires a small number of kernels, which is especial at the initial stages of breeding.

Key words*: breeding, cereal, starch granule size, accession identification, light microscopy*

Introduction. Triticale was only used as a forage crop for a long time. However, at present it is widely used in food and technical industries. Triticale varieties for different purposes must meet certain requirements, including the grain starch quality, in particular the size of starch granules. For example, varieties with large granules are more suitable for starch production, and the contrary, varieties with small starch grainules are good for bioethanol production. To increase the breeding effectiveness and to create triticale varieties with a given set of characteristics, it is necessary to develop and improve methods for evaluating and selecting starting material for char-

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acteristics of interest, which allow one to quickly and accurately analyze a large number of accessions. Identification of breeding material by granulometric structure of starch and selection of sources with various sizes of starch granules will contribute to more targeted creation of triticale varieties for different purposes and thus accelerate and increase the breeding efficiency.

Review of literature, problem statement. Currently, triticale is one of the most promising cereals. The search for effective methods of creating new forms, growing technologies and approaches to triticale grain processing for different industries has intensified in the world. Bioethanol from triticale is one processing possibilities [1]. The main requirements for alcohol-distillate triticale varieties are high grain yield as well as high content and quality of starch [2, 3].

Starch is deposited in endosperm cells in starch granules, the size and shape of which differ in different crops. For example, in wheat and triticale they are oval-round or lentil-like and reach 25–40 μm, in rye – oval with a distinctive crack and a size of 40–50 μm [4]. The starch fermentability depends on the granule size. Small granules have a larger surface area per unit weight and are more easily destructed mechanically in the milling process, which, in turn, increases the area of reaction with enzymes converting starch into bioethanol [5].

Evaluation of breeding material for size and uniformity of starch granules using microscopy is an affordable and widely used method that allows analyzing a great number of accessions within a short time. This method is widely used in studies of starch originated from different cereals, potato and cassava [6, 7, 8]. However, in most cases, when conducting this analysis, researchers make do with describing the shape or size of granules without statistic processing of the obtained data and applying them in breeding [9, 10].

The study purpose was to develop a method for evaluating triticale breeding material and to determine the starch granule size distribution in order to select forms with various sizes of starch granules for further use in creating varieties suitable for starch and bioethanol production.

Materials and methods. The study was conducted in the Department of Cereal Breeding and Seed Production of the NSC "Institute of Agriculture of NAAS" in 2016–2017. The total number of accessions analyzed to determine the starch granule size was 142 winter triticale breeding lines and varieties and 22 winter bread wheat. To describe the method of selection, the results of evaluation of nine accessions, which are the most typical and reflect all the diversity of the collection in terms of granule size distribution, are discussed in detail in the article. The essence of the method is to determine the starch granule size by light microscopy. A laboratory grinder LZM-1, microscope MBI-3 with a binocular adjustment AU-12 were used. A USB camera was used to digitize the images, and the ImageJ program was used to estimate the granule sizes and tabulate the results.

Results and discussion. Based on our investigation, the method for estimating the triticale starch granule size distribution was developed. The analysis is divided into four steps: 1 – preparation of samples; 2 - taking microphotographs of starch granules; 3 - processing images in the ImageJ program, and 4 - statistical processing of data. For the analysis, 10 kernels of each triticale accession were ground on a laboratory grinder LZM-1. Then the resulting flour was placed on a glass slide, stained with 2 ml of glycerol-free Lugol's solution (5% iodine, 10% potassium iodide, 85% distilled water). After reaching full staining (1 min), starch granules in the visual field were photographed using a digital USB camera at a total magnification of x45 (lens - x20, binocular adjustment - x1.5, camera - x1.5). There was no eyepiece, because it was replaced by a camera lens. The granule size was determined in the ImageJ program. Granules larger than 10 μm were only taken into account, as the number of smaller granules was insignificant. At least 100 granules were measured for each accession. The maximum, minimum and average sizes were determined, and then the variances and coefficients of variation were calculated. The starch granule uniformity and sizes were evaluated by analysis of variance, and accessions with the smallest variation of this feature were singled out

Table 1 shows the sizes of starch granules in nine typical triticale accessions, which differ in their granulometric composition.

