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# SOLUTIONS FOR CALCULATING THE VELOCITY OF WATER CURRENTS IN ARTIFICIAL DRAINAGE BASINS AND THEIR SAFETY DIRECTIONS AGAINST EROSION ON THE NATURAL RELIEF

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**Abstract**: Estimation of erosion risk of soils and lands is necessary to predict their possible degradation and develop measures to prevent erosion. Such an assessment is important for solving the problems of the restoration of eroded soils, since it is necessary to provide for the potential energy of erosion processes, which can be manifested even in the presence of erosion control measures and in the remediated areas. This article discusses approaches to assessing the dangers of linear and planar soil erosion on the ordinary chernozem. The article deals with the issues of understanding the structure of soil erosion processes and formulas for calculating the velocity of water currents in artificial drain basins and their erosion-safe directions on the natural relief. The main principles for calculating the velocities of water currents in artificial drain basins and their erosion-safe directions are given. This article presents the synthesis of the information from published sources regarding the peculiarities of the soil cover and the erosion process on the ordinary chernozems.

**Key words**: artificial drainage basins, artificial rain, calculation the intensity of the surface leakage, ordinary chernozem, Negrea locality, potential erosion, volume of liquid spills.

## INTRODUCTION

Soil degradation is a combination of processes leading to a change in the function of the soil as an element of the natural environment, quantitative and qualitative deterioration of its properties and regimes, and a decrease in the natural and economic value of land. At the same time, natural and economic value is understood as the quality of land, determining the nature and effectiveness of their use, the participation of soil cover in ensuring the functioning of ecosystems (including agro-ecosystems) and the existence of natural landscapes [1, 9, 12, 13, 16, 20, 23, 27, 29 and 37].

Annually, the areas of eroded soils increase on arable land by 0.4-0.5 million hectares. From 50 to 100 thousand hectares drop out of arable land annually due to the growth of ravines. The length of ravines is > 1 million km with an area of 15 million hectares. The processes of flushing of soils and ravines are intensified as a result of compaction of soils with heavy agricultural machinery. On heavily compacted soils, harvest reduction reaches 50 %.

Particular attention should be paid to the fate of ordinary chernozem, which in the past was considered one of the most fertile soils in the world, badly damaged by mismanagement. This is only 7 % of the total area, but it houses more than 40 % of the entire arable land and produces about 80 % of all agricultural products. Ordinary chernozems have already lost 25 % of humus. Damage to ordinary chernozems, especially strongly affects the fertility of soils of arable land in general [7, 10, 15, 17, 26, 28, 32, 34 and 37].

## MATERIALS AND METHODS

Large areas of ordinary chernozems are washed away. In some places, the flushing reaches such a level that horizons of the rock that are almost deprived of fertility leave the surface instead of the humus horizon. In vast spaces, the upper, most fertile layer of ordinary chernozems is demolished during dusty storms, and shafts of this layer, up to several meters in height, accumulate near forest strips.

The data cited point to the need to take into account the conditions for erosion processes to prevent possible soil degradation. For these purposes, it is necessary first of all to propose indicators and criteria for assessing erosion. In the international project UNEP [22, 31, 32, 34, 35, 36] it is recommended to assess the erosion state in three aspects:

*Condition:* Percentage of erosion on the surface; type of erosion; outcrops of the subsoil, the area occupied by ravines; thickness of soil; deposits on the dams, % per year.

*Degree of manifestation:* transfer of fertile land to erosion-hazardous (marginal) categories, % of the area per year; volume of loss of sand deposits, t/ha per year; an increase in the area of eroded soils, % of the total area of productive land; loss of soil root layer; annual revaluation of the state.

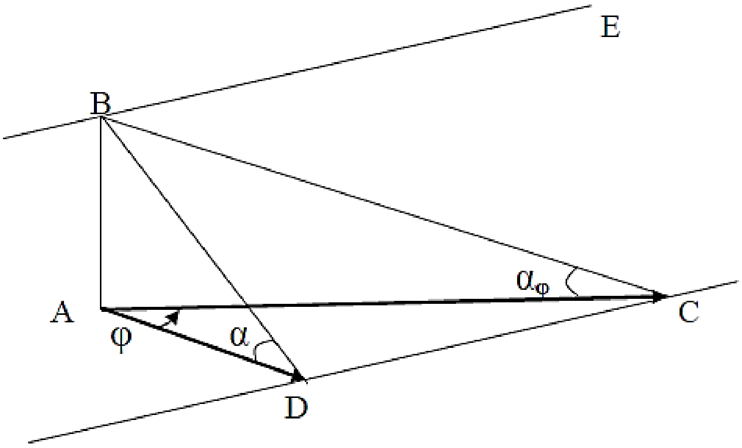
*Danger of manifestation:* slope, %; potential loss of soil, t/ha per year.

