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ECOLOGICAL AND BIOLOGICAL FEATURES OF FORMATION OF MILLET SEEDS

The analytical review of domestic and foreign literary sources on the condition and prospects of grain and seed production in Ukraine for the period up to 2025 was carried out. The top directions of millet breeding and seed production were determined. The ecological and biological features of formation of high-quality seed grain of millet (Panicum melliaceum L.) were analyzed. It was established that the formation and development of seeds of a millet plant is not simultaneous, and accordingly its supply with nutrients is also different. The level of this supply is connected with the intensity of photosynthesis and the flow of mineral nutrients, which, in turn, is determined by environmental conditions. The interrelation of these conditions with the relevant seed quality indexes is not only of scientific interest, as its morphological and physiological and biochemical properties affect the sowing qualities of the seed grain.
Keywords*: millet, seeds, sowing qualities, yield properties, ecological and biological features of formation, production forecast.*

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ЕКОЛОГО-БІОЛОГІЧНІ ОСОБЛИВОСТІ ФОРМУВАННЯ НАСІННЯ ПРОСА

Наведено аналітичний огляд вітчизняних і зарубіжних літературних джерел, щодо стану та перспектив виробництва зерна і насіннєвого матеріалу в Україні на період до 2025 року. Визначено пріоритетну напрями селекції і насінництва проса. Проаналізовано еколого-біологічні особливості формування високоякісного насіннєвого матеріалу проса посівного (Panicum melliaceum L.). Встановлено, що утворення й розвиток насіння на рослині проса відбувається неодночасно, відповідно й забезпеченість його поживними речовинами також неоднакова. Рівень цієї забезпеченості пов'язаний з інтенсивністю фотосинтезу та надходженням елементів мінерального живлення, що, в свою чергу, визначається умовами зовнішнього природного середовища. Встановлення взаємозв'язку цих умов з відповідними показниками якості насіння має не лише науковий інтерес, так як його морфологічні та фізіолого-біохімічні властивості впливають на посівні якості насіннєвого матеріалу.

Ключові слова: *просо, насіння, посівні якості, врожайні властивості, еколого-біологічні особливості формування, прогноз виробництва.*

Target setting. One of the most important tasks of Ukraine's agricultural sector is to increase grain production. Moreover, it is necessary to increase not only the level of productivity, but also to improve its quality. The solution to this problem is possible through the improvement of the seed system at the state level, constant strain renovation and variety changing, as well as the improvement of the existing and introduction of new varietal technologies.

In recent years, the grain production in Ukraine has increased significantly and, according to the State Statistics Committee of Ukraine [1], the gross grain yield for year 2019 reached 75.08 million tons, which not only provides internal food security but will also increase grain exports to foreign markets to 54 million tons [1]. At the same time, the gross yield of millet in 2019 amounted to 159 thousand tons, which is more than 84 thousand tons in comparison with 2018 (110%). According to the forecasts of domestic researchers [2], gross yield of cereals and legumes for the period up to 2025 may increase to over 100 million tons. However, to ensure such a gross yield of cereals, it is necessary to reach a European level of the yield, which is now twice lower than in the European Union and three times than in the USA. Production of high quality seed grain remains one of the actual provisions for obtaining high-yielding plantings of field crops. Thus, according to Academician V.V. Kyrychenko [3], to ensure the sowing of the forecasted areas, it is necessary to have up to 4.0 million tons of high quality seeds of cereals every year, of which 1.8-1.9 million tons are winter and 1.2 million tons are spring cereals. At the same time, the priority directions for selection and seed production of millet are genetic improvement of varieties focused on getting of raw materials for the production of high quality food, pharmaceutical, feed and technical products of natural origin, as well as the creation of varieties containing starch of amylopectin direction of use.

Goal of research – is to theoretically substantiate and determine the optimal agro-ecological conditions for millet growing, which ensure maximum yield of high quality seeds.

Statement of basic materials. The technology of growing seed and commercial crops has a number of differences. Many scientists on the study of peculiarities of formation of sowing qualities and yield properties of seeds note that a high level of yield is not yet a guarantee of obtaining high sowing qualities [4]. In addition, there is data in the literature that the quality of seeds decreases under conditions of maximum yield formation. Thus, according to V.V. Lykhochvor [5], the highest yield of seeds and its biological value is achieved at a yield level of 4.0–4.5 t/ha. Further increase of productivity, as well as its decrease beyond the limits of 3 t/ha does not allow receiving high-quality seed grain.

In the technology of plant growing a significant role in seed crops is given to knowledge of the biology of culture, critical periods of its development, features of reaction to abiotic, biotic and anthropogenic factors during the formation and development of seeds, conditions of its diversity.

The interrelation of a plant organism with the external environment begins from the time of its formation. Concerning ontogeny, a seed is an embryonic stage of plant development. Formed on the maternal organism, the seed feels the influence of all the conditions of this plant existence. The factors that contribute to successful growth and development of plants usually promote the formation of high-quality seeds, and, conversely, those that inhibit plants also worsen the quality of seeds.

