UNIVERSITY **POLITEHNICA** OF BUCHAREST

Faculty of Biotechnical Systems Engineering
Biotechnical Systems Engineering Doctoral School

DOCTORAL THESIS ABSTRACT

CERCETĂRI PRIVIND CREȘTEREA PERFORMANȚELOR ECHIPAMENTELOR PENTRU DESCHIS CANALE DE UDARE

RESEARCH ON INCREASING THE PERFORMANCE OF EQUIPMENT FOR OPENING WATER FURROWS

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CONTENTS

KEYWORDS: equipment for opening and partitioning water furrows, qualitative work indices, energy indices, 3d structural analysis for the palette support and the palette, 3d structural analysis for the rotor with palettes working body.

FOREWARD

One of the most important and oldest human activities is agriculture. Depending on the crops established, climate plays an important role, agriculture being closely linked to water sources and the precipitation regime for the vegetation to develop. Climate change and weather instability have meant that the water reaching the plants varies greatly so that sufficient and safe production cannot be guaranteed, irrigation being the solution to the problem.

Current scenarios predict that climate change will increase the water deficit in southern Romania. Climate change has the potential to affect agriculture through changes in temperature, distribution and rainfall. This problem indicates the need to develop integrated technologies that increase the efficiency of rainwater use and support the quality of the soil and the environment, ensuring higher agricultural production, with lower costs.

The compartmentalized furrow is the result of a mechanical work of the soil that leaves behind furrows interrupted by mounds of soil, at adjustable intervals, to form small pools of accumulated water. During rain, excess water is accumulated in these basins, so that it can be slowly absorbed by the soil, thus eliminating the possibility of runoff outside the cultivated perimeter.

The paper is structured in 6 chapters, developed in 260 pages, contains 319 figures and graphs, 277 mathematical relations, 49 tables, as well as a bibliography consisting of 159 references. Also, the paper includes at the end a series of annexes (19 pages) presenting materials and data related to the studies and research conducted.

The Doctoral Thesis "**Research on increasing the performance of equipment for opening water furrows**" presents a synthesis of theoretical and experimental research conducted by the author regarding the working process of equipment for opening and partitioning water furrows, but also the execution of a new type of equipment.

In **chapter 1**, titled "*Introduction"*, some aspects of the importance of water and its decisive role in obtaining crop yields are presented, as well as how soil works positively influence the retention of as much water as possible during dry periods, and in wetter regions ensures good drainage of water to greater depths.

In **chapter 2**, *"Current state of achievements in the field of equipment for opening and partitioning water furrows*" are presented aspects regarding the opening compartmentalized furrows and its importance in obtaining advantageous crop yields, but also, very succinctly, constructive solutions of equipment with the help of which the most efficient use of water in agriculture is achieved.

In **chapter 3**, "*Contributions to the mathematical modelling of the work process and to the constructive and functional optimization of equipment for opening and partitioning watering furrows*" are presented studies on the modelling of the process for the working body with the active surface such as mouldboard, butting plough; modelling the process for the working body with the active surface of the blade type (palette); establishing the shape of the palette; contributions to the optimization of equipment for opening and partitioning water furrow; the use of cam mechanisms in equipment for opening and compartmentalizing furrow and the optimal synthesis of the rotary cam and rotary tappet with roller for opening and compartmentalizing water furrow whose results were used for the design and execution of the cam-tappet equipment for partitioning water furrows presented in the thesis.

In **chapter 4,** "*Experimental research on the work process and performance of equipment for opening and partitioning water furrows"* are presented the experiments performed with the equipment for opening and compartmentalizing water furrows mounted on the DMBC5device for modelling soil in compartmentalized furrows for weeding crops, simultaneously on 5 intervals, , with the PCVM2 + EMBC equipment for modelling the soil in compartmentalized furrows in vine plantations and with the PCVM2 equipment for modelling the soil in compartmentalized furrows at vine plantations + cam -tappet control system - furrow compartmenting.

For this purpose, the soil modelling device consisting of a frame with tractor coupling triangle, working depth adjustment and depth limiting wheels, soil loosening blades, butting plough and furrow compartmentation equipment, DMBC5, was compared with conventional technology for sunflower cultivation in two localities in southern Romania, Crânguri and Mărculești. The device for modelling the soil in compartmentalized furrows for weeding crops provides a viable option that has positive effects on soil properties and ensures increased crop yields compared to conventional works.

The experiments in exploitation conditions for the aggregate formed by PCVM2.2 + EMBC2 were performed on the experimental lot PFA Sârbu Ion Filimon, Gura Vadului locality, Tohani Viticultural Center, Prahova County, at the Research-Development Station for Viticulture and Vinification Murfatlar county Constanța and on the experimental plot belonging to INMA-Bucharest.

In the second part of the chapter the statistical analysis of the experimental data for the equipment for opening water channels is made using the available data resulting from the experiments performed. The analysis of the qualitative indices of the machine for four working versions, on the initial load-bearing structure and on the modified structure of the equipment, the analysis of the energy indices, the statistical and theoretical modelling of the processing force produced by the pallet, the mathematical modelling of the tensile strength theoretical research of the forces acting on the equipment using experimental data to create the mathematical model.

The results were used for: analysis of qualitative indices of the working process, establishing the forces that require the load-bearing structure (in order to perform structural analysis), establishing relations of tensile strength useful in calculating the energy balance, in establishing the power source required to drive the machine (equipment).

At the end of the chapter are presented: synthetic conclusions on the experimental determinations made on the process of opening and compartmentalizing watering furrows, some conclusions regarding the additional forces required for the use of equipment for opening and compartmentalizing watering furrows and how to achieve qualitative indices by the equipment.

In **chapter 5,** "*Research on the structural analysis of the equipment for opening and partitioning water furrows using the finite element method*" is performed the structural analysis of the load-bearing structure of the EDCBU, the 3D structural analysis of the frame, the 3D structural analysis for the palette and palette support, the 3D structural analysis for the working body - the palette, in the case of the two equipment, the equipment with cam-tappet rotor equipment. Following the results obtained, conclusions were drawn regarding the maximum value and the area in which the equivalent stress is manifested, the values obtained for the reaction forces, the field of relative displacements in the structure and their maximum value.

Chapter 6 "*Conclusions. Original contributions. Perspectives*", presents the general conclusions arising from theoretical studies and experimental research conducted on the process of opening and partitioning water furrows. Also, the personal contributions of the author regarding the studied phenomena and the experimental research conducted within the doctoral thesis are presented. New research directions are presented, which may be the subject of theoretical studies and experimental research approached in the future by other researchers. The author considers that this doctoral thesis is a contribution to the clarification of some aspects related to the process of opening and partitioning water furrows, which can be deepened in further research.

Chapter 1. INTRODUCTION

1.1. General considerations

The soil is the surface layer of the earth's crust and consists of mineral particles, water, air, organic matter and living organisms. It is important for humanity being a system that fulfils many vital functions such as: food / biomass production, source of biodiversity / habitats; species and genes; storage and processing of many substances; source of raw materials; geological and archaeological heritage; carboniferous basin; serves as a platform / physical environment for humans and human activities [131].

Recently, there has been a significant increase in the number of inhabitants on the planet, which inevitably leads to an increase in the amount of food needed for consumption. The need for food in large quantities also implies the need for an appropriate amount of clean fresh water for food production. Increasing water demand for human activities, on the one hand, and climate change, on the other, have made it difficult for many regions to find sufficient freshwater resources to meet their own needs. The further cultivation of plants, without depleting the clean water resources of nature, forces us to increase the efficiency of water use in agriculture [100].

In weeding crops, the uniform storage of water is achieved with the help of interrupted (compartmentalized) furrows, in which case it is necessary to make an enlarged section of the furrow to accumulate as much water as possible.

1.2. Importance of water in agriculture

For growth and development, plants need the existence of appropriate vegetation conditions that refer to the presence of air, light, water, heat and nutrients.

Reflecting on the role that water plays in the development of phenomena that take place during the life of plants, the following conclusion is reached: in the absence of water everything dries out [94].

The living conditions on the planet are also met by the constant circuit of water in nature (Fig. 1.1.). This circuit also participates in the stabilization of the energy (heat) stored in the steam. Water evaporates from the oceans and is stored in clouds that can travel long distances to the middle of the continents. The rain that falls from them ensures the precipitation for the soil. Some of this moisture is absorbed by the soil, some is used by plants, some evaporates and the rest reaches rivers and streams that flow back into the ocean from where the entire circuit resumes by evaporation [59,64].

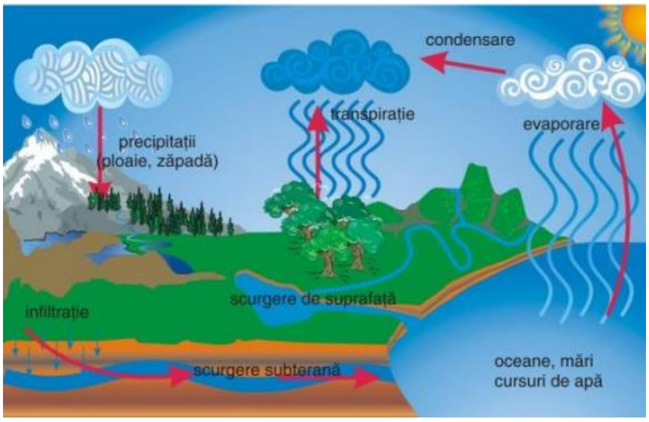


Fig. 1.1. The water circuit in nature [16]

Preserving a quantity of water in the soil can be achieved by: stopping losses, reducing erosion, organic fertilization, weed control, mechanical works to increase soil porosity by promoting better storage of water from rainfall, making curtains to protect plants (Fig. 1.2.) and soil mulching (maintaining a layer of plant residues on the soil surface) [14].