The listed indicators characterize in detail the phenomena and processes of erosion. However, the task of further improving the assessments should be, first, the development of quantitative criteria for comparing situations that change over time in order to determine the significance of the changes that are taking place. Secondly, taking measures to assess the state, degree or risk at any given time [2, 7, 8, 10, 11, 14, 18, 21, 27, 29, 30 and 33].

Erosion-safe called such areas of cultivation of land, for which furrows that appear because of cultivation, there will be no accelerated erosion. To design an erosion-safe spatial arrangement of the boundaries of agricultural fields and drainage gutters, it is expedient to calculate the information spatial fields of the vector of erosion-safe directions of water flows [1, 6, 16, 19, 23, 25, 28, 30, 33, 34, 36 and 37]. Vector lines of erosion-safe working slopes determine such fields. The main parameter of this field is the angle φ between the direction of the maximum slope and the permissible direction of the land cultivation.

Using the symbols of figure 1, we define the slopes of the slope in different directions [7, 16, 21 and 36]:

$$tg\ \alpha = AB/AD;\ tg\ \alpha_\varphi = AB/AC;\ AC = AD/cos\ \varphi$$



α – tilt angle; BE, DC – segments of horizontals, m; BD – segment runoff lines, m, AD – its horizontal position, m; AB – horizontals section, m; AC - horizontal slope line in the direction *φ*, m.

**Figure 1.** *The derivation of the relationship between the slopes of different directions*

Thus, the slope in the direction of φ is related to the slope of the slope by the dependence [7, 16, 21 and 36]:

$$J\varphi = J \cdot cos\ \varphi,$$

Where: $J = tg\ \alpha;\ J\varphi = tg\ \alpha\varphi$

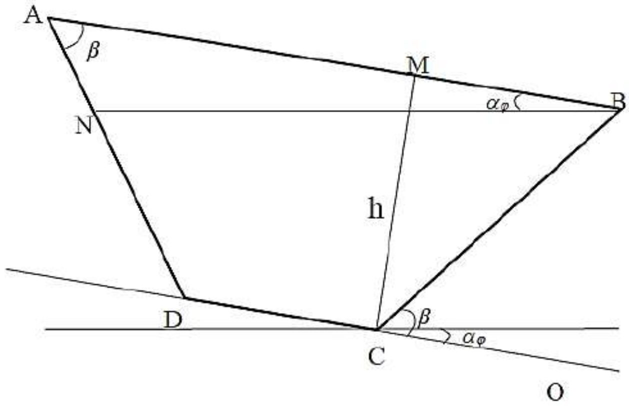
Considering this dependence, the Chezy-Manning formula takes the form [7, 16, 21 and 36]:

$$v_н = n\text{-}1\, R^{0,67}\, (Jcos\varphi).$$

Where: $v_н$ - not blurring the flow rate of this soil, m/s, which in this case must be achieved by selecting the appropriate value *φ*;

*R* - hydraulic flow radius provided the maximum filling of the basin with water, m.

As can be seen from figure 2, the calculation of φ is complicated by the fact that artificial furrows and hollows are formed parallel to the slopes, and the surface of water flows tends to a horizontal level.



$\alpha_\varphi$ – angle of inclination in the direction $\varphi$; h – depth of hollow; AB = $B_1$, DC = $B_2$ - top width and the bottom.