Plant growth and development takes place under a different combination of environmental conditions. In addition, the seeds that develop on the mother plants are closely linked to the leaves that supply photosynthesis products, and to the root system that provides it with water and nutrients. The level of such provision of plants depends on the effect on them of environmental conditions, some of which improve, while others, on the contrary, impair the optimal flow of metabolites to the ripening seeds. However, even under the same conditions of nutrient supply, it is still affected by a number of factors: unequal daylight hours, light quality and intensity, different temperatures, etc. This is especially applicable for crops with a long flowering period, whereby the seeds that are formed on the plant can get into various changing environmental conditions. The consequence of such influence of ecological factors is the formed seeds, which, even within the same inflorescence, can have different morpho-physiological parameters [6].

Thus, it was established [7] that the duration of flowering, plumpness and ripening of the seeds of millet varieties in the territory of Ukraine varies from 12 to 50 days. At the same time the seeds are formed in different parts of the panicle, which differs both in linear sizes and weight, and in terms of sowing quality. It should also be noted that millet has significant differences from other plants of the cereal family in a number of biological properties. First of all, it is a large biological plasticity of the crop, high bushiness (millet is capable to form up to 10 or more stems), as well as a very high reproduction factor (the number of grains in the panicle can vary from 100 to 3000 and more). As a result, millet is capable of producing the record harvests of up to 20.1 t/ha.

There are significant differences in various varieties of millet and early ripeness. Thus, its growing period changes more than in 2.5 times – from 50 to 130 days [8].

Some of the factors influencing the quality of seeds are temperature and water regimes during its formation. Thus, prolonged action of soil and air drought causes thinning of grains; they have low weight and subsequently form weak seedlings. In addition, the germination energy of shrivelled seeds is increased, so it is poorly stored.

M.M. Kuleshov studied the influence of weather conditions on plant development, as well as the formation of sowing qualities and yield properties of seeds. Thus, he found [9] that in the years with high temperatures and significant moisture deficit, especially in the critical period of the crop development, the processes of flowering and fruiting of corn seeds lasted almost 40 days, the share of pollinated cobs was 41%, with seed yield – 13,3 hwt/ha. However, in favorable years for seed development, when the average daily temperature and humidity were within the average long-term values, the duration of pollination was only six days, the share of pollinated cobs was 97% and the yield was 59.4 hwt/ha. The author notes that the unfriendliness of

plant development affects the heterogeneity of seeds within the variety in terms of sowing qualities and yield properties.

Other scientists also point to the biological heterogeneity of seeds caused by non-simultaneity of flowering and the appearance of reproductive organs. Thus, according to the research of Ye.H. Kyzylova [10], the dependence of the corn seeds quality on temperatures during pollination-settling periods found expression in different germination energy of seeds and the strength of their initial growth. In the first two days of pollination, the average air temperature was only 12–14 ° C, and its relative humidity was 60–70%. This led to the formation of seeds with reduced sowing qualities, germination energy decreased by 3 – 4% compared to this figure in the seeds formed at air temperatures at the level of 20-22 °C. The plants formed from seeds with reduced germination energy lagged behind in growth and development.

According to the observations of scientists [11] in comparison with other field crops, millet also has a significant unevenness of seed ripening and a strong ability to its falling. Thus, the seed from the upper part of the panicle ripens the first and has the greatest weight. However, by the time of the seed ripening in the lower part, it is already falling. During the same period, the stems and leaves remain green. Such features are quite valuable, because in the case of drought or early mowing, the seed formation can continue due to the nutrients of the stem and leaves.

A similar dependence has been established for other crops. Thus, Yu.B. Konovalov [12] noted a certain relation for wheat between the level of yield, the amount of precipitation and the average daily air temperature in different growing periods.

Similar data were also obtained for rice by M.P. Krasnook and colleagues [13]. In the experiments of V.M. Romanchev [14] in the early period of sowing the formation of buckwheat seeds occurs under less favorable conditions (low positive temperature, excessive rainfall, lack of solar insolation), which leads to a significant shortage of the seed yield – 2 hwt/ha at the average yield of 12–14 hwt/ha. Other properties of seeds also change. Thus, the phenomenon of seed hardiness in perennial legumes is also often the result of rainless weather conditions at the time of its ripening, and in cereals under the influence of weather conditions changes the hull content and chemical composition of seeds.

Millet belongs to warm-season crops, in which there are no signs of winter hardiness – it is damaged at a temperature of +1 °C, and dies at a temperature of -2-3°C. The millet overcomes high temperatures quite easily unlike other cereals. Thus, even at +40 °C its respiratory cells remain elastic for 48 hours, and photosynthesis does not stop even at +45 °C and above. As a plant of short daylight, the millet ripens very fast under conditions of intense light at 10-12 hours of daylight. However, increasing the duration of daylight during the vegetative period slows down its transition to generative development, thus forming a larger leaf-stem mass, and subsequently increases the yield [15].

In the scientific literature there is also information about the influence of lighting conditions on the formation of reproductive organs of millet plants and the quality of future yield. Thus, the scientists [16] note that the millet plants are particularly sensitive to intense light. Low light intensity during flowering-fruiting periods causes complete infertility of spikelets, and under optimal conditions there is an accelerated transition of plants to fruiting, weighty high-quality seeds are formed. In addition, the authors emphasize that the different varieties of millet have different requirements for light intensity.