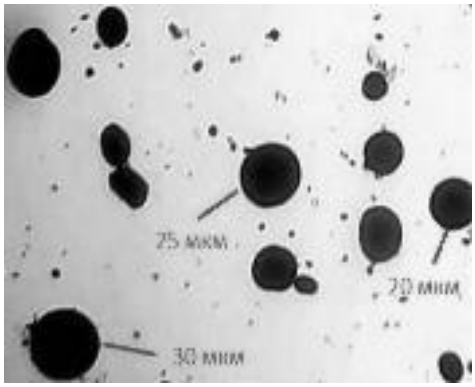
Table 1

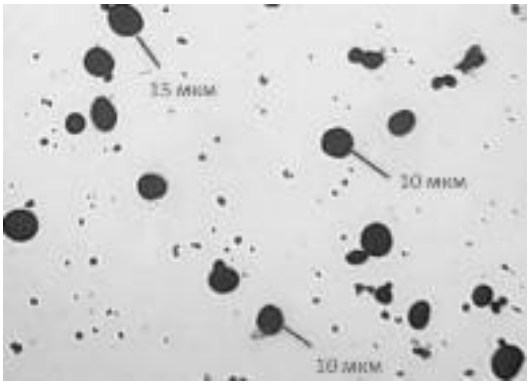
Starch granule sizes in winter triticale varieties and lines, 2016–2017

Variety/line	Starch granule size, μm			Variance	Coefficient of variation, %
	Maximum	Minimum	Mean		
169	22,9	14,2	16,7	5,2	13,6
242	23,4	10,2	16,8	8,9	17,8
158	27,4	12,4	16,9	16,0	23,6
171	26,7	12,6	18,3	19,7	24,2
130	26,9	14,4	19,8	14,7	19,3
209	29,0	13,1	20,3	20,3	22,2
186	35,5	13,0	21,4	35,6	23,9
193	33,2	16,4	23,2	28,9	23,2
223	31,1	14,8	23,5	42,4	28,5
LSD_{05}		-	2,7	-	-

The method of selection of breeding material using microphotography of starch granules with subsequent image processing is an affordable, economical, simple and effective approach to phenotyping triticale varieties and hybrids by physical parameters of starch. This method can be used for express-analysis of large numbers of accessions and does not require complicated laboratory equipment. The time required for a complete investigation of one accession is shorter than seven minutes, but if the preparation and evaluation of a batch of accessions are conducted simultaneously, the total time of analysis is significantly reduced.

Identification of winter triticale accessions by granule size distribution showed that they had various maximum, minimum and average granule sizes with considerable dispersion. The maximum size of granules ranged 22.9 to 35.5 μm; the minimum – 10.2 to 16.4 μm. The average size of granules is the most objective characteristic of the granulometric composition of starch, since there may be very few granules with maximum and minimum sizes (Fig. 1).





Starch granules in winter triticale variety 223 *Starch granules in winter triticale line 24*

Fig. 1. Winter triticale starch granules (micrograph taken at x45 magnification)

Varieties with uniformly small starch granules are the most suitable for bioethanol production, as they are characterized by better fermentability. Therefore, it is also relevant to assess collection accessions for the uniformity of starch granule size distribution.

Basing on the results of evaluation of accessions by the size of starch granules, we have developed and obtained a patent for a utility model "Method of Selection of Triticale Breeding Material by Granulometric Composition of Grain Starch" (No 140021 dated 02.10.2020). As we confirmed, this method can be successfully used to evaluate accessions of other cereals, which can significantly expand the possibilities of its use [11].

Conclusions. Our method of selection of triticale accessions based on evaluation of the starch granule particle size distribution allows one to quickly and accurately analyze new breeding material, to increase the breeding effectiveness, and to create varieties for different purposes, such as bioethanol or starch production.

