INTERNATIONAL SCIENTIFIC JOURNAL

MECHANIZATION IN AGRICULTURE & CONSERVING OF THE RESOURCES



Issue 5
2020

Year LXVI, ISSN print2603-3704, ISSN web 2603-3712

SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING
BULGARIAN ASSOCIATION OF MECHANIZATION IN AGRICULTURE

PUBLISHERS

SCIENTIFIC-TECHNICAL UNION OF MECHANICAL ENGINEERING "INDUSTRY-4.0"
BUGLARINA ASSOTIOATION OF AGRICULTURAL MACHINERY

ISSN (PRINT) 2603-3704, ISSN (ONLINE) 2603-3712

YEAR LXVI ISSUE 5 / 2020

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Investigation of the power interaction of the ploughshare digger working body with the soil and sugar beet root for the conditions of its vibratory digging

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Abstract. *the basic principles of the theory of interaction of the vibrating digging working body with the body of the root crop fixed in the soil at vibrating digging of sugar beets are developed. The force interaction of ploughshare diggers with the soil is considered in the work. The values of normal soil reactions acting on the ploughshare of the excavating working body are determined, which, when vibrating in the longitudinal-vertical plane, can dig out the bodies of sugar beet roots from the soil. Based on the obtained equations describing this process, the prerequisites for finding the kinematic and structural parameters of the excavating working body are developed.*
KEY WORDS: *WEDGE THEORY, VIBRATION DIGGING OF ROOT CROPS, NORMAL REACTION, PARAMETERS OF DIGGING ORGAN*

1. Introduction

Vibratory digging of sugar beet roots has become widespread in many beet-growing countries. It has a number of advantages over other methods of excavation. Therefore, this technological process requires a detailed analytical study and further development of advanced vibrating excavations. When performing any technological process, the necessary conditions are to ensure productivity, reduce energy consumption and improve the quality of the technological process. With regard to beet harvesters, a necessary condition for ensuring the quality of the technological process is, first of all, non-damage of roots during their digging. It is quite obvious that the greatest probability of damage to the roots exists in the presence of shock interaction of the working body of the beet harvester with the body of the root, fixed in the soil. Therefore, there is a need to investigate the theoretically specified shock interaction and on the basis of the results to determine the kinematic and structural parameters of the excavating working bodies from the conditions of non-damage of roots during their vibrational excavation.

2. Preconditions and means for resolving the problem

Fundamental theoretical studies of the process of vibratory digging of roots were carried out in [1] - [7]. However, the interaction of the vibrating digging organ with the body of the root crop fixed in the soil is not considered here. Only in [8] and [9] are some experimental results of the shock interaction of the pendulum copier with the root head. In this paper, the interaction of the vibrating digging organ at the moment of its meeting with the body of the root crop, ie at the moment of simultaneous impact of both plowshares on the root crop, is investigated.

3. Results and discussion

Consider the force interaction of ploughshare diggers with the soil, using the basic provisions [1]. For this purpose we will make the power scheme on which we will represent an element of a soil layer KL, inside which, in the center, is the root, which is approximated by a body having a conical shape (Fig. 1). Under the action of soil support forces, which are presented in the form of evenly distributed intensity load $\bar{q}$, layer element KL is in the channel of the ploughshare digger between its working surfaces and is consistently compressed at translational movement of the digger. The force of soil support, which is transmitted directly to the root, is denoted as $\bar{Q}$. In the soil layer KL there is a stressful state, which is due to the action of normal forces $\bar{N}$ and friction forces $\bar{F}$ at the points of his contacts K and L with the working surfaces of wedges. As a result on the part of the root that is inside the layer KL, (the lower part of the root remains trapped in the undeformed layer of soil) the force $\bar{Q}$, acts, which is due to the forces of soil support $\bar{q}$. On the other hand, forces $\bar{P}'_{xi}$, $\bar{P}'_{yi}$, $\bar{P}'_{zi}$ act directly on this part of the root, (i = 1, 2), which are transmitted from the work surfaces of the wedges, where the corresponding forces arise $\bar{P}_{xi}$, $\bar{P}_{yi}$, $\bar{P}_{zi}$, (i = 1, 2).

Fig. 1 shows each of these forces acting from the working surfaces of the plowshares with the corresponding index. Thus, the forces acting from the working surface $A_1B_1C_1$ on the soil layer, marked with index 1 – $\bar{P}_{x1}$, $\bar{P}_{y1}$, $\bar{P}_{z1}$, and forces acting directly on the root from this surface – $\bar{P}'_{x1}$, $\bar{P}'_{y1}$, $\bar{P}'_{z1}$. Forces acting on the soil layer from the work surface $A_2B_2C_2$ marked with index 2 – $\bar{P}_{x2}$, $\bar{P}_{y2}$, $\bar{P}_{z2}$, and forces acting directly on the root from this surface, respectively – $\bar{P}'_{x2}$, $\bar{P}'_{y2}$, $\bar{P}'_{z2}$. The action of these forces on the root is determined by their formation on the working surfaces of wedges and the nature of transmission in the deformed layer of soil. The force of the bonds with the soil is designated as $\bar{R}$, it is conditionally located on the axis of the root and is directed in the general case vertically downwards, but at direct extraction of a root from soil it can be laid out along the corresponding axes of coordinates (on fig. 1 it is presented by projections R_x and R_z).

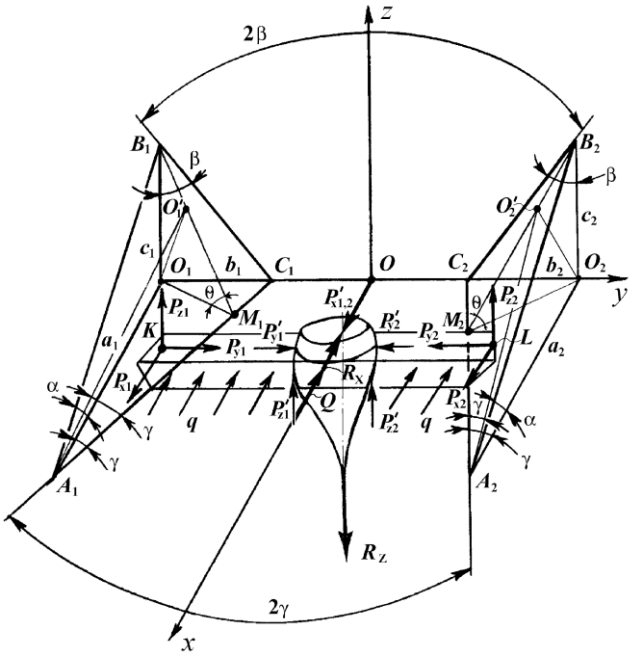


Fig. 1. Interaction of the ploughshare digging working body with the soil and sugar beet root

We will define these forces. In general, as shown in Fig. 2, a, b, c, forces $\bar{P}_{xi}$, $\bar{P}_{yi}$, $\bar{P}_{zi}$ (i = 1, 2) in vector form will be equal to:

for the plane $A_1B_1C_1$:

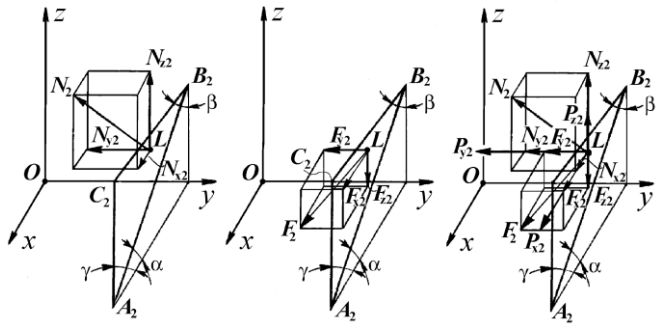
$$\begin{aligned} \bar{P}_{x1} &= \bar{N}_{x1} + \bar{F}_{x1}, \\ \bar{P}_{y1} &= \bar{N}_{y1} + \bar{F}_{y1}, \\ \bar{P}_{z1} &= \bar{N}_{z1} + \bar{F}_{z1}. \end{aligned} \quad (1)$$

similarly for the plane $A_2B_2C_2$:

$$\begin{aligned} \bar{P}_{x2} &= \bar{N}_{x2} + \bar{F}_{x2}, \\ \bar{P}_{y2} &= \bar{N}_{y2} + \bar{F}_{y2}, \\ \bar{P}_{z2} &= \bar{N}_{z2} + \bar{F}_{z2}. \end{aligned} \quad (2)$$

where $\bar{N}_{xi}, \bar{N}_{yi}, \bar{N}_{zi}$, ($i$ = 1,2) – normal reactions of working surfaces of wedges in projections on corresponding axes of coordinates; $\bar{F}_{xi}, \bar{F}_{yi}, \bar{F}_{zi}$, ($i$ = 1,2) – the forces of friction of the soil layer against the working surfaces of the wedges are also in projections on the corresponding coordinate axes.

We will analyze the action of each of the forces included in expressions (1) and (2) and form an effort that transmitted directly to the root. Thus, the vertical forces from blade surfaces $\bar{P}'_{z1}$ and $\bar{P}'_{z2}$ try to squeeze the root out of the soil (especially that part of it that is pinched in the soil); horizontal transverse forces $\bar{P}'_{y1}$ and $\bar{P}'_{y2}$ also try to squeeze the root, like a wedge-shaped body from the ground. Horizontal forces $\bar{P}'_{x1}$ and $\bar{P}'_{x2}$ (in Fig. 2.1 they are marked as the total force $\bar{P}'_{x1,2}$), acting in the direction of the ploughshare digger, together with the force $\bar{Q}$ also try to push the root out of the soil, but the direction of the force $\bar{Q}$ is opposite to the digger movement. However, depending on soil properties and other factors, the strength of the support $\bar{Q}$ may be insignificant, and then $P'_{x1,2} > Q$, and the root will move forward under the action of horizontal force $R_c = P'_{x1,2} - Q$, from which it is possible to break off the root in the area of its pinching in the undeformed layer of soil. Therefore, the quality of work of ploughshare diggers will be in the case of creating a significant amount of effort by the digger $\bar{P}_{zi}$ and $\bar{P}_{yi}$ and, conversely, small values of forces $\bar{P}_{xi}$.



a *b* *c*

Fig. 2. Scheme of forces acting on one of the wedges of the ploughshare digging body:

a – normal component $\bar{N}_2$ and its projections on the coordinate axis; *b* –friction force $\bar{F}_2$ and its projections on the coordinate axis; *c* – the total forces transmitted from the surface of the wedge: $\bar{P}_{x2}, \bar{P}_{y2}, \bar{P}_{z2}$.

Values and directions of forces $\bar{N}_i$ and $\bar{F}_i$, which determine the forces $\bar{P}_{xi}, \bar{P}_{yi}, \bar{P}_{zi}$, ($i$= 1, 2), depend on many factors: the properties and condition of the soil, the value of root-to-soil bond forces $\bar{R}$, geometrical parameters of digger wedges and angles of their installation in relation to the direction of movement, speed of translational movement, etc.

Consider further the effect of angles α, β and γ on the forces values $\bar{P}_{xi}, \bar{P}_{yi}, \bar{P}_{zi}$ (i = 1, 2), which form the pressure of the working plane of the wedge on the soil layer and on the root crop. Consider this on the example of one of the planes of the ploughshare, assuming that the second plane will be similar. As you can see from Fig. 2.2, a, at the point of contact L there is a normal reaction $\bar{N}_2$, which can be represented as projections on the corresponding coordinate axes – N_{x2}, N_{y2}, N_{z2}. If you find these projections of the normal reaction, it is possible to find the force of friction $\bar{F}_2$, which can also be represented as projections on the same coordinate axes – F_{x2}, F_{y2}, F_{z2} (fig. 2, *b*).

We find further the values of the forces $\bar{N}_{xi}, \bar{N}_{yi}, \bar{N}_{zi}$, which are directed along the corresponding coordinate axes and depend on the direction of the force vector itself $\bar{N}_i$ ($i = 1,2$). But we will make analytical expressions at once for two planes of the digger. For the plane $A_1B_1C_1$ they will be equal:

$$\begin{aligned} &N_{x1} = N_1 \cos\left(x, \hat{\bar{N}}_1\right), \; N_{y1} = N_1 \cos\left(y, \hat{\bar{N}}_1\right), \\ &N_{z1} = N_1 \cos\left(z, \hat{\bar{N}}_1\right). \end{aligned} \quad (3)$$

For the plane $A_2B_2C_2$ in accordance:

$$\begin{aligned} &N_{x2} = N_2 \cos\left(x, \hat{\bar{N}}_2\right), \; N_{y2} = N_2 \cos\left(y, \hat{\bar{N}}_2\right), \\ &N_{z2} = N_2 \cos\left(z, \hat{\bar{N}}_2\right), \end{aligned} \quad (4)$$

where $\cos\left(x, \hat{\bar{N}}_i\right), \cos\left(y, \hat{\bar{N}}_i\right), \cos\left(z, \hat{\bar{N}}_i\right)$ – guides cosines of the force vector $\bar{N}_i$ (i = 1,2).

Now we find the dependence of these guide cosines on the angles α, β and γ, which determine the construction parameters of the ploughshare digger. To do this, denote by a_i, b_i and c_i, (i = 1,2), segments of coordinate axes that cut off the working faces of the wedges. And for the plane $A_1B_1C_1$ it will be the segments a_1, b_1, c_1; for the plane $A_2B_2C_2 - a_2, b_2, c_2$. Then the coordinates of the three points of each plane of the wedges ($A_1B_1C_1$ and $A_2B_2C_2$) in the adopted coordinate system *Oxyz* will be respectively equal:

$$\begin{aligned} &x_{A1} = a_1; \quad y_{A1} = -\frac{A_1A_2}{2}; \quad z_{A1} = 0; \\ &x_{B1} = 0; \quad y_{B1} = -\frac{A_1A_2}{2}; \quad z_{B1} = c_1; \\ &x_{C1} = 0; \quad y_{C1} = -\left[\left(\frac{A_1A_2}{2}\right) - b_1\right]; \quad z_{C1} = 0; \\ &x_{A2} = a_2; \quad y_{A2} = \frac{A_1A_2}{2}; \quad z_{A2} = 0; \\ &x_{B2} = 0; \quad y_{B2} = \frac{A_1A_2}{2}; \quad z_{B2} = c_2; \\ &x_{C2} = 0; \quad y_{C2} = \left(\frac{A_1A_2}{2}\right) - b_2; \quad z_{C2} = 0. \end{aligned} \quad (5)$$

We use the basic provisions of analytical geometry [2] and, on the basis of (5), we make the equations of planes $A_1B_1C_1$ and $A_2B_2C_2$ in the form of such determinants:

$$A_1B_1C_1:\begin{vmatrix} x_{A1}-a_1 & y_{A1}+\dfrac{A_1A_2}{2} & z_{A1} \\ -a_1 & b_1 & 0 \\ -a_1 & 0 & c_1 \end{vmatrix}=0;$$

$$A_2B_2C_2:\begin{vmatrix} x_{A2}-a_2 & -y_{A2}-\dfrac{A_1A_2}{2} & z_{A2} \\ -a_2 & -b_2 & 0 \\ -a_2 & 0 & c_2 \end{vmatrix}=0. \quad (6)$$

From fig. 1 we see that the values of the corresponding segments a_i, b_i, c_i, (i = 1,2) on the corresponding coordinate axes will be equal to:

$$a_1=\frac{b_1}{\tan\gamma};\quad a_2=-\frac{b_2}{\tan\gamma};\quad c_1=\frac{b_1}{\tan\beta};$$
$$c_2=-\frac{b_2}{\tan\beta};\quad b_1=b_2=\frac{\left(A_1A_2-C_1C_2\right)}{2}. \quad (7)$$

If we reveal the obtained determinants (6), we have the following equations of the surfaces of the wedges of the ploughshare digger:

$$A_1B_1C_1:\ \left(x_{A1}-a_1\right)\left[b_1c_1-0\cdot 0\right]+\left(y_{A1}+\frac{A_1A_2}{2}\right)\times$$
$$\times\left[0\cdot\left(-a_1\right)-\left(-a_1\right)\cdot c_1\right]++z_{A1}\left[\left(-a_1\right)\cdot 0-b_1\left(-a_1\right)\right]=0,$$
$$A_2B_2C_2:\ \left(x_{A2}-a_2\right)\left[\left(-b_2\right)\cdot c_2-0\cdot 0\right]+\left(-y_{A2}-\frac{A_1A_2}{2}\right)\times \quad (8)$$
$$\times\left[0\cdot\left(-a_2\right)-\left(-a_2\right)\cdot c_2\right]+z_{A2}\left[\left(-a_2\right)\cdot 0-\left(-b_2\right)\left(-a_2\right)\right]=0.$$

After substitution (7) in (8) and the corresponding transformations, we find the equation of the working planes of the ploughshare. They are as follows:

$$A_1B_1C_1:\qquad x_{A1}\tan\gamma+y_{A1}+z_{A1}\tan\beta+\frac{C_1C_2}{2}=0, \quad (9)$$

$$A_2B_2C_2:\qquad x_{A2}\tan\gamma-y_{A2}+z_{A2}\tan\beta-\frac{C_1C_2}{2}=0. \quad (10)$$

It is known that for vectors normal to the planes expressed by equations (9) and (10), the guide cosines will have the following values:

$$\cos\left(x,\hat{\bar{N}}_i\right)=\frac{\tan\gamma}{\sqrt{\tan^2\gamma+1+\tan^2\beta}},$$
$$\cos\left(y,\hat{\bar{N}}_i\right)=\frac{1}{\sqrt{\tan^2\gamma+1+\tan^2\beta}}, \quad (11)$$
$$\cos\left(z,\hat{\bar{N}}_i\right)=\frac{\tan\beta}{\sqrt{\tan^2\gamma+1+\tan^2\beta}}.$$

Now, if we substitute (11) in (3) and (4), we obtain the values of the projections of the normal components of the forces $\bar{N}_i$ (i = 1, 2) of the surfaces of the wedges on the corresponding coordinate axes. For the plane $A_1B_1C_1$:

$$N_{x1}=\frac{N_1\ \tan\gamma}{\sqrt{\tan^2\gamma+1+\tan^2\beta}};\ N_{y1}=\frac{N_1}{\sqrt{\tan^2\gamma+1+\tan^2\beta}};$$
$$N_{z1}=\frac{N_1\ \tan\beta}{\sqrt{\tan^2\gamma+1+\tan^2\beta}}; \quad (12)$$

for the plane $A_2B_2C_2$:

$$N_{x2}=\frac{N_2\ \tan\gamma}{\sqrt{\tan^2\gamma+1+\tan^2\beta}};\ N_{y2}=-\frac{N_2}{\sqrt{\tan^2\gamma+1+\tan^2\beta}};$$
$$N_{z2}=\frac{N_2\ \tan\beta}{\sqrt{\tan^2\gamma+1+\tan^2\beta}}. \quad (13)$$

Since the found values of projections of the normal components of the working surfaces of the wedges, that is, the ability to determine other forces transmitted from them to the ground layer and directly to the root.

Thus, the values of normal soil reactions, which act on the ploughshares of the digging working body, have been determined. When providing vibrations in the longitudinal-vertical plane, the bodies of sugar beet roots may dig out of the soil.

4. Conclusions

The basic principles of the theory of interaction of the vibrating digging working body with the body of the root crop fixed in the soil at vibrating digging of sugar beets are developed.

The values of normal soil reactions acting on the ploughshare of the excavating working body are determined, which, when vibrating in the longitudinal-vertical plane, can dig out the bodies of sugar beet roots from the soil.

5. References

1. Vasylenko P.M., Vasylenko V.P. Metodyka postroenyya raschetnykh modelej funkcyonyrovanyya mekhanycheskykh system (mashyn y mashynnyh agregatov). Uchebnoe posobye. – Kyev: USKhA, 1980. – 137 s.
2. Vasylenko P.M. Vvedenye v zemledelcheskuyu mekhanyku. – Kyev: Silgosposvita, 1996. – 252 s.
3. Vasylenko P.M., Pogorelyj L.V., Brej V.V. Vybracyonnyj sposob uborky korneplodov. Zhurnal: Mekhanyzacyya y elektryfykacyya socyalystycheskogo selskogo khozyajstva, Moskva, 1970, №2. – S.9 – 13.
4. Sveklouborochnye mashyny (konstruyro-vanye y raschet) // L.V. Pogorelyj, N.V. Tatyanko, V.V. Brej y dr.; pod obshh. red. L.V. Pogorelogo. – Kyev: Tehnyka, 1983. – 168 s.
5. Bulgakov V.M., Golovach I.V. Teoriya vibracijnogo vykopuvannya koreneplodiv. – Zbirnyk naukovykh pracz Nacionalnogo agrarnogo universytetu «Mekhanizaciya silskogospodarskogo vyrobnycztva», 2003, Tom XIV. – S. 34-86.
6. Babakov Y.M. Teoryya kolebanyj. – M.: Nauka, 1968. – 560 s.
7. Bulgakov V.M., Golovach I.V. Teoriya poperechnykh kolyvan koreneplodu pry vibracijnomu vykopuvanni. – Praci Tavrijskoyi derzhavnoyi agrotekhnichnoyi akademiyi. Vypusk 18. Melitopol, 2004. – S. 8-24.
8. Bulgakov V.M., Golovach I.V. Pro vymusheni poperechni kolyvannya tila koreneplodu pry vibracijnomu vykopuvanni. – Visnyk Kharkivskogo nacionalnogo tekhnichnogo universytetu silskogo gospodarstva imeni Petra Vasylenka: Zbirnyk naukovykh pracz. Vypusk 39. Kharkiv: KhNTUSG, 2005. – S. 23-39.
9. V. Bulgakov, I. Golovach. Rozrobka matematychnoyi modeli vyluchennya koreneplodu z gruntu // Tekhnika APK, 2006, № 6, 7, 8. – S. 36-38;
10. Bulgakov V.M., Golovach I.V. Teoretychne doslidzhennya povzdovzhnikh kolyvan koreneplodu u grunti yak u pruzhnomu seredovyshhi pry vibracijnomu vykopuvanni. – Visnyk Kharkivskogo nacionalnogo tekhnichnogo universytetu silskogo gospodarstva imeni Petra Vasy`lenka: Zbirnyk naukovyh pracz. Vypusk 44, tom 2. Kharkiv: KhNTUSG, 2006. – S. 131-155.
11. Golovach I.V. Teoriya bezposerednogo vyluchennya koreneplodu z gruntu pry vibracijnomu vykopuvanni. – Visnyk Kharkivskogo nacionalnogo tekhnichnogo universytetu silskogo gospodarstva imeni Petra Vasylenka: Zbirnyk naukovykh pracz. Vypusk 44, tom 2. Kharkiv: KhNTUSG, 2006. – S. 77-100.
12. Butenyn N.V., Luncz Ya.L., Merkyn D.R. Kurs teoretycheskoj mekhanyky. T.II. Dynamyka. – M.: Nauka, 1985. – 496 s.
13. Bulgakov V.M., Golovach I.V. Utochnena teoriya vykopuyuchogo robochogo organu lemishnogo typu // Visnyk agrarnoyi nauky Prychornomorya. Specialnyj vypusk 4(18). Tom I. – Mykolayiv: MDAU, 2002. – S. 37-63.
14. Pogorelyj L.V., Tatyanko N.V. Sveklouborochnye mashyny: ystoryya, konstrukcyya, teoryya, prognoz. – Kyev: Fenyks, 2004. – 232 s. 15. Bulgakov V.M. Sveklouborochnye mashynu. Monografyya. – Kyev: Agrarnaya nauka, 2011. – 351 s.
16. Bulgakov V.M. Teoryya sveklouborochnykh mashyh. Monografyya. – Kyev: Izdatelskyj centr Nacyonalnogo agrarnogo unyversyteta, 2005. – 245 s.
17. Zuckerrüben: Erntetechnik und Bodenschutz / FAT-Berichte Nr. 567 // Eidgenssische Forschungsanstalt für Agrarwirtschaft und Landtechnik (FAT), CH-8356 Tänikon TG – 2001. S. 1 – 19.
18. Roller O. Entblatten statt Köpfen / Dr. Olaf Roller // Zuckerrüben Journal № 2 // Rheinischer Landwirtschafts-Verlag GmbH. – 2010, S. 14 – 15.
19. Merkes R. 50 Jahre Prodaktionstechnik im Zuckerrübenbau in Deutchland / R. Merkes // Zuckerrübe. – 2001, № 4. – S. 214 – 217.

Theoretical and methodological features of soil water regime optimization in pedagogical technologies of agroengineers training for innovative project activity

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Summary. *Innovative scientific-technical and pedagogical bases of studying in higher education institutions by future specialists in agroengineering of the theory and calculation fundamental questions of sprinkler nozzles and devices of machines for irrigation of agricultural crops are presented. Some constructive schemes of nozzles, namely, deflector, crack, etc. are analyzed. Graphs for determining the range of the jet and determining the rational shape of the nozzle are given. It is proved that all this can be effectively applied both in the educational process during the study of agricultural machinery and equipment by students and in research and production practice. Depending on the purpose, tasks, methods of technological processes of irrigation disintegration of a water jet on drops is analyzed. An algorithm for calculating the working bodies of sprinklers is presented, it can be used by agricultural engineers during their design activities. It is established that it is effective when students first study and analyze the state of agricultural production, for example, during internships, identify shortcomings of technological processes, opportunities for improvement, level of technical support, and then, using theoretical knowledge, mastered methods of engineering calculations, design and construct working bodies of sprinklers. Formulas for determining the radius of the irrigation sector, the maximum angle of the rocker arm at which the nozzle is attached, the total travel time of the rocker arm in both directions, the speed of the liquid in the jet and more are given. The methodological features of functioning of various designs of nozzles of sprinklers are theoretically described. The results of scientific research presented in the article can be used as didactic material in lectures, during laboratory-practical classes, independent work of students, as well as graduate students and scientists at the stage of design and construction of reclamation machines. The main theoretical provisions are recommended to be included in the list of test tasks for assessing the readiness of agricultural engineering for innovative project activities. It is noted that the study of the basics of designing the working bodies of irrigation machines is one of the factors of a holistic conceptual system of protection of soils and water resources. Emphasis is placed on the fact that soil and water resources are important objects and prerequisites for the development of reclamation machines and the formation of special design competencies of agricultural engineers.*

KEYWORDS: *AGROENGINEERING, TECHNOLOGICAL PROCESS, TECHNOLOGY TRAINING, METHODOLOGY, SOIL, WATER RESOURCES, DESIGN, AGRICULTURAL MACHINERY, SOIL PROTECTION.*

1. Introduction

In almost all countries of the world work is being carried out on the development of land reclamation − part of methods aimed at optimizing agricultural production and the general rise in soil productivity. Under hydraulic reclamation is understood a system of measures that regulate the water regime of the territory. Irrigation, drainage, flooding, delay of surface runoff and control of soil erosion belong to hydraulic reclamation and are carried out with the help of hydraulic structures.

The change of water regime should be carried out both at excess, and at insufficient moistening of the soil as for normal development of plants the soil should be moderately moistened [1].

One of the reasons for the insufficient development of technical means of reclamation in Ukraine, including irrigation machines, is the lack of highly qualified agro-engineering personnel [2], able to design machines with optimal parameters and use them efficiently. In this regard, it is advisable to conduct special technical and pedagogical research aimed at developing modern machines for irrigation, improving the methodological support of the educational process, improving its quality, development of professional competencies [3] of agricultural engineers.

The developed pedagogical technology should provide continuity of educational process in designing and designing of cars, studying of soil and water resources, their protection and preservation [4, 5].

2. Prerequisites and means for solving the problem

Curricula for future agricultural engineers provide the study of problematic issues of land reclamation, soil protection and water resources. As it is noted in [2, 5] throughout the period of study during lectures, laboratory-practical classes, practitioners, students study these issues relevant to modern agricultural production systematically and consistently.

During the design of reclamation and tillage machines, agrochemical, mechanical-technological and other characteristics of soil and water resources are taken as initial data. For example, the agrochemical properties of soils that students study, use in their project activities include - the content of humus, nitrogen, phosphorus, potassium, soil acidity; and to the physical and mechanical properties - the specific gravity of the soil, the angles of internal and external friction, particle size, ultimate bearing capacity, modulus of elasticity, humidity, etc. [6].