1.5. Soil erosion and measures to combat it

The water from precipitation is distributed in the soil and in the atmosphere as shown in figure 1.5. [57].

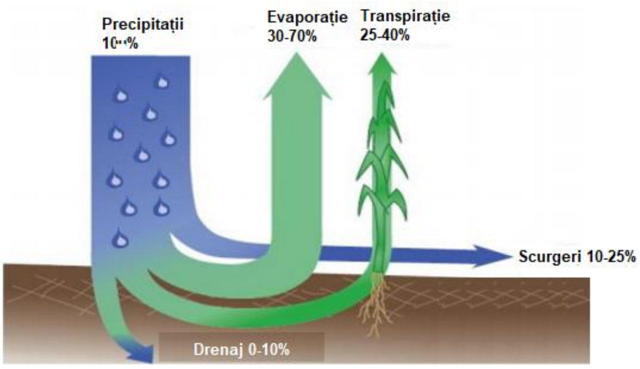


Fig.1.5. The manner the rain water is distributed [57]

On sloping lands, part of the water flowing to the base of the slope produces the phenomenon of soil erosion (Fig. 1.6.).

a) b)

Fig. 1.6. Manifestation of soil erosion (a), (b) [6]

1.6. Soil modelling work

One of the mechanical works, used to combat water stagnation or its uncontrolled leakage, is the work of soil modelling. Soil surface modelling works are carried out to facilitate the management of water along the row of plants or its uniform storage.

Fig. 1.10. Field with and without water furrows [14] **Fig. 1.11.** Equipment for the construction of furrows [10]

Chapter 2. CURRENT STATE OF ACHIEVEMENTS IN THE FIELD OF EQUIPMENT FOR OPENING AND PARTITIONING WATER FURROWS

2.1. Description of the work process

Water management or uniform storage along the row of plants is done with the help of continuous or compartmentalized (interrupted) furrows. The work of opening water furrows, also known as thinning (soil modelling), which, at first, was performed with horse-drawn weeds, is done using equipment that works in aggregate with an agricultural tractor. The equipment are composed of butting ploughs that make the furrow whose section is in triangular shape and the modelers that make its finishing and obtaining the final section in parabolic shape (Fig.2.1.) [10,14].

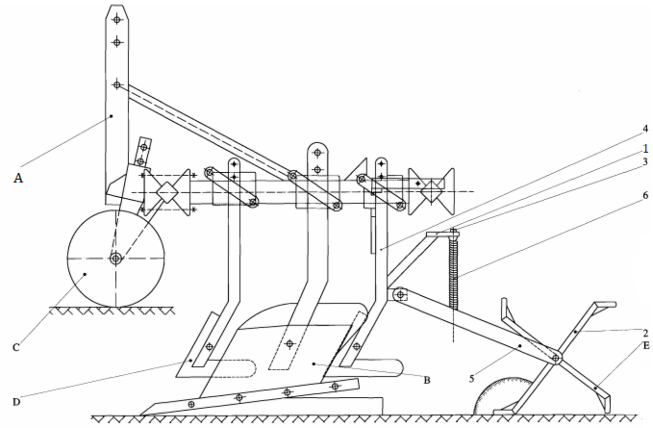


Fig.2.1. Equipment for opening and partitioning water furrows consisting of a frame with a gripping triangle (A), plough bodies (butting plough) (B), support wheels (C), hoe blades (D), finishing and partitioning mechanisms (E) [10]

The finishing and partitioning mechanism (E) consists of a support (1), a rotor (2) with palettes, a mechanism (3) for pressing the palette on the ground, a vertical support (4), a bracket (5) and pressure spring (6) [10].

Fig.2.2 (a), (b). Appearance of the partitioned furrow when using the LEPA system [14]

In Fig. 2.4. is presented how the compartmentalization of the furrows influences the action of the three factors, soil, water and sun on the crops where this technology is applied.

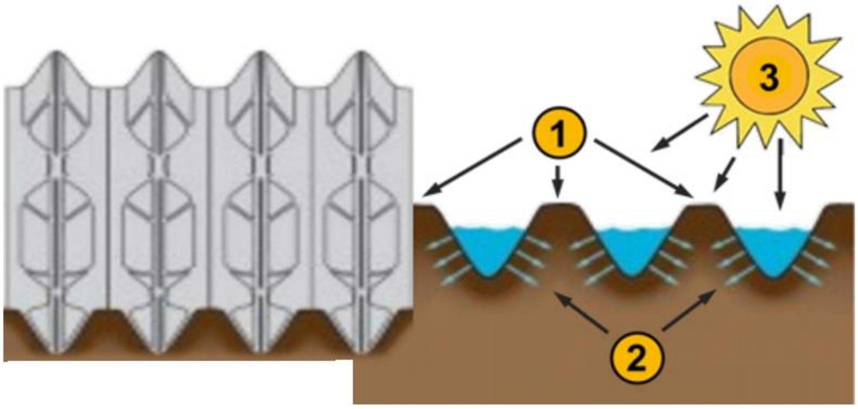


Fig. 2.4. The manner how soil, water and sunlight factors influence the crop in the case of partitioning [42,107]

The furrows can be continuous or compartmentalized and can be successive or alternative, and by their execution is aimed to obtain an enlarged section of the furrow necessary for the accumulation and transport of as large a volume of water as possible (Fig. 2.5. -2.8.).

a) b)

Fig. 2.5. a), b) Continuous furrows and partitioned furrows after rain [14,112]

The formation of compartmentalized furrows reduces the phenomenon of erosion. In Fig. 2.9., the alluvium collected in an experiment is presented [101].

When performing the work of opening and compartmentalizing water furrows, the main purpose is to recover as much water as possible, which is possible by obtaining a large section of the furrow, as well as correlating the distance between rows with the dimensions of the reservoirs delimited by furrows [34].

a) b)

Fig. 2.9. Highlighting the erosion phenomenon in the case of non-partitioned furrows (a) and in the case of partitioned furrows (b) [102]

2.2. Equipment used for the construction of water capture basins

The constructive and functional analysis of mechanically operated equipment for opening and partitioning watering furrows used in vine plantations and in the technology of weeding crops, implies the need to study the constructive characteristics of these equipment, their operation and work process, so as to have the possibility to recommend the best constructive solution that meets the requirements of the users.

The soil work of furrow compartmentalization was first used on Great Plains, USA by C.T. Peacock and a farmer from Arriba, Colorado. Research on the efficiency of furrow compartmentation for soil and water conservation as well as increasing crop yields has been done on the sites of several large centres, including Colby - Kansas, Hayes - Kansas, Woodward - Oklahoma and others [79,97].

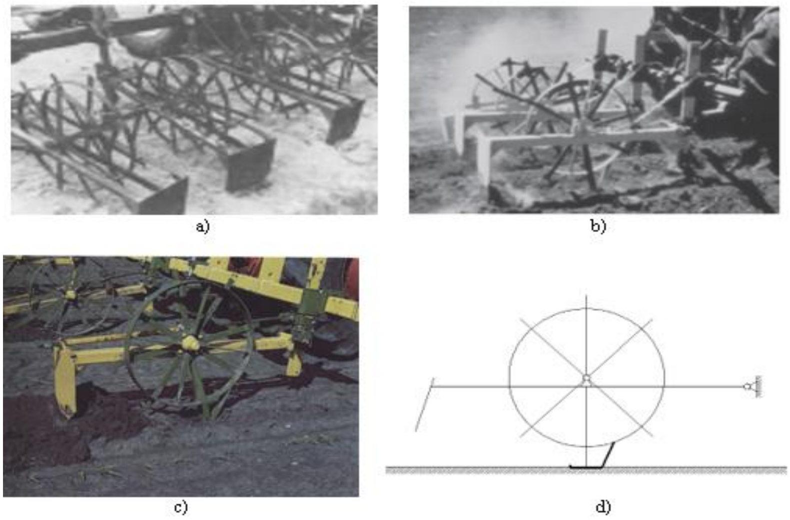


Fig 2.11. Equipment for opening and partitioning wate furrows with shovels (a), (b), (c) and kinematic diagram for these equipment (d) [37,52]

Pocket Pitter equipment is designed to provide the benefits of water accumulation work in reservoirs made in crops with a small distance between rows, such as onions, carrots, sugar beet, beans. The equipment makes long and narrow depressions, with a minimum mobilization of the ground (Fig. 2.24.) [4].

Fig. 2.24. Pocket Pitter equipment for making short-distance crop imprints (a), (c), kinematic diagram of the equipment (b) and the shape of the field imprinted with the equipment for making short-distance crop imprints (d), (e), (f) [5]

RT850 equipment is used conduct soil loosening works and to make basins for capturing water for weeding crops (Fig. 2.30.) [156].

In the case of equipment for opening and compartmentalizing irrigation canals without locking systems of active components, the formation of dams is achieved by the amount of soil accumulated in front of the active bodies. Through soil accumulation, a certain pressure is created on the surface of the blade and when the necessary force is obtained to unlock it, the rotation is followed by the formation of the dam and then the continuation of the channel opening process (Fig. 2.31.) [56].

