PROTECTION OF SOILS AND WATER RESOURCES AS AN IMPORTANT FACTOR IN FORMING PREPARATION TO THE PROJECT ACTIVITY OF FUTURE AGROENGINEERS IN INSTITUTIONS OF HIGHER EDUCATION

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***Summary**. Here are presented the results of scientific researches on the study of the bases of protection of soils and water resources by future agroengineering specialists in higher education institutions. In the educational process of agroengineering training, it is important to develop a motivational and cognitive criterion of preparing the future specialists for the project activity on the basis of fundamental knowledge of the mechanical and technological properties of agricultural materials such as soil, water, fertilizers, pesticides, plants, shrubs, trees, as well as other additional products and agricultural waste, etc., for the purpose of carrying out the necessary environmental measures that will ensure the optimization of the parameters of technological processes, machines and structures which are being developed, constructed and projected. Innovative pedagogical technology of teaching is developed according to the method of gradually increasing the amount of educational material, which comes as a result from previously learned and mastered material. It is recommended that about 20% of the training program for agroengineering to be directed by obtaining general and special environmental competencies. The acquired special professional skills of agroengineers will ensure the development of project activity on the basis of preservation and multiplication of natural resources.*

***KEYWORDS:** AGROENGINEERING, TECHNOLOGICAL PROCESS, TECHNOLOGY TRAINING, METHODOLOGY, SOIL, AGRICULTURAL MACHINERY, SLOPES, WATER EROSION.*

1. Introduction

One of the prerequisites for Ukraine's entry into the European community of higher education is full implementation of the ideas of protecting the natural environment within the educational process, scientific activity, organizational and educational work. Environmental protection system of educational process organization in pedagogical technologies of forming the readiness for future activities of future specialists in agroengineering is a model of cross-cutting preparation based on the combination, identification and professional understanding of ecological problems on soil protection, water resources and the influence of this choice on the technology of cultivating agricultural crops, as well as the use of technical means of agricultural mechanization. The purpose of implementation of the environmental system of the organization of the educational process is to expand measures for the protection of soil and water based on improving the quality of training of agroengineering specialists and, accordingly, ensuring their competitiveness in the labor market and the prestige of Ukrainian higher education in the world educational space. Formation of the environmental outlook and culture in the pedagogical technologies of project preparation of agroengineering is one of the main components of the organization of problem learning. It is recommended that about 20% of the educational program for agroengineering training to be directed by obtaining general and special environmental competencies, that is, they should be fully aware of the problematic issues of soil and water protection in Ukraine and in the world as in general and to be able skillfully prevent the deterioration of the ecological condition in case of its occurrence.

Prerequisites and means for solving the problem

At the International scientific conference “Conserving soils and water”, which was organized by a Scientific-Technical Union of Mechanical Engineering (Sofia), which took place on 31.08-03.09.2016 in Burgas (Bulgaria), a report was presented «The peculiarities of the work of tillage machines on the sloping lands» [1], in which the problematic issues of agriculture on the slopes are considered, and as a result are shown the methodological aspects of theoretical analysis, experimental research and production verification of the work of soil machinery in these conditions are presented, taking into account the soil fertility, as well as the optimization of the state of water resourcesIt is worth noting that in the technology of growing crops on sloping lands can be used general purpose vehicles, although the use of special tools, such as those considered in [2] is more expedient. The world agricultural science and practice are leaning towards the use of soil protection technology, which means the cultivation of soil without rotation of the upper formation layer. As shows the practice and results of plow research with plow crowns are used in some farms, however, scientists are advised that the area of irrigated agricultural land shouldn’t exceed 30%. The world experience in farming shows that the technology of "zero tillage" is gaining in popularity, that is, sown crops without breaking the upper layer of the soil. This technology stabilizes the microbiological complex in the soil, and organic residues contribute to the accumulation of moisture and suppression of seed germination, growth and development of weeds.