During the lectures future agricultural engineers receive general theoretical knowledge, get acquainted with the algorithms for calculating machines. Laboratory-practical classes expand and deepen their knowledge of the basics of the theory, calculation and design of reclamation machines, irrigation systems, land protection and protection of soil and water resources, etc. Students develop the ability to innovative project activities especially deeply during the course and master's theses [2, 7].

At the initial stage of training, future agricultural engineers study the general concepts of erosion processes [2, 7].

Many scientific conferences have addressed the issue of soil and water protection. For example, at the II International Scientific Conference "Protection of Soils and Water Resources", the report was presented − «The main components of studies and research of conserving soils and water in technologies of agroengineers training" [4]. 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 based on the method of a consistent cross study of the material based on the objective relationship of disciplines and provides a qualitatively higher level of professional competencies formation of agroengineers on the basis of preservation and even multiplication of natural resources. The report of [4] states that the current issues of soil science are devoted to many works by well-known scholars, for example, P. Zaicka [8], M. Manojlovič [9], R. Meissner [10] and others.

At the IV International Scientific Conference "Soil and Water Resources Protection 2019" candidate of Technical Sciences, Associate Professor Viktor Pryshliak, Dr. in Agriculture, Prof., Corresponding Member of the National Academy of Agrarian Sciences of Ukraine Basil Kurylo a report was made on the topic: «Soil and water resources as important objects and prerequisites for the design of agricultural machines and the formation of professional competencies of an agricultural engineer». The report notes that in pedagogical technologies for the formation of professional competencies of future agricultural engineers in agricultural institutions of higher education, much attention is paid

to the problematic issues of soil and water resources. Some concepts and categories used in the educational process during the study of agricultural machinery and equipment by students are analyzed. Depending on the purpose, tasks, receptions of technological processes types of reclamation actions are pointed out, the example of calculation of working bodies of cars is resulted. In general, an innovative pedagogical technology of cross training has been developed, aimed at the formation of professional competencies of future agricultural engineers. It is noted that their activity will be successful provided the efficient use of soil and water resources as important objects and prerequisites for the development of machines.

An important research and production problem is the optimization of nutrient and water regimes of the soil on the slopes. There are different scientific works devoted to the peculiarities of soil preparation for sowing crops on sloping lands, optimization and management of technological processes in these conditions [1, 7, 8, 12, 13].

Bendera I. [14], Duganets V. [15], Man`ko V. [16] and others made a significant contribution to the development of the theory and methods of professional education of future agricultural engineers, improving the quality of formation of their special competencies.

Analysis of agricultural land reclamation measures, features of the educational process in agricultural institutions of higher education showed that the theory and calculation of sprinklers for irrigation machines in the technology of agricultural engineers training for innovative project activities require further scientific development.

3. Results and discussion

Creating an optimal water regime for seed germination, growth and plant development is a very important factor that affects crop yields, quality of products grown. During their training, students study the optimal water regimes for different crops, irrigation technologies and design features of sprinklers. Scientific and pedagogical research has shown that future agricultural engineers have difficulties in calculating the working bodies of sprinklers and it should be noted that the search for optimal design parameters is important for agricultural machinery, and optimal operating modes for agricultural machinery.

High quality of the educational process is achieved when students conduct engineering and technological calculations, participate in laboratory and field research. We will give an example of the theory and calculation of nozzles and devices of sprinklers and installations which is used in scientific and technical activity and pedagogical technologies of preparation of agroengineers for innovative design activity.

Fig. 1 presents a diagram of a reflex nozzle used in sprinklers and installations.

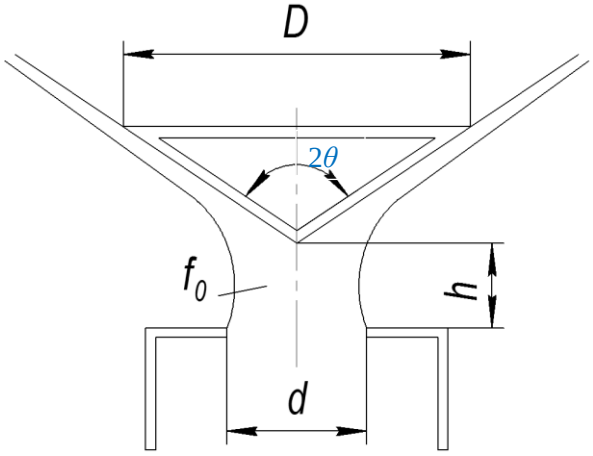


Fig. 1. *The scheme of the deflector nozzle [1]*

Usually take the following ratios: $h = d$; $D = 2d$; $2\theta = 120^0$ (Fig. 1).

Irrigation radius R can be determined by the following formula [Mac488]:

$$R = \frac{H}{0{,}43 + 0{,}0014\frac{H}{d}}, \quad (1)$$

where H − pressure in front of the nozzle hole.

One of the important advantages of slotted nozzles (Fig. 2) is their simplicity.

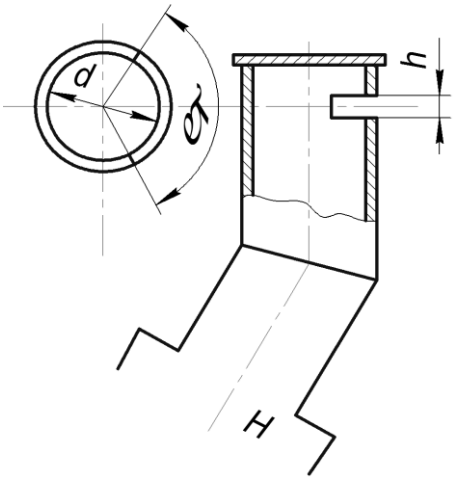


Fig. 2. *Scheme of a slot nozzle.*

Such a nozzle can be obtained by sawing on any pipe. The angle of the spray nozzle φ_p is determined from the following relation: $\varphi_p = (0{,}7 \div 0{,}9)\varphi$.

Smaller values of the numerical coefficient correspond to smaller values of the angle φ.

The radius of the irrigated sector is determined by the formula:

$$R = \frac{H}{1{,}15 + 0{,}0003\frac{H}{h}}. \quad (2)$$

The recommended ratio of the length of the slit to its width is 1:5, 1:10. The irrigated area has the shape of a sector with an angle φ_p. Approximately at a distance of $1/5R$ from the nozzle irrigation does not occur.

Medium-jet sprinklers are used on most modern sprinklers and installations. Their designs are mostly of the same type, although they have some significant differences.

The principle of operation is approximately as follows. The jet flowing from the barrel meets on the way a rotary deflector and a reflective blade. The front end of the rocker arm is pushed to the side, and the rocker arm is turned. When leaving the jet, the deflector rotates relative to the rocker arm. The rocker arm, twisting the spring, rotates at an angle of about 90°, then under the action of the spring returns to the previous position.

After reaching the initial position, the rocker strikes the tide on the barrel with its tide and turns it at an angle of 2–5° in the course of movement. The jet at this point hits the back of the deflector and returns it to its original position. Then the front end of the rocker is pushed out of the jet again and the process is repeated.

The barrel performs a continuous rotation. The jet irrigates the circular area. The design can work without a reflecting blade. In this case, more precise adjustment of the position of the deflector relative to the jet is required [1].

With the conditional replacement of the action of the jet on the curved rotary deflector and the blade by the action of only one blade located on the middle radius, in accordance with Figs. 3, a) and b) the value of the angular velocity of the rocker arm after the deflector exits the jet will be

$$\omega = 2\sqrt{\frac{pfr\varphi \sin\alpha}{J_к}}, \quad (3)$$

where J_k − the moment of inertia of the rocker arm;

φ − the angle of rotation of the rocker arm at which the jet acts on the deflector, $\varphi = (2\div3)\varphi_m$;

p − the pressure in front of the nozzle.

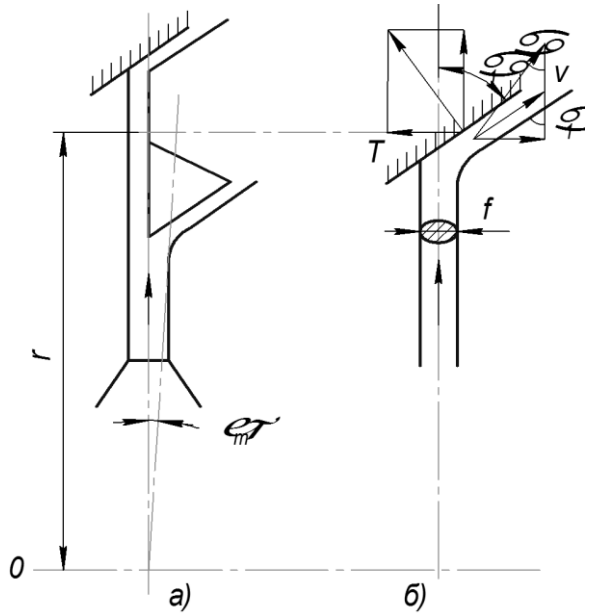


Fig. 3. Scheme of the deflector of the medium-jet sprinkler [1].

Due to the fact that the flow is not completely deflected by the deflector

$$\alpha = (0{,}7 \div 0{,}8)\alpha_1. \quad (4)$$

The maximum angle of rotation of the rocker arm

$$\varphi_{\max} = \frac{2pfr\sin\alpha}{M_n}, \quad (5)$$

where M_n − the average value of the moment created by the spring during the rotation of the rocker arm.

The angle of rotation of the device in one stroke of the rocker arm

$$\psi_a = \frac{8pfr\varphi\sin\alpha}{M_T}\left[\frac{me^2}{J_к} + \cos^2\theta\right]\cos^2\theta, \quad (6)$$

where M_T − the moment of friction that slows down the rotation of the apparatus and is equal to the sum of the moments of friction in the bearing and the rubber cup [1].

Full moving time of the rocker arm in both directions

$$t = 4\frac{\sqrt{J_к pfr\varphi\sin\alpha}}{M_n}. \quad (7)$$

Long-jet sprinklers are used in cases where it is possible and appropriate to create a pressure in the pipes 4 … 6 at.

Common are devices with gear or tine mechanisms of rotation, which are driven by a small turbine, which rotates under the action of the main jet energy, which is formed by the device with a turbine drive.

Mechanisms are often introduced into the structure to provide the apparatus of reverse rotation within the sector of the circle for irrigation in the sector in a given direction. The angle of the sector is usually adjustable.

The jet of water flowing from the nozzle rotates the turbine. On the axis of the turbine there is a gear that rotates the worm gear. The gear through the shaft transmits rotation to the worm gear connected with the worm gear. There is an eccentric pin on the axis of the gear, which makes the frame swing. The ratchet mechanism consisting of two hinged rods, a spring and a pawl is established on a frame. Under the action of a compressed spring, the pawl is pushed away from the stationary gear on one side, due to which a slow intermittent rotation of the sprinkler around the vertical axis is carried out. The fixed gear has a series of protruding fingers. At an emphasis of a shank of a pawl in one of them its position changes, its other party starts to work and the direction of rotation of the device changes.

Thus it is possible to carry out watering on sector.

The number of revolutions of the turbine per minute is determined by the formula:

$$n_T = \frac{60u}{\pi D}, \quad (8)$$

where u − circular velocity of the ends of the blades in m/s;

D − the diameter of the turbine at the ends of the small blades, m.

The circular speed of the ends of the blades can be determined by the formula

$$u = k_0 v, \quad (9)$$

where k_0 is the coefficient of circular velocity, $k_0 = 0.7\ldots 0.8$;

v − the velocity of the liquid in the jet, m/s.

The velocity of the liquid in the jet is determined by the formula

$$v = \varphi\sqrt{2gH}, \quad (10)$$

where φ − the speed factor, $\varphi = 0{,}97$;

g − acceleration of free fall, $g = 9{,}8$ m/s^2;

H − pressure in front of the nozzle, m of water column.

The number of revolutions of the long-jet sprinkler is equal to:

$$n_a = \frac{n_T}{i}, \quad (11)$$

where i − the total gear ratio between the turbine and the body of the apparatus [1].

In other designs of long-jet sprinklers, in which the driving force that rotates the barrel is the reaction of the jet, the vacuum created by the jet, a special turbine operating from a single jet or a rocker arm that oscillates, as in medium-jet devices.

One device usually forms one or two jets.

The range of the jet for medium- and long-jet nozzles can be determined by one of the following empirical formulas:

$$R = 0{,}42H + 1000d \quad (12)$$

or

$$R = \frac{H}{0{,}5 + 0{,}25\frac{H}{d}}. \quad (13)$$

The formulas are valid for the angle of inclination of the jet to the horizon of 30°, i.e. for the angle corresponding to the greatest range, and the ratio

$$\frac{H}{d} \geq 800, \quad (14)$$

where H − the pressure in front of the nozzle, meter of water column;

d − the diameter of the jet, m.

The range of the jet can also be determined using the experimental graph shown in Fig. 4. For different diameters of jets, a series of curves is constructed that determine the relationship between H and R.

The spray of the jet into droplets is determined by the ratio H/d (Table 1).

Table 1: *Disintegration of the jet into drops [1]*

H/d	Jet characteristics
up to 900	Solid, which does not fall apart into drops
900−1500	Weak decomposition into drops, not suitable for irrigation
1500−1600	Disintegration into drops of medium size, which are suitable for irrigating grasses in meadows and pastures
1700−1800	Disintegration into droplets of medium size, suitable for irrigation of closed farms. cultures
2000−2200	Disintegration into small drops, suitable for irrigation of all crops
2500−2600	Disintegration into very small drops, suitable for irrigating seedlings of the most delicate plants and flowers

The range of the jet, defined on the graph (Fig. 4), can be obtained only with a properly designed barrel and non-rotating sprinkler.

The range of the jet during the rotation of the apparatus around the vertical axis with a speed of 0,3 … 1 per minute is reduced by 10 … 15% compared to the range of the jet without rotation of the apparatus.

The rational shape of the trunk is shown in Fig. 5. The larger angle of inclination to the horizon is selected at a pressure of 1,5 … 3 at, a smaller − at a pressure of more than 6 … 8 at. Essential for the formation of the initial section of the jet is a sedative 1, which consists of a series of partitions parallel to the axis of the barrel, dividing its living section into a number of narrow channels.

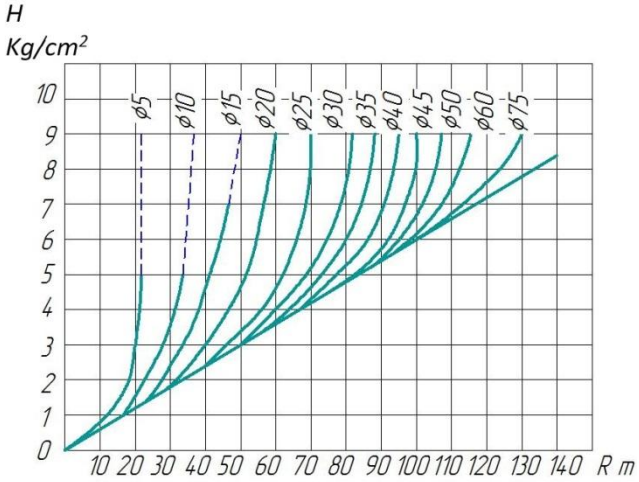


Fig. 4. *Schedule to determine the range of the jet [1].*

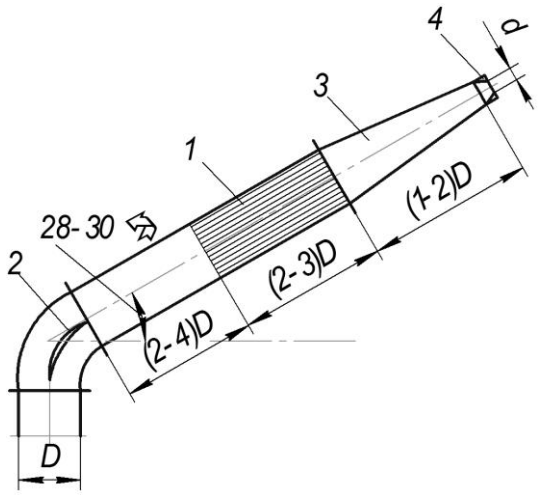


Fig. 5*. The scheme of a long-jet trunk:*
1 – quietering; 2 − edge; 3 − cone; 4 − nozzle.

The length of the cells of the quietering should be 12 … 15 times their width. The diameters of the barrel and the quietering should be 3 … 4 times the diameter of the nozzle.

In the crank it is necessary to install the edges 2, which prevent the occurrence of transverse circulation of velocity in the flow.

In medium-jet and some long-jet barrels, the cone 3 is not placed, and the nozzle 4 is located directly behind the output end of the sedative. The rational shape of the nozzle is shown in Fig. 6, a.

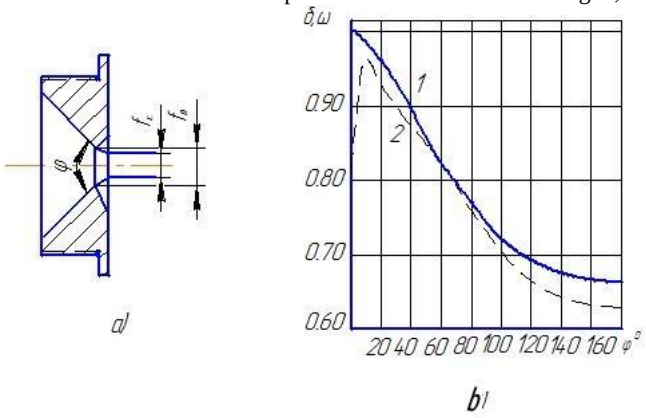


Fig. 6. *Rational shape of the nozzle.*

Water consumption through such a nozzle is determined by the formula

$$Q = \delta f_0 \sqrt{2gH}, \quad (15)$$

where δ − the flow rate, which is determined depending on the angle of conicity of the nozzle φ along curve 2 (Fig. 6, *b*).

Curve 1 gives the value of the compression ratio ε of the jet:

$$\omega = \frac{f_c}{f_0}. \quad (16)$$

This factor determines the diameter of the nozzle required to create the desired jet.

Here is an example of laboratory work to determine the moisture content of soils and other agricultural materials [17, 19].

The purpose of this laboratory work is to consolidate and expand knowledge to determine soil moisture, conducting experimental research in the laboratory or field, processing the data and analyzing the results [18, 19].

The theoretical part of the laboratory-practical work analyzes the concept of humidity and the need to determine it at different stages of seed germination and growth and development of plants. That is, humidity is determined in order to:

- operating conditions of agricultural machinery;
- to control the technological process performed by the machine (soil moisture in layers before and after the passage of the working body of the machine, the dynamics of humidity change, etc.);
- to characterize the conditions of development of agricultural plants.

Soil moisture can be determined directly or indirectly.

Direct measurements of soil moisture and some agricultural materials are carried out using special electrical devices. This method is convenient because it does not take much time.

However, errors can often occur depending on the internal structure of the material and its condition, so such measurements should be made only when high accuracy is not required.

The most common way to determine the moisture content of agricultural materials is to dry the samples in electric ovens at a temperature of 100−105° C. Depending on the condition of the material and its physical and mechanical properties, the sampling method, sample size and sample should be different.

The most common way to determine the moisture content of agricultural materials is to dry the samples in electric ovens at a temperature of 100−105° C. Depending on the condition of the

material and its physical and mechanical properties, the sampling method, sample size and sample should be different.

The accuracy of determining the moisture content of the material mainly depends on the quality of weighing and drying.

Students during laboratory and practical work determine the absolute humidity of the material (%) as the ratio of the mass of water to the mass of dry material.

Drying cabinet DC-150 designed for drying various agricultural materials in the laboratory. The winding of the slider rheostat is connected in series to the heating element of the drying cabinet, which is placed inside the stand and allows to change the temperature of the cabinet in the range of 85-150° C [17].

The temperature is regulated by moving the handle of the rheostat slider, the extreme positions of which are marked with the inscriptions "Input" and "Output" on the right wall of the stand.

After loading the cabinet, the thermometer is installed in the upper hole of the ventilation cap so that its lower end does not touch the samples placed on the upper board. During heating, the temperature is controlled. If it is necessary to reduce the temperature, change the resistance of the rheostat by moving the slider from right to left.

After getting acquainted with the order of work, students perform it, draw up a report and protect [17, 18].

After studying the mechanical and technological properties of soil and other agricultural materials, students conduct engineering, technological and energy calculations of machinery and equipment for agricultural reclamation. As an example, we will partially consider the laboratory-practical work "Development of complete and incomplete schedules of water supply for crop rotation", which is performed by students of the speciality 208 "Agroengineering", while studying machinery and equipment in agricultural reclamation [1].

Purpose: To study the features and master the method of calculating the internal economic network and the method of drawing up incomplete and complete schedules of water supply in irrigation processes.

First, students learn the basic theoretical principles and definitions, as well as general information about irrigation systems.

Thus, the operation of irrigation systems − a set of organizational and technical measures necessary to maintain all structures of the system in working order and ensure the most efficient use of irrigation water.

On the main and distribution channels, up to watering the farm lands, operation is carried out by management of irrigation system and operational sites.

Distribution of water on farm lands between general and separate irrigation plots, as well as irrigation of crops is carried out through the in-farm irrigation network.

After the completion of the construction of the irrigation system, the internal network of irrigation canals and structures is transferred by act to the water user (farm) and comes entirely under his control.

The water user is responsible for the proper condition of the domestic irrigation network, the rational use of irrigation water, as well as for the effective development of irrigated lands.

The operation of the on-farm irrigation network carried out by the farm consists of the following technological processes:

1) performance of irrigation of agricultural crops according to the plan of water use, in proper agrotechnical terms and according to the necessary norms providing cultivation of high and steady crops;

2) maintenance of domestic irrigation and drainage canals and structures on them in proper condition;

3) prevention of water losses from canals and structures;

4) drainage of excess water into the drainage network to prevent waterlogging and salinization of lands;

5) planting different trees by the canals and organization of plant care.

In these works related to the operation of the on-farm irrigation network, farm workers - irrigators, must take an active part. They must not only irrigate crops, but also repair and prepare irrigation networks and structures for irrigation, mow and spray canal slopes with herbicides; make sure that the canals and structures are in good condition; participate in the preparation of internal water use plans.

Irrigation on farms should be carried out on the basis of a water use plan. The on-farm water use plan of the farm is drawn up simultaneously with the production plan [1].

The knowledge that students aquire in lectures and laboratory-practical classes are used during course and diploma design, research work [20]. Topical issues of soil and water protection must be highlighted here.

4. *Conclusion*

The article presents the results of research of innovative scientific, technical and pedagogical bases of study by future specialists in agroengineering of fundamental questions of the theory and calculation of sprinklers and devices of machines for irrigation of crops. In these innovative pedagogical technologies for the formation of professional competencies of future agricultural engineers, much attention is paid to the problematic issues of optimizing the water regime of seed germination, plant growth and development, protection of soils and water resources. An algorithm for calculating the working bodies of sprinklers is presented, it can be used by agricultural engineers during their design activities. The obtained results of scientific research can be used as didactic material in lectures, during laboratory-practical classes, independent work of students, as well as graduate students and scientists at the stage of design and construction of reclamation machines.

5. *References*

1. Machinery and equipment in agricultural land reclamation: Textbook / H.M. Kaletnik, M.G. Chausov, M.M. Bondar, V.M. Pryshliak and others. – K.: Hi-Tech Press, 2011. – 488 p.

2. Pryshliak Viktor. Soil and water resources as important objects and prerequisites for the design of agricultural machines and the formation of professional competencies of an agricultural engineer / Viktor Pryshliak, Vasyl Kurylo // Mechanization in agriculture & conserving of the resources: International scientific journal. – Sofia, Bulgaria: Scientific-technical union of mechanical engineering “Industry-4,0” Bulgarian association of mechanization in agriculture, Year LXV, Issue 4 / 2019. – 120-125.

3. Higher education standard of Ukraine of the first (bachelor) level of higher education degree − "bachelor", branch of knowledge − 20 "Agrarian sciences and food of specialty" − 208 "Agrarian engineering" // Approved and put into effect by the order of the Ministry of Education and Science of Ukraine from 05.12.2018, № 1340. − Access mode: https://mon.gov.ua/storage/app/media/vishcha-osvita/zatverdzeni%20standarty/12/21/208-agroinzheneriya-bakalavr.

4. Pryshliak Viktor. The main components of studies and research of conserving soils and water in technologies of agroengineers / Viktor Pryshliak // Scientific technical union of mechanical engineering INDUSTRY-4.0. – Sofia, Bulgaria: Bulgarian association of mechanization in agriculture, YEAR LXIII, ISSUE 5/2017. – 207-210, ISSN PRINT 0861-9638, ISSN WEB 2534-8450.

5. Pryshliak Viktor. 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 / Viktor Pryshliak // Mechanization in agriculture: International scientific journal. – Sofia, Bulgaria: Scientific-technical union of mechanical engineering “Industry-4,0” Bulgarian association of agriculture machinery, Year LXIV, Issue 4 / 2018. – 141-145, ISSN (PRINT) 0861-9638, ISSN (WEB) 2534-8450.

6. Panchenko A.N. Theory and calculation of agricultural machines: Laboratory workshop / A.N. Panchenko. – Dnepropetrovsk: Dnepropetr. state agr. univ., 2002. – 396 p.

7. Designing of agricultural machines. Tutorial / I.M. Bendera, A.V. Rud, Ya.V. Koziy et al.; edited by. I.M. Bendery,

A.V. Rudya, Ya.V. Koziy. – Kamianets-Podilskyi: FOP Sisin OV, 2010. – 640 p.

8. Zaika P.M. The theory of agricultural machines. T. I (Ch. 1). Machines and tools for soil cultivation. – Kharkiv: Eye, 2001. – 444.

9. Manojlovič M., Bogdanovič D., Čabilovski R, Marijanušić K. The status of thace elements in soils on organic and conventional farm in Serbia // MECHANIZATION IN AGRICULTURE: International scientific journal. – Sofia, Bulgaria: Scientific technical union of mechanical engineering Bulgarian association of mechanization in agriculture, YEAR LXII, Issue 4/2016. – 12-14, ISSN web 2534-8450.

10. Meissner Ralph, Rupp Holger, Seyfarth Manfred, Gebel Michael. Use of sophisticated lysimeter types to measure soil water balance parameters with high accuracy // MECHANIZATION IN AGRICULTURE: International scientific journal. – Sofia, Bulgaria: Scientific technical union of mechanical engineering Bulgarian association of mechanization in agriculture, YEAR LXII, Issue 4/2016. – 15-18, ISSN web 2534-8450.

11. Agriculture: textbook / M.S. Kravchenko, Yu.A. Zlobin, O.M. Tserenko; edited by M.S. Kravchenko. – K.: Libid, 2002. – 496 p.

12. Bondar S.M., Pryshliak V.M., Shymko L.S. Management of complex machines in manufacturing processes cultivation: monograph. – Nizhyn LLC "Publishing" Aspect-Polygraph", 2015. – 524.

13. Pryshliak Viktor. Study of physical and technological processes of planting crops on slopes of priority agricultural crops in bioethanol industry / MOTROL: Motoryzacja i energetyka rolnictwa, An international journal on operation of farm and agri-food industry machinery. – Lublin–Rzesów: Mot. and Energ. Rol., Commission of Motorization and Energetic in Agriculture, 2013. – Vol. 15, No 5, 181-187.

14. Bendera I.M. Theory and methodology of organization of independent work of future specialists in mechanization of agriculture in higher educational institutions: diss. ... doct. ped. sciences: 13.00.04 / Bendera Ivan Mykolayovych. – K., 2008. – 579 p.

15. Duganets V.I. Theory and practice of production training of future specialists in agrarian-engineering direction: diss. ... doct. ped. sciences: 13.00.04 / Duganets Viktor Ivanovych. – Kamenets-Podilsky, 2015. – 501 p.

16. Man`ko V.M. Theoretical and methodological foundations of step-by-step training of future engineers-mechanics of agricultural production: Author's abstract dis. doct. ped. sciences: 13.00.04. – Ternopil., 2005. – 40 p.

17. [Voit] Voityuk D.H. Agricultural Machine Theory: Workshop [Text]: Textbook / D.H. Vojtyuk, S.S. Yatsun, M.Ya. Dovzhik; edited by S.S. Yatsun. – Sumy: University Book, 2008. – 200 p.