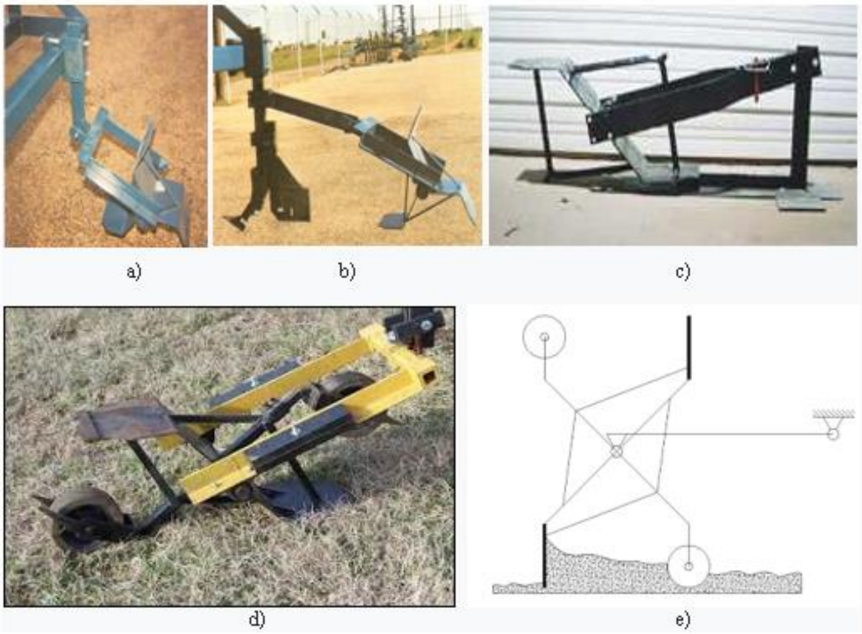


Fig. 2.32. Construction solutions for equipment for the partitioning of furrows with three-blade rotor (a), (b), two-blade rotor (c), two-blade rotor and two support wheels (d) and the kinematic diagram for the two-blade and two support wheels version (s) [110,123]

In order to limit the risks of runoff and transfer of soil and phytosanitary products in case of a violent storm after planting, Grimme company has developed the "Terra Protect" device, which has shovel-type partitioning bodies, to form dams between rows (Fig. 2.37.) [88].

a) b) c)

Fig. 2.37. "Terra Protect" partitioning equipment produced by Grimme (a), (b), (c) [88]

"Briggs Tied Ridger" equipment was developed to prevent rain and irrigation water from flowing from established crops especially on sloping ground, thus achieving a significant reduction in surface erosion, reduced fertilizer losses and a reduction in water requirements. (Fig. 2.39.) [147].

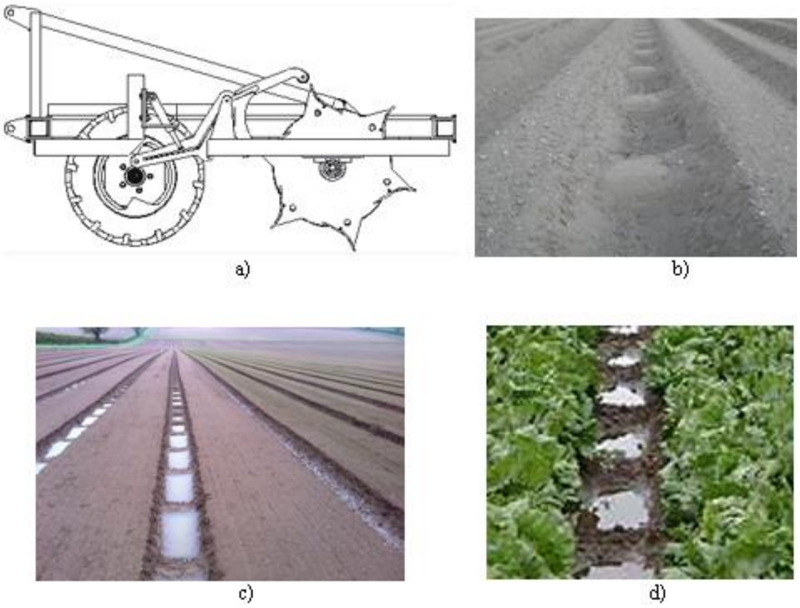


Fig. 2.39. Furrow profile created by Briggs Tied Ridger equipment, (b), (c), (d) and kinematic diagram, (a) [147]

Equipment for modelling the soil in compartmentalized furrows for weeding crops, simultaneously on 5 intervals, DMBC-5, (Fig. 2.40.).

Fig. 2.40. DMBC-5 equipment for modelling the soil in partitioned furrows for weeding crops (a), (b), (c), (d) [106,108]

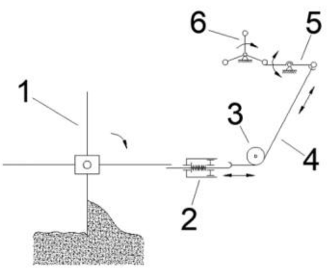


Fig. 2.43. Kinematic diagram of the control system for furrow partitioning equipment [104]: 1- rotor with palettes; 2-trigger device; 3-roll; 4-cable; 5-lever drive; 6-cam drive

The furrow partitioning equipment, mounted on the rear bar of the frame, consists of a camshaft, mechanisms for transmitting motion to the bolts that lock the palettes and three, four or five rotors with palettes. The rotational movement of the right-side wheel is transmitted by a chain drive to an axis positioned parallel to the second square bar (rear), an axis that has some cams positioned next to each working unit (Fig. 2.43.). During the rotation, the camshaft will operate the lever / cable mechanism from each section in the direction of unlocking the palette with the locking bolt and, by rotating the palette, the furrow compartmentation dam will be made, and by cyclic unlocking of the rotor, depending on the distance travelled by the device, compartmentation dams will be made at predetermined distances. The rotors have four or three trapezoidal palettes.

The equipment for modelling the soil in compartmentalized furrows at vine plantations, simultaneously in two furrows on an interval, PCVM2,2 + EMBC2-0 (Fig. 2.45.), makes compartmentalized furrows in vine plantations, at a distance of 20-40 cm in a row, in order to accumulate water from precipitation in the soil.

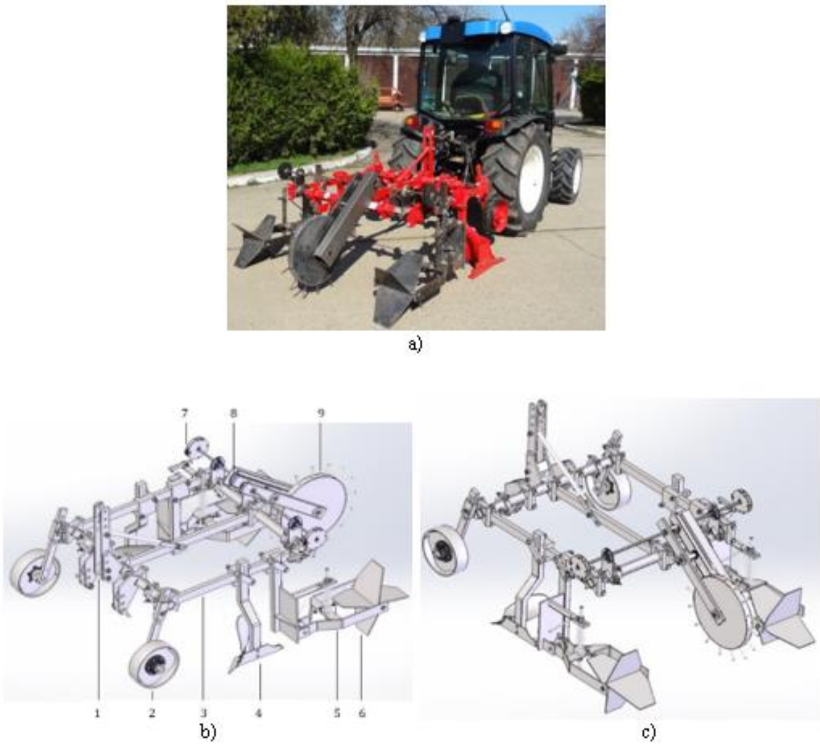


Fig. 2.45. Equipment for modelling the soil in partitioned furrows at vine plantations, simultaneously in two furrows on an interval, PCVM2,2 + EMBC2-0, (a), (b), (c) [111]: 1 gripping triangle; 2 support wheel; 3 frame; 4 body; 5 locking element; 6 rotor with palettes; 7 cam; 8 chain drive; 9 spur wheel

The equipment consists of the following main subassemblies: a left plough body; a right plough body; a unit for making compartmentalized furrows, provided with a control system and, optionally, two arrow blades if simultaneous hoeing is desired. The plough bodies with left support and right support are mounted on the plough frame in the lateral parts corresponding to the plough, with the overturning of the furrow towards the inside of the row, having the supports of the bodies deformed towards the outside of the frame. The unit for making compartmentalized furrows (Fig. 2.46.) consists of the following main parts: the control mechanism, the rotor support, the rotor with palettes and the mechanism for pressing the scraper blade on the ground. The adjustment of the control mechanism of the furrow compartmentation equipment allows the realization of soil dams along the furrow at distances of 1.5; 3 or 6 m.