**Figure 2.** *The parameters of the furrow*

As a result, there is a distortion of the hydraulic furrow radius, which depends on the slope of the slope and the orientation of the furrow on the slope. Such a distortion is taken into account in calculations of φ for cross-sections of the furrow at the points of the regular network by successively solving the equations [7, 16, 21 and 36]:

$$S_{ABCD} = 0{,}5 \cdot (AB + DC) \cdot h$$

$$BC = \sqrt{\left(\frac{AB - DC}{2}\right)^2 + h^2}$$

$$\beta = \arcsin\left(\frac{h}{BC}\right)$$

$$\alpha_\varphi = \mathrm{arctg}(\mathrm{tg}\alpha \sin \varphi_{0})$$

$$AN = \frac{AB \sin \alpha_\varphi}{\sin(\pi - \alpha_\varphi - \beta)}$$

$$S_{ABN} = 0{,}5 \cdot AB \cdot AN \cdot \sin\beta$$

$$S_{NBCD} = S_{ABCD} - S_{ABN}$$

$$P = BC + CD + (BC - AN)$$

$$R = \frac{S_{NBCD}}{P}$$

$$\varphi_1 = \arccos\left(\frac{v_н \cdot n}{R^{0,67} \cdot tg\,\alpha^{0,5}}\right)^2$$

The symbols in these formulas remained unchanged. The problem is solved by successive approximations. First, φ is assigned a deliberately large value, for example, $\varphi_0$ = 890. Calculate the value of $\varphi_1$ sequentially using formulas. If $\Delta\varphi = |\ \varphi_0 - \varphi_1\ | > \xi$, where ξ is an admissible error, then the calculations are repeated starting from formula. In this case, the value of φ1 is substituted into formula, and so on, until the difference, Δφ becomes admissible. In practical calculations, ξ = 0.01 radian [7, 16, 21, and 36].

The maximum velocities are acquired by concentrated water currents, for which the primary channel is the artificial furrow or the shaft, which appeared due to the specific cultivation of sloping lands.

The algorithm can be applied to a furrow of an arbitrary cross-section.

The maximum possible speed of the water flow in the basin of a given direction on the slope is calculated by formula. In this formula, the hydraulic radius is defined as follows. First, the slope of the slope (J) is calculated at the point of the cross-section of the trough, for which the R and the slope in the direction of the trough (Jφ) are determined.

Further calculations are carried out in the following sequence [7, 12, 13 and 21]:

$$\cos\varphi = J/J\varphi$$

$$\sin\varphi = \sqrt{1-\cos\varphi^2}$$

After this, using these formulas, calculate the hydraulic radius and determine the maximum speed of the water flow from ender formula.

***Formulas for the prediction of soil washout***

Among the wide variety of mathematical models of flushing, the universal US soil loss equation (USLE) occupies a special place, which, in addition to the more advanced variant known as RUSLE, is still widely used for forecasting soil erosion in many countries [7, 16, 21, and 36]. The USLE model has this general form:

$$A = R\cdot K\cdot L\cdot S\cdot C\cdot P,$$

Where: $A$ – ground washout module, t/ha year, and many of them are factors:
$R$ – erosive properties of rain;
$K$ – pliability of soil erosion, t/ha/year;
$L$ – slope length;
$S$ – steepness of the slope, $^{0}/_{00}$;
$C$ – vegetation and crop rotation;
$P$ – effectiveness of anti-erosion measures.

To calculate the mutual influence of the relief factors L*S in the Gosstandart [7, 11, 12, 13, 21], the formula:

$$L*S = L^{0.5}(0.0011*S^2 + 0.0078*S + 0.0111)$$

Other factors are considered using reference data as constants at the local territorial level of detail coefficients [12, 16].

To calculate the soil washout modules on complex slopes, using this formula, the correction factors for equal slope segments are used as multipliers, which are given in Table 1.1 [12]. Since even elementary slopes often have a complex shape, and the drainage lines that limit them are not parallel, the question arises as to the length of the slope (L) and its individual lengths of the same length. The length of the slopes should be determined by the formula [7, 12, 13, 21]:

$$L_j = \sum_{i=1}^{m} \frac{F_i}{b_i},$$

Where
$L_j$ - length $j$ elementary slope (EC), m;
$F_i$ – area, $m^2$;
$b_i$ – width of bottom side i elementary information cell (EIA), m;
$m_j$ - the number of such cells within j elementary slope.

In this case, the elementary slope is a part of the slope bounded by adjacent drainage lines, and the elementary information cell is a quadrilateral bounded by neighboring horizontals and drainage lines.

**Table 1**. Correction factors for the calculation of A for 5 equal length segments of the slope length [12]

| Sequence number of the segment from the watershed to the baseline of the slope | Coefficients |
|---|---|
| 1 | 0.45 |
| 2 | 0.82 |
| 3 | 1.06 |
| 4 | 1.25 |
| 5 | 1.42 |

## RESULTS AND DISCUSSIONS

The degrading effect of soil erosion is not limited to removing fertile layers and worsening of its physical, chemical, hydrological and biological properties [5].