18. Sereda L.P. Laboratory Workshop on Theoretical Course of Agricultural Machines / L.P. Sereda, V.M. Pryshliak. – Vinnytsia: OC VSAU, 2007. – 72 p. [Mec93] Mechanical and technological properties of agricultural materials. Workshop: Textbook / D.H. Voituk, O.M. Tsarenko, S.S. Yatsun et al.; edited by S.S. Yatsun. − K .: Agrarian education, 2000. − 93 p.

19. Механіко-технологічні властивості сільськогосподарських матеріалів. Практикум: Навч. посібник / Д.Г. Войтюк, О.М. Царенко, С.С. Яцун та ін.; за редакцією С.С. Яцуна. – К.: Аграрна освіта, 2000. – 93 с. Mechanical and technological properties of agricultural materials. Workshop: Textbook / D.H. Voituk, O.M. Tsarenko, S.S. Yatsun et al.; edited by S.S. Yatsun. − K .: Agrarian education, 2000. − 93 p.

20. Pryshliak Viktor. Development of innovational technologies of agricultural machines projecting and their influence on the formation of professional competencies of agricultural engineer / Viktor Pryshliak // Mechanization in agriculture & conserving of the resources: International scientific journal. – Sofia, Bulgaria: Scientific-technical union of mechanical engineering "Industry-4,0" Bulgarian association of mechanization in agriculture, Year LXV, Issue 2 / 2019. – 66-69, ISSN (PRINT) 2603-3704, ISSN (WEB) 2603-3712.

Utilization of tractors and agricultural machinery

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Summary:*Regardless of the length of the period of use of the equipment, due to a change in technology, an increase in maintenance costs or the introduction of new requirements with a change in legislation, the machines become obsolete and are disposed of.*
The main methods for utilization of tractors and self-propelled agricultural machinery are considered. The equipment necessary for the disposal is also described. The methodology for determining the costs for utilization and the value of the equipment for utilization of the whole machine, element-by-element utilization and utilization after defecting has been supplemented.
KEY WORDS: *UTILIZATION, LIFE CYCLE, MACHINES, EQUIPMENT, DEFECTS, COSTS, CONTROL AND MEASUREMENT OPERATIONS, RECYCLING.*

Agricultural machinery, as well as all other machines from the beginning of their development to the end of their use go through a number of stages, united under the so-called life cycle. This term is used for complex, science-intensive production.

Life cycle according to ISO 9004-1 are a set of processes performed from the moment of occurrence of needs for a certain production, to the moment of satisfaction of these needs and utilization of the product / machine. Figure 1 shows the main stages of the life cycle of a technical product related to the manufacturer and its user.

The longest period of the life cycle of agricultural machinery is the period of operation. Given the specifics of agricultural activities, this period can be divided into two subperiods: use of machinery for its intended purpose and storage period.

The service / warranty and post-warranty / when using the agricultural machinery is extremely important for the users. In principle, the manufacturer chooses one of the following options from the following 1) to perform the service in its own bases and staff; 2) to delegate this activity to an official representative (dealer); 3) to provide the activity to a specialized service company. The advantage of using a service company is that it has qualified staff in the area and can provide a high level of service.

With the expiration of the warranty period of the machines, the service activity gradually passes to these companies. The reasons are mainly organizational or economic

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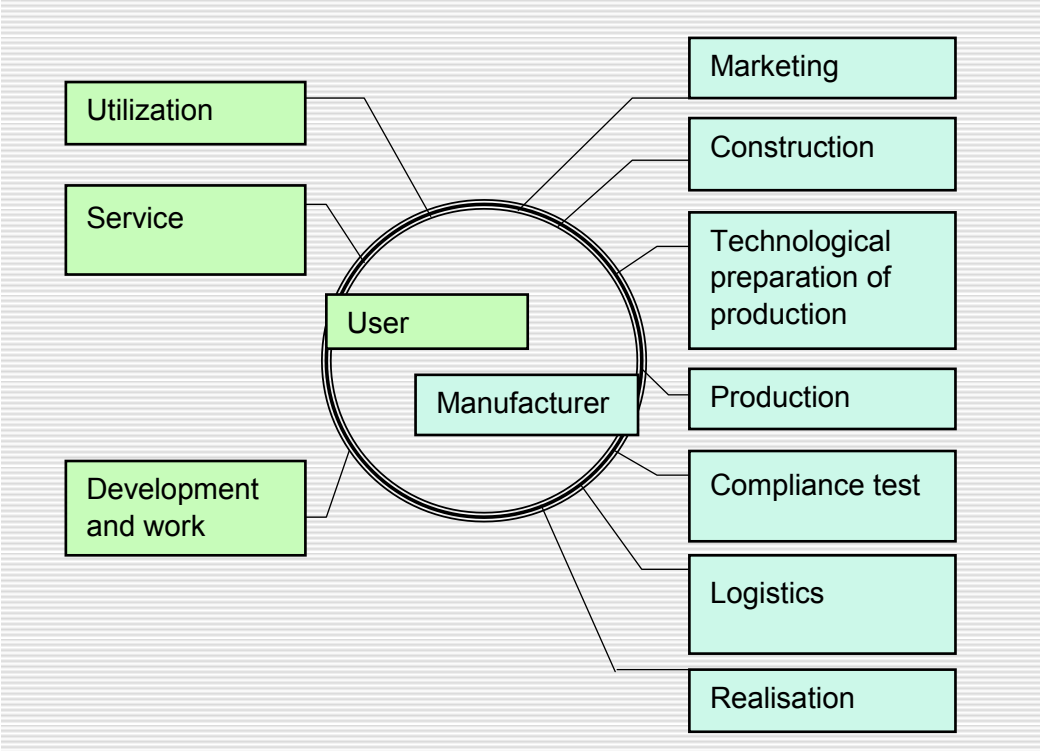


Figure.1 *Life cycle of tractors and self-propelled agricultural machinery*

In turn, the service activity also has a life cycle. It is characterized by lagging behind stages of the life cycle of machines. At the time when the machine is in the stage of maturity, the service cycle is at the beginning of the development stage. About 70% of their income from service work companies realize when the production and sales of machines are declining. For example, if the life cycle of a tractor is 8-12 years, then the service is more than 3 times longer. The income from service work for the life cycle of machines is 4-5 times higher than the prices of machines.

Regardless of the length of the period of use of the equipment, due to a change in technology, an increase in maintenance costs or the introduction of new requirements with a change in legislation, the machines become obsolete and are disposed of.

The separation of the utilization process as a separate stage is imposed by the requirements for environmental safety, namely: reduction of environmental pollution with various toxic substances, reduction of unregulated landfills, resource savings and production of low cost raw materials

Disposal is also important with a view to conserving and reusing resources. The amount of metal in tractors and self-propelled agricultural machinery is easy to process and should not be left to rust in landfills. The possible ways of utilization of the equipment are planned at the stage of production. In general, the life cycle of the machine is considered complete after complete and environmentally safe disposal.

To perform the works on utilization of the machines, a base [1,2] with universal, special and specialized equipment is required, including the following main groups of equipment for:
- draining of various working liquids / oils, brake fluid, freons, etc./, including pumps and devices to them;
- cutting of metals, electrocautery and welder;
- capacities for collecting different types of liquids;
-crushers for metals, necessary to obtain pieces of similar size, for more convenient transportation;
-control-measuring devices and devices;
- lifting and transport equipment.

Methods for utilization of tractors and self - propelled agricultural machinery

For the utilization of tractors and self-propelled agricultural machines, three main approaches or combinations of them are used:

1. Complete utilization

This method is used for rapid disposal or in the absence of equipment to perform it, but is the most irrational from an economic point of view. It is used in cases when the machine is physically or morally worn out and cannot be used (due to lack of residual resources or economic benefit).

The value of the machine in case of complete utilization is the price of the scrap, minus the deduction fees, costs for preparation / draining of various liquids, removal of batteries, electronic components, dismantling of elements impeding transport, etc./ and for transport.

$$C_Y^1 = G_M . C_{CK} - (C_{Tp} + C_Y + C_T),$$

where C_y^1 is the value of the machine at disposal, BGN

G_M - machine weight, tons;

C_{CK} - the price of the scrap, BGN / ton;

C_{Tp} - costs for dismantling of elements and transport, BGN

C_y - costs for collection and utilization of fuel and lubricants, BGN;

C_T - fees paid under the current legislation upon scrapping of the machine, BGN.

2.Element-by-element utilization

In this method of utilization, after collecting fuel and lubricants, tractors and self-propelled agricultural machinery are disassembled into units and assemblies. They are sorted according to the materials from which they are made. Such an approach is applicable to harvesting machines and devices for self-propelled agricultural machinery and stationary equipment for primary processing of products.

In this case, the value / revenue from disposal / can be determined as follows:

$$C_y^2 = \sum_{k=1}^{K} G_{ke} . C_{цм} + \sum_{l=1}^{L} G_{чм} . C_i - (C_p + C_y + C_T + C_{Tp} + C_{AM})$$

,

where C_y^2 is the value of the machine at disposal, BGN.

C_{ke} - the weight of the k-th element of non-ferrous metal, tons;

$C_{цм}$ - the price of non-ferrous metal scrap, BGN / ton;

$k = 1 - K$ - the number of non-ferrous metal elements;

$G_{чм}$ - - the weight of the l-th element of ferrous metals, tons;

$C_{чм}$ - - the price of ferrous scrap, BGN / ton;

$l = 1 - L$ - the number of ferrous metal elements;

C_p - costs for separation of ferrous and non-ferrous metals, BGN

C_{AM} are the depreciation deductions for the equipment used for utilization, BGN

3.Disposal after defect

The durability and reliability of each machine depends on a number of subjective and objective factors, such as: staff qualifications, work environment, the nature of the workload, the frequency of service and the quality of its performance, etc. When working, even the same elements of one machine fail through different designs. This applies in full force to self-propelled agricultural machinery and is sufficient reason to assume that taking into account the wear of individual elements with the valuation of their residual life is the correct way to determine the liquidation value of the machine. Figure 2 shows the residual life of the main elements of universal tractors with mechanical transmission after 10 years of use at an average annual load of 800 to 1000 hours [3,4].

In this case it is necessary to perform: disassembly of the machine elements, inspection and division of the elements into groups with and without residual resource, evaluation of the elements without residual resource for scrap and evaluation of the elements with residual resource as second-hand. The valuation of the residual resource requires the use of reliable statistical information about the average resource of the main elements of the machine, market prices of new and used spare parts, requirements and time for disassembly and assembly of elements, the need for specialized equipment for adjustments and adjustments, etc. n.

The analysis of the a priori information [3,4,5] and the performed researches [5] shows that the total labor intensity ($t_{кио}$) of the control and measuring works is a complex function of the type:

$$t_{кио} = f(t_{nuo}, t_{до}, t_{кuo}),$$

where t_{nuo} is the labor intensity of the cleaning and washing operations, hours;

$t_{до}$ - labor intensity of dismantling operations, hours;

$t_{кuo}$ - labor intensity of control and measurement operations, hours.

Taking into account the complexity and complexity of the control and measurement works [7], the total costs for their implementation can be presented as follows:

$$C_p = C_{nuo} + C_{до} + C_{кuo},$$

where C_{nuo} is the cost of cleaning and washing operations, BGN;

$C_{до}$ - the cost of dismantling operations, BGN;

$C_{кuo}$ - the prime cost of the control and measuring operations, BGN

- cost of cleaning and washing operations

These include the cleaning of dust and mud, external washing before the control-diagnostic examination, as well as cleaning and washing of individual elements in the process of the control itself.

The cost of cleaning and washing works is calculated by the formula:

$$C_{nuo} = \sum_j \{\sum_i C_i (t_{knd}^i + t_{el}^i)\} \quad \text{за}$$

$$\forall i = \overline{1, m}, \; j = \overline{1, n},$$

where t_{knd}^i, t_{el}^i, respectively, the average duration of the operations for cleaning and washing of the machine and the elements and before the control-measuring operations, hours;

Ci - the value of one hour of work in the i-th qualification category, BGN / h.

- cost of control and measurement operations

The cost of control and measurement operations is:

$$C_{кио} = \sum_{j} \left\{ \sum_{i} C_i t_b^i + t_{nb}^i) \right\}, \qquad \forall i = \overline{1}, \overline{m}, \quad j = \overline{1}, \overline{n}$$

where t_b^i is the average duration of the control-measurement operation when using built-in sensors;

t_{nb}^i - the average duration of the diagnostic operation when using external sensors, instruments and other equipment.

C_i - the value of one hour of work in the i-th qualification category, BGN / h.

From here the determination of the residual value of the individual elements of the machine on the basis of their unused resource, in case of defect can be done by the formula:

$$C_{oi} = k_i . \left[\frac{t_p}{t_{ie}} \right] . C_{не} ,$$

where C_{oi} is the residual value of the i-th element of the machine, BGN;

k_i - the coefficient taking into account the number of identical elements of the machine.

t_p - the resource of the element after the measurement, operating hours or liters of fuel;

t_{ie} - the resource of a new element of the i-th type, operating hours or liters of fuel;

The total value of the residual life items that can be used as second-hand spare can be determined by the expression:

$$C_o = \sum_{m=1}^{M} C_{oi}$$

where C_o is the residual value of the elements of the machine, BGN

$m = 1 - M$ - the number of elements of the machine that meet the condition for profit, BGN.

Then the value of the machine in this method of disposal will be:

$$C_y^3 = \sum_{k=1}^{K} G_{чм} . C_{цм} + \sum_{i=1}^{L} G_{цм} . C_{цм} + C_o - C_P .$$

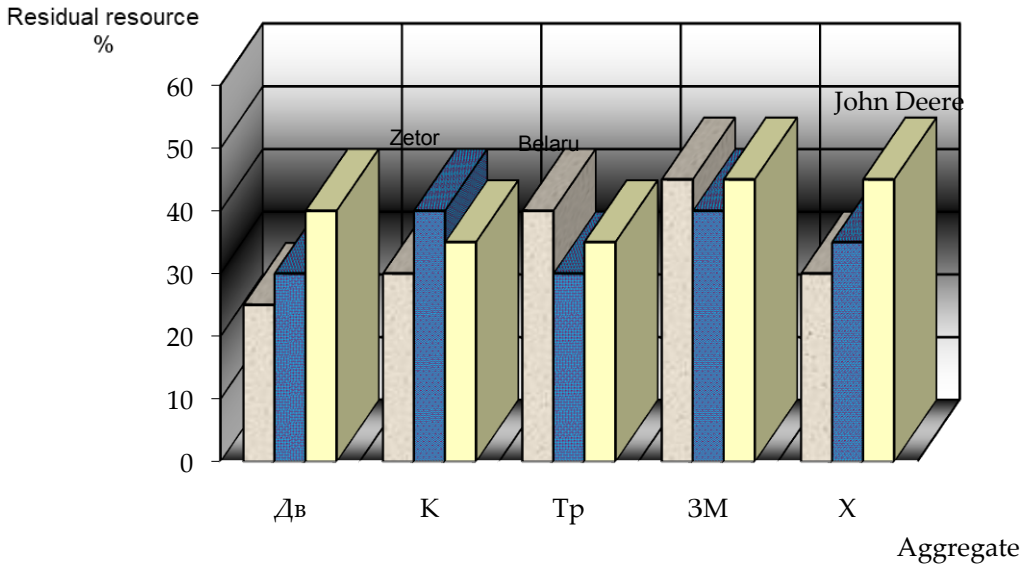


Figure 2. *Residual life of basic elements of Belarus, Zetor and John Deere tractors during utilization after 10 years of use at an average annual load of 800-1000 operating hours: Дв. - engine; K-cabin; Tr-transmission; 3M rear axle; X-hydraulics.*

Conclusions:

1. The stages of the life cycle of complex technical products, such as tractors and self-propelled agricultural machinery, are reviewed. Particular attention is paid to disposal with a view to recycling scrap and protecting the environment from pollution.
2. The main methods for utilization of tractors and self-propelled agricultural machinery are reviewed. The equipment necessary for the disposal is also described. The methodology for determining the costs for utilization and the value of the equipment for utilization of the whole machine, element-by-element utilization and utilization after defecting has been supplemented.

References:

1.Kangalov Pl. Methods and tools for diagnosis. Ruse: RU „A. Kanchev ", 2013. ISBN: 978-619-90013-3-2
2.Kangalov Pl. Design of repair and dealerships. Ruse: RU „A. Kanchev ", 2013. ISBN: 978-619-90013-4-9
3. Mihov M. Exchange elements for repair service of agricultural machinery - Proceedings of the Scientific Conference of the Higher School - College "Telematics", 2007, p.132-140.
4. Tasev G., Ts. Vasilev, D. Korchakov, Investigation of the characteristics of the flow of failures in individual and joint repair of sites, FTA, 1999, №3-4, p.58-62.
5. Tasev GA, Research of the structure and the basic parameters of the repair service system of the equipment in agriculture, S., 2001 (Dissertation for awarding the scientific degree "DOCTOR OF TECHNICAL SCIENCES").

Assessment of chemical composition of soil solution of water repellent soils from Maritza-Iztok coal basin

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Abstract: *The ionic composition and dissolved organic carbon (DOC) in soil solution of four soil profiles, from the area of Obruchishte were analyzed and relationships with soil hydrophobicity were discussed. It was found that the greatest variation and leaching of NO^{3-}, SO_4^{2-} and Ca^{2+} were from the profile of Obruchishte under ash, while of Na^+ from Obruchishte under pine. In Obruchishte profile after cereals the highest content of Cl^-, PO43- and NO_3- were found in the investigated soil solution. No significant correlation was found between the chemical elements and WDPT, except for Obruchishte, stubble. In this profile a significant correlation was found between the Ca2+ and Mg2+ concentrations and WDPT. Significant relationship ($R^*=0.63$, $p<0.05$) between DOC and WDPT was established only at the experimental profile Obruchishte under ash. Differences in the distribution of soluble organic carbon in soil profiles in our studies is most likely due to the heterogeneity of the geological materials used as a substrate for reclamation of the studied sites*

Keywords*: CHEMICAL COMPOSITION, DOC, SOIL SOLUTION, TECHNOGENIC SOILS, RECLAMATION, WATER REPELENCY*

1. Introduction

Worldwide mining activities cause serious negative effects on the landscape and relief, hydrosphere, atmosphere, soils, biodiversity, geo-ecological equilibrium, etc. It was found that the overburden dumps at the coal mines in South-Eastern Europe were often characterized by elevated bioavailability of metals, lack of sufficient moisture, increased compaction, relatively low organic matter content and water repellency [1]. According to [2,3,4] water repellency affects infiltration, water flow and the transport of chemical elements in soils. The primary effect of water repellency is poor infiltration and reduction in the rate of water infiltration [5], which also affects the movement of macroelements along the depth of the profile. There are a few studies [1] on the influence of hydrophobicity in Technosols on the behavior and transport of these elements and soil water repellency.

The objective of the present study was to assess the cationic and anionic composition and DOC in the soil solution, obtained from Technosols reclaimed with coal ash by profile depth and investigates their relation with soil hydrophobicity (soil water repellency).

2. Materials and Methods

Four soil profiles of hydrophobic technogenic soils from the area of Maritza-Iztok coal mine region in Bulgaria were studied. The sites were near Obruchishte village, subject to tuft vegetation, pine vegetation, under ash reclamation (investigated in 2017) and stubble (investigated in 2019). The soil properties of the experimental sites and their physico-chemical characteristics are presented in detail in our previous studies [1,6,7,8]. Soil pH/Eh were measured in a soil:water slurry of 1:2.5. Texture was analysed by the method of Kachinski [9]. Soil water-repellency (soil hydrophobicity) was measured by the water drop penetration time (WDPT) method [10]. Soil samples at the field were classified as non-repellent (WDPT < 5 s), strongly (60 s < WDPT< 600 s) and severely > 600s water repellent according to the scale of [5].The soil solutions were obtained by the following method: in soil water ratio 1:5, shaking for 1 hour, centrifuging and filtering through 0.45 μm acetate cellulose filter [11]. Anions in the soil solution (Cl^-, NO_3^-, SO_4^{2-}, phosphates and dissolved organic carbon (DOC) were analysed with Spectroquant tests, Merck Millipore (PHARO 100). Cationic composition of soil solution was determined by AAS (Perkin Elmer).

3. Results and Discussion

The data obtained show that in the different profiles the pH values varied from 2.96 (Obruchishte under tuft) to 4.10 (Obruchishte 1-3) and they are classified as strongly acid . The high acidity at the studied profiles is a result of the weathering of black clays, predominantly pyrite present in the overburden layers. The CEC is the highest at Obruchishte under ash (72.0-76.0 $cmol.kg^{-1}$) and is the lowest in Obruchishte pine vegetation (52-58.5 $cmol.kg^{-1}$). The highest levels of the exchangeable Ca (29.1-38.6) was found in the areas of Obruchishte under ash, the lowest Ca (11,9-18,3) and Mg (3.3-3.7) were from Obruchishte under tuft profile. Exchangeable Al was established in Obruchishte profile, under ash 16,0-23,1 $cmol.kg^{-1}$.

It was established that studying the mobility of chemical elements in the liquid phase, as well as their migration through the soil profile, allows a better picture of their behavior than doing other geochemical studies of the terrains. Significant differences in the concentration and distribution of the macroelements in soil solutions from natural and reclaimed soils were observed by [12,13,14]. The results show low pH and high ions concentration (especially of sulfates).

3.1. Anions content

Our results show that the nitrate contents in all the studied profiles are low. The values of nitrates are from 10.0 – 14.4 $mg.l^{-1}$, except for Obruchishte under ash where nitrates accumulate in the deeper soil layers, reaching 19.6 $mg.l^{-1}$, while the lack of vegetation, could be the reason for their leaching in the soil profile (Fig. 2). However, in the studied profiles, the maximum permissible concentration level (MPCL) of 50 $mg.l^{-1}$ for the nitrate content of drinking water was not exceeded (Regulation No9/2001) [15]. The concentration of chlorides in all investigated sites for 2017 does not exceed 10 $mg.l^{-1}$. It is found that unlike nitrates the highest content is in the surface and subsurface soil layers of the studied profiles (0-10 and 20-30 cm). Regarding the content of phosphates, highest concentrations and variations are reported in Obruchishte under pine, ranging from 0.1 to 7.7 $mg.l^{-1}$, while in the other profiles phosphates are very low and they almost do not change in depth.

In Obruchishte under pine profile lower content of sulfates are observed, ranging from 580 to 880 $mg.l^{-1}$, with a slight variation along the profile depth (Fig.1), compared to the Obruchishte under ash, where sulfates content is almost double, reaching 1780 $mg.l^{-1}$. At Obruchishte site under tuft, the sulfates are in the range from 1260 to 1500 $mg.l^{-1}$, with a slight variation along the profile depth. The high sulfate contents of the study areas are associated with the materials by which they were reclaimed, predominantly pyrite. Our data correspond with our previous data [1] and those of [16] who also found that soluble compounds, such as SO_4^{2-}were at significant concentrations in the leachates at Technosols.

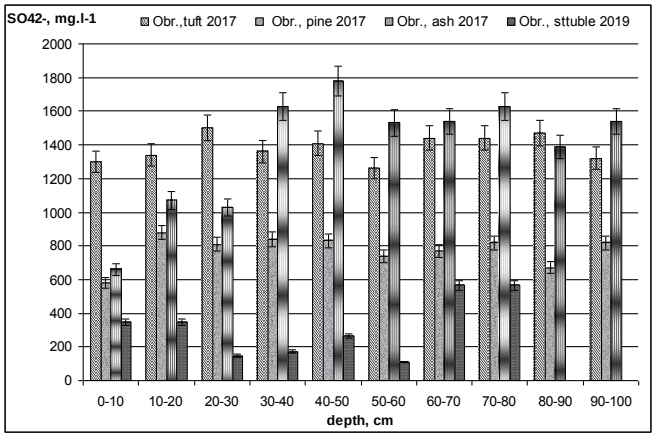


Figure 1. *Content of sulphates (mg.l^{-1}) at soil depth (0-100 cm) at the experimental profiles at Obruchishte sites*

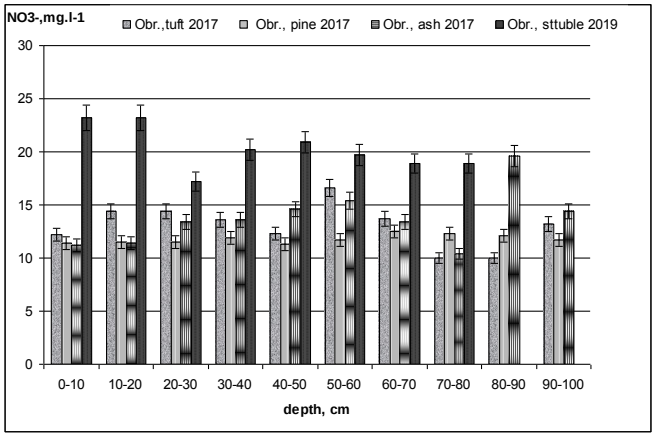


Figure 2. *Content of nitrates (mg.l^{-1}) at soil depth (0-100 cm) at the experimental profiles at Obruchishte sites*

Data show that the concentration of nitrates (17.2 – 23.2 mg.l^{-1}), chlorides (reaching to 27.2 mg.l) and phosphates (0.3-12.6 mg.l^{-1}) in water extracts from Obruchishte, after cereals (stubble), in 2019, are the highest. These concentrations could be explained by the import with fertilizers and herbicides in the cultivation of cereals. Data show that the content of the sulphates anions vary widely from 110 to 567 mg.l^{-1}, such as the highest content is measured in the 65-85 cm layer.

3.2. Cations content

Data show that the lowest are the values of potassium and sodium in water extracts received from the Obruchishte under tuft profile (1.13 -3.06 mg.l^{-1} for K^+ and from 1.90 to 8.45 mg.l^{-1} for Na^+, respectively). The highest concentrations are estabiched in the Obruchishte under pine reaching to 10.26 mg.l^{-1} for K^+ and to 52.30 mg.l^{-1} for Na^+. An increasing of sodium content in layers 70-100 cm is found at three of the investigeted profiles, but it is most pronounced in Obruchishte under pine vegetation (Fig. 3). In contrast to them at Obruchishte, stubble in 2019 we detected a decrease in the deeper layers. As could be seen that in the solutions obtained from the profile of Obruchishte under ash, that the highest contents of calcium were established reaching 312 mg.l^{-1}, and the lowest in the Obruchishte under pine (47-204 mg.l^{-1}), while the concentrations in Obruchishte under tuft ~ 234 mg.l^{-1} (Fig. 4). The results obtained show that in the water extracts from Obruchishte under stubble in the autumn of 2019, the concentration of calcium varies significantly with values from 17.96 to 302.03 mgl^{-1}, until the magnesium is quite low compared with the other profiles researched to 12.83 mg.l^{1}.

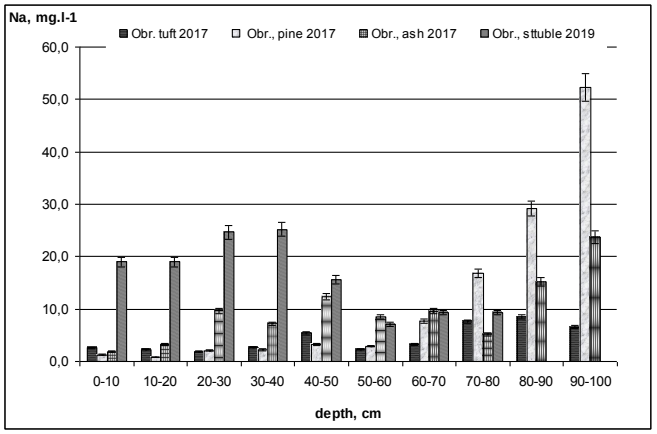


Figure 3. *Content of sodium (mg.l^{-1}) at soil depth (0-100 cm) at the experimental profiles at Obruchishte sites*

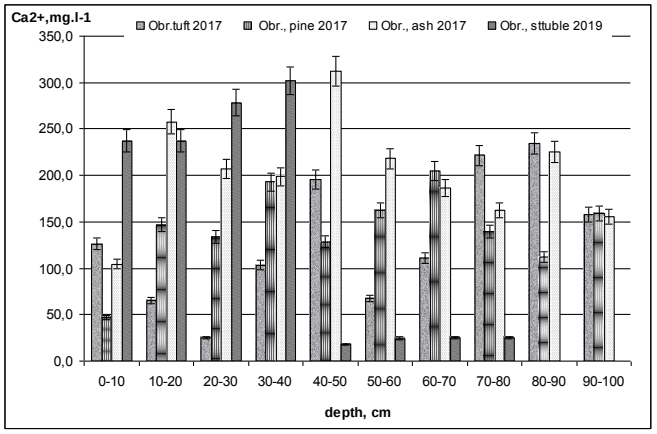


Figure 4. *Content of calcium (mg.l^{-1}) at soil depth (0-100 cm) at the experimental profiles at Obruchishte sites*

Our results showed that the investigated soil profiles are water repellent to a different extent (by small to extreme hydrophobicity, [6,7]**,** but no correlation between the macroelements in the water extracts and water repellency (WDPT, s) was found, with some exceptions, such as in the Obruchishte under stubble where we found a positive correlation with chlorides (R**= 0.917), calcium (R*= 0.518), magnesium (R*= 0.663) and weak with nitrates (R= 0.462).