Chapter 3 CONTRIBUTIONS TO THE MATHEMATICAL MODELLING OF THE WORK PROCESS AND TO THE CONSTRUCTIVE AND FUNCTIONAL OPTIMIZATION OF EQUIPMENT FOR OPENING AND PARTITIONING WATERING FURROWS

3.1. General aspects

The use in the process of opening and partitioning water furrows of a working body with an active surface of the mouldboard type, respectively butting plough, and of a working body with an active surface of the blade type, respectively the palette, at an increased speed regime, requires to study the working process in these conditions. It is known that the working speed also influences the tensile strength [24, 116].

3.2. Modelling the working process for the active organ with the active surface of the mouldboard-butting plough type

The active bodies for opening the water furrows (butting ploughs) are formed by two symmetrical mouldboards, joined together and provided at the top with an arrow-type coulter (Fig. 3.1.). By moving the working bodies in the soil, the lower contours of the mouldboards and the coulter cut and detach a layer of soil, which is raised on the surface of the mouldboards. It is accelerated, overturned and deposited in the sides, forming elevations. Following the butting ploughs, a furrow is formed [154].

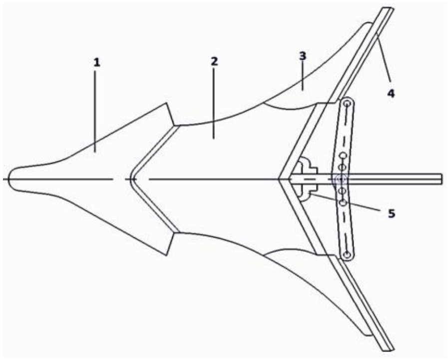


Fig. 3.1. Butting plough [130]: 1 arrow type coulter, 2 mouldboard chest, 3 mouldboard wings, 4 mouldboards extension, 5 furrow opening adjustment rod

To determine the relative motion of soil particles in their movement on the active surface of the working body (butting plough), as well as for qualitative and quantitative assessments of this movement, it is assumed that the movement of a particle is a vertical movement, started at a certain angle to the main direction of travel of the equipment.

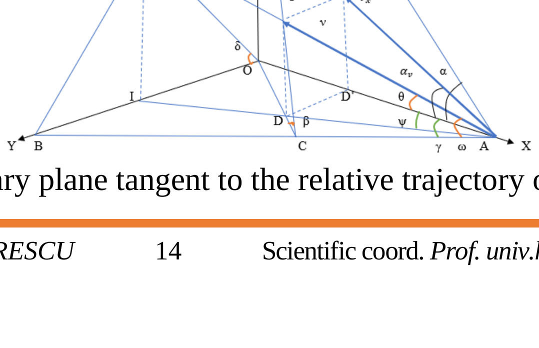


Fig. 3.2. The elementary plane tangent to the relative trajectory of the soil particle [19]

From the analysis, it results:

$$\sin\omega = \frac{4\cdot tan^3\frac{\alpha}{2}}{(1+tan^2\frac{\alpha}{2})\sqrt{4+\left(1-\frac{1}{tan^2\frac{\alpha}{2}}\right)\cdot sin^2\gamma}} \quad (3.5)$$

In the case of relative speeds, assuming that their changes over time are small compared to the absolute speed, the absolute speed can be considered as the movement speed of the machine, denoted v_m, in Fig.3.2., the component can be determined in the direction of the OX axis of the absolute speed as:

$$v_x = v_m \cdot (1 - \cos\alpha) = 2\cdot v_m \cdot \sin^2\frac{\alpha}{2} \quad (3.6)$$

Soil particle dynamics under the action of the active working surface

Dynamics studies the motion of the butting plough, taking into account the forces acting on it. The equipment with working bodies is actuated by the traction force. The butting plough behaves like a body with a double mouldboard. The lower part of mouldboards dislocates the soil layer. The dislocated soil is raised on the surface of mouldboards and overturned to the sides. During the overturning, it receives a kinetic energy, which influences the resistance of the butting plough. Goriacikin proposed formula mirrors the physical essence of the work process performed by butting plough [116]:

$$R_{modelling} = f\cdot G_{equipment} + 2\cdot k\cdot a\cdot\frac{b}{2} + 2\cdot\varepsilon\cdot a\cdot\frac{b}{2}\cdot\vartheta_m^2 \quad (3.7)$$

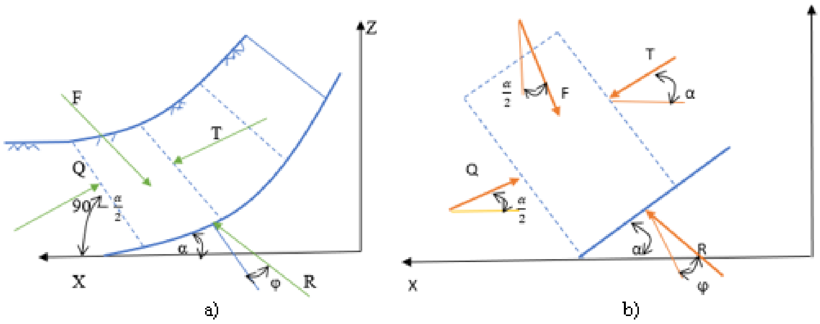


Fig. 3.3. Representation of the active surface of the butting plough during work; a) soil furrow in contact with butting plough; b) the forces acting on an isolated part of the furrow

Determination of the reaction force Q

The determination of this force is done by projecting all the forces acting on the particle on the OX and OZ axes, and the following is obtained:

$$Q = \frac{T\cdot\cos\varphi + F\cdot\sin(\varphi+\frac{\alpha}{2})}{\cos(\varphi+\frac{\alpha}{2})} \quad (3.13)$$

Relation (3.13) gives the expression of the force Q as a function of forces T and F to be determined.

Determination of the inertia force F

To determine the inertia force F, which appears as a dynamic pressure due to the displacement of the soil particle on the curve portion of the active surface of the butting plough, the theory of variation of the amount of motion is used.

Under these conditions is possible to write:

$$\bar{F} = \frac{dm}{dt}\cdot\overline{v_x} = m'\cdot\overline{v_x} \quad (3.15)$$

If equation (3.6) is considered, the relation can be written:

$$\bar{F} = m' \cdot \overline{v_m} \cdot (1 - \cos\alpha) \tag{3.17}$$

Determination of friction force T

To determine this force, consider the volume element dV of a furrow portion, as in Fig. 3.4. The resultant of forces T and T - dT, acting on this element, is arranged in the normal direction at the curvature element ds and has the value:

$$dN = dN_1 + dF_n \tag{3.23}$$

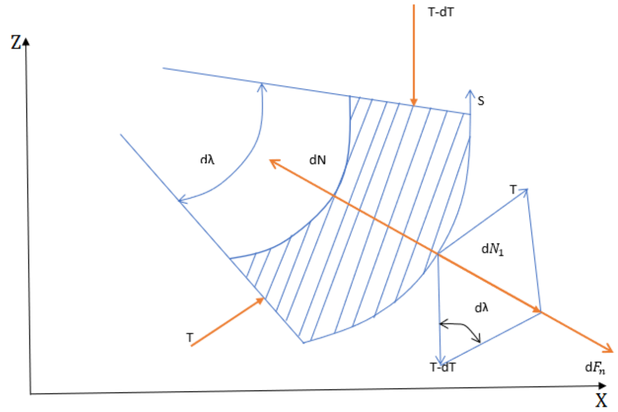


Fig. 3.4. Determination of inertia and friction forces acting on a portion of the furrow

$$dT = f \cdot T \cdot d\lambda + f \cdot m' \cdot v \cdot d\lambda = f \cdot d\lambda \cdot (T + m' \cdot v) \tag{3.25}$$

$$T = m' \cdot v \cdot (e^{f\lambda} - 1) \tag{3.27}$$

ε = global coefficient,

$$\varepsilon = \frac{\rho}{2 \cdot g} \cdot \left[\left(1 - \cos\frac{\alpha}{2}\right) + \frac{(e^{f\lambda} - 1) + sin\alpha \cdot (\tan\frac{\alpha}{2} + f)}{1 - f \cdot \tan\frac{\alpha}{2}}\right] \tag{3.32}$$

Therefore, the total tensile strength is [19]:

$$R_r = a \cdot b \cdot v_m^2 \cdot \varepsilon \quad (N) \tag{3.36}$$

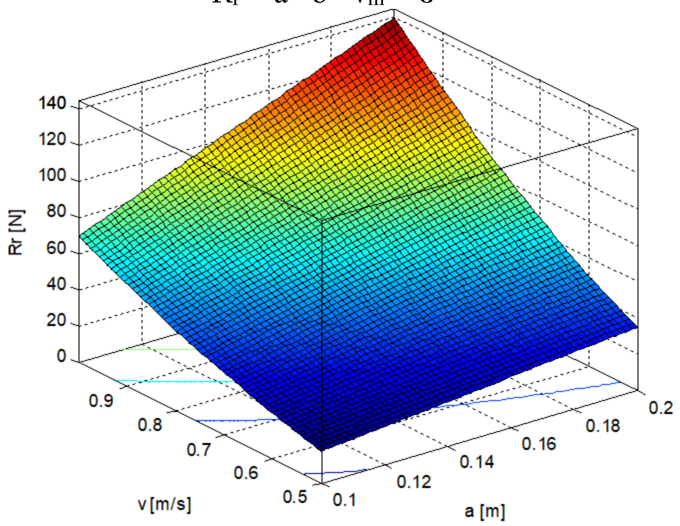


Fig. 3.5. Variation of the tensile strength generated by the butting plough, depending on the working depth a = 0.1 - 0.2 m and the working speed v_m = 0.5 - 1 m / s, the working width b = 0.35 m of the butting plough and the coefficient ε = 2000 kg / m^3

3.3 Modelling the working process for the active organ with the active surface of the blade-palette type

The resistance force R_p encountered during the movement during operation of the blade is:

$$R_p = R_1 + R_2 \qquad (3.37)$$

where: R_1 - is the displacement resistance (by dragging) of the soil mass in front of the blade;
R_2 - resistant force of soil movement on the palette.

