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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**ЕКОЛОГІЧНО-БІОЛОГІЧНІ ОСОБЛИВОСТІ ФОРМУВАННЯ НАСІННЯ ПРОСА**

Наведено аналітичний огляд вітчизняних і зарубіжних літературних джерел з питань формування зерна і насінневого матеріалу у країні на період до 2025 року. Визначено пріоритетні напрями селекції і насінництва проса. Проаналізовано екологічно-біологічні особливості формування високоякісного насінневого матеріалу проса посівного (Panicum miliaceum L.). Встановлено, що утворення й розвиток насіння на рослинні проса відбувається неодночасно, відповідно й забезпеченість його похідними речовинами також неоднакова. Інтенсивність роки збільшення впливу екологічних факторів на процес формування насіння визначається умовами зовнішнього природного середовища. Встановлено взаємозв’язку цих умов з відповідними показниками якості насіння має не лише науковий інтерес, ала і який морфологічні та фізіологічні особливості впливають на посівні якості насінневого 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 agronomic 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 72.8 million tons, which is more than 4.5 million 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. Kryuchenko [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 net are: high sowing qualities; they have low weight and subsequently form weak seedlings. In addition, the germination energy of shrivelled grains; they have low weight and subsequently form weak seedlings. 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 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. Kzyzylova [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 humidity 60–80%. Thus, 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 a feature is not desirable, 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 hardness – 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. Light is a significant factor, 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-fructifying periods causes complete infertility of spikelets, and under optimal conditions there is a noticeable increase in the yield of 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 of plant development. 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 millet plant on its millet plant is of type C₃. It is economical in terms of moisture, C₃ plants produce almost twice more carbohydrates per unit of water absorbed compared to C₄ plants, and at high temperatures this difference increases. As a typical representative of crops with photosynthesis of type C₄, 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 C₃-type it is possible to draw a conclusion about their high productivity, which exceeds the productivity of plants of C₄-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 turger 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.M. Murzamadiyeva [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. In 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. Kzyzylova [10] notes that the geographical conditions significantly affect the quality of seeds and overlap varietal differences by 9-16%.

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 Sonia 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 t/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 with mineral nutrients 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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