Table 1. *Correlation coefficients between anions and cations and water repellency (WDPT, s) at Obruchishte sites*

WDPT, s / ions, mg.l	Obr.,tuft 2017	Obr., pine, 2017	Obr., ash, 2017	Obr., stubble,2019
NO_3^-	R= 0,30	R= -0,38	R= 0,14	R= 0,46
Cl-	R= -0,77	R= 0,49	R= - 0,39	R= 0,91
PO_4^{3-}	R= 0,02	R= -0,50	R= -0,20	R= -0,07
SO_4^{2}	R= 0,15	R= 0,39	R= 0,24	R= 0,07
K^+	R= -0,07	R = -0,70	R= -0,29	R= -0,48
Na^+	R= -0,32	R= -0,55	R= -0,05	R=0,36
Ca^{2+}	R= -0,26	R= 0,28	R= 0,01	R= 0,51
Mg^{2+}	R= -0,43	R= -0,66	R= -0,17	R= 0,66

3.3. DOC content

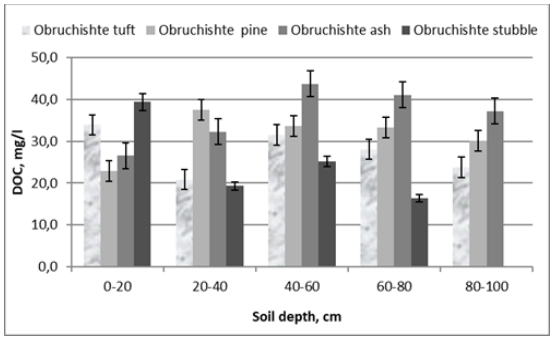


Figure 5. *Variation in DOC (mg.l^{-1}) at soil depth (0-100 cm) at the experimental profiles at Obruchishte sites*

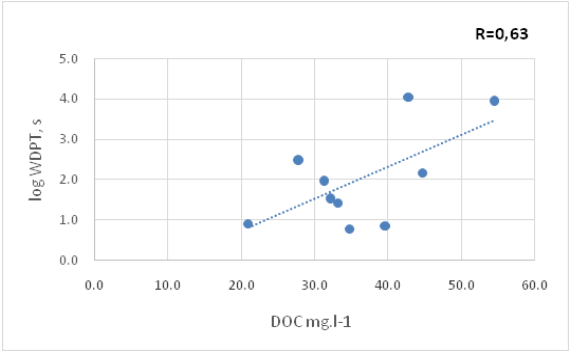


Figure 6. *Correlation between DOC and WDPT*

The higher concentrations of DOC in the surface layers (0-20 cm) in the profiles of Obruchishte under tuft (34 mg.l^{-1}) and Obruchishte (for stubble - cereals) (39 mg.l^{-1}) were observed (Fig 5). The reason for it is probably the vegetation that develops on them and the decomposition of plant residues, which directly affect the concentration of the soluble matters in surface soil layers. Changes in the DOC usually concern the surface layers, and in the deeper soil layers changes in the concentration of soluble forms of organic carbon are much lower or not found [17,18]**.**

In the Obruchishte profile under the pine forest vegetation, the concentration of DOC showed an increase in the depth of the soil layers. The ability of DOC to vary the depth of the soil within even a single site is usually related to the different intensity of formation, transformation and sorption of soluble compounds along the depth of the soil profile [19]**.**

Significant relationship (R*=0.63, p<0.05) between DOC and WDPT was established only at the experimental profile Obruchishte under ash (fig. 6). A positive weak correlation was found (R = 0.40, p <0.05), between DOC and WDPT in the profile Obruchishte (for stubble - cereals).

4.Conclusion

The data obtained show that in 2017, the greatest variation and leaching of nitrates and sulfates was found for the profile from Obruchishte under ash (without vegetation), followed by Obruchishte under tuft, and the lowest values and movement of these anions were found under pine vegetation. Higher content and variation of chlorides and phosphates were found in Obruchishte under pine, unlike the other two profiles. In 2019, the highest content of chlorides, phosphates and nitrates was found in the investigated water extracts from Obruchishte under stubble compared with the other profiles. Obviously, the cultivation of cereals has influenced to different extent the content and behavior of chemical elements in the soil profiles studied. Our data show that the nutrients in the profiles of reclaimed soils are very different from those in the natural soils and the levels of nitrates, available phosphorus and potassium are significantly lower, while of sulfates are much higher than those in natural soils. No positive correlation was found between WDPT and chemical elements (anions and cations) except for Obruchishte under stubble after cereals. Differences in the distribution of soluble organic carbon in soil profiles in our studies is most likely due to the heterogeneity of the geological materials of yellow-green, gray-green and black clays, used as a substrate for reclamation of the studied sites, which form the mineral layers of these hydrophobic soils.

Acknowledgements

This work was supported by the National Science Fund, Bulgaria, project: DN 06/1 2016-2019 “Organic molecular markers and pollutants in hydrophobic soils”

5. References

1. I. Atanassova, M. Benkova, Ts. Simeonova, L. Nenova, M. Banov, S. Rousseva, S. Doerr, Influence of soil water repellency on heavy metal mobility in coal ash reclaimed Technosols, Journal of Environmental Protection and Ecology, **20** (4), 1667–1679 (2019)

2. C. Ritsema, L.W. Dekker, Water repellency and its role in forming preferred flow paths in soils, Aust. J. Soil Res., **34**: 475-487 (1996)

3. T.W.J. Bauters, T.S. Steenhuis, D.A. Di Carlo, J.L. Nieber, L.W. Dekker, C.J. Ritsema, J.-Y. Parlange, R. Haverkamp, Physics of water repellent soils, J. Hydrol., 231–232: 233-243 (2000)

4. H. Gerke, E. Hangen, W. Schaaf, R.F. Huttl, Spatial Variability of Potential Water Repellency in a Lignitic Mine Soil Afforested with *Pinus nigra*. Geoderma, **102** (3–4), 255 (2001)

5. L.F. De Bano, Water repellent soils: a state-of-the-art. *USDA Forest Service General Technical Report PS W-46*. Berkeley, CA, 21 (1981)

6. I. Atanassova, M. Banov, T. Shishkov, Z. Petkova, B. Hristov, P. Ivanov, E. Markov, I. Kirilov, M. Harizanova, 2018a. Relationships between soil water repellency, physical and chemical soil properties in hydrophobic technogenic soils from the region of Maritsa-Iztok coal mine in Bulgaria, Bulgarian Journal of Agricultural Science, **24** (Suppl. 2), 10-17 (Bg) (2018a)

7. I. Atanassova, M. Benkova, M. Banov, Ts. Simeonova, L. Nenova, M. Harizanova, Geochemical associations in technogenic soils (Technosols) of contrasting hydrological characteristics from the region of Maritsa-Iztok coal mine in Bulgaria, Bulgarian Journal of Agricultural Science, **24** (suppl.2) 18-26 (Bg) (2018b)

8. Ts. Simeonova, M. Benkova, L. Nenova, I. Atanassova, Chemical composition of soil solution of Technosols from a coal mine region in South-Eastern Europe, Bulgarian Journal of Soil Science, **3** (1), 4-12 (2018)

9. N.A. Kachinskii, *Soil physics.* Part I, Moscow, High school Press, 323 (In Russian) (1965)

10. S.H. Doerr, L.W. Dekker, C.J. Ritsema, R.A. Shakesby and R. Bryant, Water repellency of soils: the influence of ambient relative humidity, Soil Science Society of America Journal, **66** (2), 401-405 (2002)

11. M. Katoh, M. Satoshi, T. Sato, Single-step extraction to determine soluble lead levels in soil, International Journal of Geomate, **3**(2), 375-380 (2012)

12. D.M. Howell, S. Das Gupta, B.D. Pinno, M.D. MacKenzie**,** Reclaimed soils, fertilizer, and bioavailable nutrients: Determining similarity with natural benchmarks over time, Canadian Journal of Soil Science, **97** (2), 149-158 (2017)

13. W. Schaaf, M. Gast, R. Wilden, J. Scherzer, R.Blechschmidt, R.F. Hüttl, Temporal and spatial development of soil solution chemistry and element budgets in different mine soils of the Lusatian lignite mining area, Plant and Soil, **213**(1-2), 169-179 (1999)

14. R. Wilden, W. Schaaf, R.F. Hüttl, Soil solution chemistry of two reclamation sites in the Lusatian lignite mining district as influenced by organic matter application, Plant and Soil, **213** (1-2), 231-240 (1999)

15. Regulation №9.2001. For the water quality, intended for drinking and domestic purposes, State Gazette, 30/28.03.2001, (in Bulgarian)

16. H. Huot, G. Sere, P. Charbonnier, M.O. Simmonot, J.L. Morel, Lysimeter monitoringas assessment of the potential for revegetation to manage formed iron industry setting ponds, Sci.Total Environ. **256**:29-40 (2015)

17. R.G. Qualls, Comparison of the behavior of soluble organic and inorganic nutrients in forest soils, For. Ecol. Manage, **138**, 29–50 (2000)

18. B. Michalzik, K. Kalbitz, J.H. Park, S. Solinger, E. Matzner, Fluxes and concentrations of dissolved organic carbon and nitrogen – a synthesis for temperate forests, Biogeochemistry. **52,** 173–205 (2001)

19. K. Kalbitz,, S. Solinger, J.H. Park, B. Michalzik, E. Matzner, Controls on the dynamics of dissolved organic matter in soils: a review, Soil Sci, **165,** 277–304 (2000)

The influence of long-term agricultural use of soils of the dry subtropical zone of Azerbaijan on its morphological and agrochemical properties

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Abstract: *The aim of the research was to study the influence of natural vegetation and intermediate sowings of fodder crops on the formation in the profile of (WRB, 1998) Gypsisols and Gleyic Calsisols and Irrigated Gypsisols and Gleyic Calsisols soils of the dry-steppe and semi-desert zones of Azerbaijan genetic horizons. It has been established that significant morphological changes are common to the thickness of the humus horizon, the depth of carbonates and agrochemical parameters of the studied soils. Their maximum values in the arable layer are established in Irrigated Gypsisols and Gleyic Calsisols soils under the collection of 3 green mass crops per year from 1 ha: the thickness of the humus horizon increased to 0.25 and 0.27 cm, respectively, humus - up to 2.73 and 3.00%, the amount of absorbed bases - up to 25.71 and 30,80 mg-eq / 100 g of soil, mobile phosphorus - up to 30.9 and 34,00 and exchange potassium - up to 317.3 and 423,1 mg / 100 g of soil. In accordance with the WRB system (2015), Irrigated Gypsisols can be classified - Irragric Cambisols (Protocalcic, Clayic), and Gleyic Calsisols - Irragric Gleyic Calcisols (Calcic, Loamic).*

KEYWORDS: *HORIZON THICKNESS, HUMUS, ABSORBED BASES, MOBILE PHOSPHORUS, EXCHANGE POTASSIUM, AGROCHEMICAL PROPERTIES*

1. Introduction

Human economic activity, as a factor of soil formation, affects the soil-forming process both directly and indirectly through other factors, taking on the leading functions of regulating the interrelation between soil and cultivation crops[1].Some researchers believe that a natural zonal soil formation process occurs in arable soils, which does not differ from the process under natural vegetation, while others point at profound fundamental changes in the natural soil formation process [2].The transformation of natural biocenoses into agrocenoses is always accompanied by a change in morphological and physical parameters, as well as the qualitative and quantitative composition of organic residues. A quantitative account of such changes makes it possible to determine the speed and direction of soil formation processes [3].Accounting for the content and reserves of nutrients, their distribution in the soil profile makes it possible to establish the amount of available nutrients for crops, their biogenic accumulation, the direction of migration and participation in the biological circulation of elements, which is very important for increasing agricultural production in the dry subtropical zone of Azerbaijan.

The aim of the study is to assess changes in the morphological and agrochemical parameters of soils in the dry subtropical zone of Azerbaijan under the influence of their long-term agricultural use.

2. Prerequisites and means for solving the problem

The studies were carried out in 1998-2018. on virgin (Gypsisols, in WRB 2012) and irrigated gray-brown (Irragri Gypsisols, in WRB 2012, Absheron) and meadow-serozem (Gleyic Calcisols and Irragri Gleyic Calcisols, in WRB 2012, Kura-Araksin lowland) soils according to the scheme:1. virgin land *(Carex pachystylis, Poa bulbosa, Caragana frutex, Alhagi, Artemísia, Sálsola), 2. Secále cereále → Zéa máys; 3. Medicágo; 4. Zéa máys (spring sowing); 5. Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa; 6. Hórdeum* (for grain, farm sowing). Cultivation agrotechnics - zonal with some changes for each option. Repetition - 4-fold, plots area -72 m2. The climate is subtropical with dry hot summers, the amount of active t^0 is 4500 - 48480C, the arrival of FAR is 120-133 kcal / cm2, the amount of precipitation is 180 - 330 mm per year; days with air t^0> 100-285-330 and soil> 50 -315-360.

The laying of soil sections, their description, the selection of soil samples and the establishment of the preliminary classification name of the soil in the field were carried out according to the *Guidelines for Soil Description* (FAO, 2012) and according to the methods[4-7].

In soil samples, the following were determined: humus, mobile compounds of phosphorus and potassium, pH, carbonates [8]. Based on morphological and physicochemical properties, the name of gray-brown and meadow-serozem soils was given according to the International Soil Classification based on the Abstract Base (WRB) 2015[7].

Virgin and irrigated gray-brown soils (Gypsisols and Irragri Gypsisols, in WRB 2012) are located at an altitude of 50-165 m above sea level, geographic coordinates - 40 ° 28'871 "N and 49 ° 39'969" E, and meadow-sierozem soils (Gleyic Calcisols and Irragri Gleyic Calcisols, in WRB 2012) - located at an altitude of 48.80 m above sea level, geographical coordinates - 40 ° 29´37.689 "N and 47 ° 43´34.456" E.

3.Results and discussion.

The morphological features of the soil profile are a stable external characteristic of soils, and even a short-term anthropogenic influence on the soil leads to changes in morphological features [9]. That is, a plow horizon is formed, with characteristic features that differ from the original genetic horizons of natural soils and is a cultivated horizon with the preservation of the zonal appearance [10, 11]; it affects the direction and intensity of soil formation.

Gypsisols and Irragri Gypsisols. Studies have established that significant changes in the morphological profile of the soil are manifested mainly in the form of an increase in the humus horizon, the depth, as well as the thickness of the carbonate layer. These changes increase on the sowing of row crops, permanent cultivation of barley and on virgin soil, where the depth of occurrence of carbonates is higher, which is associated with higher evaporation from the surface associated with the thinning of the vegetation cover.

Permanent sowing of *Hórdeum* (variant 6) reduces the thickness of the humus horizon of the soil due to the low input of fresh organic matter into the soil. In all studied variants of the experiment in accordance with the "Classification and diagnostics of soils of the USSR" [12] and FAO 2015 [7] - Gypsisols and Irragri Gypsisols - thin, low-humus, which shows the homogeneity of the soil cover of the experimental area.

For the sample, we present a morphological description of the soil profile of section **No. A-12** (according to WRB-2015), laid down in the 5th option. The territory is located in the Experimental Economy Research Institute of Fodder, Meadows and Pastures of the Ministry of Agriculture of Azerbaijan, 500 m from the Baku-Shemakha highway, at an altitude of 87 m above sea level, geographical coordinates - 40028'26.37 "N, 49039'38 , 81 "E. SU, 27 ° C; WC - 2, LP - <100. Soil - Irragri Gypsisols.

The parent rocks are highly gypsum-bearing clayey deposits of deluvial origin and weathering products of tertiary clays. AA4M, IB, IF, vegetation: *Secále cereále + Vicia sativa + Brássica nápus*

→ Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa, ST, Hp - 0-25 cm.

A' 0-25 10 YR4/2, N, CL, GR, PD3, M (2-5 mm) и C (> 25cm 5mm), (M - < 2mm –200, > 2mm->20), F - 0.5 -2 mm, E,M, M –15-40%, ca, *pF-3, SC, MO 2-10% и N, ST, SC;

A" 25-53 10 YR5/2, CL , PD3, SB, FRF, AS, E, M - 15- 28cm 40%, C, F, MO 2-10% и N, PM, ca,P, I;

B 53-77 10 YR 4/6, CL, FM, FRF, M –2-5 mm, VF- < 0.5 24 cm mm, C, F-0.5-2 mm и F --< 2mm -20-50% и > 2mm-2-5%, ST 10-25, ca, PM, HA, *pF 3-2, D;

B/C 77-117 10 YR 5/4, CL, PD3, CR, F- 0.5-2 mm, 40 cm VF -< 0.5mm, F –0.5-2mm, C, ST 10-25%, PM, SL 0-5%,C;

C 117-129 7.5 YR 4/6, CL 25-40% silt, PD4, F - 0.5-2mm, 12cm MO 2-10%, VF, SC, SL, ST, N, S, pF*-3, V – < 2%, C;

C 129-152 2.5 YR 8/3, CL, LU, PD4, SC , MO 2-10% 23 cm and N, CS, F.

The results of the morphological description of section №A-12 show that the thickness of the arable horizon (0-25 cm) is 25 cm. The profile of this section up to the Cca horizon (117-129 cm) is described by the main tone 10YR, and in the Cca horizon (117-129 cm) - in a tone of 7.5 YR, deeper - in a tone of 2.5 YR [14].
In the morphological description of the soil profiles of other variants of the experiment, the following horizons were established: A' from 22 to 24 cm thick; A"- from 35-49 to 51 cm; B - from 57-65 to 75 cm; B/C - from 100 cm to 113 cm and C - from 121-129 to 148 cm, which corresponded to the statistical parameters of the morphological properties of the gray-brown soils of the Absheron Peninsula (Table 1). The middle of the soil profile consisted of transitional horizons (from humus to parent rock - B, B/C and C. Their total thickness in virgin soil was 64 cm, *Secále cereále → Zéa mays* - 49 cm, *Hórdeum* (farm sowing) - 64 cm. The Significant level of the occurrence of carbonates is noted under Hórdeum (65-119 cm), slightly under the Zéa máys of spring sowing (110-120 cm) and is lowered to a depth of 129-152 cm in variant 5.

In variants 3 and 5, the root system of *Medicágo* and grass mixtures (variant 5) intensively used moisture from the layer of 0-51-53 cm and thereby slowed down the rising migration of carbonates. For 20 years, the capacity of A' under *Hórdeum* (farm sowing) was 22 cm, under *Medicágo* - 24 cm, and the highest - under variant 5 (25 cm). This is completely logical - the different depth soil cultivation, depending on the type of intermediate mixed sowing of crops, in order to obtain 3 harvests of green mass per hectare per year, different depths of penetration by the root system of crops and the year-round supply of fresh organic matter of grass mixtures contributed to the approach of soil formation processes to virgin analogues.

Table 1: *Agrochemical indicators for the genetic horizons of the morphological profile of gray-brown soil*

Variant	Horizon, см	Power, cm	pH of water	Hhumus, %	mg-eq/ 100 g of soil		mg / kg soil	
					Ca	Mg	P2O5	K2O
	A'	0-22	7,9	2,19	14,34	9,50	20.0	242.8
	A"	22-50	8,9	1,28	10,78	9,36	16.0	203.0
	B	50-75	9,2	0,98	8,40	10,22	14.0	157.3
	B/C	75-100	8,0	0,50	6,95	7,90	5.3	110.5
	C	100-122	8,8	0,10	6,85	3,95	-	37,9
1	A	0-13	8,1	1,96	15,0	7,36	11.7	226.6
	A	13-35	8,6	1,34	12,75	11,40	7.00	211.0
	A/B	35-57	8,8	0,67	11,25	5,86	5.7	161.3
	B	57-100	8,4	0,38	6,88	8,11	2.00	152.3
	C	100-121	7,8	-	7,81	4,34	0,42	22,6
2	A'	0-23	8,2	2, 13	16,24	7,55	18.0	227.0
	A"	23-50	8,6	1,27	12,39	6,45	14.0	195.7
	B	50-75	8,9	0,61	9,44	5,28	11.7	144.3
	B/C	75-100	9,1	0,27	7,96	3,67	5.3	100.7
	C	100- 124	9,1	0,05	7,61	6,70	2,8	46,1
3	A'	0-24	8,0	2,51	20,60	10,99	27.8	269.5
	A"	24-51	8,6	1,60	19,76	10,55	20.0	231.2
	B	51-75	8,9	1,20	16,15	8,45	18.7	182.3
	B/C	75-113	8,5	0,52	11,61	4,67	10.6	131.5
	C	113-148	8,0	0,17	9,37	7,42	6,9	76,9
4	A'	0-22	8,3	1,88	14,97	5,01	15,6	215.4
	A"	22-49	8,8	1,10	11,75	4,66	12.9	178.5
	B	49-73	9,2	0,55	12,40	6,12	10.2	130.3
	B/C	73-110	9,0	0,15	11,36	4,51	3.7	74.6
	C	100-120	8,3	-	9,17	7,26	1,9	38,7
5	A'	0-25	8,4	2,73	21,25	4,95	30.9	317.3
	A"	25-53	8,8	1,72	20,40	4,45	25.7	241.0
	B	53-77	8,9	1,32	16,80	6,00	22,3	192,3
	B/C	77-117	9,0	0,71	13,80	11,0	17.0	140,0
	C	117 -129	8,0	0,17	10,87	6,08	10,4	92,1
6	A'	0-22	8,1	1,60	13,87	4,64	13.1	158.7
	A"	22-43	8,6	1,19	12,31	4,12	10.4	121.6
	B	43-65	8,8	0,60	11,75	4,66	5.0	77.9
	B/C	65-100	9,0	0,09	9,89	4,59	2.7	50.1
	C	100-119	8,2	0,01	5,26	4,36	1,0	33,1
	C	119-129	7,6	0,01	3,11	4,09	traces	11,7

Notes: Original soil, № A-13; 1.Virgin, № R-1; 2.*Secále cereále → Zéa mays,* № A-1; 3.*Medicágo,* № A-10;; 4.*Zéa mays,* № A-8; 5.*Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max+ Sorghum + Ama-ránthus→Hórde-um+Vicia sativa,* № A-12; 6. *Hórdeum,* № A-6

It has been established that the reaction of the medium in all variants of the upper horizons is weakly alkaline (pHwater - 8.0-8.1), and in the lower ones - upon transition to the carbonate horizons - alkaline (pHwater - 9.0-9.1), which corresponds to irrigated gray-brown soils of Azerbaijan [13]. Over a twenty-year period of permanent cultivation of *Hórdeum*, the humus content in the A' layer was –1.60%, in the A"–1.19%, which is due to an increase in the mineralization of organic matter and a lack of plant material. In the variant of obtaining 3 harvests of green mass per year per hectare, the humus content in A' is higher than –2.73%, which is associated with the year-round intake of fresh plant residues of grass mixtures into the soil. The largest amount of absorbed bases with a predominance of calcium cation, mobile phosphorus and exchangeable potassium was noted in the soil also under variant 5. It was noted that the amount of absorbed bases increased with an increase in humus in the soil, which indicates the important role of humus in the formation of an absorption complex in the upper soil horizons. Based on the data obtained according to the international classification of soils of the world (WRB 2015), irrigated gray-brown soils can be classified as Irragric Cambisols (Protocalcic, Clayic).

Gleyic Calcisols and Irragri Gleyic Calcisols (in WRB 2012). Studies have shown that permanent sowing of *Hórdeum* (variant 6) reduces the thickness of the humus horizon of the soil. In all studied variants of the experiment in accordance with the "Classification and diagnostics of soils of the USSR" [12] and FAO 2015 [7] - Gleyic Calcisols and Irragri Gleyic Calcisols - thin, low-humus, which shows the homogeneity of the soil cover of the experimental area.

For the sample, we present a morphological description of the soil profile of section № K-3 (according to WRB 2015) under variant 5. The territory is located in the Experimental Economy of the Institute of Soil Science and Agrochemistry in Ujar (Kura-Araksin lowland), 600 m from the Baku-Kazakh highway, at an altitude of 16 m above sea level, geographical

coordinates - 40030'20.13 "N , 47040'26.14 "E. SU-29 ° C, WC 2, LP -<10^0.

Soil - Irragri Gleyic Calcisols. The parent rocks are deluvial-alluvial loams. AA4M, IB, IF, vegetation: *Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa,* ST, Hp - 0-27 cm.

A' 0-27 7,5YR 5/6, CL, SB + GR, FR, M (2-5mm) and
27 cm C (>5mm), F–0.5-2mm, E, M, M - 15-40%,
*pF 3-2, SC, MO 2-10% and N;

A" 27-56 7,5YR 5/6, CL, SB +CR,F, FR, M (2-5mm) and
29 cm C (>5 мм), F–0.5-2mm, E, M, M – 15-40%,
*pF -2, PM, MO 2-10% and N, C;

A"/B 56-77 7.5 YR 5/3, CL, SB, PD4 , F, M - 15-40%, M (2-
21cm 5 mm) and C (>5mm), F - 0.5-2mm, *pF -2, SC,
ST 10- 25%,N, C, W;

B/C 77-122 2,5 YR 8/7, PD4 , CL, F, CR +SB, F, M (2-5
45 cm mm), F- 0.5-2mm, *pF -2, SC, MO 2-10% and N,
G, İ;

C 122-155 10 YR 6/3, C, PD4, F -2-5%, LU, FM -2-6mm, MO
33 cm 2- 10%, SC, *pF 3-2 .

The morphological description of section № K-3 shows that the thickness of the arable (0-27 cm) horizon is 27 cm.

The profile of this section up to the B/C horizon (77-122 cm) is described by the main tone 7.5YR, and in the B/C horizon (77-122 cm) - in 2.5 YR tone, then - in 10 YR tone [14].

In the morphological description of the soil profiles of other variants of the experiment, the following horizons were established: A' (arable horizon) with a thickness of 22 to 26 cm; A" (subsoil) - from 44 to 54 cm; B - from 63-75 to 76 cm; B/C - from 103 cm to 119 cm and C - from 129 -137 to 152 cm, which corresponded to the statistical parameters of the morphological properties of irrigated meadow-serozem soils of the Kura-Araks lowland.

On virgin soil, these parameters along the soil profile corresponded to 14, 37, 61, 102, 131 cm (Table 2).

The middle of the soil profile for all variants consisted of transitional horizons (from humus to parent rock - B, B C, and C. A significant level of occurrence of carbonates was noted under *Hórdeum* (63 - 103 cm), somewhat lower under *Zéa máys* of spring sowing (74 - 109 cm) and lowered to a depth of 122-155 cm in variant 5.

The root system of Medicágo and grass mixtures (variant 5) intensively used moisture from the layer of 0-54-56 cm and thus slowed down the rising migration of carbonates.

For 20 years, the thickness of the arable horizon (A1) under *Hórdeum* (farm sowing) was 22 cm, under *Medicágo* - 26 cm, and the largest - under variant 5 (27 cm).

This is due to the different depth soil cultivation, depending on the type of intermediate mixed sowing of crops in order to obtain 3 crops per hectare per year, the depth of penetration of the root system of crops and the year-round supply of fresh organic matter.