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СПОСІБ ДОБОРУ ВИХІДНОГО СЕЛЕКЦІЙНОГО МАТЕРІАЛУ ТРИТИКАЛЕ НА ОСНОВІ ГРАНУЛОМЕТРИЧНОГО СКЛАДУ КРОХМАЛЮ ЗЕРНА

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Мета дослідження: вивчення гранулометричного складу крохмалю зерна, розробка способу оцінки селекційного матеріалу тритикале та виділення зразків з різним розміром крохмальних гранул для подальшого використання в створенні сортів, придатних для виробництва крохмалю та біоетанолу.

Матеріали і методи. Дослідження проводили в 2016–2017 рр. в ННЦ «Інститут землеробства НААН». Під час дослідження було проаналізовано 142 зразки тритикале озимого. Гранулометричну структуру крохмалю визначали методом світлової мікроскопії з наступною обробкою в програмі ImageJ.

Обговорення результатів. На основі проведених досліджень розроблено спосіб оцінки гранулометричної структури крохмалю зерна тритикале. Проведення аналізу цим способом проходить у чотири етапи: підготовка зерна, одержання мікрофотографій гранул крохмалю, обробка зображень у програмі ImageJ, статистична обробка одержаних даних. Ідентифікація гранулометричної структури крохмалю у зразків тритикале показала, що вони мають різні максимальні, мінімальні та середні розміри гранул за значної варіації. Найбільшого значення (23,2 и 23,5 мкм) середній розмір досягав у зразків 193 і 223, а найменшим (16,7–16,8 мкм) був у зразків 169 і 242. Інші зразки характеризувалися середніми розмірами від 16,9 до 21,4 мкм. Одержано патент на корисну модель «Спосіб добору селекційного матеріалу тритикале за гранулометричним складом крохмалю зерна» (№140021 від 10.02.2020)..

Висновки. Розроблений спосіб добору зразків тритикале на основі оцінки гранулометричної структури крохмалю дозволяє швидко і точно проводити аналіз нового селекційного матеріалу та підвищити результативність селекційної роботи зі створення сортів, придатних для різних напрямів використання, наприклад, для виробництва біоетанолу або крохмалю.

Ключові слова: *селекція, зернова культура, розмір крохмальних гранул, ідентифікація зразків, світлова мікроскопія*

СПОСОБ ОТБОРА ИСХОДНОГО СЕЛЕКЦИОННОГО МАТЕРИАЛА ТРИТИКАЛЕ НА ОСНОВЕ ГРАНУЛОМЕТРИЧЕСКОГО СОСТАВА КРАХМАЛА ЗЕРНА

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Цель исследований: изучение гранулометрического состава крахмала зерна, разработка способа оценки селекционного материала тритикале и выделение форм с разным размером крахмальных гранул для дальнейшего использования в создании сортов, пригодных для производства крахмала и биоэтанола.

Материалы и методы. Исследования проводили в 2016–2017 гг. в ННЦ «Институт земледелия НААН». В ходе исследования были проанализированы 142 образца тритикале озимого. Гранулометрическую структуру крахмала определяли методом световой микроскопии с последующей обработкой в программе ImageJ.

Обсуждение результатов. На основе проведенных исследований разработан способ оценки гранулометрической структуры крахмала зерна тритикале. Проведение анализа этим способом проходит в четыре этапа: подготовка зерна, получение микрофотографий гранул крахмала, обработка изображений в программе ImageJ, статистическая обработка полученных данных. Идентификация гранулометрической структуры крахмала у образцов тритикале показала, что они характеризовались разными максимальными, минимальными и средними размерами гранул при значительной вариации. Наибольший средний размер (23,2 и 23,5 мкм) установлен у образцов 193 и 223, а наименьший (16,7–16,8 мкм) – у образцов 169 и 242. Другие образцы характеризовались средними размерами от 16,9 до 21,4 мкм. Получен патент на полезную модель «Способ отбора селекционного материала тритикале по гранулометрическому составу крахмала зерна» (№1440021 от 10.02.2020).