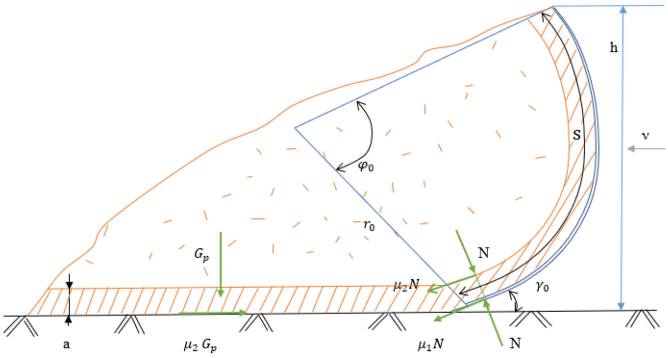


Fig. 3.6. Process of filling the blade [40]

$$R_2 \cdot s = a \cdot b \cdot s \cdot \rho \cdot g \cdot h + \mu \cdot \rho \cdot g \cdot h \cdot b \cdot s^2 \qquad (3.44)$$

and:

$$R_2 = \rho \cdot g \cdot h \cdot b \cdot (a + \mu \cdot s) \quad \text{(N)} \qquad (3.45)$$

$$R_1 = \mu_2 \cdot G_p = \mu_2 \cdot V \cdot \rho \cdot g \qquad (3.47)$$

$$R_p = R_1 + R_2 = \mu_2 \cdot V \cdot \rho \cdot g + \rho \cdot g \cdot h \cdot b \cdot (a + \mu \cdot \rho \cdot s) = \rho \cdot g \cdot [\mu_2 \cdot V + h \cdot b \cdot (a + \mu \cdot s)] \qquad (3.48)$$

The value of the force resistant to the movement of the material layer on the palette can also be determined in another way [18]

$$R_p = R_1 + R_2 = \mu_2 \cdot G_p + \mu_1 \cdot G_p \cdot \cos^2\gamma_0 = G_p \cdot (\mu_2 + \mu_1 \cdot \cos^2\gamma_0) \qquad (3.58)$$

respectively:

$$R_p = \frac{b \cdot h_1^2}{2 \cdot \tan\alpha} \cdot \rho \cdot g \cdot (\mu_2 + \mu_1 \cdot \cos^2\gamma_0) \qquad (3.59)$$

respectively:

$$R_p = \rho \cdot g \cdot b \cdot v_m \cdot t \cdot [a + v_m \cdot t \cdot (\mu + \frac{\mu_2}{2})] \quad \text{(N)} \qquad (3.63)$$

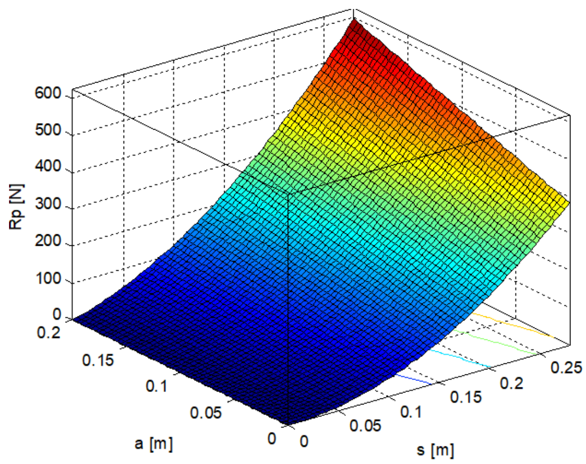


Fig. 3.8. Variation of the tensile strength generated by the blade, depending on the working depth a = 0.0 - 0.2 m, on the distance s = 0 - 0.28 m, the working width b = 0.35 m.

3.5. Contributions to the optimization of the equipment for opening and partitioning water furrows

The watering channel should have an isosceles trapezoidal cross section (Fig. 3.11.).

To express the purpose function, in relation to the parameters of the problem, the following data is used:

$A = \frac{(B+b)h}{2}$ is the area of the trapezoidal section; (3.81)

$\mathcal{P} = 2l + b$, the perimeter used; (3.82)

α, the angle between the large base B and the side l.

$$b = \mathcal{P} - 2l,\ B = \mathcal{P} - 2l + 2l\cos\alpha,\ h = l\sin\alpha, \quad (3.83)$$

$$A = \mathcal{P}l\sin\alpha - 2l^2\sin\alpha + l^2\sin\alpha\cdot\cos\alpha, \quad (3.84)$$

For the case of the watering furrows for weeding crops h = 0.17 m:

$$\begin{cases} l = \frac{h}{\sin\alpha} = \frac{0.17}{0.866} = 0.1963 \approx 0.2\text{m} \\ \text{b} = l = 0.2\text{ m} \\ \text{B} = 2 \text{ x } l = 0.4\text{m} \end{cases} \quad (3.89)$$

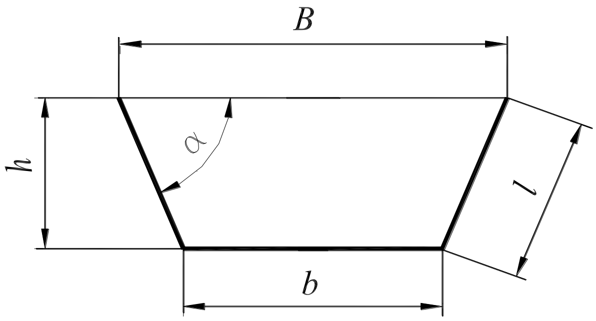


Fig. 3.11. Shape of the cross section of the water furrow

3.6. Use of cam mechanisms to control the equipment for opening and partitioning water furrows

Below is the synthesis of a rigid memory to command the working organs, to make dams at the desired distance along the length of the watering channel. This rigid memory consists of a rotating cam and a rotating lug with a roller. The cam-tappet mechanism has the advantage that it allows the working parts of the machine to shape the shape of the gutter according to needs.

Fig. 3.12. presents a sketch with the section and the cam control mechanism.

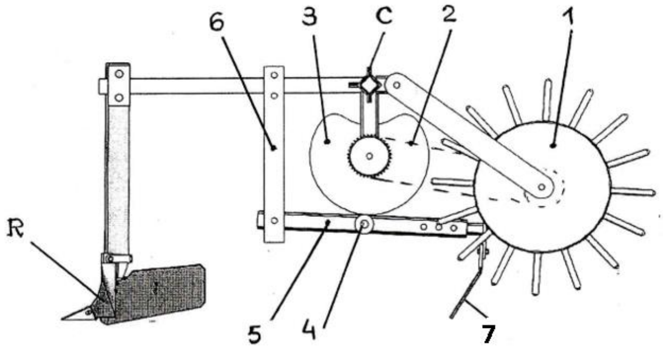


Fig. 3.12. Unit with cam-tappet control mechanism

The synthesis of the rigid memory for the control of the equipment for opening and partitioning water furrows involves several phases, namely: choosing the type of mechanism for control; establishing the cam-to-tappet transmission functions; determining the minimum gauge of the mechanism; cam profile synthesis.

Out of the different types of cam mechanisms, a mechanism with a rotating cam and a tappet with a rotating movement with a roller is chosen for this equipment, as seen in Fig. 3.14.

For the present case, the transmission functions whose diagrams of reduced accelerations are of sinusoidal and cosinusoidal form were considered.

In Fig. 3.16., the variation diagrams of the sinusoidal transmission function are presented.

Relations (3.113) – (3.122) form a system of 10 nonlinear equations with variables: $A, B, C, D, E, F, G, H, I$ and J . After solving the system is obtained:

$$A=\frac{\pi}{u} \quad B=\frac{\pi}{u} \quad C=0 \quad D=1 \quad E=0 \quad F=\frac{\pi}{1-u}$$
$$G=\frac{\pi}{1-u} \quad H=-\frac{\pi}{1-u} \quad I=1 \quad J=0. \qquad (3.123)$$

Using relations (3.124) and (3.125), was formed the function file **lsin.m,** presented in ANNEX 3.2.

In the case of the cosinusoidal transmission function (Fig. 3.17.), the curve representing the reduced acceleration, y'', consists of two cosinusoids connected at the abscissa point $x = u$.

Using relations (3.143) and (3.144), was formed the function file **lcos.m,** presented in ANNEX 3.3.

For the equipment for opening and partitioning water furrows, the optimal synthesis of the mechanism with rotating cam and tappet with rotating roller movement is made.

From the synthesis of rigid memory results: $L_{tappet} = BC_2 = 327$ mm; $r_{max} = 198.223$ mm; $r_{min} = 107.499$ mm; $r_{roller} = 33$ mm. In Fig. 3.22. is presented the kinematic scheme of the mechanism resulting from the synthesis.