Table 2: *Agrochemical indicators for the genetic horizons of the morphological profile of meadow-serozem soil.*

Variant	Horizon, cm	Power, cm	pH of water	Humus, %	mg-eq/ 100 g of soil		mg / kg soil	
					Ca	Mg	P2O5	K2O
	A'	0-23	7,95	2,39	17,73	6,17	16,0	257.1
	A"	23-51	8,79	1,90	12,37	6,08	15.0	140.1
	B	51-75	8,59	1,05	7,59	5,86	11.4	99.1
	B/C	75-109	8,72	0,26	5,27	6,21	5.3	64.7
	C	109-139	7,99	trace	6,02	6,00	1,7	35,9
1	A	0-14	7,88	2.40	18,83	5,05	27,3	290,2
	A	14-37	7,91	1,85	14,05	6,37	12.8	230,4
	A/B	37-61	7,87	1,15	11,30	6,87	9.2	181,5
	B	61-102	7,86	0,42	7,06	8,20	2.0	119,0
	C	102-131	7,69	0,10	4,67	3,69	trace	44,1
2	A'	0-25	7,82	2.25	19,47	3,34	19,3	291,2
	A"	25-49	8,01	1,83	11,20	4,40	17,6	163,6
	B	49-75	8,10	0,89	7,56	5,80	11,3	109,8
	B/C	75-110	8,91	0,37	5,23	8,05	4,5	52,7
	C	110-141	8,66	0,07	5,00	6,05	2,3	54,7
3	A'	0-26	7,88	2.82	20,32	8,50	29,5	397,5
	A"	26-54	8,22	2,07	17,17	6,00	24.3	200,4
	B	54-76	8,13	1,45	15,72	7,00	17,5	137,3
	B/C	76-119	8,79	0,70	10,00	9,20	7,4	90,5
	C	119-152	8,77	0,23	8,11	4,25	6,2	77,9
4	A'	0-23	8,11	2.13	18,37	2,94	17,3	238.0
	A"	23-45	8,48	1,33	11,04	5,29	16,1	134.0
	B	45-74	8,92	0,80	9,85	4,19	5,2	83,4
	B/C	74-109	7,89	0,23	9,32	5,71	3.0	30.8
	C	109-137	8,69	trace	4,76	7,11	1,7	23,1
5	A'	0-27	7,69	3,00	21,30	9,50	34,00	423,1
	A"	27-56	8,11	2,38	19,21	8,22	24,60	280,1
	B	56-77	8,45	1,54	18,23	7,77	18,3	169,2
	B/C	77-122	8,68	0,74	15,55	9,21	7,8	100,2
	C	122-155	8,73	0,31	9,33	5,87	3,21	47,8
6	A'	0-22	8,00	1.96	17,71	3,36	15,4	209,7
	A"	22-44	8,86	1,44	11,00	5,58	13,1	111,2
	B	44-63	7,91	0,75	8,42	5,62	4,0	76,4
	B/C	63-103	8,26	0,13	7,82	5,75	1.0	24,7
	C	103-129	8,00	0,02	4,87	6,09	trace	14,7
	C	129→	9,00	-	2,01	5,11	-	0,79

Notes: Original soil,№ K-1; 1.Virgin, № M -24; 2.*Secále cereále → Zéa mays,* № K-4; 3.*Medicágo,* № K-6; 4. *Zéa mays,* № K-8; 5.*Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max+ Sorghum + Ama-ránthus→Hórde-um+Vicia sativa,* № K-3; 6. *Hórdeum,* № K-11

The reaction of the medium in all variants of the upper horizons is slightly alkaline (pHwater - 7.82-8.0), and in the lower horizons - during the transition to carbonate horizons - alkaline (pHwater - 8.66 - 9.0), which corresponds to irrigated meadow-serozemic the soils of the Kura-Araks lowland [13].

During the period of permanent cultivation of *Hórdeum,* the humus content in the A' layer of the soil was ‑1.96%, in A"‑1.44%. In the variant *Secále cereále + Vicia sativa + Brássica nápus → Zéa máys + Glycine max + Sorghum + Amaránthus → Hórdeum + Vicia sativa*, the humus content in A' is higher - 3.0%, in A" (subsoil) - 2.38%, which is due to with a year-round supply of fresh root and stubble residues of grass mixtures to the soil. The largest amount of absorbed bases with a predominance of calcium cation was also noted under variant 5 (in A' it was 30.8 mg-eq / 100 g of soil), gradually decreasing along the profile to 15.2 mg-eq / 100 g (in the C horizon of the soil).

In all variants of the soil profile, the supply of mobile phosphorus and potassium decreased from high in A to low in the B/C and C horizons. Between the agrochemical indicators of the experimental variants: the humus content, the amount of absorbed bases, the amount of mobile phosphorus and exchangeable potassium, there are close reliable (tf > tst) correlations (0.79 ± 0.16 ... 0.98 ± 0.06).

Based on the data obtained according to the international classification of soils of the world (WRB 2015), irrigated meadow-sierozem soils can be classified as Irragric Gleyic Calcisols (Calcic, Loamic).

4.Conclusion

1. A Munsell color book was used to describe the color of the soil samples. The color of the profiles of the irrigated gray-brown soil is described by the tones of the Munsell scales - 10YR - 7.5 YR and 2.5

YR. And the color of the profiles of the irrigated meadow-serozem soil is in tones 7.5YR -2.5 YR and 10 YR.

2.Under the influence of long-term various agricultural uses, the following genetic horizons are formed in the profile of irrigated gray-brown and meadow-serozem soils: A1, A2, B, B/C, C.

3. Considering these changes, in accordance with the WRB 2015 system, irrigated gray-brown soils can be classified as Irragric Cambisols (Protocalcic, Clayic), and meadow-serozemic soils - Irragric Gleyic Calcisols (Calcic, Loamic).

5. References

1. I.P. Makarov. *Soil fertility and agriculture sustainability* (Moscow, Kolos, 1995, 288 p.)
2. N.M.Pavlyuk, V.G. *Gaskevich Gray forest soils Opillia* (Lviv: LNU named after Ivana Frank, 2011, 322 p.)
3. *Field guide to soils of Russia* (Moscow, Publisher: Dokuchaev Soil Institute, 2008, 82 p.)
4. *Soil description manual* (Rome, FAO, 2012, 100 p.)
5. *Guidelines for soil description* (4th edition, Rome, FAO, 2012, 2014, 186 p.)
6. *World reference base for soil resources 2014* (International soil classification system for naming soils and creating legends for soil maps Update 2015, FAO 2015, 192 p.)
7. *Agrochemical methods of soil research* (Moscow: Nauka Publishing House, 1975, 656 p.)
8. A.K.Ulanov The influence of different uses of arable land on the morphological and agrochemical properties of the chestnut soil of Transbaikalia (Conference: Soils of Russia yesterday, today, tomorrow. Publishing house: Vyatka State University, 2017, pp. 100-107)
9. M. P. Babaev, F.M.Ramazanova*, E. A. Gurbanov, The Influence of the Intermediate Sowings of Fodder Crops on Granulometric and Microagagregate Composition Genetically Different Soils in the Arid Subtropical Zone of Azerbaijan (Agrochemistry J, 3 (2020), pp. 19–31)
10.V.N.Semendyaeva, *The influence of agricultural use on the properties of soils in Western Siberia* (Novosibirsk, 2011, p.168)
11. *Classification and diagnostics of soils in the USSR* (Moscow, Kolos, 1977, 225 p.)
12. *Munsell Soil Color Charts* (Michigan, Grand Rapids, 2009)
13. Babaev M.P., Ramazanova F.M., Nadzhafova S.I., Gurbanov E.A., *Soils of the Republic of Azerbaijan (Irrigated soils of the Kura-Araks lowland and their productive capacity)*, (Moscow: LAMBERT Academic Publishing, 2019, 287 p.)

Growth analysis of sweet pepper for investigation effect of wood ash and poultry litter on plant

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Abstract: *The present study uses the method of soil crops to study the fertilization of the soil, changes in the content and forms of nutrients, the effectiveness of various forms of nutrients introduced by the resulting of soil improver - a mixture of waste – wood ash and poultry litter, by means of a vegetation experiment. Sweet pepper Capsicum annuum subsp. macrocarpum L. was selected for the experiment, variety of gate type - Gold medal 7. The results of the study prove the ability to use soil improvers, good resistance of the leaves to sudden intense changes in climatic conditions. The root systems of all mixtures are well developed and strong, stable with good agrochemical parameters compared to that of the zero sample.*

Keywords: *SOILS, SOIL IMPROVER, WOOD ASH, POULTRY LIITER*

1. Introduction

Globally, a sustained trend towards sustainable agriculture is being captured. The European Union is aiming for greener agriculture so that scarce resources are managed more effectively. This is based on the concept of growth in sustainable productivity and a longer resource base existence to feed a growing population. Innovative approaches also improve rural life.

The concept of sustainable development takes into account the specific characteristics of each region and helps to develop its potential. The development of regional and local food systems, which can play an important role in reducing greenhouse gas emissions in agriculture and the agri-food system, is supported, while saving energy, improving the health of the nation, and enhancing the overall sustainability of agriculture. One of the main points for implementing good sustainability systems and minimizing the negative environmental impact of agriculture is the reduction of the use of synthetic fertilizers by using animal and integrated systems to retain significant levels of carbon in the soil. The utilized agricultural area for 2019 in Bulgaria is 45.4% of the area of the country and differs by 0.1% from the previous year [1] On the other hand, the cost of fertilizers and plant protection products is 37.2 EUR /ha [2].

Manure from poultry farms (MPF) is a waste product that belongs to group II contaminators, as it is also a carrier of energy and optimal for autotrophic organisms the content and ratio of biogenic chemical elements. Although the organic substances contained therein are fully included in the biogeochemical cycles of the cycle of substances, there are certain features that make it difficult to solve the problem. Above all, the organic substances in manure are of high concentration. Their composition is not permanent and depends on many factors – the species, age and state of health of the animals, the quality of the feed and the composition of the ration, metabolism, season, etc. The amount of MPF received, without bedding, per 1000 laying hens is 10 091 kg of dry matter for 12 months. Daily feces in laying hens are determined about 10% of the mass of birds. A direct relationship between the feed consumed and the fresh MPF received has been established - approximately 1.15 kg of fresh manure is obtained per 1 kg of feed consumed [3]. It contains thirteen of the most important nutrients for plants – N, P, K, Ca, Mg, S, Mn, Cu, Zn, Cl, B, Fe, Mo, which makes it a valuable fertilization tool. [4] Fresh MPF from laying hens contains about 1.0-1.8% nitrogen, 0.8-1.2% phosphorus, 0.5-0.7% potassium. "Typical" dry matter and nutrient content in MPF - 25-46% dry matter, 13-17 kg/t nitrogen, 4-21 kg/t phosphorus, 3-15 kg/t potassium [2].

The number of birds as of December 31, 2019 in Bulgaria is 0.3% higher than December 31, 2018 and reaches 15.6 million. Number. Laying hens and adolescents increased by 2.2% to 7.107 million. number [5]. Of these, 4.785 million the number are stock carriers, 1.084 thousand 1.238 million. the number are adolescents. In the poultry farms with 10,000. and more laying hens and adolescents are reared 86.9 % of the birds or 6.2 million. Number. [5] The choice of an effective method and technique for treating poultry waste is particularly important for areas where larger poultry plants are concentrated, increasing the risk of environmental pollution and endangering human health. One of the biggest challenges in modernizing poultry production is the need to balance the feeding of arable soils and the reduction or elimination of harmful effects on the environment, while respecting animal welfare regulations. The results of the practices carried out and the studies and tests carried out in different poultry farms demonstrate the economic and environmental expediency of the application in practice of the different types of composting or thermal treatment, as well as the usefulness of different sorbents with a direct impact on the carbon dioxide content of the atmosphere. A disadvantage of these best practices is the duration of treatment for composting and high initial investments and operating costs in thermal treatment [6].

The present study aims to apply an integrated approach by using appropriate additives from biomass ash avian excrement, which on the one hand improves the balance of nutrients and, on the other hand, to change the characteristics of new products in order to achieve greater efficiency in production and application in a shorter time. After characterizing the properties of the new products obtained, test vegetation vascular trials to assess agrochemical effectiveness should be planned and carried out. The proposed new solution is constructed on the basis of waste from poultry farms with additional waste products from other production and raw materials. The aim is to make integrated utilization of several types of waste, drying of waste to the desired humidity, stabilization and decontamination of the waste in order to improve its properties and composition. As a result, it is expected that once the bioactive components are destroyed, the release of smelling gases will be discontinued. This will allow for its further processing without the need for special measures. Thus, it is assumed that the end result is achieved in the face of a product that can be used as a soil improver.

2. Study area, methods and materials

Used raw materials and waste

As the main raw material resource, bird waste from the Big Dutchman system, adopted by ET "Valentin Georgiev – VALDIS" in the cultivation of stock carriers, provides the opportunity to provide sufficient area for each bird and is of utmost importance for its health and general condition. The poultry farm is located outside urbanized areas and quiet areas. The activity of the company is carried out on the territory of Kyustendil Municipality in the village of Shishkovtsi, which is located about 9 km north of the town. Kyustendil. The poultry farm is remote from the residential area of the village and they are not reached by intensely smelling substances inherent in this type of activity.

The operator holds complex permit No 313-H0-A0/2008, updated by Decision No 313-H0-A1/2015. According to the Annual

Environment Report (EDS) 2017. [7] The operator has declared an annual capacity of 70 536 bred birds. Production halls are cleaned twice a week and the formed waste – poultry manure is handed over to the population for fertilization of agricultural land. If temporary storage is necessary, the bird manure shall be stored on a separate site. A total of 584 tonnes of bird manure was formed on the site in the past year. For the purpose of research, fresh poultry waste shall be used. As the first basic approach for the effectiveness of the application of the method is to reduce the content of the content so as to avoid pollution of water, soil and ambient air. Wood ash obtained in the processing of pulp wood in "Svilosa-AD" is also used. As a result of the organized incineration of wood waste [8] wood ash is generated in an amount of about 10 000 tonnes per year. Wood ash contains all mineral nutrients that are not volatile in the thermal combustion process. They are in the same proportions as elements as they were in the structure of the wood mass used for combustion, from which they are suitable for improving soil structure and reservistity [9,10].

Materials

***Development of soil improvers*.** To achieve the objectives of this study, two mixtures of with different content of poultry litter and wood ash were prepared:

Mixture 1.1 - Poultry excrement: Wood ash: Sulphur acid (9:1:1)

Mixture 5.1 - Poultry excrement: Wood ash (1:1)

After complete homogenization of the mixtures, they are granulated by an extruder. The developed soil enhancers are characterized by Optical emission spectrometry with inductively coupled plasma High Dispersion ICP-OES Prodigy. The selected waste and other raw materials have been found to have a structure and composition which identifies them as carriers of basic and micro-nutrients, without overweight heavy and toxic elements, allowing them to be classified as suitable components for obtaining soil improver [11];

Vegetation experiment (VE). To evaluate the effectiveness of the application of the created soil improvers, a vegetation experiment was conducted.

Pepper in our country is grown in all areas of the country. 63,982 tonnes in total per year in Bulgaria is extracted pepper with an average yield of 18 726 kg/ha [12]

Pepper is selected, which representative belongs to the species Capsicumannuum from the sem. Solanaceae subspecies of large-fruited pepper Capsicumannuumsubsp.macrocarpum, variety type capies - Gold medal 7. [13].

Seed sowing and plant care

The seeds are flat, rounded kidney, smooth, glossy, light yellow to intensely yellow. Pure variety seeds Gold Medal 7, of the same size, are selected. They are disinfected with a 70% alcohol solution and then very well washed with water.

Sprouted seeds are sown at a depth of 2 cm in polyethylene buckets containing 0,5 kg of soil. After germination, two plants are left in the vessels in each bucket. They are watered every day and are kept at a constant temperature of 20 ^{0}C. The nursery period for early Polish production is 85 days. After this period, the plants are grafted to continue vascular trials.

3. Results

Soil production for sowing

The soil is treated at 30-32 cm deep, well homogenized, dried and sifted through a sieve of 2 mm and a chemical analysis has been carried out. The soil is mixed with quartz sand in a ratio soil: sand 25:100. A lack of heavy metals above the limit concentrations and insufficient nutrients in the soil itself have been found. Mixing with the sand is done to mimic poor soil, with measured pH = 7.2.

Loading of vascular experiments.

For the vegetation experiments, plastic containers measuring h= 140 mm x d=166 mm were used. In each container is placed in an equal amount of soil - 1 kg. (1.1s and 5.1s) Each mixture is placed 50 g in a container. The control without improver a code 0 was also planted.

Vegetation experiment

In the initial period, pepper has slow growth. It sprouts for 7-8 days. Until the formation of the first actual leaves pass 25-30 days. The entire seeding period is 85 days, after which they undergo vegetation vascular trials and are grafted into poor soil. The variety has a long growing season of about 65 days. Pepper plants bloom throughout the growing season. The formation of fruits strongly decreases when the first fruits are not picked in a timely manner. For the purposes of vegetation experiments, pepper has not been torn off in a timely manner. The duration of the vegetation tests shall cover 100 days and shall include the fertility period. In the process of taxonomy, diameter and height of the stem, total number of leaves and flowers, number and size of fruits were observed and measured. The recording of the parameters is carried out by direct observations and direct weekly measurements. Further data processing was carried out on the basis of a comparison of the reported taxonomic data, with the results averaging from the three vessels for each sample [14].

Botanical feature of the leaf mass

The leaves are simple, with handles. The leafy petura in shape is elliptical to a lancet and with a pointed tip. The leaves are located individually. The following Figures 1 and 2 show the evolution of the leaf mass during the 100 days of vegetation development, with a summary picture of powder and tablet form for each mixture compared to the zero sample, which is the control for the development of the leaf mass.

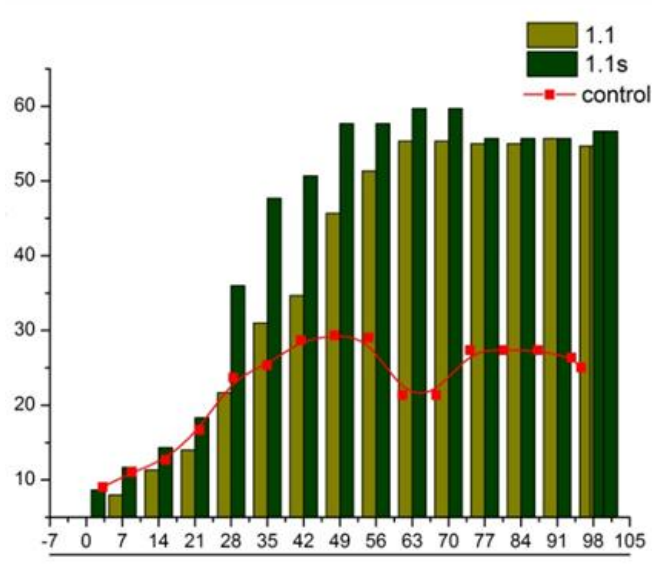


Fig. 1 *Development of leaf mass in powder and tablet form of a mixture 1.1 X - days, Y- number of leaf mass*

In mixture 1.1 from the beginning, the leaf mass in plantations nourished with powder form develops faster, and from the 28th to the 70th day this is the most intense, then equalizes with the leaf mass of the plants nourished their tablet form. The leaves are light green and withstand high and low temperatures for the season At a mixture of 5.1 to the 28th day, the two forms of the mixture move in the same range of leafing, with a slight preponderance of the tablet shape. The leaves are the same colour as in the 1.1 mixture, but have a greater sensitivity to temperature changes and at the end of the growing season there is less leaf mass than 1.1.

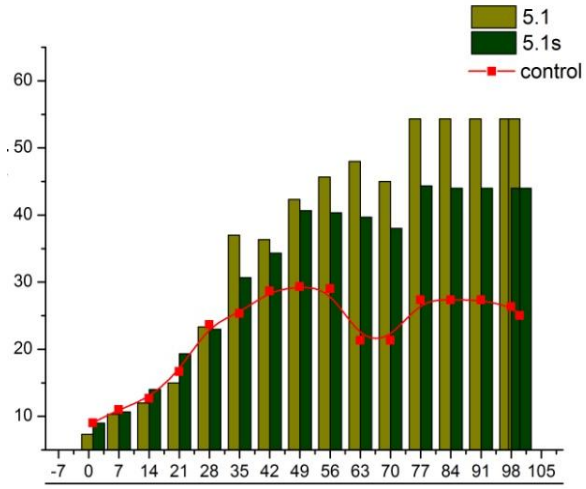
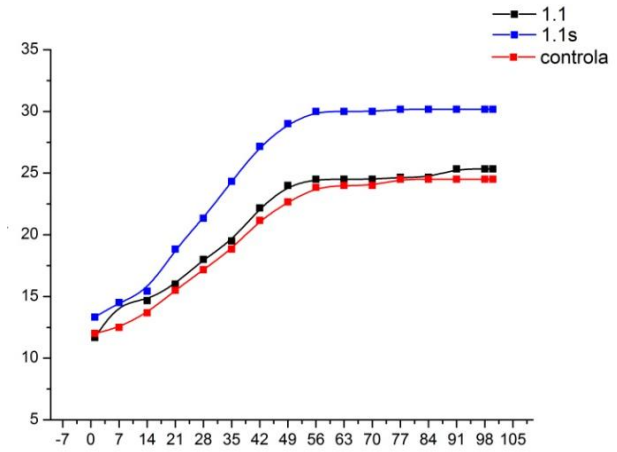


Fig.2 *Development of leaf mass in powder and tablet form of a mixture 5.1 X - days, Y- number of leaf mass*

Botanical feature of the stem mass

The stem was originally herbaceous. As vegetation progresses, its lower part gradually stiffens. It is healthy and sustainable. It remains upright and after a load of fruit. The stem branches after the first dozen leaves. Forms between two or four main branches. Each branch forms two new ones, which are different in length and thickness. Stronger branches form the main axes of the plant. Until the first branching from the pavement buds of the leaves do not grow side branches.

The following figures (3 and 4) illustrate the development of the stem mass in height and thickness of the stem. During the 100 days of vegetation development, a summary picture of powder and tablet form was taken for each mixture, compared to the zero sample, which is the control for the development of plants



Фиг.3 *Height of stem mass (in mm) of powder and tablet form of mixture 1.1. Coordinate X - number of leaf mass, Y - days*

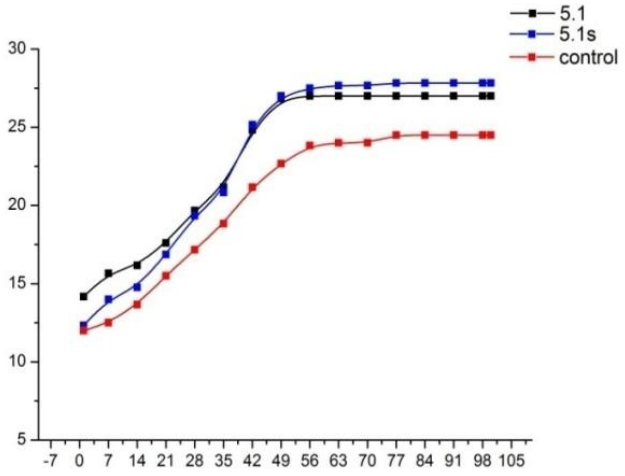


Fig. 4 *Height of stem mass (in mm) of powder and tablet form of mixture 5.1. Coordinate X - number of leaf mass, Y - days*

The height of the stem varies from 25 to 31 cm and the height of the stem of the control is 24 cm. In mixtures 1.1, there is a significant difference in the growth of the stem mass depending on the shape of the imported nourishing substances, with a higher growth of the stem in the powder form. At 5.1, a significant difference in growth between the two forms was not observed. Depending on the angle at which the branches come out, plants with a tucked or scattered habitat are formed. In the conducted experience, all plants have a sprawling habitat. The thickness of the stem is about 6 mm.

Botanical feature of the root system

The root system is bearded. The main root is short and strongly branched. The main part of the roots are located at a depth of 140 mm and a width of 116 mm in diameter around the plant.

With the relatively shallowly located root system can explain the great requirements of this plant to the mechanical composition of the soil, its humidity and nutrient content. In sample 1.1 in both forms of nourishment, the root system is highly developed, as in the tablet form the granules are woven into the root system and are whole. Mixture 5.1 also has a very robust and highly developed root system with tightly woven tablets in them.

Botanical characteristic of colors and fruits

The experiment at lasted 45 days. At the end of the experiment, there were no surviving plants in the control samples. Data tracking plant development are summarized in **Table 1**.



Fig.6. *Taxonomy, 100th day – control sample*

***Table 1**. Plant development*

Days	Control	1.1	1.1s	5.1	5.1s
1	1 bud		2 buds	0.6 buds	2 buds
7	2.6 buds	2.3 buds	3 buds	2.6 buds	3 buds
14	3 buds	3.3 buds	3.6 buds 2 colors	3.3 buds	2 buds
21.	1.5 buds 2 colors	4.3 buds 1.3 colors	5.3 buds 5.3 buds	6 buds	3.3 buds 2 colors
28	1.5 buds 2.5 colors	7 buds 2 colors	4 buds 6 colors 1 small fruit	7 buds 3.6 colors	5.3 buds 2 colors
35.	3 colors 1 small fruit	5.6 buds 5 colors	3.6 buds 7 colors 1 fruit-4 cm	5.3 buds 4.3 colors	3.6 buds 3.6 colors
42	3.6 colors 1 fruit – 3 cm	8 buds 6.6 colors 1 fruit – 1.4 cm	1 bud 3.6 colors 1 fruit-7.6 cm	4 buds 7.3 colors	5 colors 1 fruit - 6 cm
49	1 fruit – 4 cm	6.6 colors 4 buds 1 fruit – 2.5 cm	1 fruit-4 cm 1 fruit-9.5 cm	3 buds 8.3 colors	3 colors 1 fruit – 7.7 cm
56	1 fruit – 5 cm	1.6 colors 1 fruit –5.2 cm	1 fruit-4.5 cm 1 fruit-10.8 cm	7.6 colors 1 fruit	1 fruit – 9.8 cm
63	1 fruit – 5.5 cm	1 color 1 small fruit 1 fruit–7.4 cm	1 fruit-5 cm 1 fruit-11.2 cm	8 colors 1 fruit – 5.5 cm	1 fruit – 10.3 cm
70.	1 fruit – 7.3 cm	1 color 1 small fruit 1 fruit–8 cm	1 fruit-5.3 cm 1 fruit-11.8 cm	2.3 colors 1 fruit – 7.3 cm	1 fruit – 11.3 cm
77.	1 fruit – 7.3cm	1 color small fruit fruit–9.3 cm	4 buds 6 colors 1 small fruit	1 fruit – 8 cm	1 fruit – 11.5 cm
84.	1 fruit – 8 cm	1 color small fruit fruit–9.8 cm	fruit-5.5 cm fruit-12.3 cm	1 fruit – 9.5 cm	1 fruit – 11.5 cm
91.	1 fruit – 8 cm	1 color small fruit fruit–10.3 cm	fruit-5.5 cm fruit-12.6 cm	fruit – 10 cm	fruit – 12 cm
98	1 fruit – 8.5 cm	1 color small fruit fruit–10.5 cm	fruit-5.5 cm fruit-13.4 cm	fruit – 10 cm	fruit – 12 cm

In the process of growth in the first week of vegetative trials, the presence of first buds in the control and mixture 5.1 was noted. in the second week all mixtures have almost leveled amounts of buds as in the 21st day. Over the next week, taxonomy results are again leveled for all mixtures. Between the 49th and 56th days, all mixtures are already indicated in the process of fruit formation. The growth of the control over the others is slower, with mixtures of 5.1 when the fruits are fully ripened, the pepper sizes of 8 to 13.4 cm are reached at 1.1s. Figures 5 and 6 show the final results of the vegetation experiment of the zero sample and mixture 1.1



***Fig.5** Taxonomy, 100th day - mixture 1.1 respectively tablet (right) and powder (left) form*

Conclusion

From the taxonomic measurements carried out at the end of the vegetation experiments for each plant, the indicators for the stem and leaf mass, the root system and the fruit were determined. The results of the study prove the ability to use soil improvers, good resistance of the leaves to sudden intense changes in climatic conditions. The root systems of all mixtures are well developed and strong, stable with good agrochemical parameters compared to that of the zero sample.