At the II International Scientific Conference "Protection of Soils and Water Resources", which took place from 30.08 to 02.09.2017, a report was presented in Burgas (Bulgaria) «The main components of studies and research of conserving soils and water in technologies of agroengineers training” [3]. This report partially discloses the scientific and methodological bases for soil and water exploration by future specialists in agroengineering in higher education institutions. Innovative pedagogical technology of development of project activity is developed in the form of a method of a consistent cross-cutting study of the material based on the objective relationship of disciplines and provides a qualitatively higher level of formation of professional competencies of agroengineers on the basis of preservation and even multiplication of natural resources. The report of [3] states that the current issues of soil science are devoted to many works by well-known scholars M. Scykuli, P. Zaichi [4], N. Dol, O. Hnatenko, L. Petrenko, M. Kapshtika, M. Manojlovič [5], R. Meissner [6] and others. An especially important scientific and production problem is the optimization of nutrient and water regimes of the soil on the slopes. A number of scientific works are devoted to the features of soil preparation for sowing crops on sloping lands, optimization and management of technological processes in these conditions. These include [1, 7, 8]. The role of science in the educational process is growing more and more. The classical, practically oriented, as well as the most up-to-date developments and developments of scientists in the form of didactic materials are covered in textbooks, manuals, methodological developments, and they are used in the training process of agroengineering.

It is worth noting that due to the considerable scientific contribution of scientists, agroengineering pedagogical science and educational practice have great achievements. Significant contribution to the development of the theory and methods of vocational education were done by I. Bender [9], V. Duganets [10], V. Manko [11], O. Kulchytska, I. Lerner, V. Rybalka, M. Dumchenko, N. Kuzmina, P. Luzan, and others.

Over the past decades, theoretical and experimental studies of the impact of design training on the formation of professional competencies of future specialists in agroengineering, the results of which are presented in [12], are conducted on the basis of agrarian universities of Ukraine. In [13], the peculiarities of using the method of projects in pedagogical theory and practice of forming professional competences of future agroengineers in higher education institutions are highlighted. The method of projects in pedagogical teaching technologies involves solving actual production of problems in agrotechnical issues. With the help of this method, a concrete result is obtained in the form of innovative scientific and technical documentation or other product, that can be presented, publicly defended, passed on to the customer.

The textbook [Ma], which consists of the theoretical part, a block of laboratory work and test tasks, is widely used in the educational process for the agroengineering preparation. It presents the results of research on the man-caused pollution of soils, their detoxification and recultivation, describes the design, methodology of calculation and design of machinery and equipment for land preparation to develop, culturotechnical works and irrigation of fields, regulation of water regime of the soil, laying open channels, their maintenance and purification , formation of anti-filtration screens of irrigation systems, determination of the stability of the bulk part of anti-erosion structures on slopes, studying the influence of soil categories on productive level and its resistance to the bulldozer and other field machinery, etc.

The above-mentioned accents of scientific issues are prerequisites and means of paradigm and didactics for solving actual problems of protection of soils and water resources in pedagogical technologies of forming readiness for future activities of future specialists in agroengineering in higher education institutions.

2. *Results and discussion*

As noted in [3], an important factor in preparing for the project activity of future specialists in agroengineering in higher education institutions is a fundamental study and comprehensive study: the state of soil with the detailed composition of their mechanical composition (solid, liquid and gaseous); agrophysical (acidity, percentage of humus, nitrogen, phosphorus, potassium and other chemical elements) and technological properties (hardness, characteristics of external and internal friction, resistance to deformation, viscosity, adhesiveness, plasticity, abrasiveness, ability to loosen and shred, etc.); water regimes; machinery and technology.

Studying the role of soil in the biosphere, students understand that soil is an indispensable intermediary between inanimate and living nature, and a very important link in various cycles that goes through the perimeter of the geographic envelope. If this link is destroyed, for example, by soil erosion processes or by various anthropogenic influences, then the natural functioning of the biosphere will be broken. Therefore, now that the land is used intensively for the purposes of agriculture and other economic needs, especially the actual and problematic issues are the protection of soils, which are the basic basis of the planetary living conditions and the restoration of living matter and life on earth.

The main cause of soil pollution is human activity, which is sometimes illiterate and carefree. As a result of the influence of the anthropogenic factor, in particular the irregular, irrational exploitation of land, a large proportion of the fertile layer is the subject to erosion and is lost annually. Thus, over the past 100 years, the process of erosion has captured 27% of the total land area which are occupied by agricultural land.

With the harvest the human withdraws from soil minerals and organic components, thereby impoverishing it. Therefore, it is necessary constantly to replenish the stocks of these substances in the soil by fertilizing it. Carefully cultivating and fertilizing the soil, following the sequence of crops in rotation, one improves soil fertility so that most modern arable soils should be considered artificial, created by human beings. During the design and construction of machinery for agricultural purposes must be skillfully taken into account all environmental properties of machine units, which determine the conditions for combating water and wind erosion, soil compaction, pollution and production of harmful compounds, etc.