Выводы. Разработанный способ отбора образцов тритикале на основе оценки гранулометрической структуры крахмала позволяет быстро и точно проводить анализ нового селекционного материала и повысить результативность селекционной работы по созданию сортов, пригодных для разных направлений использования, например для производства биоэтанола или крахмала.

Ключевые слова: *селекция, зерновая культура, размер крахмальных гранул, идентификация образцов, световая микроскопия.*

THE METHOD OF GETTING THE INITIAL BREEDING MATERIAL OF TRITICALE BASED ON THE GRANULOMETRIC COMPOSITION OF GRAIN STARCH

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Purpose of the research is to study the granulometric composition of grain starch, develop a method of evaluation breeding material of triticale and selections forms with different sizes of starch granules for further use in creating varieties suitable for the production of starch and bioethanol.

Materials and methods. The research was carried out in 2016–2017 at the NSC "Institute of Agriculture of the NAAS". During the study, 142 samples of winter triticale were analyzed. The granulometric structure of starch was determined by light microscopy followed by processing in the ImageJ program.

The discussion of the results. On the basis of our research, we have developed a method for assessing the granulometric structure of triticale grain starch. The analysis is separated to four phases: preparation of the seed, getting of the micro photos of the starch granules, working

with images in the “ImageJ” program, statistical analysis. Identification of the granulometric structure of starch in winter triticale samples showed that they were characterized by different maximum, minimum and average granule sizes with significant variation. The largest average size (23.2 and 23.5 microns) was found for samples 193 and 223, and the smallest (16.7-16.8 microns) - for samples 169 and 242. Other samples were characterized by average sizes from 16.9 to 21.4 microns. The patent for a useful model "Method for the selection of breeding material for triticale according to the granulometric composition of grain starch" (No. 1440021 dated 02/10/2020) was received.

Conclusions. The developed method for sampling triticale based on the assessment of the granulometric structure of starch makes it possible to quickly and accurately analyze new breeding material and increase the effectiveness of breeding work to create varieties suitable for different uses, for example, for the production of bioethanol or starch.

Key words: *breeding, grain crops, starch granule size, sample identification, light microscopy*.

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VARIABILITY IN CHEMICAL COMPOSITION OF EGGPLANTS AND SWEET PEPPERS

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The dry matter, vitamin C and total sugar contents were determined in eggplant and sweet peppers fruits to establish patterns in these substances, depending on the subspecies and color of fruit in and to investigate the dynamics of these indicators during sweet pepper ripening. The dry matter content was found to depend on the subspecies and fruit color in eggplant. The stability of the "dry matter content" and "vitamin C content" indicators was evaluated. It was shown that the effects of the subspecies and varietal characteristics on the dry matter in eggplant accounted for 61 - 65%. The effect of the cultivation weather factor accounted for 20%, and the factor interaction effect – for 15–18%. The vitamin C stability in eggplant is above average, regardless of the subspecies. There was an upward trend in the dry matter content in sweet pepper accessions with industrially mature dark fruits. The vitamin C content depended on the fruit maturity degree, and the vitamin C amount, in the first place, depended on the genotype. There was an upward trend in the total sugar content in accessions with industrially mature cream and yellow fruits. It was found that the genotype effect on the vitamin C content in sweet pepper fruits ranged 72 to 75%. The effect of the cultivation weather factor accounted for about 26%, and the factor interaction effect – for 20–22%.

Key words: *eggplant, sweet pepper, dry matter, vitamin C, content, variability, stability.*

Introduction. Vegetables are a major source of vitamins and trace elements for humans. Therefore, the quantitative and qualitative chemical composition of vegetable products is extremely important.

Review of literature, problem statement. Recently, eggplant has become increasingly popular due to its taste and high contents of beneficial chemicals such as vitamins B, PP and C, potassium, calcium, phosphorus, magnesium and sodium. Eggplants contain small amounts of copper, zinc and aluminum, however, due to balanced contents of iron, manganese and cobalt

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