4. References

1. BANSIK 2019: MAFF, **№ 367** (2019)
2. National Strategy for Sustainable Development of Agriculture in Bulgaria in the period 2014 – 2020 г.
3. D. Kostadinova, D. Dermendjieva, R. Stefanova, Animal Sciences, **LII, 3**, 42-53, (2015)
4. J. Chastain, J. Camberato, P. Skewes, *Chapter 3b in: Confined Animal Manure Managers Certification Program Manual B Poultry Version*, CHAPTER 3b,**2**, (2001)
5. Agrostatistics. Poultry farming in Bulgaria in 2019 MAFF № **370**, (2020)
6. Commission Implementing Decision (EU) 2017/302 of 15 February 2017
7. Annual Environmental Report 2017г, (2018)
8. M. Cieplik, B. Coda, H. Boerrigter, A. van der Drift and J. H. A. Kiel, ECN, Petten, ECN-C-04-016 (2004).;
9. A. Al-Otoom, L. Elliott, B. Moghtaderi, T. Wall, , Fuel, 84(**1**), 109-114, (2005)
10. T. Kuba, A. Tscholl, C. Partl, K. Meyer, H. Insam, Ecosys. and Env., **127**, 43–49, (2008)
11. E. Serafimova, V. Petkova, *Bulgarian Chemical Communication, Proceeding of the VII th National Crystallographic Symposium*, **5**, 15-22, (2018)
12. MAFF, Vegetable Production, (2019)
13. V. Dimov, *IX National Thematic Seminar – Agriculture and Everything about it*, (2003)
14. S. Tandy, J. Healey, M. Nason, J. Williamson, D. Jones, S. Thain., Biores. Tech. **101,** 5431–5436, (2010)

Water - yield relationships of lettuce plants for different irrigation strategies

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Abstract: *The greatest fresh water user sector is agriculture worldwide. The optimum utilization of current water supplies is necessarily prerequisites particularly in water poor climates. It is almost impossible to obtain economical crop yield without irrigation in those types of environments. In general, vegetables are high water consuming crops and well responses to the adequate soil moisture levels in rooting depths. Correct irrigation program is vital important for reaching target optimal production. The present study aimed to analyze irrigation programs affect on yield and water use efficiency, WUE, of lettuce plant for different growing conditions. In accordance of previous studies, maximum yield was obtained from full irrigation treatment. Lettuce plants were not tolerant wide irrigation intervals e.g. 2 or 3-day ideal for optimal yield and quality. Evapotranspiration, ETc, was highly dependent on lettuce varieties, availability of soil moisture content in root systems as well as climatological factors, and ranged between 413 mm and 208 mm. The planting geometry also had effect on lettuce yield. The irrigation system is important, but the most important issue is proper water management for enhancing crop production. Use of sprinkler or drip irrigation system should be highly recommended for better yield, quality as well as efficient water usages or water savings in vegetable farming under correct irrigation program.*

KEYWORDS*: LETTUCE PLANT, IRRIGATION SYSTEM, AGRO - WATER MANAGEMENT.*

1.Introduction

Lettuce, well adapted to cool ecology, is one of the most used items at salad as well as widely growing plant due to better economy for farmers [1]. It is known as high water consuming plant and has positive response to sandy loam or clay loam soil as well as well drainage condition. The head yield of lettuce varies from 30 to 40 t/ha depending on the lettuce variety and agricultural practices as well as growing ecologies [2]. Vegetables as well as fruits are rich of mineral matters and vitamins whereas they have low energy content. Therefore, they are very important role to play for human health. The balanced consumption of those may result reductions in risks of heart and vessel diseases, hypertension, and problems relevant to digestive systems as well as chronic diseases [3]. Water and fertilizer are two important components to achieve maximum yield. Drip irrigation having high water productivity has produced better lettuce yield under well management. The reason behind that such irrigation system results optimal water status within root systems via frequent and light water applications, consequently high and qualified lettuce yield [4-5]. Water and energy efficiencies as well as crop yield can be improved noticeable under pressurized irrigation methods such as sprinkler or drip with well agricultural water management [6]. Irrigation is very important role to play in increasing crop yield in water shortage areas. Agriculture is plenty freshwater user sector so water saving should be started at irrigation in first [1, 7, 8] and increasing water use efficiency, WUE, is the main strategy particularly at water limited environments [9-10]. In irrigation program, proper estimation of crop coefficient, kc, is very important, and under well-moisture status, kc values of lettuce may be as 0.7, 1.0 and 0.95 for initial, mid-season and end of late season, respectively [11-12].

The main aim of present study is to assess influence of irrigation water management on yield and water productivity of lettuce for different environments.

2. Material and Methods

In this paper, yield, some yield components and WUE values were obtained from literatures relevant to the lettuce irrigation researches performed at different growing ecologies. The findings of those studies were analyzed, and then practical solutions for better lettuce production were presented.

3. Results of the previous studies and discussion

a) In first study, lettuce (cv Royal) yield and WUE were researched under different irrigation regimes at Bekaa Valley, Lebanon [13]. The soil of research had 170 mm/m available water capacity, AWC, with 1.41 g/cm^3 bulk density. The irrigation was based on 30% depletion of AWC in soil depth of 0-90 cm. Evapotranspiration was determined by using both lysimeter, placed on center of the experimental field, as well as water budget equation. Irrigation regimes were I-100 (100% replenishment of soil water depletion), I-80 (80% of applied water of I-100), and I-60 (60% of applied water of I-100). Soil moisture monitoring was made by gravimetric method.

In results, ETc values for 70-day growing season, from planting to harvest, were found as 433 mm for lysimeter and 413 mm for I-100 treatment by water budget equation. ETc values obtained from the water budget equation were determined as 375 mm and 337 mm for I-80 and I-60 treatments, respectively. ETc finding from present study is higher than report of Santosh *et al.* [14].

The WUE values for I-100, I-80 and I-60 were calculated as 17.7, 13.7, and 13.4 kg/ha/mm, respectively. The difference of WUE between lysimeter and control treatment of I-100 was found not significant. The WUE value of present study is higher than findings of winter and summer growing season, but lower than the fall growing season by report of da silva *et al.* [15].

The yield of lettuce for lysimeter, I-100, I-80, and I-60 treatments were as 7.7, 7.3, 5.1, and 4.5 t/dry matter/ha, respectively. There was little difference between lysimeter and I-100 treatment. The study clearly showed that lettuce plant is highly sensitive to the water deficiency so deficit irrigation has resulted yield difference e.g. although 20% deficit irrigation applied to the I-80 treatment, the yield reduction was more than 30% in that irrigation program by comparison to I-100 (full-irrigation) treatment.

b) In second study, effects of different irrigation and nitrogen regimes on yield and yield components of drip-irrigated lettuce (*Lactuca sativa* var. longifolia) were researched under glasshouse condition at Konya, Turkey [5]. In such study, irrigation regimes were amount of water depth of 100% evaporation from Class A Pan (I1), 80% of I1 (I2), and 60% of I1 (I3). Four nitrogen levels were 0 (N1), 100 (N2), 200 (N3) and 300 kg N /ha (N4).

In results, head weights were 355 g, 340 g, and 338 g for I1, I2, and I3 treatments, respectively. The marketable head weights were found as 335 g, 322 g, and 308 g for I1, I2, and I3 treatments, respectively (Table 1). Different irrigation regimes as well as N doses had no significant differences in both yield and yield components of lettuce plant. In that case, it is obvious that I3 treatment can be highly recommended in areas having water shortage regions such as Konya Closed Basin of Turkey for irrigation of more areas with current water supplies. In addition, low N level is suggested to avoid contamination of groundwater supplies, and N saving since groundwater has used intensively during irrigation season in Konya plain.

c) In third study, irrigation, nitrogen and planting geometry effects on yield of drip-irrigated lettuce was examined at New Delhi, India during the growing seasons (October-February) of 2008-2009 and 2009-2010 under Sandy Clay Loam (SCL) with bulk density of 1.58

g/cm^3 [16]. Two irrigation intervals namely 2-day (I1) and 4-day (I2); two nitrogen doses namely 60 kg N/ ha (N1) and 100 kg N/ha (N2) and three different plant geometries namely 45 x 30 cm (row spacing cm x plant spacing cm) (P1), 30 x 30 cm (P2), and 17.5x30 cm (P3) were studied. In results, I1 produced maximum yield as about 34 t/ha and 31 t/ha for first and second growing year, respectively (Table 2). N2 had the highest yield as about 32 t/ha and 27 t/ha for those growing years, respectively. P3 was found superior in accordance of yield over other plant geometries of P1 and P2. As expected from the table 2, I1N2P3 combination led to maximal yield for both growing seasons. As a result, 2-day irrigation interval, 100 kg N/ ha and 17.5x30 cm planting arrangement produced the greatest yield. The yield obtained from current study is inline with Santosh *et al.* [14] as about 32 t/ha, and as about 30 t/ha of da Silva *et al.* [15] for fall growing season.

d) In fourth study, different irrigation levels affect on yield and some yield parameters of drip irrigated-lettuce plant growing at plastic house and under field conditions were idenfified during the periods November-February of 2014 – 2015 and 2015-2016 growing season at Khangpur, India [14].

The irrigation regimes were based on the crop water requirement, CWR, as follows;

I1- Application of 120% of CWR within plastic house
I2- Application of 100% of CWR within plastic house
I3- Application of 80% of CWR within plastic house
I4- Application of 60% of CWR within plastic house
I5- Application of 1000% of CWR at outside plastic house (open field environment).

In results, maximum plant height as 36.3 cm was obtained from I2 treatment whereas the lowest one as 26.1 mm from I-5 treatment (Table 3). The finding is almost full agreement with result of Acar *et al.* [5] since they found that value around 30 cm. The greatest head diameter was found as 13.3 cm and 13.5 cm from I1 and I2 treatments, respectively.

The leaf number per plant was about average 30 for growing plastic house condition. This value is lower than the report of Acar *et al.* [5] since they found as about 42 depending on the irrigation regimes. The reason behind producing better leaf number could be differences in variety, cultural practices, and management of water and N doses as well as mainly environmental conditions.

The highest yield was found in I2 treatment as about 36 t/ha. Among treatments, I5 resulted minimum values in all examined parameters. The seasonal water requirements of lettuce for plastic house and open field conditions were determined as 219 mm and 339 mm, respectively. Growing lettuce in plastic house was more favorable over open fields due to the possibly better environmental control in protected environments.

e) In fifth study, effects of growing seasons of winter, summer and autumn on yield, ETc and WUE of micro-sprinkler irrigated three lettuce varieties were researched at Brazil [15]. The lettuce cultivars were planted 40 cm apart between rows and plants. The micro-sprinkler had 60 L/h discharge rate. Irrigation was performed twice a day.

Autumn growing resulted better yield comparison to winter and summer growing e.g yields for winter, summer and autumn seasons were about 20, 13 and 41 t/ha at Curly lettuce variety (Table 4). The lowest yield was obtained from Red variety in whole growing seasons. The average yield of combined three varieties for fall growing season is around 30 t/ha and is agreement with some reports [16, 14].

The maximum and minimum ETc values were determined from summer growing season as 208 mm and from winter growing season as 125 mm. The kc values for entire, initial, middle and final stages were found as 0.82, 0.80, 1.07, and 0.70, respectively.

Autumn growing season produced maximum WUE in all lettuce verities. In such growing season, curly variety had greatest WUE as 28.5 kg/ha/mm (Table 5). Autumn is favorable for ideal lettuce growing in tropical environment like Brazil. The WUE values of this present study relevant to winter and summer growing seasons are lower, but higher in fall growing season than results of Karam *et al.* [13].

f) In sixth study, 4 levels of N levels, as Control (N0: no Nitrogen application), 25 (N25), 50 (N50), and 100% (N100) of the ideal crop N requirement and 4 levels of irrigation, as Control (I0: no irrigation), 25 (I25), 50 (I50), and 100% (I100) of crop water needed were researched to determine response of drip irrigated-lettuce (*Lactuca sativa* L. var. longifolia) at Pomona, California during the periods fall 2017 and spring 2018 [17].

In general, biomass yield was found higher in 2018-spring growing condition (Table 6). The maximum biomass yields were obtained from treatments of I100 as 3632 kg/ha and N100 as 2763 kg/ha in spring growth period. In accordance of yield value, spring growing is favorable for lettuce farming.

However, the maximum WUE was found as 7.46 kg DM/m^2 from I25 treatment at fall growing season. Among the irrigation treatments, the highest nitrogen use efficiency, NUE, was calculated as 38 kg DM / kg N from the spring growing condition. In N treatments, the maximum NUE was found as 57 kg DM / kg N from spring growing. In study, I100N100 had resulted higher lettuce yield and I50N25 resulted maximum WUE and NUE in both research seasons. In better water saving at water shortage regions such as California, and avoid contamination of groundwater resources via more N applications in agriculture, I50N25 combination can be highly recommended for lettuce farming.

g) In this seventh field study, irrigation intervals of 1 (I1), 2 (I2), 3 (I3) and 4-day (I4) affect on yield and WUE were investigated for drip irrigated lettuce plant (*Lactuca sativa* L.) at King of Estawani under soil condition of sandy-loam [18]. In results, I3 treatment gave the highest mean fresh weight of 319 g/plant whereas I4 (stressful treatment) resulted minimum as 155 g/plant. Similarly the maximum and minimum mean dry weights of 17.4 g/plant and 8.8 g/plant were recorded from the I3 and I4 treatments, respectively.

The applied water was found the highest as 304 mm in I1 treatment whereas the lowest at I4 treatment as 64 mm (Table 7). WUE was found as maximum at treatment of I3 as about 3.9 g/mm. As a result, although applied water was 82 mm at I3 treatment, it produced greatest mean fresh weight, mean dry weight as well as WUE of 3.89 g/mm. I3, three-day irrigation interval, treatment could be resulted better income for farmers producing lettuce under field condition as well as greater water saving due to the less amount of water use or higher WUE.

4. Conclusion

Proper selections of lettuce variety, growing season with environments are very important role to play for improving lettuce yield. In general, full irrigation has resulted maximum lettuce yield so it can be recommended. Beside those, irrigation interval is very important for ideal lettuce growing consequently better yield and quality. In the light of the this assessment, 2 or maximum 3-day irrigation interval is highly recommended since greater than 3-day e.g. 4-day or over may cause great yield and quality reductions due to the occurrence water stress through root systems. Sprinkler and drip irrigation systems are well adapted to the lettuce irrigation. They are also very water productive technologies and have resulted high irrigation efficiency under correct management. Therefore, utilization of those irrigation techniques should be improved for putting more areas into lettuce production.

Table 1. *Irrigation regimes affect on yield and yield components of lettuce [5]*

Irrigation levels	Head weight (g/plant)	Marketable head weight (g/plant)	Leaf number per plant	Head height (cm)	Head diameter (cm)	Root length (cm)
I1	355	335	42	31	40	18
I2	340	322	40	30	45	18
I3	338	308	44	31	40	17
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS

NS: None significant

Table 2. *Drip-irrigated lettuce yield under different irrigation interval, N levels and planting designs [16]*

Treatments	**Lettuce Yield (t/ha)**	
	2008-2009	2009-2010
I1	34.4	31.3
I2	27.5	25.1
N1	29.5	24.7
N2	32.4	27.1
P1	26.5	21.9
P2	29.3	24.5
P3	37.0	31.3
I1N1P1	28.1	25.3
I1N1P2	31.0	28.2
I1N1P3	39.2	36.0
I1N2P1	30.9	27.8
I1N2P2	34.1	31.0
I1N2P3	**43.1**	**39.6**
I2N1P1	22.4	20.2
I2N1P2	24.8	22.6
I2N1P3	31.3	28.8
I2N2P1	24.7	22.2
I2N2P2	27.3	24.8
I2N2P3	34.5	31.7

Table 3*. Yield and yield components of lettuce for combine 2-year [14]*

Irrigation Levels	Plant height (cm)	Head diameter (cm)	Leaf number per plant	Leaf fresh weight (g/plant)	Leaf dry weight (g/plant)	Yield (t/ha)
I1	32.1	13.3	30.4	400	35.6	31.7
I2	36.3	13.59	31.8	409	38.2	35.7
I3	31.8	11.2	28.5	357	28.7	29.5
I4	30.3	10.4	25.7	332	26.4	26.4
I5	26.1	9.8	22.5	298	23.7	18.2

Table 4. *Lettuce yields in accordance of varieties and growing seasons [15]*

Lettuce cultivars	Yield (t/ha)		
	Winter	Summer	Autumn
Looseleaf	11.6	18.5	22.1
Curly	19.7	13.4	40.7
Red	8.0	7.5	27.1

Table 5. *ETc and WUE of lettuce depending on variety and growing season [15]*

Growing period	ETc (mm)	WUE (kg/ha/mm)		
		Looseleaf	Curly	Red
Winter	125	9.3	15.8	6.4
Summer	208	8.9	6.4	3.6
Autumn	143	15.5	28.5	19.0

Table 6. *Irrigation and N levels affect on yield, Water Use Efficiency, WUE, and Nitrogen Use Efficiency, NUE [17]*

Treatments	Biomass (kg/ha)		WUE (kg DM/m^2)		NUE (kg DM/ kg N)	
	2017-Fall	2018-Spring	2017-Fall	2018-Spring	2017-Fall	2018-Spring
I0	1274	1117	0.00	0.00	13.20	13
I25	1606	1869	7.46	4.71	15.94	20
I50	1854	3114	4.29	3.95	20.10	33

I100	2120	3632	2.45	2.24	22.07	38
N0	1525	1968	4.60	3.58	0.00	0
N25	1628	2388	5.00	4.27	38.77	57
N50	1770	2613	5.43	4.85	21.06	31
N100	1932	2763	5.81	5.23	11.50	17

Table 7. *The irrigation interval-yield and WUE relationships [18]*

Irrigation Interval	Mean Fresh Weight (g/plant)	Mean dry weight (g/plant)	Applied water (mm)	WUE (g/mm)
I1	239	13.4	304	0.79
I2	266	13.4	147	1.81
I3	319	17.4	82	3.89
I4	155	8.8	64	2.40

5. References

[1] Acharya SK., Shukla YR., Khatik PC. Effect of water regime on growth and yield of lettuce (*Lactuca sativa* L.). The Biascan. 2013. Vol. 8, No. 1. P. 201-206.

[2] Denli N. Marul Yetiştiriciliği. 2015. T.C Gıda, Tarım ve Hayvancılık Bakanlığı, Tarımsal Araştırmalar ve Politikalar Genel Müdürliğü, Alata Bahçe Kültürleri Araştırma Enstitüsü, Erdemli-Mersin (In Turkish).

[3] Sezgin AC. Fruit, Vegetable and our health. Journal of Tourism and Gastronomy Studies. 2014. P. 46-51 (In Turkish).

[4] Yurtseven E., Bozkurt DO. Effects of irrigation water quality and soil moisture content on crop yield and quality of lettuce. Tarım Bilimleri Dergisi. 1997. Vol.3, No. 2. P. 44-51 (In Turkish).

[5] Acar B., Paksoy M., Türkmen Ö., Seymen M. Irrigation and nitrogen level affect lettuce yield in greenhouse condition. African Journal of Biotechnology. 2008. Vol.7, No. 24. P. 4450-4453

[6] Yavuz D., Yavuz N., Suheri S. Energy and water use for drip-irrigated potato in the Middle Anatolian region of Turkey. Environmental Progress & Sustainable Energy. 2016. 35. P. 212-220.

[7] Yavuz D., Yavuz N., Seymen M., Türkmen Ö. Evapotranspiration, crop coefficient and seed yield of drip irrigated pumpkin under semi-arid conditions. Scientia Horticulturae. 2015a. 97. P. 33-40.

[8] Yavuz D., Seymen M., Yavuz N., Turkmen Ö.. Effects of irrigation interval and quantity on the yield and quality of confectionary pumpkin grown under field conditions. Agricultural Water Management. 2015b. 159. P. 290-298.

[9] Alkhader AMF., Abu Rayyan AM. Improving water use efficiency of lettuce (*Lactuca sativa* L.) using phosphorus fertilizers. Springer Plus. 2013. Vol. 2. P. 1-8.

[10] Yavuz N., Çiftçi N., Yavuz D. Effects of different irrigation interval and plant-pan coefficient applications on yield and quality parameters of oil sunflower grown in semi-arid climate conditions. Arabian Journal of Geoscienses. 2019. https//doi.org/10.1007/s12517-019-4867-1

[11] Anonymous. Crop Coefficient For Use in Irrigation Scheduling. 2001. Water Conservation Factsheet, British Columbia, Ministry of Agriculture, Food and Fisheries, P. 6.

[12] Allen RG., Pereira LS., Raes D., Smith M. FAO Irrigation and Drainage Paper No. 56: Crop Evapotranspiration (Guidelines for computing crop water requirements), 2006. FAO, Rome, 300 (9), D05109.

[13] Karam F., Mounzer D., Sarkis F., Lahoud R. Yield and nitrogen efficiency of lettuce under different irrigation regimes. J. Appl. Hort. 2002. Vol. 4, No. 2. P. 70-76.

[14] Santosh DT., Reddy RG., Tiwari KN. Effect of drip irrigation levels on yield of lettuce under polyhouse and open field condition. Int. J. Curr., Microbiol.,App., Sci., 2017. Vol. 6, No. 7. P. 1210-1220.

[15] da Silva VPR., Tavares AL., Sousa TIF., da Silva TGF., de Holanda RM., de Souza EP., da Silva BB., Braga CC., Almeida RSR. Evapotranspiration, water use efficiency and cropcoefficient of three lettuce varieties grown in a tropical region. Revista de Ciencius Agrerias. 2018. Vol. 41, No. 8. P. 798-805

[16] Patil T., Singh M., Khanna M., Singh DK., Hasan M. Response of lettuce (*Lactuca sativa* L.) to trickle irrigation under different irrigation intervals, N application rate and crop geometry. Ind. Jn. Of Agri. Econ. 2013. Vol. 68, No. 4. P. 573-582.

[17] Ansari M. Role of irrigation and nitrogen fertilizer stress on lettuce growth and development in precision agricultural system. 2018. MSc thesis, Faculty of California State Polytechnique University, Pomona, P. 68.

[18] Dlamini MV., Zwaine S. The effects of regulated deficit irrigation on the growth and yield of lettuce (*Lactuca sativa* L.) grown in the Malkerns Area, a region in the Kingdom of Estewani (Southern Africa). Asian Journal of Advances in Agricultural Research, AJAAR. 2020. Vol. 12, No. 3. P. 1-7.

Study of the influence of the irrigation regime on the quantity and quality of tomatoes grown in plastic greenhouses

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Summary: *To establish the influence of the irrigation regime on the quantity and quality of tomatoes grown in plastic unheated greenhouses, research was conducted in the experimental field of the Pushkarov Institute in Chelopechene, Sofia. Different irrigation regimes have been tested, keeping from fully satisfying the needs of the crop from water to irrigation with a 20% reduction and a 20% increase in irrigation norms. The control variant is irrigated at 100% realization of the irrigation norm, calculated by (E0) evaporation from a free water surface by an evaporator class "A".*
It has been established that the reduction of the irrigation norm due to the limited water supply leads to a corresponding reduction of the yield, which is not proportional to the reduction of the irrigation norm.
The quality of the obtained production - tomatoes determined by the content of dry matter, vitamin "C" and total sugars deteriorates with increasing amount of irrigation rate.
KEY WORDS: *IRRIGATION REGIME, QUANTITY AND QUALITY OF YIELD, TOMATOES, PLASTIC UNHEATED GREENHOUSES*.

Introduction

In an area of non-traditional cultivation of vegetable crops in unheated plastic greenhouses, such as Sofia, research on irrigation regimes remains relevant given the changes in climatic factors. The existing shortage of irrigation water and the rising cost of water irrigation technology in which water is used more efficiently. Its application in cultivation facilities, in which the values of the climatic factors change, requires the establishment of the values of the elements of the irrigation regime of the cultivated crops.
Studies of [1,8] prove that irrigation, as an element of agricultural technology has a significant impact on yields and quality of vegetable products. According to [8], increasing the size of the irrigation rate adversely affects the quality of yields. In their studies of [3,7] they prove that insufficient as well as excess irrigation leads to a reduction in yield and a decrease in the quality of production.
For their normal development and fruiting it is necessary for the soil moisture to be over 85% of the field capacity [6,9]. The best results in terms of water use by plants are obtained with drip irrigation. This method fully meets the requirements for sustainable agriculture and organic fruit production, incl. ensures high yields and product quality and reduces unwanted side effects, [2].

The aim of the study is to establish the influence of the irrigation regime on the quantity and quality of the yield from tomatoes grown in plastic unheated greenhouses under drip irrigation.

Material and method

The studies for establishing the influence of the irrigation regime on the yields and the quality of the yield of tomatoes grown in plastic greenhouses were conducted in the period 1988-1990 in the experimental field of the Pushkarov Institute in Chelopechene, Sofia region.
The following irrigation options were tested:
Pre-irrigation humidity - 85% of field capacity

- 120% realization of the water application rate / option 1 /;
- 100% realization of the water application rate/ option 2 /;
- 80% realization of the water application rate/ option 3 /;
- 100% E0 realization of the water application rate by evaporator class “A” / variant 4/.

The irrigation rate for evaporator class "A" is calculated by the formula:

$$m = E_0 \,.\, K_i$$

where: m is the magnitude of the water application rate in mm;
E_0 - evaporation by evaporator class "A" in mm;
K_i - biological coefficient of the culture (in the experiment Ki = l, 32).

The water application rates for the other variants are calculated according to the formula:

$$m = \left[10.H\,a.\ \left(ППВ - \delta_T пр.вл.\right)\right].K$$

where m is the magnitude of the irrigation rate, mm;
α - the bulk density of the soil in gr / cm3;
H - the depth of the active soil layer, m (in the experiment H = 0.5 m);
Field capacity - maximum field moisture content in% relative to the absolutely dry weight of the soil;
δт пр вл - pre-irrigation soil moisture in% compared to the absolutely dry weight of the soil;
K - the coefficient of reduction of the irrigation norm, taking into account the area occupied by the plants in 1 dka, in the experiment K = 0.67%, ie 67% of the area is irrigated.

In the case of drip irrigation, the amount of the entire irrigation rate is not given, as in the case of other irrigation methods. Reduction is required at the expense of the non-irrigated area. For this purpose, the formula of [5] was used, taking into account the planting scheme. After calculating the irrigation rate for option 2, the norms of the other options are established according to its size.

The experiment was performed on leached cinnamon forest soil, which is characterized by the following water-physical properties: field capacity - 20.2 relative to the absolute weight of the soil, bulk density at field capacity 1.54 g / cm^3 and permanent wilting point 10.38%, compared the weight of absolutely dry soil

Results and discussion

The results obtained from the experimental years are one-way, as the experiment was performed under controlled conditions, and the experimental years have similar meteorological conditions.

The data from the realized irrigations show that in order to maintain the soil moisture in the range between 85 - 100% of field capacity in large-fruited tomatoes 33 irrigations with an water application rate of 16.3 mm were realized, and in small-fruited 23 irrigations with an water application rate of 16.0 mm on average. for the research period, (Table 1).

The maximum irrigation norms in the period of the greatest water consumption can be given in 3 - 4 days and to satisfy the needs of the plants. At 1.5 atmospheres pressure they are realized in 2-3 hours.

The established irrigation norms can be used for the design of the irrigation network, and the irrigation norms for compiling the general water balance in the greenhouses.

Table 1. *Irrigation regime and yields of tomatoes on average for the period of study of the experimental field Chelopechene, Sofia*

Variants	Tomatos variety "Carmelo"					Tomatos variety "Balka"				
	N	m	M	Y	R%	N	m	M	Y	R%
120% M	33	19.8	653	12112	104	23	19.3	444	8971	108
100% M	33	16.3	537	11590	100	23	16.1	370	8289	100
80% M	33	13.2	435	10535	91	23	12,9	297	7934	96
100% M evaporator Class "A"	33	16.0	528	11038	97	23	15,9	366	7901	95

N - number of waterings; m- water application rate, mm; M - irrigation rate, mm; Y - total yield, kg / dka; R– relative yield,%.

The highest yield of tomatoes grown under soil and meteorological conditions for the Sofia field is formed in the variant with 120% realization of the Water application rate 12112 kg / dka. The variant with 100% Water application rate follows - 11590 kg / dka on average for the research period. The yields in the variant irrigated by evaporator class "A" are close to the yields obtained in the variant with 100% realization of the Water application rate . The increase of the Water application rate by 20% has led to a slight increase of the yields to 4%, and with the decrease of the Water application rate by 20%, the yield has decreased by 10% (Table 1, Fig. 1).