Great attention of environmental issues is given to future agricultural engineers studying the agricultural machinery discipline. Here are some of the points of the program of the indicated academic discipline [15], which are largely concerned with environmental issues in agriculture and pedagogical research, which has been given the most attention.

The program [15] has the point 1.1.3. − Machines for soil protection systems of agriculture. It specifies the following questions for study: the main types of machines; the structure and workflow of flat-cutters-deep-thrusters, chisel plows, slit-cutters, etc.; combined soil cultivating units; types of working bodies of machines, aggregates, their main parameters; hydro equipment; technological adjustment of machines and aggregates, control and evaluation of the quality of soil cultivation; safety measures. According to this paragraph, students study methods of cultivation and machines for controlling water erosion [16], starting with terms, definitions and categories. For example, erosion is called erosion by water washing and wind blowing of fertile soil particles. All soils are more or less vulnerable to erosion. Accordingly, any agricultural machine, and especially a soil cultivation one, to a greater or lesser extent, should be anti-erosion. However, it is generally considered anti-erosion only those machines that carry out operations, the main purpose of which is to combat soil erosion. Such operations include snow removal, terracing, gluing, hanging, loosening of soil with preservation of stubble.

For water erosion, soils are particularly prone at slopes, and the method of their anti-erosion treatment depends on the steepness of the slopes. When steepness of slopes is up to 6°, it is recommended to cultivate the soil with the preservation of the stubble or mulching of the fields, the formation of holes, transverse ridges, and the like. When steepness of slopes is from 6° to 13°, it is expedient to create special rollers, drainage grooves and cracks filled with organic substances (peat, manure, plant remains or branches). When steepness of slopes is more than 13° it is necessary to create terraces. All this kind of work is conducted with plow plows and special machines for the construction of terraces.

Students have a formed key content and conceptual device, which is based on the understanding that in the field of plant growing, land resources form the basis of agricultural activities and the soil environment, is the main means of production. The soil is subjected to various impacts on it of mineral fertilizers, pesticides, working bodies, as well as supporting and moving elements of machine-tractor aggregates. It is important that this effect does not destroy the structure of the soil, but retains its natural fertilizing properties, and even better, helps to raise them. Students should be aware that in the future, highly skilled agricultural production specialists should not only prevent negative erosion but also take care of the growth of soil fertility.

During the study of the discipline "Mechanical and technological properties of agricultural materials" [17], students study and investigate the physical and technological properties of the soil as a cultivating object, the harmful effects of the support and propulsion machinery and tractor aggregates on the soil, the mechanical and technological properties of fertilizers as' the mechanism of mechanized introduction into the soil, the properties of the sowing material, the technological properties of the pesticides used for the protection of plants, etc.

The curriculum of the subject "Agricultural Machines" [15] provides for the completion of the course work [18], which is the final stage of studying the discipline. For each of the topics of the course work there is a section that reveals the mechanic-technological preconditions for the development of the machine, as well as the issue of environmental protection.

Land reclamation is the most expensive component of the intensification of agriculture. But these costs quickly pay off because the productivity of irrigated land is 4-5, and drained – 1,5 ... 2 times higher than the ones which are not reclaimed. An important role belongs to amelioration in the protection of the environment, and the implementation of measures aimed at the integrated and rational use and protection of water, land and forest resources.

Therefore, the study of land reclamation machines by future agroengineers is of great importance. Students study reclamation machines at lectures, laboratory and practical classes, while undergoing internships, both independently and under the direction of a teacher.

As an example, let's consider one of the 11 laboratory and practical works (the ninth one) conducted by students of specialty 208 "Agroengineering", studying machines and equipment in agricultural land reclamation − "Justification of the breadth of the berm of the terrain of soil protection technological processes" [14]. The purpose of the work: to study the features of efficient use of sloping lands and to acquire practical skills in preventing erosion processes, as well as to explore the possibility of increasing the soil fertility on the basis of a system integrated approach to the development of technological processes for the construction of terraces using the method of justification of the width of berm.

Initially, future specialists in agroengineering study theoretical positions and conceptual apparatus for the construction of berm terraces, as well as the peculiarities of soil protection processes in the cultivation technologies of various crops and fruit plantations on the slopes. At the initial stage of laboratory work, students study general information on the justification of the breadth of berm terraces. They realize that the berm on a slope separates one terrace from another, and their width must be due to the stability of the terraces in the event of destruction of the slotted slopes. It is known that the stability of the terraces depends on many factors, including slope steepness [3, 14]. Under the condition of placing on the canvas of two rows of fruit trees, the width of the berm is chosen taking into account the optimal distance between the rows of plantations on adjacent terraces.