The results of the pedological researches carried out in Negrea locality allow the elaboration and implementation of an argumentative scientific project to reduce the unfavorable consequences of the degradation processes of the ordinary chernozem in the hill area of the Middle Prut [3, 4].

In the process of carrying out the detailed mapping of the ordinary chernozem, it has been established that the microterase of the slopes under the multiannual plantations and other anti-erosion measures in the past of the total use of the territory under vines and orchards has led to the decrease of the soil washing processes on the slopes. The passage of land to arable land without measures to combat erosion increased fertile soil losses on slope lands by comparing data according to the classification given in Table 2 [15].

**Table 2.** Classes of surface erosion hazard for arable land prone to erosion [15]

| **Name** | **Land losses estimated (t/ha/year)** |
|---|---|
| - absent | ≤ 1 |
| - poorly | 2 – 5 |
| - moderately | 5 – 15 |
| - strongly | 15 – 30 |
| - very strongly | ≥ 31 |

The researches revealed that the ground cover pedagogy on the territory of Negrea locality is formed mainly of ordinary chernozems with different degrees of erosion and soft and delluvial soils typical of arable land. It was found that arable lands occupy 87.3%, landslides - 12.7% of the total area of studied territory. The complexity of the soil cover is due to the predominance in its structure of soils with different degrees of erosion that occupy 83.1% of the total area.

As a result of soil erosion after 40-45 years, they lost from the initial thickness of the loose layer as follows: poorly eroded - 6 cm; moderately eroded - 11cm; strongly eroded - 19 cm. Therefore, the main soil degradation factor is surface and deep-water erosion.

In this paper are also presented the data on leakage control plots of turbulence under the influence of artificial rain of a certain intensity. The amount of water drained from the plot was determined by the volumetric method. According to the data obtained, depending on the degree of soil erosion, the leakage coefficient increased from 0.06 - 0.12 at the beginning of the observations to 0.39 - 0.52 at the end of them.

For the poorly eroded soil the losses were 9.3 t/ha, the moderately eroded 12.8 t/ha, increasing up to 22.2 t/ha in the soil with a high degree of erosion. Therefore, the permissible limit of soil losses is over 1.6-3.7 times. A practical conclusion follows from this finding: technological processes of preventing and / or combating soil erosion within the receiving basin have to be differentiated and correlated with the intensity of the erosion process [3, 4].

Liquid and solid spills in soils with different erosion rates were determined in the field on control plots of 3 $m^2$. On these plots simulated artificial rains of certain intensity with a portable aspiration device (Figure 3).

The artificial water supply was carried out from the 3000 liter tank. The duration of the artificial rain was 30 minutes, with an intensity of 2 mm/min. A control of water has been connected to the sprinkler in order to maintain a stable flow rate of 6 l/min. The amount of water drained from the plot was determined by the volumetric method. The amount of washing soil was estimated by determining the turbidity of samples taken every 5 minutes over the balloon with a volume of 500 $cm^3$.

The amount of washed pedolite from the slopes is sedimented within the boundaries of the receiving basin in the form of cumulus soils and irreversibly lost. It has been established that about 1.1 million tonnes of fertile soil with a medium humus content of about 2.5% were lost from the surface of 283 ha of land irreversibly in historical aspect.

It appears that about 3.9 thousand t/ha of humiferous soil [3, 4] were lost from each hectare affected by erosion on an irreversible average.

The surface leakage intensity detects sensitive changes during artificial rain. According to the data obtained, depending on the degree of soil erosion, the leakage coefficient increased from 0.06 - 0.12 at the beginning of the observations to 0.39 - 0.52 at the end of them. Between the values of the drain coefficient and the infiltration, velocity of the rainwater there is an inverse correlation. Thus, the infiltration rate decreases from 1.77 - 1.88 mm/min at the beginning of the rain to 1.18 - 0.97 mm/min at its end.

Ordinary chernozems investigated with varying degrees of erosion differ essentially from the turbidity of the leakage. From the presented data it results that the medium eroded soil turbidity was 41.22 g/l, the soil with moderate degree of erosion 48.47 g/l and the strongly eroded soil 73.28 g/l. It is worth mentioning that the values of the leak turbidity decrease essentially over time, irrespective of the degree of soil erosion. The highest leakage load with washed earth material is recorded at the incipient phase. Towards the end of the artificial rain, the turbidity of the spills decreases in the middle by about 24% [3, 4].