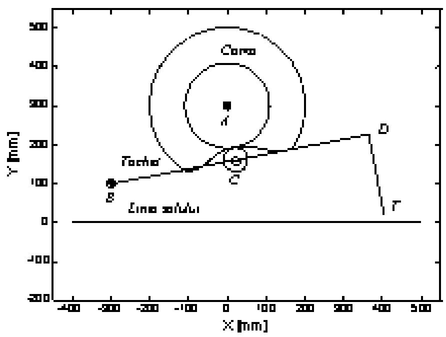


Fig. 3.22. Kinematic diagram of the resulting mechanism

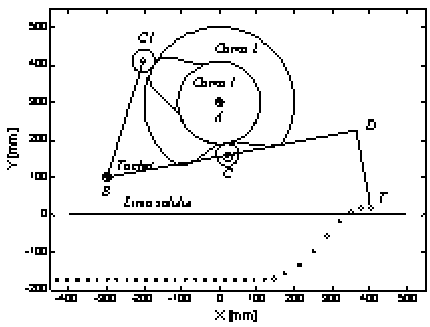


Fig. 3.23. Kinematic diagram of the double cam mechanism

In Fig. 3.24.-3.26. are presented the graphs of movement, speed and acceleration of the T point, representing the lower part of the working body.

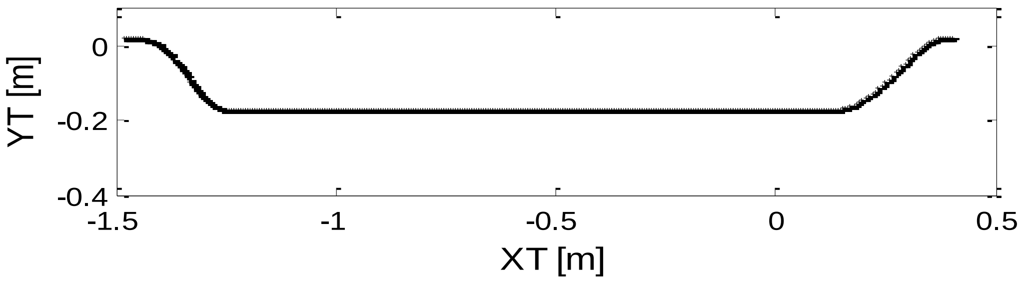
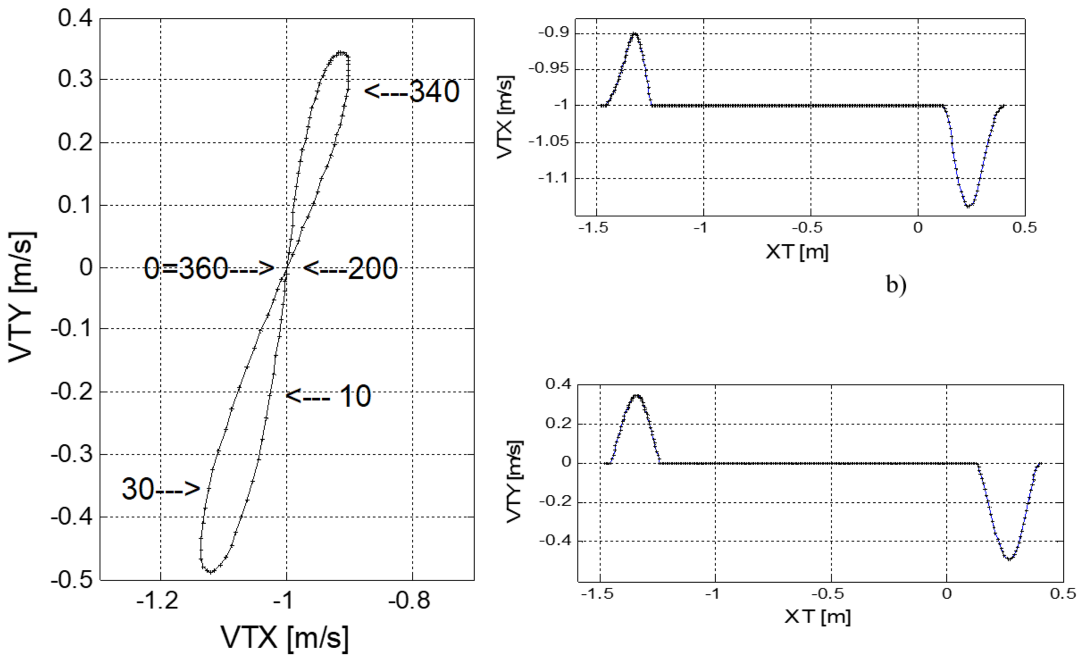
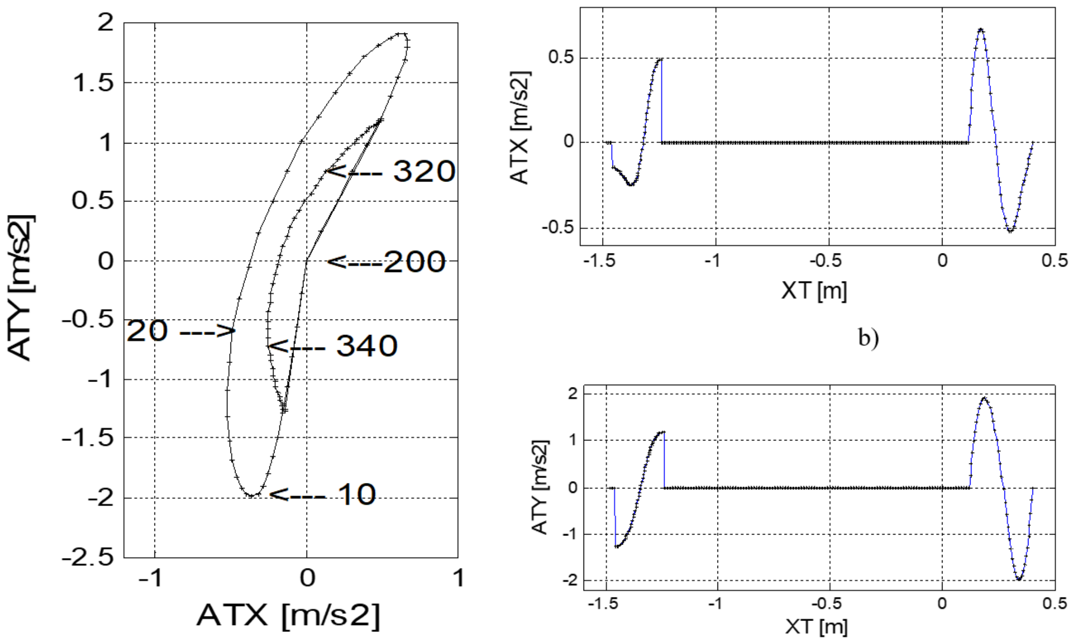


Fig. 3.24. The trajectory of the T point at a complete rotation of the cam



a) c)

Fig. 3.25. a), b) and c) T point velocity graphs



a) c)

Fig. 3.26. a), b) and c) T - point acceleration graphs

Chapter 4. EXPERIMENTAL RESEARCH ON THE WORK PROCESS AND PERFORMANCE OF EQUIPMENT FOR OPENING AND PARTITIONING WATER FURROWS

4.1. Experimentation in operating conditions of the equipment for soil modelling in compartmentalized furrows on 5 DMBC-5 intervals

4.1.3. Place and conditions of experimentation

The experiments in operating conditions of the DMBC-5 equipment were carried out in 2018 in two places (Crânguri - Giurgiu County and Mărculești - Călărași county), on an alluvial chernozem or vermic chernozem soil, on a sunflower crop.

Fig. 4.6. Aspects during the experiments

4.1.7. Determination of qualitative work indices

The following qualitative work indices obtained by the palette rotor were determined under operating conditions, these indices being, in fact, the dimensions of the resulting furrow (Fig. 4.13.), as follows: depth of water furrows, H_d; the width of the bottom of the furrow, B_d; upper width of the furrow, B_b; furrow height, H_b; distance between furrows, L_d.