The most common method for calculating slopes is the method of circular cylindrical sliding surfaces. In the theoretical substantiation of the stability of the bulk part of anti-erosion structures on the slopes one can assume that the surface of the slip is previously known and it coincides with the surface of the slope [3, 14]. The position of the arc center of the most dangerous surface of the slide (Fig. 1) is determined by the method of selection.

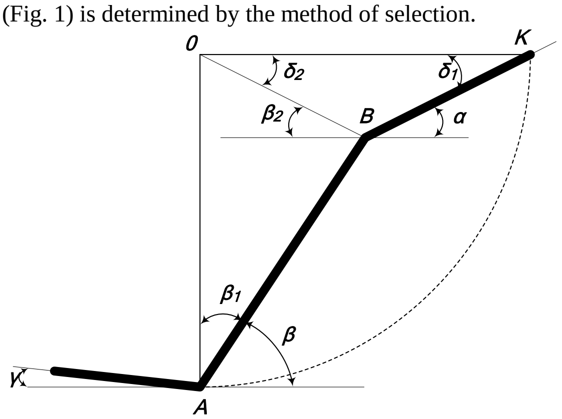

Fig. 1. Design scheme for determining the width of berm terraces, taking into account the stability of slopes against its displacement.

Prof. V. Fillenius has set a number of rules for finding the center of such an arc. Using his recommendations, students first find the center of the arc of the slip surface, which is located at the point of intersection of two beams drawn from the top and bottom of the slopes at angles β_1 and β_2 (Fig. 1). It is assumed that the soil is inherent only to the inoculation.

Accepting the center of the arc with the slipping point of intersection of the rays taken at the angles β_1 and β_2, we can say that the actual slip curve in the slope shifts will be left of the curve AK (Fig. 1), since the soil, besides the inoculation, also has its friction.

In this way, the solution of a problem can be determined by a slightly larger berm width, comparing it with the definition of it by successive approximations, using the method of positioning of circular cylindrical surfaces.

On Fig. 1. $AB = h$ − the size of the slot, and VK − the width of the berm. From the drawing it is clear that

$$OB = \frac{h \sin \beta_1}{\sin(\beta + \beta_1 + \beta_2)}; \quad (1)$$

$$AJ = OK = R = \frac{h \sin(\beta + \beta_2)}{\sin(\beta + \beta_1 + \beta_2)}; \quad (2)$$

$$\sin \delta_1 = \frac{OB}{R} \sin(\alpha + \beta_2) \frac{\sin \beta_1 \sin(\alpha + \beta_2)}{\sin(\beta + \beta_2)}, \quad (3)$$

from here

$$\delta_1 = \arcsin \left[\frac{\sin \beta_1 \sin(\alpha + \beta_2)}{\sin(\beta + \beta_2)} \right]. \quad (4)$$

Then

$$\delta_2 = 180^\circ - \delta_1 - 180^\circ + \beta_2 + \alpha = \alpha + \beta_2 - \delta_1. \quad (5)$$

Knowing the magnitude of the angle δ_2, we determine the berm's width by the formula:

$$a = BK = \frac{R \sin(\alpha + \beta_2 - \delta_1)}{\sin(\alpha + \beta_2)} = \frac{h \sin(\beta + \beta_2) \sin(\alpha + \beta_2 + \delta_1)}{\sin(\beta + \beta_1 + \beta_2) \sin(\alpha + \beta_2)}. \quad (6)$$

Replacing in the formulae (6) the values of h and δ_1 with their determinations, we obtain:

$$a = B \frac{\sin(\alpha + \gamma) \sin(\beta + \beta_2)}{\sin(\beta - \alpha) \sin(\beta + \beta_1 + \beta_2)} \times \frac{\sin\left[\alpha + \beta_2 - \arcsin \frac{\sin \beta_1 \sin(\alpha + \beta_2)}{\sin(\beta + \beta_2)}\right]}{\sin(\alpha + \beta_2)\left[1 + \sqrt{\frac{\sin(\beta + \gamma) \sin(\varphi - \alpha)}{\sin(\varphi + \gamma) \sin(\beta - \alpha)}}\right]} = B\varepsilon, \quad (7)$$

where ε – is a sampled curve when the width of the berm is B.

The results of the calculating of the level (7) show that due to the terms of change of the steepness of the slope and the width of the level the width of the berm is growing too. According to the agrotechnical demands the fruit trees are planted on the slope in a chess order (Fig.2). In that case the width between the lines of trees l_2 and the distance between the trees in each row l_1 will be different.