**Figure 3.** *Determination of volume and turbidity of leakages under artificial influence of certain intensity [4]*

## CONCLUSIONS

Annually, the areas of eroded soils increase on arable land by 0.4-0.5 million hectares. From 50 to 100 thousand hectares drop out of arable land annually due to the growth of ravines. The length of ravines is > 1 million km with an area of 15 million hectares. The processes of flushing of soils and ravines are intensified because of compaction of soils with heavy agricultural machinery. On heavily compacted soils, harvest reduction reaches 50%.

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The water permeability of the ordinary chernozems is maximal at the not eroded chernozem and decreases gradually depending on the degree of soil erosion, being the smallest for the eroded ordinary chernozem. The increase in the degree of erosion of soils worsens their physical properties, which influence water permeability; aggregates hydraulic conductivity decreases and the resistance of the structural compaction of arable and posts.

## BIBLIOGRAPHY

1. ABRAMOV, A. On the account of vegetation cover in determining erosion-permissible irrigation norms. Prevention of irrigation erosion of soils in Central Siberia. Krasnoyarsk, 1982. pp. 42-45.
2. BROWN, L. Preventing soil erosion. The world of the eighties. Moscow: Progress, 1989. pp. 295-317.
3. COJOCARU, OLESEA, CERBARI, V. Comparative characterization of the properties of not eroded and eroded ordinary chernozems in the basin of reception of the Middle Prut Plain. In: Agricultural Science Magazine, No 1. 2013. UASM. pp. 12-16. ISSN 1857-0003.
4. COJOCARU, OLESEA. Combating soil erosion of the ”Negrea” receiving basin in the hill area of the Middle Prut. Chisinau, 2016, 163 p. ISBN 978-9975-56-312.
5. DOKUCHAEV, V.V. On the issue of soil of Bessarabia. Chisinau, 1950. 55 p.
6. Instructions for the determination of calculated hydrological characteristics in the design of anti-erosion measures in the European territory of the USSR. M., 1979. 62 p.
7. KONDRATIEV, S. Mathematical modeling of the formation of rainwater runoff and water erosion on a small agricultural catchment area. Water resources. 1989. No 3. pp.14-22.
8. KUZNETSOV, M. Anti-erosion resistance of soils. Moscow: Izd-vo Mosk. University, 1981. 135 p.
9. KUZNETSOV, M., GLAZUNOV, G. Erosion and protection of soils. Moscow: Izd-vo Mosk. University, 1996. 135 p.
10. GERRARD, F.J. Soils and forms of relief. L: Nedra, 1984. 208 p.
11. GORSTKO, A. Introduction to the modeling of ecological and economic systems. Rostov-on-Don: Publishing house of the Rostov University, 1990. pp. 103-111. ISBN 5-7507-0094-1.
12. GOST 17.4.4.03-86 (ST SEV 5300-85). Protection of Nature. Soil. Method for determining the potential hazard of erosion under the influence of rain.
13. GOST 17.5.1.02-85. Protection of the Earth's nature. Classification of disturbed lands for reclamation.
14. GUDSON, N. Soil protection and erosion control. M., 1974. pp. 204-215.
15. FLOREA, N. şi alții. Metodologia elaborării studiilor pedologice. Partea III. Indicatorii ecopedologici. Bucureşti, 1987. 226 p.
16. LAVROVSKY, A. On the question of constructing a model for runoff and flushing of soil during storm erosion. Regularities in the manifestation of erosion and channel processes in various natural conditions. Moscow: Izd-vo MGU, 1987. pp. 89-90.
17. LARIONOV, G. Erosion and deflation of soils: basic regularities and quantitative estimates. Moscow: Izd-vo MGU, 1993. pp. 187-198.
18. LISETSKIY, F. Modern problems of erosion: monograph. Belgorod: Constant, 2012. pp. 405-449. ISBN 978-5-9786-0248-7.
19. MAKKAVEEV, N. Riverbed and erosion in its basin. Moscow: Publishing House of the Academy of Sciences of the USSR, 1955. pp. 321-343.
20. Methodical recommendations for the calculation of surface runoff and washout of soils in the study of water erosion. Ch:, 1975. 88 p.
21. MIRTSKHULAVA, T. Engineering methods for calculating and predicting water erosion. Moscow: Kolos, 1970. pp. 232-236.
22. POBEDINSKY, A. Impact of cuttings on the regulation of spruce forests. Forest science. 1971. No 2. pp. 7-14.
23. Project criteria. Soft-Hardware for Global Land. Soil Monitoring System. Naiorobi: UNEP, 1983. 99 p.
24. ROZHKOV, V. New information technologies in soil science; progress and delusion. Vest. agricultural science. No. 12. 1991. pp. 31-38.
25. ROZHKOV, V., ROZHKOVA, S. Soil Informatics. M: Izd-vo Mosk. University Press, 1993. 190 p.
26. SHCHEPASHCHENKO, G., LIVEROL, M., ROZHKOV, V., SHCHEPASHCHENKO, D. Methodological recommendations for assessing the erosion hazard of lands and the development of a system of soil protective measures in conditions of variable tropics (on the example of the Republic of Cuba). M .: 1990. 60 p.