The effect of light on plants is diverse, and it acts not only as a source of energy, but also as a kind of regulator or agent. A typical example of such an action is the light sensitivity of plant seeds. The reaction of seeds to light in different varieties of plants has its own distinctive features. Thus, the seeds of some crops under its action increase their sowing qualities, and others show inhibition of germination. There are also plants whose seeds are neutral in this regard [17].

Millet plant has its own characteristics concerning the accumulation of organic matter in the process of photosynthesis. Thus, according to the research [18], the photosynthesis in millet plant is of type C_4. It is very economical in terms of moisture, C_4 plants produce almost twice more carbohydrates per unit of water absorbed compared to C_3 plants, and at high temperatures this difference increases. As a typical representative of crops with photosynthesis of type C_4, the millet uses nitrogen more efficiently and accumulates a large amount of dry matter per unit of assimilated nitrogen, so even under adverse conditions in critical periods of growth and development can form a high level of proper yield. Having considered the above concerning the plants with photosynthesis of C_4-type it is possible to draw a conclusion about their high productivity, which exceeds the productivity of plants of C_3-type almost twice, as well as about high resistance of such plants to adverse environmental conditions.

A number of scientists also point out the influence of weather conditions during the certain phases of growth and development of millet on the formation of its productive and qualitative properties. Thus, in terms of drought resistance, the millet is one of the first among field crops. Under conditions of prolonged drought, the millet seeds can be in an anabiosis phase for up to 30-40 days or more, without losing viability. When it rains, the millet seeds germinate and quickly form a secondary root system, which is characterized to use even a small amount of rain efficiently. The value of the transpiration coefficient at the level of 162 to 447 indicates that millet requires much less moisture to form a unit of dry matter than other cereals, and even with sufficient moisture, it continues to use moisture sparingly [11].

It was found [19] that the millet is able to restore turgor even after 45 hours of drought, with crop losses not exceeding 30% and the weight of 1000 seeds – 20-25%.

According to the observations of M.A. Murzamadieva [20], millet tolerates drought most easily at the beginning (seedling and leaf-tube formation period), as well as at the end of the growing season (ripening phase). However, the lack of moisture during the panicle earing and ripening significantly reduces the number of fruiting ears in the panicle, the weight characteristics of the seed (its weight of 1000 grains and grain-unit) also worsen. In addition, according to O.I. Rudnyk-Ivashchenko [21], during the grain formation and filling, higher protein content in millet grains accumulates under weather conditions with high temperature and low humidity. In addition, it was found that the excess moisture of soil and air during seed formation also has a negative impact on its quality characteristics. Under such unfavorable conditions, fungal diseases of plants develop strongly, the intensity of respiration increases sharply. The consequence of such phenomena is the strengthening of the hydrolysis of organic matter in the grain and the outflow of hydrolysis products into the leaves, stems and partly to the root system.

It is also known that the varieties of different origins react differently to the influence of weather factors of the year of crop formation. According to E. Nesterenko [22], the quality of seeds in different varieties of spring wheat varies differently depending on weather conditions. Thus, the weight of 1000 grains in the variety Skelya varied from 31.5 to 42.5 g, and in the variety Diamant – from 24.1 to 39.4 g.

Zonal conditions for growing different varieties of sowing millet also affect both the level of yield and grain quality. Ye.H. Kyzylova [10] notes that the geographical conditions significantly affect the quality of seeds and overlap varietal differences by 9-16%.

The studies performed in the conditions of Kyiv region have established a significant influence of soil and climatic conditions on the yield properties of the millet seeds [23]. Thus, the yield of the variety Soniachne in 1982 when sowing seeds grown in the experimental farm "Kopylovo" (Makariv district, Kyiv region) amounted to 42.6 hwt/ha (control).

When sowing seeds of the same variety, but reproduced in 1981, at the cultivars of the forest-steppe and steppe zone, this indicator increased by 4.2–8.4 hwt/ha.

However, according to the results of complex ecological variety testing of millet varieties for sowing by the sum of ranks of genotypic and ecological effects and maximum productivity potential performed by O.I. Rudnyk-Ivashchenko [21], it is established that soil and climatic conditions are the main factor for grain formation, than the millet growing area. At the same time, among ecological niches the author noted the most favorable areas for cultivation of new varieties of millet for sowing, such as: Cherkasy, Chernihiv and Ivano-Frankivsk regions, where in comparison with average productivity of variety test, the yield was from 0,37 to 2,03 t/ha.

Conclusion. Formation and development of seeds of the millet plant occurs not simultaneously, respectively, and its supply by nutrients is also different. The level of this supply is connected with the intensity of photosynthesis and the mineral nutrient enrichment, which, in turn, is determined by the conditions of the external environment. Establishing the interrelation of these conditions with the relevant indexes of seed quality is not only of scientific interest, as its morphological and physiological and biochemical properties affect the sowing quality of the seed grain.

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