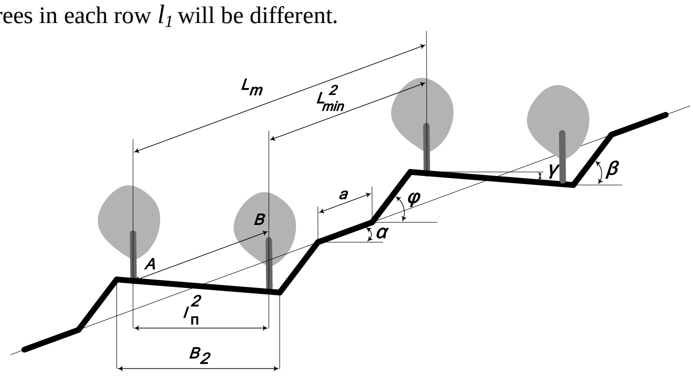

Fig. 2 The calculation scheme for determining the width of the berm on the terraces with two rows of the fruit cultures.

The distance between the fruit trees on both sides of the rhomb:

$$l = \sqrt{l_2^2 + \frac{l_1^2}{4}}. \quad (8)$$

According to the agrotecnical demands it is allowed to have the variables of data l_1 i l_2 at the slopes with the changeable steepness. The biggest distance between the fruit trees in the row is:

$$l = 2l_1. \quad (9)$$

When we have the change of length of the rhomb sides the minimal width of the cross-rowing is:

$$l_{2\min} = \sqrt{l_2^2 + \frac{l_1^2}{4} - l_1^2} = \sqrt{l_2^2 - \frac{3}{4}l_1^2}. \quad (10)$$

The results determined by the formulae (10) show that $l_{2\ min} > 2l_1$. When $l = 2l_1$ the density of planting is growing up to 18%, at the places of steep slopes with the angle of up to 15° and up to 10% − steepness more than 15°.

By agrotecnical machinery it is allowed to have the change of density of planting the fruit trees up to 20…25%. $l=2l_1$.

When we have the difference of horizontal lines and the constant width of the berm, the width of the berm can be increased.

Let's determine the size of the berm for the terraces with the double-row planting (Fig. 2), in order to get the optimal width of double-row between the fruit trees from the side of the steep slope of the lower terrace along with the side of the steep of the upper terrace.

The width of the slope, necessary for the construction of a terrace with double-row gardening of crops (Fig. 2)

$$L = B_2\sqrt{\frac{\sin(\varphi+\gamma)\sin(\beta+\gamma)}{\sin(\varphi-\alpha)\sin(\beta-\alpha)}} + a_2 = l_{2\text{п}}\frac{\cos\gamma}{\cos\alpha} + \sqrt{l_2^2 - \frac{3}{4}l_1^2}, \quad (11)$$

where B_2 and a_2 − respectively the width of the surface and berm on terraces with double-row plantation;

l_{2n} − the width of the row spacing measured on the surface.

Then the minimum width of berm for terraces with double-row plantation is:

$$a_2 = l_{2\text{п}}\frac{\cos\gamma}{\cos\alpha} + \sqrt{l_2^2 - \frac{3}{4}l_1^2} - B_2\sqrt{\frac{\sin(\varphi+\gamma)\sin(\beta+\gamma)}{\sin(\varphi-\alpha)\sin(\beta-\alpha)}}. \quad (12)$$

The solution of equation (12) shows that with increasing steepness the width of the berm decreases. The rapid change of the function $a_2 = f(\alpha)$ at α = 15° happens due to the transition of the width of the intermediate row from 6,5 to 8 m. The width of the berm decreases due to the increase in the length of the bulk and slotted slopes and the increase of steepness at a constant (6,5 or 8 m) width of row spacing.