27. SOZIKIN, N. Hydrological significance of forest litter and physical properties of forest soils. Water regime in the forests. M., 1939. Issue. 18. pp. 34-56.
28. SRIBNIY, I. Average annual runoff of water and soil washing off the slopes. Water construction on small rivers. Kyiv: Budivelnyk, 1977. pp. 145-147.
29. SURMACH, G. Relief formation, forest-steppe formation, modern erosion and anti-erosion measures. Volgograd, 1992. 175 p.
30. SURMACH, G. Experience in calculating the flushing of soils to build a complex of erosion control measures. Soil science. 1979. No 4. pp. 92-103.
31. SVETLICHNY, A. Mathematical modeling of water erosion: the problem of classification. Вісник Одеського національного університету. Geografic and geological sciences. 2010. Volume 15. No 5. pp. 32-39.
32. SVETLICHNY, A. Principles of improving empirical models of soil washing. Soil science. 1999. No 8. pp. 1015-1023.
33. SVETLICHNY, A. Erosiology: theoretical and applied aspects: monograph Sumy: ITD ”University Book”, 2004. pp. 376-410. ISBN 966-680-170-1.
34. SVETLICHNY, A. The problem of verification of spatially-distributed mathematical models of water erosion of soils. Bulletin of the Odessa National University. Geografic and geological sciences. 2013. Vol. 18. No 3. pp. 38-48.
35. VINOGRADOV, B. Remote indicators of desertification and soil degradation. Soil science. 1993. No 2. pp. 98-103.
36. VORONIN, A., KUZNETSOV, M. Experience in assessing the erosion resistance of soils. Soil erosion and channel processes. Issue. 1. M., 1970. pp. 99-115.
37. ZASLAVSKY, M.N. Erosiology. M: High School, 1983. 320 p.

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# MISCANTHUS GIGANTEUS (SOIUL TITAN), PARTICULARITĂȚILE BIOLOGICE ȘI PROTECȚIA INTELECTUALĂ A SPECIEI ÎN REPUBLICA MOLDOVA

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**Abstract:** In the last years, the issue of the protection of varieties as an intellectual property on the territory of the Republic of Moldova is of great importance. And since the Republic of Moldova has very few own fossil energy resources, the problem of using renewable energy sources has been and remains very current.

For biomass production on an industrial scale, it is necessary to select, improve and implement energy crops that use to the maximum the active photosynthetic solar energy during the vegetation period, accumulate a considerable quantity of dry substances with optimal and reduced founding, maintenance, harvesting and processing costs.

At present, about 100 species of plants are identified in the Botanical Garden and which can be used for the production of various types of biofuel. The species *Miscanthus giganteus* was highlighted among them, which is a perennial herbaceous plant and can be kept on the same field for more than 15 years. It is vegetatively propagated by pieces of rhizomes or plantlets produced by tissue culture (seedling). The plantation of *Miscanthus* is placed on deep-cultivated, waterlogged soils.

In accordance with the variety examination procedure approved by the Law on the Protection of Plant Varieties, a National Test Guidelines for Giant Miscanthus, which meets the most important biological and physiological developmental features, has been developed for the Republic of Moldova.

**Key words:** energy crops, miscanthus giganteus, biological peculiarities, testing varieties at DUS