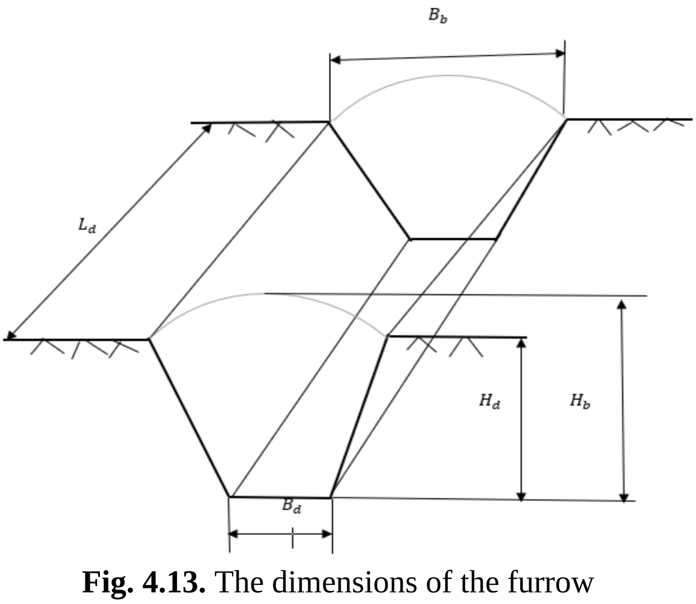
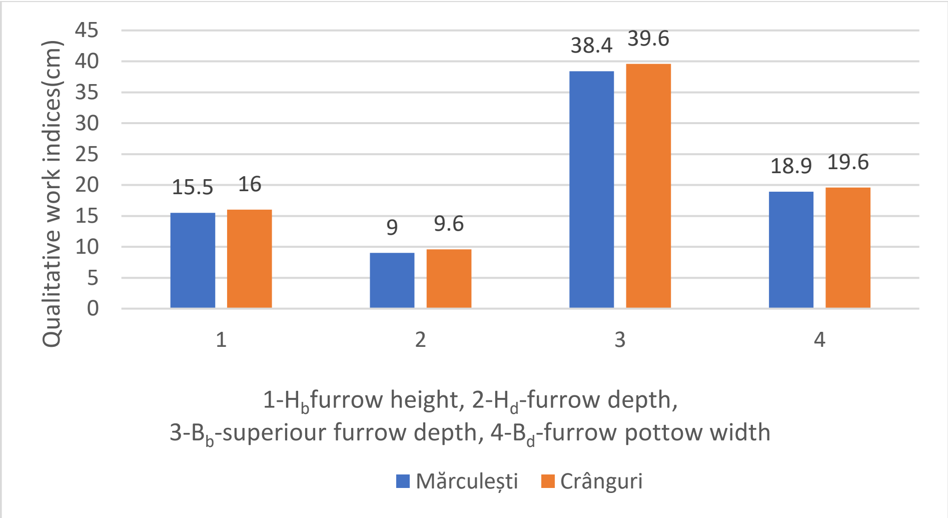


Fig. 4.13. The dimensions of the furrow

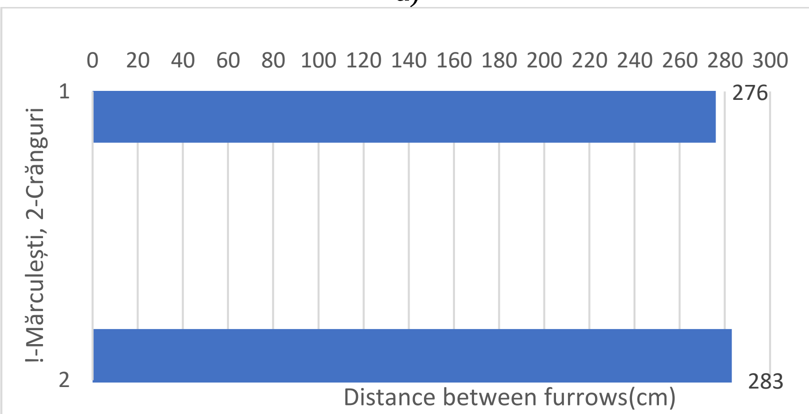
Table 4.7.
Qualitative indices of the determined furrow, for experiments in the Mărculești plot

Qualitative indices obtained						
	Repetition	**H_b, [cm]**	**H_d, [cm]**	**B_b, [cm]**	**B_d, [cm]**	**L_d, [cm]**
	1	17	8	39	20	270
	2	15	9.5	38	19	280
	3	15.5	8.5	40	18	270
	4	14	9	38	19	275
	5	16	10	37	18.5	285
Absolute average, **V_{ma}**, [cm]		15.5	9	38.4	18.9	276
Mean square deviation, **σ_a**, [cm]		1.12	0.612	2.28	0.714	6.52
Variation index, **Va,** [%]		7.2	6.8	5.94	3.78	2.36

Following the experiments made according to the standards in force, in the two places, it resulted that the qualitative work indices performed fall within the agrotechnical requirements of the soil modelling work (Fig. 4.14.).



a)



b)

Fig. 4.14. Qualitative work indices obtained in Crânguri and Mărculești plots during the year 2018

Evaluation of the efficiency of the use of the equipment for water furrow partitioning

The efficiency of the use of the equipment for water furrow partitioning is given by the harvest surplus obtained.

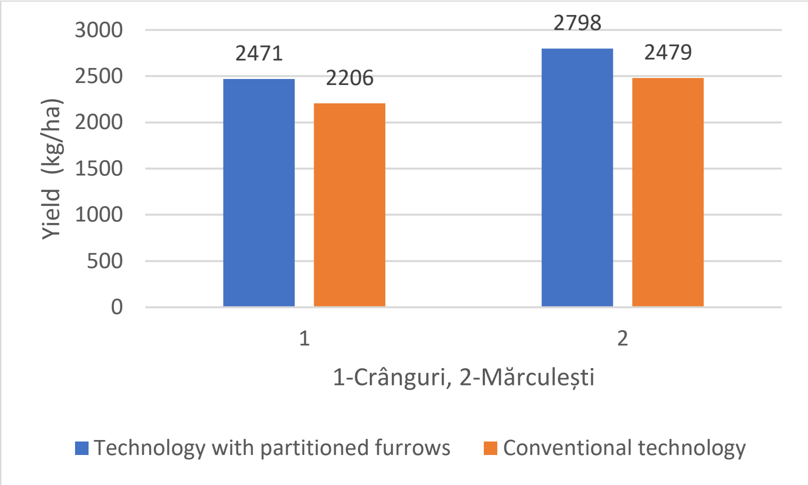


Fig. .4.16. Sunflower production using the two technologies, at Crânguri and Mărculești, in the year 2018.

Fig.4.17. The appearance of the surfaces in which the technology with compartmentalized furrows and the conventional one was used

4.1.9. Determination of energy indices

The determination of the stresses to which the equipment is subjected during the working process is performed by measuring the deformations of the component elements [12].

a) b)

Fig. 4.26. Areas where the strain gages were mounted on DMBC-5 equipment (marked in red)

Fig. 4.28. presents the variation of the traction force and of the force on the body with the working speed.

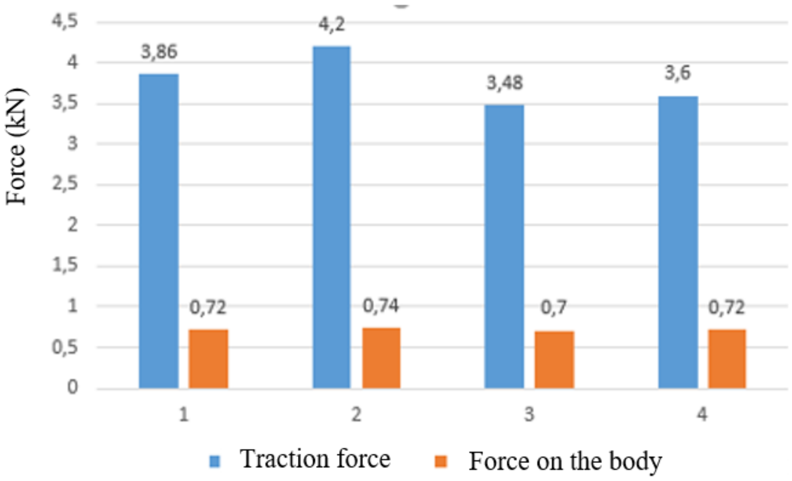


Fig. 4.28. Variation of traction force and of the force on the body for the four tests performed at four different speeds

4.3. Testing under operating conditions of the optimized PCVM2.2 + EMBC2 equipment
4.3.1. Working conditions and constructive form of the tested working bodies

The experiments in operating conditions for determining the qualitative indices were performed on the experimental field within INMA-Bucharest (Fig. 4.36.). The size of the rotor palette: 400 x 200 x 260 mm. Palette shape: straight; inclined and curved.

a) b)

Fig. 4.36. The field where the tests were performed-INMA Bucharest

4.3.7. Determination of quality indices for the equipment equipped with rotor with inclined palettes after optimization

Aspects during the experiments for determining the qualitative indices of the work performed with the rotor with optimized curved palettes are presented in Fig. 4.45., and the data measured in Table 4.16.

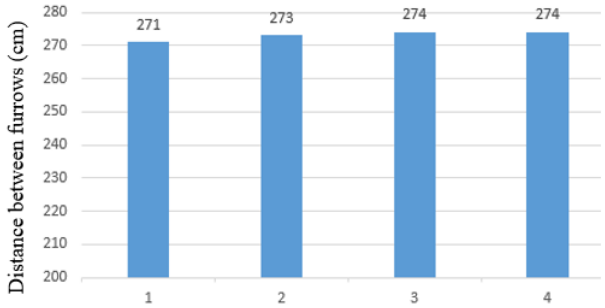
a) b)

Fig. 4.45. Equipment with inclined palettes rotor

Table 4.16.
Qualitative indices determined with the inclined palettes rotor

	H_b, [cm]	H_d, [cm]	B_b, [cm]	B_d, [cm]	L_d, [cm]
	23.5	17.5	49	18	285
	23	19	46	16.5	290
	24	17	47	17	270
	22.5	19	50	15.5	265
	21	18.5	48	16	260
Absolute average, V_{ma}, [cm]	22.8	18.2	48	16.6	274
Mean square deviation, σ_a, [cm]	1.21	0.91	1.0	0.96	13.51
Variation index, V_a, [%]	5.33	5.0	2.1	5.8	4.93

In Fig.4.47., the distance between the furrows at the initial version and at the optimized version with the three types of palettes is represented. It is observed that it does not change significantly after the optimization of the working body.