The common solution of equations (3) and (12) determines the steepness in which the width of the berm, which is determined by the stability of the slopes against their destruction, is equal to the width of the berm, which is determined by the optimal density placement of the plants. This equation has the following form:

$$l_{2\text{п}}\frac{\cos\gamma}{\cos\alpha} + \sqrt{l_2^2 - \frac{3}{4}l_1^2} - B_2\sqrt{\frac{\sin(\varphi+\gamma)\sin(\beta+\gamma)}{\sin(\varphi-\alpha)\sin(\beta-\alpha)}} = B_2\frac{\sin(\alpha+\gamma)\sin(\beta+\beta_2)}{\sin(\beta-\alpha)\sin(\beta+\beta_1+\beta_2)} \times \frac{\sin\left[\alpha+\beta_2-\arcsin\left(\frac{\sin\beta_1\sin(\alpha+\beta_2)}{\sin(\beta+\beta_2)}\right)\right]}{\sin(\alpha+\beta_2)\left[1+\sqrt{\frac{\sin(\beta+\gamma)\sin(\varphi-\alpha)}{\sin(\varphi+\gamma)\sin(\beta-\alpha)}}\right]}. \quad (13)$$

The equation (13) can be solved graphically. For $\gamma = 3°$; $\beta = 60°$; $\beta_1 = 29°$; $\beta_2 = 40°$ and $B_2 = 6$ m, the value of $\alpha = 19{,}1°$.

The greatest steepness, in which it is advisable to terrace the slopes, can be determined based on the maximum permissible depth of excavation of the soil.

Prof. A.P. Dragavtsev notes that at a depth of more than 2 m slots there is a slipping and destruction of the slotted slope. Observations by V.S. Fedotov show that at a depth of slots more than 2,5 m the slopes are destroyed.

Consequently, if the maximum permissible depth of the slot is given, one can determine the greatest steepness in the relation:

$$h_{\max} = B_2\frac{\sin(\alpha+\gamma)}{\sin(\beta-\alpha)\left[1+\sqrt{\frac{\sin(\beta+\gamma)\sin(\varphi-\alpha)}{\sin(\varphi+\gamma)\sin(\beta-\alpha)}}\right]}. \quad (14)$$

At h_{max} = 2 m, $\varphi = 35°$, $\gamma = 3°$, $\beta = 60°$ and $B_2 = 6$ m, the value of $\alpha = 19{,}4°$.

Consequently, the results of the solution of the transcendental equations (13) and (14) almost coincide with the same initial output data.

Students are advised to do the following procedure for performing a laboratory work.

1. It should be noted that this laboratory work is a continuation of the analytical study of the dependence of terrace parameters from the slope steepness index which was initiated in laboratory work No. 8, an example with the solution is given in [3].

2. It is advisable that students must carefully read and validate the main theoretical positions and methodology for justifying the width of the berm terraces when developing the technological processes of soil protection from water and wind erosion and increasing its fertility [14].

3. Based on the initial data from the individual task given by the teacher of laboratory work number 8 in the workbook it is necessary to write the parameters necessary for the calculation, namely: the width of the surface (B, m), the angle of inclination of the transverse profile of the surface to the horizon (γ, °), the angle of the bulk slope (φ, °), the slope angle of the slot to the horizon (β, °). Provided that the slope angle of the slot to the horizon is β = 60°; take β_1 = 29°; and β_2 = 40°.

4. Draw (according to the example of Fig. 2) the calculation scheme of the step terraces and indicate on the scheme the numerical parameters of the bulk part of the anti-erosion structure.

5. By the formulae (7) of this laboratory work, determine the value a - the width of the berm terraces (m) with the values of steepness of the slope, α − 10°; 12°; 14°; 16°; 18°; 20°; 22°; 24°; 26°; 28°; 30°. The resulting calculations are summarized in the table. In addition, draw a graph showing the dependence of the berm's terraces − a (m) depending on the slope steepness − α, °.

6. Based on the results of the calculations and the constructed graph, students should formulate conclusions regarding the behavior of the dependence curve of the berm's terrace - and depending on the slope steepness – α, °.

According to the results of the laboratory-practical work in accordance with their task, students compile a report covering the theoretical and practical parts and necessarily allocate a point in which they analyze the protection of soils and water resources. The reports are defended by the students to a teacher in the presence of other students, who can in this case obtain additional information, especially in such important areas as environmental protection.

3. *Conclusion*

In pedagogical technologies of preparation of future agroengineers, formation of their readiness for project activity, considerable attention is paid to the problem issues of soil and water conservation. During the entire period of study, students must study systematically and consistently, to be present at all laboratory and practical classes, they must investigate the mechanical and technological properties of soils as the main means of agro-industrial production and other objects of interaction of working bodies. In the project activity for the initial parameters primary consideration is taken of the soils with their characteristics and parameters with the obligatory preservation of their fertility in the technologies of agricultural production of plant production, as well as the properties of mineral and organic fertilizers, pesticides, various plants, shrubs, trees, agricultural waste. An example is the laboratory and practical work on land reclamation machines, which reflects the scientific capacity of the educational process of agroengineering training in higher education institutions.

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