Studies in small-fruited tomatoes variety "Balka" show that the highest yields were also obtained in the variant with 120% realization of the Water application rate 8971 kg / dka, followed by the variant with 100% Water application rate 8285 kg / dka, on average for the period of research. The yields in the variant irrigated by evaporator class "A" are close to the yields obtained in the variant with 100% realization of the Water application rate . The increase of the Water application rate by 20% has led to increase of the yields up to 8%. 20%, the yield decreased by 5% (Table 1, Fig. 1).

The results obtained for both varieties of tomatoes show that the reduction of the irrigation rate due to the limited water supply leads to a corresponding reduction of the possible maximum yield, but not proportionally. In all cases, the reduction in the yield of tomatoes grown in unheated plastic greenhouses is not adequate to the reduction in the irrigation rate (Table 1).

In general, the implemented irrigation regimes have influenced both the size and the quality indicators of tomato yield.

The obtained results show that the higher water application rates create favorable conditions for the formation of high yields, but with a lower dry matter content. Their influence on the content of vitamin "C" and total sugars is similar, ie. the maintenance of high soil moisture leads to a decrease in the quality of the production, (Table 2, Table 3).

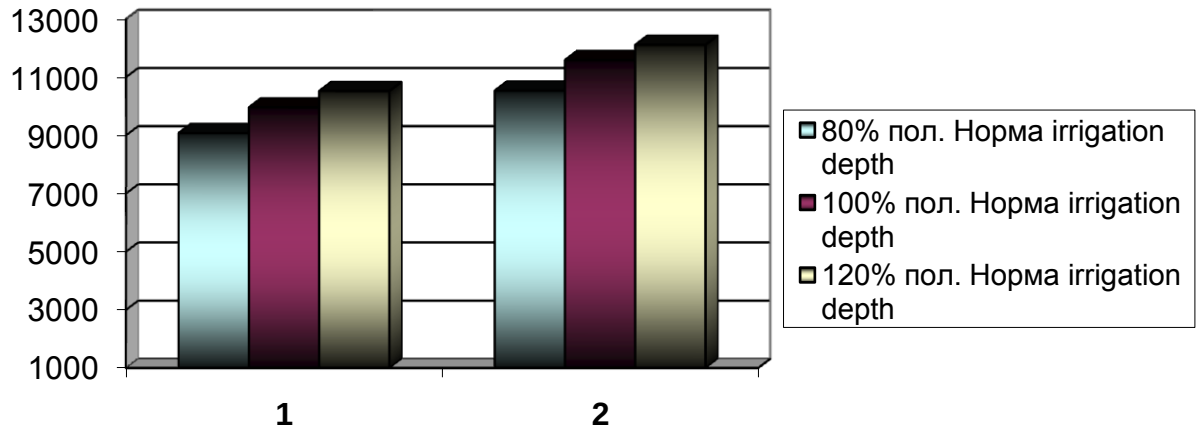


Fig.1 *Yield of tomatoes kg / dka:1 - tomatoes variety "Balka"; 2- tomatoes variety "Carmelo".*

Table 2: *Influence of the irrigation regime on the quality of the production of large-fruited tomatoes on average for the research period*

Variants	Quality of Carmelo variety tomato fruit		
	Absolute dry matter (%)	Vitamin C (mg%)	Total sugars (%)
120%M	5,28	13.88	4.56
100%M	5.54	15.50	5.01
80%M	5.94	16.90	5.36
100%M Evaporator class"A"	5.34	15.22	5.06

Table 3: *Influence of the irrigation regime on the quality of the production of small-fruited tomatoes on average for the research period*

variants	Quality of Balka variety tomato fruit		
	Absolute dry matter (%)	Vitamin „C" (mg %)	Total sugars (%)
120%M	13,7	13,7	**%**
100%M	15,0	15,0	4,3
80%M	16,0	16,0	4,8
100%M Evaporator class "A"	15,3	15.22	5,3

Conclusions from the study

It has been established that in order to obtain optimal yields of high quality for both varieties of tomatoes, it is recommended to maintain the soil moisture at 85 - 90% of the field capacity.

From the realized irrigation regimes the highest yield in both varieties of tomatoes, grown under soil meteorological conditions for the Sofia field is formed in the variant with 120% realization of the irrigation rate 12112 kg / dka (large-fruited) and 8971 kg / dka (small-fruited), followed from the variant with 100% irrigation rate 11590 kg / dka and 7934 kg / dka on average for the research period. However, the quality of the yield, expressed in terms of dry matter content, vitamin C and total sugars, deteriorates with increase in the irrigation rate.

It has been established that the reduction of the irrigation norm leads to a corresponding reduction of the yields. The reported decrease in yield for both varieties of tomatoes is not proportional to the decrease in the irrigation norm.

References

1. Veneyan S., On the irrigation norms and methods of irrigation of vegetable crops, Potato and Fruit Magazine, Moscow, 1971, issue 3, pp. 28-35

2. Bucks et al., 1982 Principles, Practices, and Potentialities of Trickle (Drip) Irrigation.

3. Gongarchuk NS, At. Mikov. News in vegetable production, Sofia, Zemizdat, Collection of reports, 1972, pp.56-65

4. Hillel et al., Advances in Irrigation 1, Academic Press, New York, 219-298

5.Freecman, B., Carzoli. Localized Irrigation. - FAO, 1980, Irrigation and Drainage, pp.36-43

6. Matev T., Irrigation of Vegetable Crops, Plovdiv, Hr. Danov, 1969, p.30

7. Mihov At., Qualities of industrial vegetable varieties, Plovdiv, Hr. Danov, 1975, pp. 45-67.

8. Puhol, M., Influence of the disturbed irrigation regime of pepper, Dissertation, Plovdiv 1984, pp.89-90.

9. Iasonidi E.O., Drip irrigation of tomatoes in greenhouses, Express Information, 1984, issue 12, series 1. pp. 5-9.

Analysis of climatic variability and determination of thermal and pluviometric limits in Albania's Southwestern Lowland Area (Vlora)

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Abstract: *The geographical distribution of plants in ecosystems and the limits of agronomic extention of plants cultivated in different areas are conditioned by the performance and climatic variabilities of these areas.The biological and productive behavior of plants in agricultural systems is determined by climate performance in general and in particular by the two main climatic parameters, temperature and precipitation.Their significant fluctuations, conditioned in recent years by climate change, are evident in the form of risky for agriculture such as prolonged droughts, severe shortages of rainfall, high summer temperatures in the form of heat waves, which further brings the effect of agronomic drought. In the thermal minimums, expressed in the form of frosts, there are observed fluctuations changes creating deviations from the average perennial performance of their occurrence. The study of thermal fluctuations, and in particular the study of the phenomenon of drought and its consequences, it is an important problem especially in areas with high agricultural character. Drought occurs when there is a shortage of rainfall for long periods, registering as a pluviometric deficit. Occurrence variations of this phenomenon are related to the rainfall cycle, but they should be considered in relation to potential climate change, especially in the Mediterranean basin where Albania is located. The study of climate variability and the identification of extreme climate phenomenas as well as the determination of thermal and pluviometric limits can be done through climate monitoring indicators. Albania's western lowland area and particulary the Vlora area, which is under consideration on this study, is an agricultural area with a great diversity of cropping cultivations. Analyzing the climate behavior of this area will enable the design of suitable cultivation technologies as well as taking measures to minimize the damages to crop production from these factors.*

KEYWORDS: *CLIMATIC ZONE, TEMPERATURE, RAIN, CLIMATIC INDICATORS, AGRICULTURE*

1. Introduction

In studies of the nature of climate and its related phenomena, it is important to clarify the concept of climate and climate parameters and what impact they have on ecological systems. "Climate" means the set of meteorological and environmental conditions that characterize a geographic region (mainly solar radiation, temperature, precipitation and wind), estimated over a long period of time, traditionally over 30 years [39]. Climate and its performance are linked to climate changes which represent the change in a relatively long period of time. Consequently, there are changed also the climate phenomena, such as the drought too. At the global level today, there are many research and studies focus on climate change, the causes of climate change and their ecological impacts, which highlight the fact that global climate change is a worldwide phenomenon [19] and the impact of human activities on them is undeniable [18].The rise of terrestrial temperature (the temperature of the atmosphere and the oceans) is one of the most visible indicators of climate change which has been increasing since 1861 and in the 20^{-th} century and this increase has been about 0.6^{0}C, from the highest in the last 100 years [25].The European Environment Agency has done a detailed analysis and has shown that in the last 100 years the average temperature in Europe has risen by 0.95^{0}C (in summer with 0.7^{0}C and in winter with 1.1^{0}C) towards of 0.76^{0}C that is recorded globally [6].The average land surface temperature has increased by 0.6^{0}C in the last three decades [12]. The Mediterranean region will be one of the regions with the highest levels of vulnerability to the effects of global warming and climate change. Projections for expected temperature levels under different scenarios predict a significant increase in temperature in the Mediterranean basin [11]. Climate change is a reality, and its impacts will be manifested in many other ways, such as water scarcity in some areas associated with drought, declining of agricultural lands, freshwater salinization, insect populations outbreaks and young pathogen explosion, species extinction, population migration, disruption of economic activities, disease, malnutrition, and increased mortality [18,27,33,37]. Global warming, among other phenomena, such as large increases in temperature expressed in the form of heat waves, is also causing the rainfall cycle to be modified and intensified, which appears in the frequency and intensity of rainfall, in the amount of moisture in the soil and in the air, water availability, drought and increased flooding probability. Climate modifications are projected to further increase the amount of water in areas where there are large quantities of water today and further reduce its availability in areas where water constraints are scarce [14]. The rainfall regime is closely related and influenced by the temperature regime, but since global warming is not uniform across the planet, precipitation also has variations that are related to the degree and uniformity of global warming. Studies show that at the European level, an annual temperature increase of about 0.8 °C and a variation in latitude as a function of latitude has been recorded, with a 40% increase in northern European countries and a 20% decrease in precipitation southern European countries, which have prolonged the drought phenomenon [24]. According to climate forecasting scenarios, at these rates the total annual precipitation in 2100 will increase further by 20-25% in Northern Europe and decrease by about 10% in Southern Europe [9]. Changes in the rainfall regime determine significant changes in ecosystems especially in the southern most areas, which have been associated with prolonged droughts. Most notable is this phenomenon in agricultural areas where rainfall and droughts have a direct impact on agricultural production. The area most affected by the change in rainfall regime and their reduction is the Mediterranean basin which is increasingly affected by drought phenomena. In Europe and in the Mediterranean there is significant seasonal and regional variability of rainfall and most of it happens during winter [18]. According to the performed studies [14], southern Europe, part of which is also Albania, is getting warmer, hotter and with less rainfall. Agriculture and rural areas will be most affected by climate change and particularly by lack of rainfall [2]. Albania will have strong restrictions on water availability for the agricultural sector. Climatic scenarios [18] estimate a decrease of between 4 and 27% in Southern Europe and the Mediterranean region; most notably this will be during the summer season [14]. According to a study [34] the main drought phenomena in Europe are identified, where Albania is most affected by the 2002 drought. Expected climate change will further extend the drought phenomenon which, according to the NDMC [27], should be understood as an extended period of below-average rainfall causing severe crop damage and falling productivity. Drought as a climate phenomenon is a complex problem that has a significant environmental impact, including agriculture, water resources management and territory [4]. Drought is a problem for agriculture as a phenomenon whose frequency is fully evaluated in the SREX report [17]. Drought as a meteorological phenomenon expresses the lack of rainfall below normal values, as agricultural drought when there is insufficient soil moisture according to the requirements of a plant, as hydrological occurrence when water supply is lacking and

as socio-economic drought when water scarcity affects people [38]. Albania, although it has a relatively small territory of 28,000 km^2, is mostly mountainous and elevated, near the Mediterranean Sea, and generally with atmospheric circulation, it presents different climatic conditions [30]. Rainfall varies widely between climate zones. The average annual rainfall for coastal areas ranges from 1000 to 1500 mm and falls mainly during autumn and winter period. Mountainous areas, especially the Albanian Alps, can reach more than 2500 mm of rainfall, with 20% - 30% of it in the form of snow [35]. Albania is characterized by high amounts of rainfall ranging from minimum values between 650 mm to 1050 mm per year in low and hilly zones and maximum values between 2300 mm and 3100 mm per year mainly in mountainous areas. The Albanian Lowland Zone is an area characterized by a moderate rainfall regime from about 650 mm to 1050 mm in its southern part (Vlora, Fier, Lushnje) to about 1050 mm up to 1450 mm in its central area (Durres, Tirana, Lezhe) and the largest in the north from 1450 mm up to 1850 mm in the area under Shkodra. Looking at the normal rainfall performance in Albania the drought paths are generally short, but under climate change scenarios, there will be a reduction in rainfall from their normal values wherever there is a fall in annual rainfall (-8.5 %), which vary from 1500 mm to the north, 965 mm to the center and 1120 mm to the south after the year 2050. Whereas in 2100 the total precipitation will fall by 18.1% and concretly in the north 1300 mm, in the center 860 mm and in the south 1000 mm with a variation from north to south from 1600 mm up to 600 mm respectively [32]. This will prolong the drought phenomenon especially in the area of the Western Lowlands of the country. The south western coastal plain, where is part and the Vlora area, it is high agricultural productive area. The Vlora area is part of the southern Mediterranean plain of the Albanian territory, at latitude 40^0 and 28 'and longitude 19^0 and 29'.This study analyzes the climate variability of the Vlora area, referring to the main climate indicators and their variations over time (temperature and precipitation), in order to identify climate fluctuations, especially for agricultural production needs.

2. Material and methods

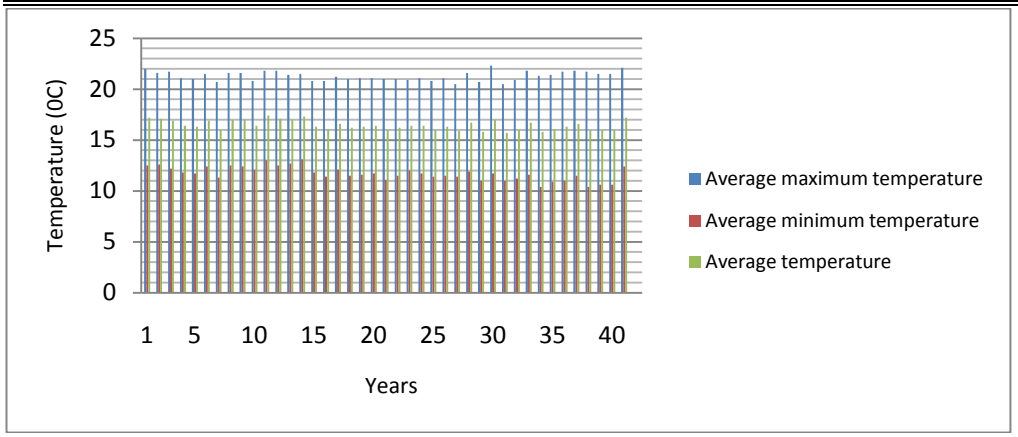
The study refers to the Vlora area for which the historical series of climatic data were collected and digitized in order to verify the climate variability for the considered period and compare them with the data of the climate forecasts developed by the [15,18] and other institutions, data that include key climatic parameters such as temperature levels (maximum, minimum and average) and rainfall amounts. In the Vlora area (Vlora A meteorological station), historical data series were obtained on temperature indices for the period 1950-1990 and rainfall for the period 1970-1986. The data were obtained from the archives of the Meteorological Stations and the Hydrometeorological Institute (data from historical meteorological series from the Meteorological Bulletin) and other data over a relatively long time period. The processing of the collected information for the purpose of identifying climate variability and climate trends in the Vlora area was done through climate indicators. Different indicators are used to determine climate behavior in different geographic areas that are selected and adapted to each area. Their use also makes it possible to identify climate trends primarely in relation to climate change. The use of climate indicators to identify extreme climate phenomena has also been considered and used by the [15]. The main problem with regard to the use of indicators is to determine the range of their values or for those considered as threshold levels to be considered in determining a particular phenomenon. In relation to temperatures, it is considered "heat waves" that level of temperatures when verified for at least 6 consecutive days in which the maximum temperature is higher than 90% of those days determined respectively by the reference climatological period (e.g., 1961-1990 or 1971-2000) [39]. Other studies [29], brings data on heat waves considering them as such when temperatures are $T \geq 20^0C$ and $T \geq 30^0C$ for three consecutive days. Regarding the rainfall, e.g., based on the amount of daily rainfall they are divided into several categories as: heavy 32-64 mm, heavy-fluid 64-128 mm and highly fluid> 128 mm [1]. Other researchers, [28], provide evidence that precipitation is heavy if exceeding 15 mm as a daily value; [8], give as a threshold value for extreme strains from 20 mm to 100 mm. Specifically, indicators elaborated by [10], are used for the analysis of climate variability and the determination of trends, based on the two main climatic parameters, temperature levels (maximum, minimum, average) and precipitation amounts.Two additional indicators of extreme rainfall events were used in the study, indicators used by [13]: a) sum of precipitation over normal climate amount, TEP (in mm) and b) extreme rainfall proportion, EP which is given as a ratio of TEP / TP (annual amount of precipitation in mm). Months with maximum rainfall amount (PM) were also analyzed to see changes in monthly rainfall intensity by year. Indicators of the Bagnlous & Gossen ombrothermic diagrams [3] were used in the study to determine the dry season periods in order to compare the drought conditions for the considered areas and to verify the changes in dry season periods in the area. The data processing is done with the help of Microsoft Excel software by creating a database in advance to facilitate the use of data by listing them as daily, monthly and yearly values, which enables them to be used in the methods specified for processing of data. The methodology used was that of the Global Climate Historical Network [31]. The analysis of the variability and tendency of the indices (intensity) used in the study that also determine the climate fluctuations has been done by the linear regression test [23]; precipitation variability related to climate change was done by the method proposed [28], which analyzes the precipitation trend with respect to the shape and degree of distribution to determine the rainy days for each analyzed year and dry periods of the year; change and trend over the years has been made by the construction of ombrothermic diagrams [3].The analysis of climate behavior changes of the considered areas was done by the method of comparing climate fluctuations from baseline conditions (from the reference year) and the trends were analyzed by comparing them with data coming from literature sources [19,36], based on projections of climate change forecasting scenarios that give future climate trends.

3. Results and Discussion

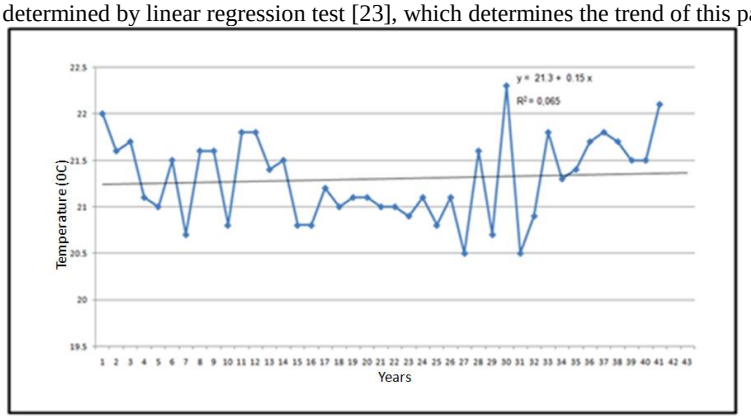
The Vlora region lies in the southwestern part of Albania. It is a coastal region bordered by two seas, the Adriatic and the Ionian Sea. The proximity to the sea and the impacts of the Mediterranean currents lead to a moderate climate, despite the easternmost stretches of mountain ranges, with the highest mountain being the Ç Mountain with 2045 m altitude. The Vlora region lies in the southern Mediterranean plain area, the part lying along the coast, the hilly southwest Mediterranean area and the southern Mediterranean mountainous area near the mountains. It is characterized by a Mediterranean climate with mild, humid winters and dry summers.The average annual temperature ranges around 10.8 °C in the Mediterranean flat area, 10.2 °C in the hilly Mediterranean area and around 9.8 °C in the Mediterranean mountainous area.The amount of annual rainfall varies from 1100 m in the Mediterranean flat area, to 1600 mm in the hilly Mediterranean area and around 2050 mm in the Mediterranean mountainous area. This region has over 2,500 hours of sunshine, which makes it suitable for many agricultural crop cultivations.

a) Analysis of variations and trends of thermal regime in Vlora area

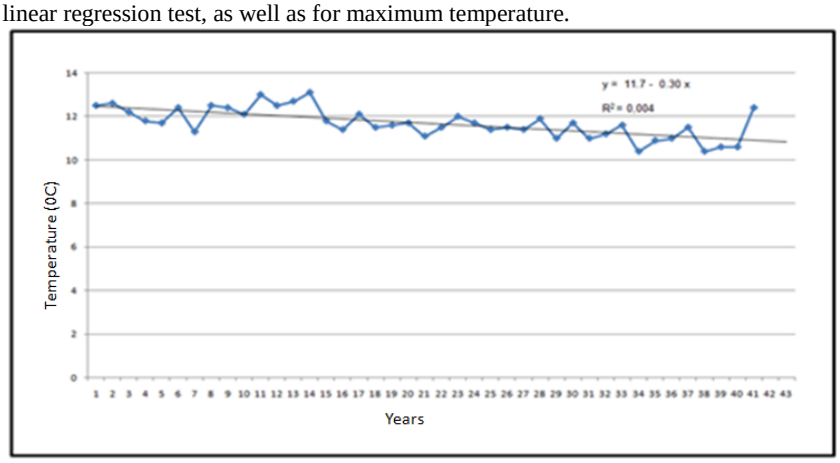
To analyze the performance of the thermal regime in the Vlora area were obtained the daily data for this station (Vlora A), for the indicators of average maximum temperature, minimum average temperature and average temperature for 1950 - 1990, ie a sufficient 40 years period to analyze the performance and variations of the thermal regime in the area. The daily values for the three meteorological temperature parameters are used in the processing, while the graphs are presented as annual mean daily values.



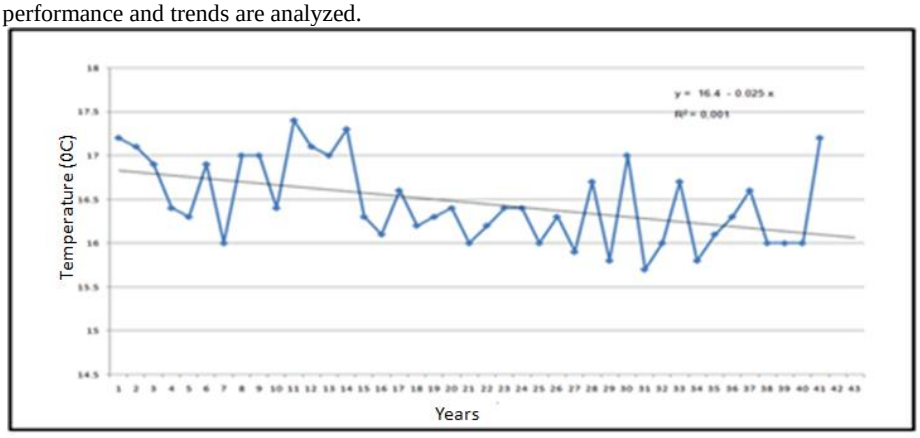
In order to determine the performance and fluctuations of the mean maximum temperature regime, graphical data analysis and trends were determined by linear regression test [23], which determines the trend of this parameter over time.



Graphical analysis of the performance of the average maximum temperature shows that it has an increasing tendency towards recent years, marking relatively higher values than reference years. This is also given by the regression equation and the correlative, albeit not very consistent. Also, the performance and fluctuations of the minimum average temperature for this area were analyzed and trends determined by linear regression test, as well as for maximum temperature.



From the graphical analysis and the performance of the relation determined by the regression equation and correlation coefficients show that the average minimum temperature has a slight downward trend, with a non-significant relationship. Also, the average temperature performance and trends are analyzed.



The analysis shows that with respect to average temperature there is a slight downward tendency but with a not very strong relation. It generally follows the performance of the minimum average temperature.

Determination of thermal climate regime trends for the Vlora area is based on 40 years of data provided by historical meteorological series and analyzed using [10] indicators described in the methodology.

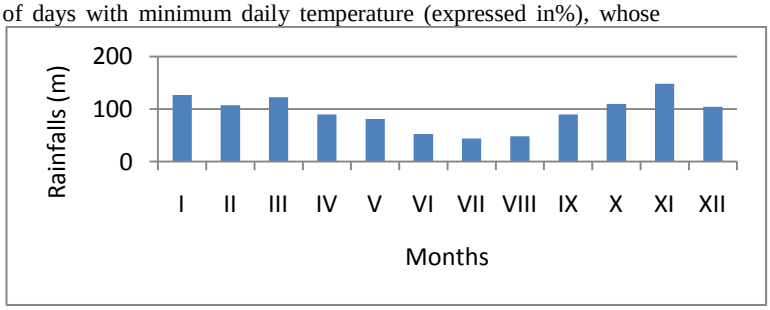
The following values are derived from data processing and analysis of values for the thermal indices considered, based on daily data for the period 1950-1990, for the Vlora area.

Tmax	Tmin	Tmed	FD (per day)	ETR (^{0}C)	GSL (per day)	HWDI (per day)	Tn90 (%)
21.3	11.7	16.4	8	35	265	48	11.1

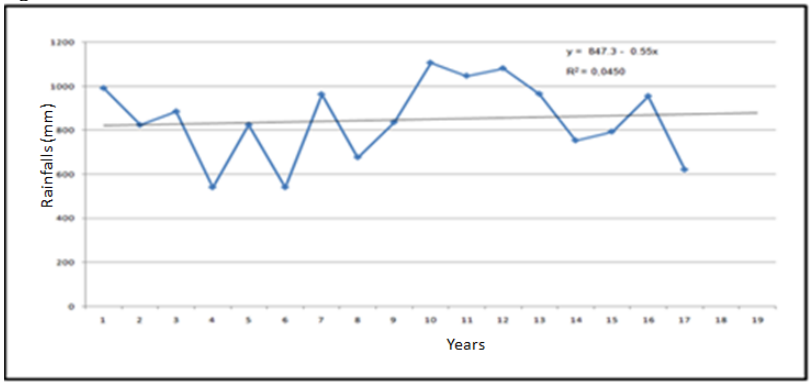
For all indicators, the analysis was done analytically and graphically through a linear regression test [23]. For the "Fd" indicator, which determines the total number of frost days (days with minimum temperatures <^{0}C) (expressed in days), the analysis shows that it has a decreasing trend in recent years which is related to the increase of temperatures, mostly maximum, marking relatively fewer days with sub-zero temperatures in recent periods compared to previous periods. This conclusion also coincides with the data obtained from climate change studies [18]. In terms of the "ETR" indicator, which expresses the radius of annual extremes and thermal extremes that gives the difference between higher temperatures year (Tn) and lower year temperatures (Tl) for the same time period expressed in ^{0}C, it results that there is generally a decrease in temperature amplitude resulting from the increase in temperature levels, especially the maximum ones. Decreasing the values of this indicator raises concerns in the cultivation of plants. In relation to the indicator "GSL", which determines the extension of the growth period giving the period between when Tdaily > 5 °C for> 5 d and Tdayly<5 ° C for > 5 days (expressed in days), the analysis shows that there is a tendency to extend this period in recent years, with a relatively stable relationship, as a result of rising temperatures. determines the elongation of heat waves giving the period with a maximum> 5 days thereafter with Tmax> 5 ° C greater than the normal value of normal Tmax for the period considered (expressed in days), the analysis shows that there is an increase of heat waves, there have been cases of high temperatures with more than 6 consecutive days, which is a threshold that determines heat waves. This is further influenced by the upward trend of maximum temperatures. Another indicator analyzed in relation to the thermal regime is "Tn90", which gives the percentage of Tmin time> 90% of days with minimum daily temperature (expressed in%), whose analysis shows that this indicator has also been decreasing as a result of the increase in the minimum temperature level, where narrowing the amplitude to the maximum temperature reduces the effect of heat, the effect of which should be taken into account for this area. consider and analyze other factors such as randomness and wind speed, air humidity. Graphical analysis of the performance of indicators through the linear regression test [23], which makes it possible to identify the linear trend (trend) of indicators related to the thermal regime, shows an increasing tendency for the Vlora area. of graphs analyzing the performance of thermal indicators to determine the tendency of thermal regime through linear regression test [23], which makes it possible to identify of the linear trend of the indicators related to this regime, for the Vlora area, it results that there is a significant upward trend of maximum temperatures, a downward trend of minimum average temperatures and a lower sensitivity to average temperatures. This has led to a decreasing trend of frosty days during winter. warm. Forecast for 2050 estimates that annual temperature rise will be 17.9 (17.6-18.2^{0}C) in southern areas by 2050 and for 2100 temperatures expected to rise by 19.8 (19.8-20.5^{0}C) in the Southern Regions of Albania [36].

b) Analysis of variability and trends of rainfall regime in Vlora area

For the analysis of the rainfall regime fluctuations in the Vlora area, daily data for the Vlora station were obtained and analyzed for the indicator amount of rainfall, expressed in mm for the years 1970 - 1986.



The graphical analysis of the data and determination of trends by linear regression test [23] was performed to determine the pluviometric regime fluctuations in the Vlora area.

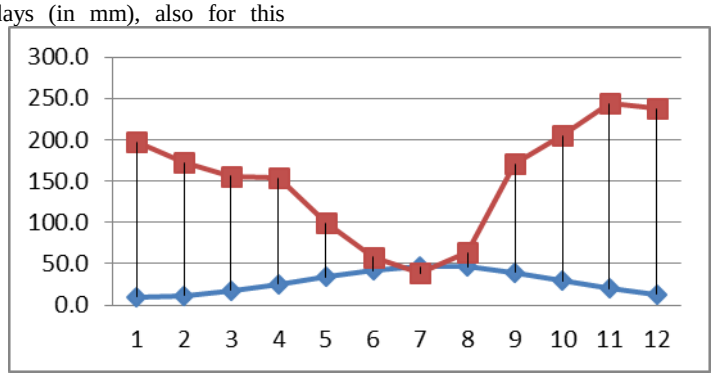


TP (mm)	PM (mm)	R10 (per day)	CDD (per day)	R5D (mm)	SDII (mm/day)	TEP (mm)	EP (mm)
847.3	62.4	24	106	128	9.07	238	0.24

Analyzing the performance of the precipitation regime in the Vlora area shows that there is a decreasing trend in recent years, ie a decrease in the annual amount of rainfall amount. The variability and trends of the precipitation regime for the Vlora area are based on perennial daily rainfall data, which were analyzed by the indicators of [10], whose obtained values give the trend of the precipitation regime over time. From the data analysis for the above pluviometric indicators, the indicator values result as following.

For all indicators, the analysis was done analytically and graphically through a linear regression test [23]. For the indicator "R10" which expresses the number of days with rainfall ≥10 mm d^{-1} (per day) the values of this indicator have been found and the analysis has been done which shows that with the passing of years there is an increase in the number of days with the amount of precipitation larger than 10 mm, which indicates that rainfall has become more intense in recent years in this area with reference to reference years. In relation to the analysis of the "CDD" indicator, which gives the maximum number of days with drought (*R*days <1 mm) (per day), the values of this indicator have been calculated and the analysis has shown that there is an increasing trend in the lastyears. This indicates that there is an increase in drought days, accompanied by a decreasing trend in precipitation levels and disturbances in their distribution. Regarding the indicator "R5d", which gives the maximum total precipitation in 5 days (in mm), also for this indicator its values were calculated where by analyzing this indicator it results that there is an increasing value indicating increase in rainfall intensity.The decreasing trend of precipitation levels and increase in values of this indicator highlights the fact that rainfall has become more intense in this area. In relation to the other indicator "SDII", which gives the daily simple intensity: annual amount/number of days with daily precipitation Rditore ≥ 1 mm d – 1 (in mm/day), also for this indicator its values have been calculated and from the calculation of this indicator and graphical processing it results that there is an increasing trend of values of this indicator which shows that rainfall has become more intense in recent years. Also, two other indicators have been calculated to enable the precipitation intensity and their distribution to be identified, the amount of rainfall over the normal climate amount, TEP (in mm) and the proportion of extreme rainfall, EP, which is given as a ratio of TEP/TP (annual amount of precipitation expressed in mm) [13]. The calculation of these two indicators and the obtained values show that there is an increase in the intensity associated with the phenomena of the shape of their distribution, which departs from the normal distribution in time.

Indicators of the Bagnlous & Gossen [3] umbrothermic diagrams were used in the study for the Vlora area, to determine the drought periods of the year in order to compare the drought conditions for the Vlora area.



Values of temperature and rainfall / Months

This conclusion also coincides with data from other studies and data provided by projections of climate forecasting scenarios for the Mediterranean Basin [18] and the Albanain clime changes reports [36], which reports that there will be -8.5% annual precipitation decline by 2050 and after 2100 the total precipitation will be decline by - 18.1% .

The analysis of the diagram shows that there is an extension of the drought periods of the year, also affected by the decrease in the amount of rainfall, as verified by the graphical representation.

Analyzing the totality of the indicators in the Vlora area, regarding the progress of the precipitation regime and determining their trends over time, for the period under analysis, it is clear that precipitation in the territory of this area has a decreasing tendency, become more intense in recent years and there is a noticeable seasonal change in their distribution.

4. Conclusions

The analyze of the performance of thermal indices for the Vlora area shows that there is a significant upward trend of maximum temperatures; a downward trend of average minimum temperatures and a lower sensitivity regarding the average temperatures. This has led to a tendency to reduce frost days during the winter season.

By analyzing the totality of the indicators related to the rainfall regime and determining their trends over time, for the period under review, it is clear that rainfall in the territory of this area has a decreasing tendency; they have become more intensive in the recent years and there is a visible seasonal difference in their distribution.

5. Reference

1. Alpert et al. (2202). The Paradoxical Increase of Mediterranean Extreme Daily Rainfall in Spite of Decrease in Total Value. InGeophysical Research Letters29(11):1536. DOI: 10.1029/2001GL013554
2. Baettig, M. et. al. 2007. Një indeks i ndryshimit të klimës: Ku mund të jetë më i dukshëm ndryshimi i klimës në shekullin e 21, Geophys. Res. Lett., 34, L01705, doi:10.1029/2006GL028159).
3. Bagnlous F,.Gaussen H. 1957. Les climats bilogiques et leur classification.Ann.De Geogr.,2,.
4. Di Stefano, V., Mestre, A., Orlandini, S. (2008): "Calcolo dell' indice SPI (standardized precipitation index) suserieclimatologiche dell' Europa meridionale e stimadellasiccitàdegliimpattisullecolture" in Rivistaitaliana di agrometeorologia n°1 Febbraio 2008 p 92-93.

5. Donat M.G., Alexander L.V., Yang H., Durre I., Vose R., Dunn R., Willett K., Aguilar E., Brunet M.,Caesar J., Hewitson B., Jack C., Klein Tank A.M.G., Kruger A.C., Marengo J., Peterson T.C.,Renom M., Oria Rojas C., Rusticucci M., Salinger J., Sekele S.S., Srivastava A.K., Trewin B.,Villarroel C., Vincent L.A., Zhai P., Zhang X. &Kitching S. (2013) "*Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: TheHadEX2 dataset*", J. Geophys. Res., 118: 2098-2118. doi: 10.1002/jgrd.50150.
6. European Environment Agency, 2004, Impacts of Europe's changing climate. An indicator-based assessment, rapportotecnico EEA n. 2/2004;http://reports.eea.eu.int/climate_report_2_2004/
7. EEA, European Environment Agency (AgenziaEuropeadell'Ambiente), (2017), "Climate change, impacts and vulnerability in Europe 2016 – An indicator-based report", Primo Rapportodell'AgenziaEuropeadell'Ambientedel 2017.
8. Easterling DR, Meehl GA, Parmesan C, Chagnon SA, Karl T, Mearns LO, 2000: Climate extremes: observation, modeling and impacts. Science 289:2068–2074
9. Ferrara V. (2007):I cambiamenti in atto in Europa www.decrescitafelice.it/pagina.php?id_sezione=15&idSottoSezione=37).
10. Frich P., Alexander L.V., Della-Marta P., Gleason B., Haylock M., Klein Tank A., Peterson T., 2002. Observed coherent changes in climatic extremes during the second half of the twentieth century. *Climate Research*, Clim Res,19, 193–212.
11. Gualdi S., Somot S., May W., Castellari S., Déqué M., Adani M., Artale V., Bellucci A., Breitgand J.S., Carillo A., Cornes R., Dell'Aquilla A., Dubois C., Efthymiadis D., Elizalde A., Gimeno L., Goodess C.M., Harzallah A., Krichak S.O., Kuglitsch F.G., Leckebusch G.C., L'Heveder B.P., Li L., Lionello P., Luterbacher J., Mariotti A., Nieto R., Nissen K.M., Oddo P., Ruti P., Sanna A., Sannino G., Scoccimarro1 E., Struglia M.V., Toreti1 A., Ulbrich U., and Xoplaki E. 2011. Future Climate Projections. In *Regional Assessment of Climate Change in the Mediterranean*: A. Navarra, L. Tubiana (eds.), Springer, Dordrecht, The Netherlands
12. Hansen J., 2006. **"**Global Temperature Change", p. 1428.
13. Haylock M, Nicholls N., 2000. Trends in extreme rainfall indices for an updated high quality data set for Australia, 1910–1998. International Journal of Climatology, 20, 1533–1541.
14. IPCC, 2007. "Fourth Assesment Report: Climate Change 2007" http://www.ipcc.ch/publications_and_data/publications_ipcc_fourth_assessment_report_synthesis_report.htm
15. IPCC,2007. *Summary for Policymakers*, Sec. 1, Sec 1.3. IPCC AR4 SYR, 2007. – B
16. IPCC, 2008. Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds.: Technical paper on climate change and water. 5. 93-96. http://www.ipcc.ch/publications_and_data/publications_and_data_technical_papers_climate_change and water.htm
17. IPCC,2012. *Summary for Policymakers*, p.8. IPCC SREX
18. IPCC, 2013. Summary for Policymakers. (2013). *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, p. 3-29*).
19. IPCC,2014. Intergovernmental Panel on Climate Change, 2014, AR5.
20. IPCC AR5. Climate Change 2014: Impacts, Adaptation, and Vulnerability.
21. Hansen J., Sato M., Ruedy R.,2012. *Public Perception of Climate Change and the New Climate Dice*, NASA Goddard Institute for Space Studies and Columbia University Earth Institute, New York, NY, USA.
22. JRC (Joint Research Centre) (2005): Climate change and the European water dimension http://ccu.jrc.it/Pubblications/Climate_Change_and_the_European_Water_Dimension_2005.pdf
23. Kendall M., Ord J. K., 1990. Time Series. Edward Arnold, London
24. Maracchi, G., Sirotenko, O., Bindi, M., 2005. Impacts of Present and Future Climate Variability on Agriculture and Forestry in the Temperate Regions: Europe. , pp.117–135.
25. Mascia, M. et al. Termometro Terra: Ilmutamentoclimaticovisto da scienza, etica e politica. Bologna: EMI; 2004. - 155 p. (Giustizia, Ambiente, Pace). - In appendicel'influenzadell'uomonell'atmosferadurantel'erain dustriale.
26. Mozell, M. & Thach, L., 2014. The impact of climate change on the global wine industry: Challenges & solutions. *Wine Economics and Policy*. Available at: http://www.sciencedirect.com/science/article/pii/S2212977414000222´
27. NDMC (2006) Understanding and defining drought http://www.drought.unl.edu/whatis/concept.htm
28. Osborn T.J., Hulme M., 2002. Evidence for trends in heavy rainfall events over the UK. *The Philosophical Transactions of the Royal Society A*, 360, 1313-1325.
29. Padoan M., 2010. Aspetti climatic e meteorologicidelleondate di calore in Veneto nel period 1992-2010 (Tesi di sperimentale di Master).p.73
30. Paxian, A., E. Hertig, S. Seubert, G. Vogt, J. Jacobeit, and H. Paeth, 2015. Present-day and future Mediterranean precipitation extremes assessed by different statistical approaches. Climate Dyn., 44, 845–860, doi:10.1007/s00382-014-2428-6.
31. Peterson TC, Vose RS, 1997. An overview of the Global Historical Climatology Network temperature database. Bull Am MeteorolSoc 78:2837–2849.
32. Third National Communication of the Republic of Albania under the United Nations Framework Convention on Climate Change, 2016.
33. Tate, a. B., 2001. Global Warming's Impact on Wine. *Journal of Wine Research*, 12(2), pp.95–109. Available at: http://www.tandfonline.com/doi/abs/10.1080/09571260120095012
34. Tallaksen, L.M., Hisdal, H., & van Lanen, H.A.J. 2009. Space-time modelling of catchment scale drought characteristics. *Journal of Hydrology*, 375, 363 – 372.
35. Teqja Z., Kopali A., Libohova Z., Owens R.P.2017. A study of the impacts of climate change scenarios on the plant hardiness zones of Albania. Journal of Applied Meteorology and Climatology, 2017. 56(3): 615-631 DOI: http://dx.doi.org/10.1175/JAMC-D-16-0108.1
36. Third National Communication of the Republic of Albania, Climate Change, (UNFCCC), 2016
37. Venkataramanan, M., Smith A., 2011. Causes and Effects of Global Warming. *Indian Journal of Science and Technology*, 4(3), pp.226–229.
38. Wilhite, D.A.; and M.H. Glantz. (1985). Understanding the drought phenomenon: The role of definitions. Water International 10:111–120.
39. WMO (World Meteorological Organization), 2002 http://www.europa.eu.int/comm/environment/climat/home_en.htm http://berkeleyearth.lbl.gov/regions/global-land http://www.ipcc.ch http:// www.worldclimate.it

Studies to establish evapotranspiration and biophysical coefficients of pears grown in drip irrigation

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Summary: *To determine the total and average evapotranspiration of pears during its cultivation under soil and meteorological conditions in the area of the village of Chelopechene - Sofia, studies were conducted on drip irrigation (KP-4.6 drip trays) of pear plantation of the variety "Hardenponova maslovka".*
Meteorological conditions during the study period influenced the size and daily average values of culture evapotranspiration.
The total evapotranspiration for the pear growth period of 536 mm was determined, and the daily values of biophysical coefficients Z, R and Kp were calculated for practical use and design, which depend on the biological features of the crop and the meteorological factors.
KEYWORDS: *EVAPOTRANSPIRATION, BIOPHYSICAL COEFFICIENTS, PEARS, IRRIGATION RATE, DRIP IRRIGATION, IRRIGATION REGIME, IRRIGATION RATE*

Evapotranspiration (ET) of each crop (including that of pears) is a major cost element in the water balance of the active soil layer and is one of the main factors determining the irrigation regime parameters. Knowledge of real evapotranspiration is necessary to predict irrigation of crops and to determine project irrigation

The results of the conducted studies in the conditions of our country [7, 8] prove that the calculation of evapotranspiration according to the formula based on the sum of the average daily air temperature is justified and correct [6,9,10].

The growing water deficit in our country, as well as the economically disadvantageous use of irrigation rates to a greater extent in the cultivation of fruit crops, incl. and pears, necessitates the use of water-saving irrigation techniques.

Drip irrigation is a technology that is increasingly used for irrigation of crops due to the ability to effectively control the processes in the irrigation system, irrigated planting and even in individual plants [4] .This method fully meets the requirements of sustainable agriculture and organic fruit production, including high yields and quality of production, reduces unwanted side effects [3] .

The aim of this paper is to determine the amount of evapotranspiration and the values of biophysical coefficients of pears grown under surface drip irrigation with KP - 4.6 drippers of two for every tree in the area of Sofia Field.

Materials and method

In order to establish the evapotranspiration of pear plantation, the Hardenponova Maslowka variety was conducted a field experiment at an experimental field of the Pushkarov Institute in Chelopechene district, Sofia, with a planting scheme 4/2 m and irrigation wings with a length of 50 m and the placement of drip traps. -4.6 surface two pieces of wood per meter.

The soil is cinnamon coloured (leached), slightly sandy-clay in the arable layer, formed on the basis of old deluvial conical materials. It is stocked poorly with nitrogen (mineral N 17.3 mg / kg), average with phosphorus P2O– 14.4 mg / 100g) and well with potassium (K2O– 45.4 mg / 100g at pH 6.6). The average for the layer 0 - 60 cm the soil has the following water-physical properties: WHC = 22.1%, moisture content - 12.3% by weight of absolutely dry soil, volume weight at WHC - 1.47 g / cm3. For the soil layer 0-100 cm the same indicators have values: WHC- 21.8%, wilt moisture - 12.3% and volume weight - 1.50 cm3.

When determining the irrigation rate for drip irrigation, a crop coefficient is used to reduce the technological area. It determines the actual area over which the irrigation rate is to be distributed and depends on the age of the plantation. The size of the irrigation rate is given by the formula:

$m=m_1 x P$,

where : m_1 is the actual irrigation rate m^3/dka, (15 mm);

P - the technological area reduction factor. P = 0.67 for the experimental year.

For soil moisture dynamics monitoring, soil samples were taken in the variant irrigated with Drosbach surface and KP-4,6 on 2 pieces of wood with irrigation rate of 16 mm in depth.

The experimental establishment of evapotranspiration (ET) of pears by ten days and in total for the growing season was made on the basis of data on the dynamics of soil moisture during the growing season and the irrigation carried out in layers of 10 cm and a total depth of 0-60 cm for the soil layer in whitch more than 85% of the main pear root system is contained, by the water balance method. On this basis, the values of the biophysical coefficients Z, R and Kp are calculated. They are the ratio between the evapotranspiration of the culture and the meteorological factors - air temperature, water vapor saturation deficits, and light hours for every ten days in% throughout the year.

The water balance calculations were done by the formula:

$ET = W_{нач.} - W_{кр.} + m$,

where: ET is the evapotranspiration in mm;

$W_{нач.}$ – the water stock in the 0-60 cm layer at the beginning of the ET period in mm;

$W_{кр.}$ – water stock in the 0-60 cm layer in the end of the period in mm;

m – irrigation rate in mm.

From the evapotranspiration data of the crop (pears), the daily values of the biophysical coefficients Z and Kp were calculated according to [5]:

$$ET = Z.\sum t,$$

where: ET is the evapotranspiration in mm;

$\sum t$ – the daily sum of daily average air temperatures in ° C;

Z – is the biophysical coefficient to be determined for each crop individually depending on the final temperature sum of the period.

Or according to [2]:

$$ET = K_p.p.(45{,}7.t + 813)/100,$$

където: ET is the evapotranspiration in mm;

p – the duration of the daylight hours for each ten-day period in% during the year;

t – the average ten-day period air temperature in °C for the period;

Kp – the biophysical coefficient.

The biophysical coefficient (R) according to [1], which is determined according to the final sum of the average daily water vapor saturation deficits for the period.

$$R = \frac{ET}{\sum D},$$

where: $\sum D$ are the daily sums of the average daily water vapor saturation deficits in mb;

ET is the evapotranspiration in mm.

Results and discussions

The meteorological conditions under which the field experiments with the crop were conducted in terms of rainfall during the period April - September 1995 are characterized compared to the multi-year observation period by a 15.3% humidity reserve . For the period May-June it was 13.3%, and for July - August it was 47.0%.
Despite the temporary drought in July, the year is characterized by good natural water security. The deficit ratio for the period April - September is 78.8%. This value characterizes the year as one of the relatively wet ones. With this deficit, the amount of rainfall and the supply of air temperature for the period - 62.9% and characterize the year as humid and relatively cool except for the period June - August, which is relatively warm.
The course of daily average values of temperatures and water vapor saturation deficits are the same and close to the average of multi-annual values (Table 1).

Table 1 *Meteorological factors coverage in 1995*

Meteorological factors coverage by vegetation periods						
Meteorological factor	April - September	May- September	April- June	May - June	June - August	July – august
rainfall	15,3	11,3	17,3	13,3	-	47,0
Daily average temperature values	62,9	56,9	-	-	41,1	43,0
Daily average values of water vapor saturation deficits	78,8	76,8	60,9	66,9	-	74,0

The need for irrigation of pears to maintain optimum soil moisture in the 0-60 cm layer is mainly determined by the amount and distribution of rainfall during the growing season.

The intensity of the ET directly affects the duration of the inter-irrigation period and hence the number of irrigations and the size of the irrigation rate.

The active soil layer under the 15 mm irrigation variant under study was prepared by feeding a single 45 mm irrigation in early July. During the irrigation period, 10 waterings were realized, the actual irrigation rate being 210 mm.

On the basis of the fallen rainfall and the submitted irrigation norms, the course and the amount of evapotranspiration of the pears were determined. For the period from the second week of May to the end of September the total water consumption is 536 mm.

The main part in the formation of the total value of the ET, in the relatively wet year, is the fallen rainfall - 307 mm, ie. 57%. The irrigation rate of 210 mm forms about 39%. The highest daily average ET values were recorded in the second and third days of July, when the period is relatively dry and warm.

The average daily ET values are in the range of 2 to 5.6 mm, and the average value for the growing season is 3.7 mm. At the beginning and end of the growing season, the values are lowest, which is due to the lower stress of the weather factors and the lower crop needs for water. The course of ET changes during the growing season is followed by the development of the culture and changes in meteorological factors.

Calculated daily values of biophysical coefficients based on experimental determination of evapotranspiration and daily sums of daily average air temperature (for factor Z, calculated by the Delebaltov, Hristov, Tsonev formula) and air temperature, duration of ten hours of light hours during this year. (for the coefficient Kp according to the Blanney, Criddle formula), the weekly sum of the average daily water vapor saturation deficits in mb (for the coefficient R calculated according to the Alpatev formula); are shown in Table 2 and Figure 1. Changes in the values of these coefficients follow changes in evapotranspiration during the growing season of the crop. The determined values of the biophysical coefficients represent an objective basis for determining the design irrigation regime and forecasting the irrigation time of the crop.
The values of the biophysical factor Z for the culture range from 0.15 to 0.28, for the Kp coefficient from 0.44 to 1.01, and for R from 0.35 to 0.66 on average over the study period.

Table 2.*Total and mid-day evapotranspiration (ET), and biophysical coefficients Z ,R and Kб during the growing season of pears*

Months	Ten-day	ET (mm)	Mid-day ET(mm)	Z	**R**	**$K_б$**
May	II	20.5	2.05	0.15	0.44	0.44
	III	30.5	2.75	0.16	0.35	0.52
Jun	I	35.4	3.54	0.20	0.48	0.64
	II	39.7	3.97	0.21	0.64	0.68
	III	40.8	4.08	0.21	0.53	0.70
July	I	44.0	4.40	0.22	0.47	0.75
	II	47.1	4.71	0.23	0.60	0.79
	III	57.3	5.21	0.24	0.50	0.87
August	I	56.2	5.62	0.25	0.66	1.01
	II	44.4	4.44	0.22	0.42	0.82
	III	36.1	3.28	0.19	0.47	0.67
September	I	32.8	3.28	0.20	0.47	0.72
	II	31.4	3.14	0.18	0.43	70
	III	20.0	2.00	0.17	0.54	-
Total ET		536(mm)	3.75	0.20	0.50	0.71

Conclusions

1. The total amount of evapotranspiration, which for the growing season of pears reaches 536 mm, as well as the daily average values and values, which range from 2.0 to 5.6 mm with two minimums - at the beginning and end of the growing season and one maximum - in July and August.

2. The percentage share of the forming elements of ET is established, with the largest share in the formation of the ET being the fallen rain 57% and the irrigation rate forming about 39%.

3.For practical use of the design results, the daily values of the biophysical coefficients - Z R and Kp, which depend on the biological characteristics of the culture and the meteorological factors, have also been calculated.

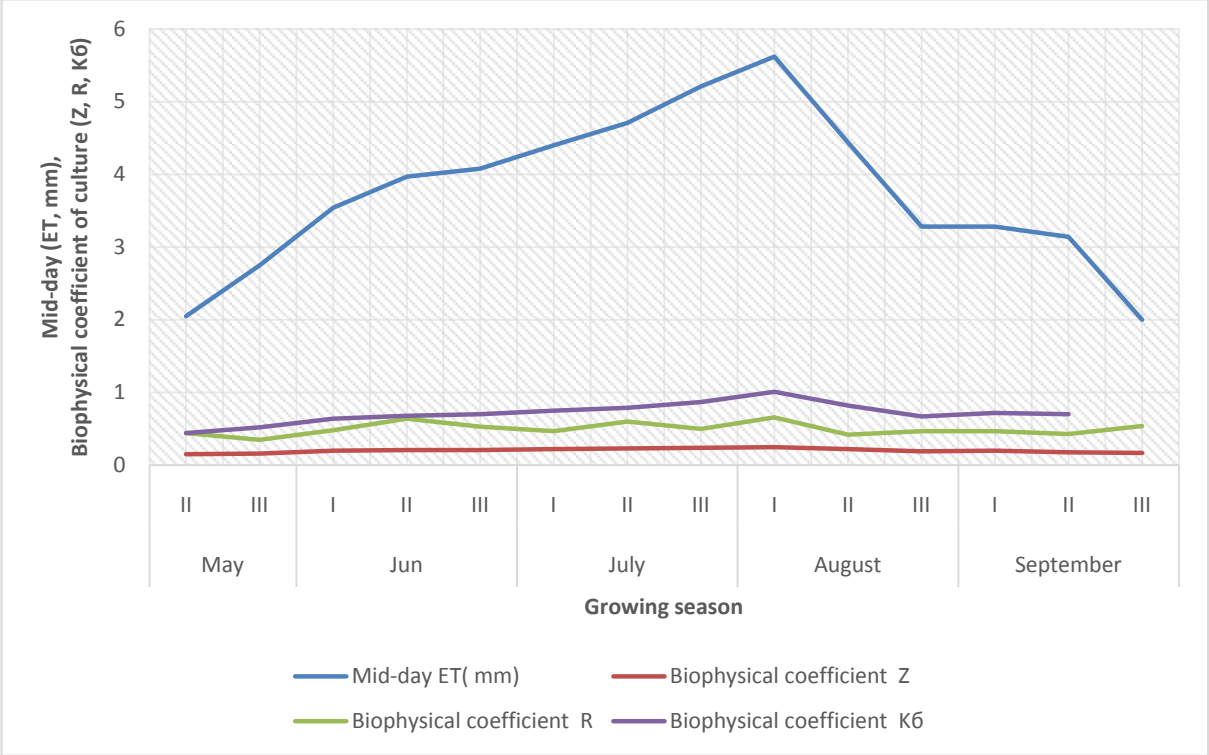


Fig.1*Mid-day evapotranspiration (ET, mm) and biophysical coefficients (Z, R, $K_б$) of drip irrigation pears for growing season*

References

1.Alpatev, A.M.1955.Questions on Evapotranspiration of Crops. Proceedings of Biologically Publishing Academy of Sciences, Moskva, pp.5

2.Blanney, H. and W. Criddle – Technical bulletin 1275, Agricultural Research Service, USA Department of Agriculture, W., 1962 , pp.78

3.Branson,R.L,Schulbach,R.S.Rauchkolb and J.M. Rible,1981.Aplication of chemicals through drip systems.In: Fereres,E,Drip Irrigation Management, Dif of Agrik.Sci.,Univ. of California, pp 201

4.Bucks.D.A.,F.SNakayman and A.W. Warrick, 1982. Principles, Practices, and Potentialities of Trickle (Drip) Irrigation. – In: D. Hillel et al., Advances in Irrigation 1, Academic Press, New York, 219-298.

5.Delibaltov, Y., H.Hristov, I.Tzonev.1962. Dising irrigation regime for the agriculturdl crops.Procecoring, IHM, 3,.5-56, (Bg).

6. Kalsheva, Sp.,1991, Participates in the groundwater in the eutonpression of agricultural crops., Dissertation, p.134, (Bg).

7. Kireva R., Mihov M., Evapotranspiration with strawberries grown in drip irrigation conditions, j."Mechanization in agriculture & conserving of the resources ", 2019, N.6, p.220-222

8. Kireva R., Mihov M., Evapotranspiration with strawberries grown in drip irrigation conditions, j."Mechanization in agriculture & conserving of the resources ", 2019, N.6, p.220-222

9. R.Kireva, Mihov M., Reduction of losses from drought by optimizing the use of water resources for irrigation of agricultural crops, j."Mechanization in agriculture & conserving of the resources ", 2019, N.5, p.190-192

10.Zahariev,T., 1985. On Methods and Formulas for Determining the Evapotranspiration of Agricultural Cultures, in Support of Technical Progress in Water Management, vol. 2, p.3-10