1 - nonoptimized straight blade, 2 – optimized straight blade, 3 – inclined blade, 4 – curved blade

Fig.4.47. Distance between furrows depending on the working body

4.3.10. Determination of energy indices

To determine the forces acting on the equipment, measurements were performed using strain gages. The following were measured: the traction force of the tested equipment and the force on the working body.

Fig. 4.52. Preparation of equipment for determining energy indices

In Fig. 4.54. - 4.55., the diagrams of variation of the traction force depending on the working speed are presented.

The analysis of the measurements shows that the force required to drive the equipment for opening and partitioning water furrows, represents about 10-15% of the total traction force required to perform the hoeing work, which justifies the low consumption of additional fuel required to perform this work.

4.4. Testing under operating conditions of the equipment for partitioning water furrows using the cam-tappet control system

Fig. 4.58. presents the equipment equipped with the cam-tappet control system for furrow compartmentation and aspects during the experiments.

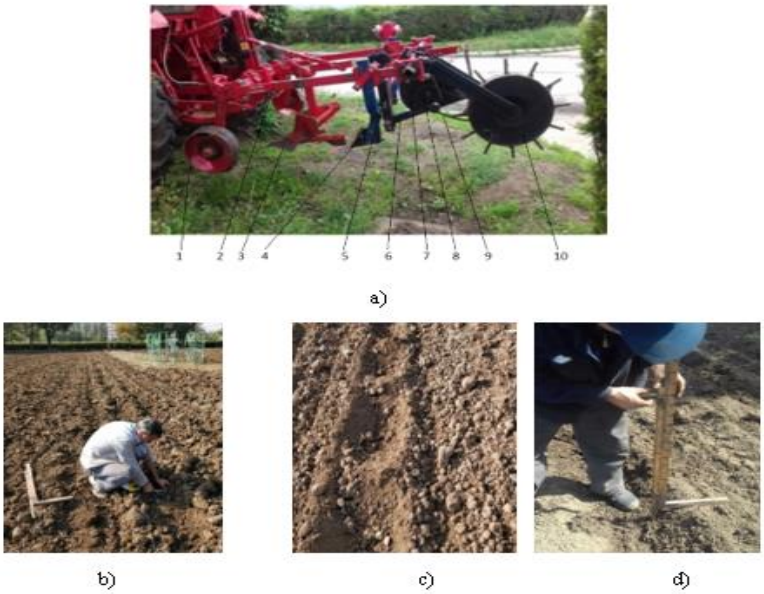


Fig. 4.58. Equipment fitted with the cam-tappet system a): 1 - copy wheel, 2 - frame, 3 – plough body, 4 - arrow blade, 5 - tappet holder, 6 - tappet, 7 - cam, 8 - chain wheel, 9 - chain, 10 - spur wheel) and aspects during the determination of qualitative indices b), c), d)

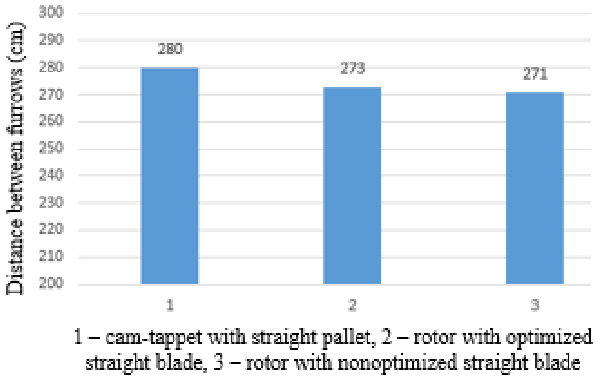


Fig. 4.63. The distance between furrows for the three straight-blade equipment versions

From Fig. 4.63. it is observed that in the case of the equipment equipped with cam-tappet control system, the distance between furrows corresponds to the calculated one, therefore, we can conclude that this equipment ensures a higher precision than the one with rotor for the same type of working body.

4.4.4. Determination of energy indices

To determine the forces acting on the equipment or perform measurements, strain gages were used, mounted according to Fig. 4.64.

Fig. 4. 64. Manner of placing strain gages

In Fig. 4.66., the manner of variation of the traction force according to the speed of movement of the machine for the four types of working bodies is represented (Annex 4.3.).

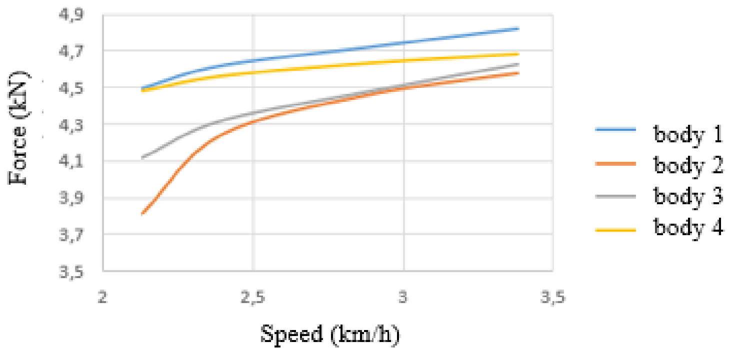


Fig. 4.66. Variation of traction force with the speed for the four types of working bodies

In Fig. 4.70., the manner of variation of the force on the working body is represented for the four constructive versions at four speed regimes of the equipment.

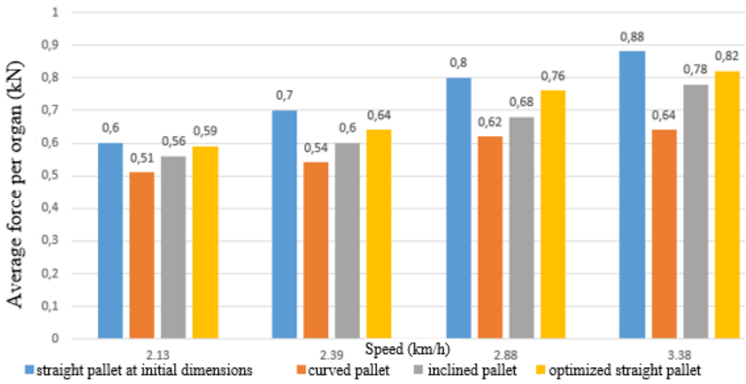


Fig. 4.70. Variation of the force on the body for the four constructive versions at four speed regimes of the equipment.

From Fig. 4.70. it is observed that the force on the body increases with the increase of the speed of movement, having the lowest values for the body equipped with the optimized curved palette.

4.5. Statistical analysis of experimental data for the equipment for opening water furrows

The descriptive statistical analysis was made for the available experimental results, resulting from the experiments performed with two structural versions of the equipment for opening water furrows. These versions are shown in figures 4.71. - 4.72.

The graphical representation of the experimental data distribution for the five qualitative indices (each for four versions of EDCBU), are given in Fig. 4.86.-4.90.

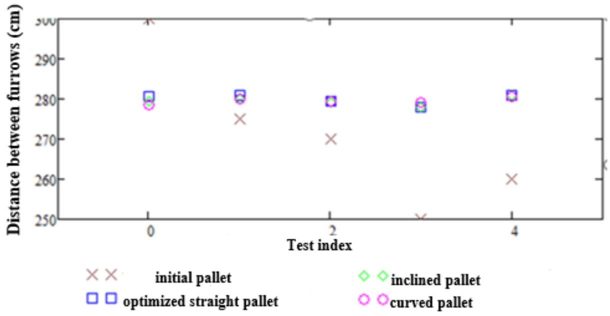


Fig. 4.90. Distribution of L_d measured values

In Fig. 4.94., the areas of the cross sections of the furrows opened by the four versions are graphically represented.

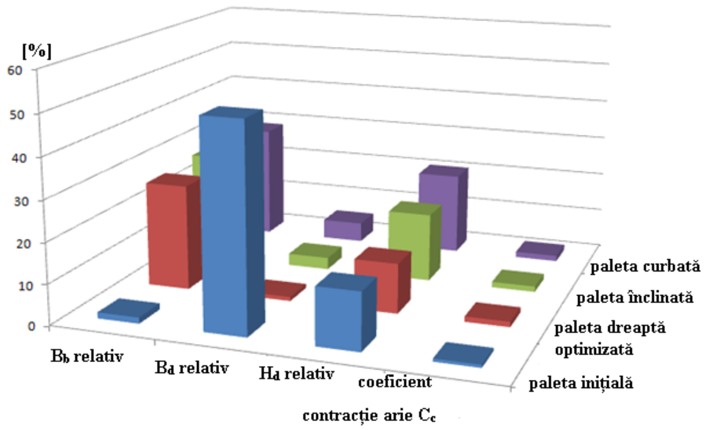


Fig. 4.94 Graphical representation for the behaviour of the qualitative indices in relation to the reference unit of the standard palette (new load-bearing structure, except for the standard rotor version).

A synthetic image on the distribution of experimental data regarding the quality indices of the work performed by EDCBU (cam version), can be obtained using boxplot representations, as shown in Fig. 4.95. - 4.98.

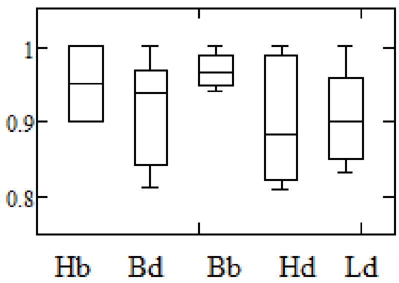


Fig. 4.95. Boxplot representation for the standard version (initial bearing version).

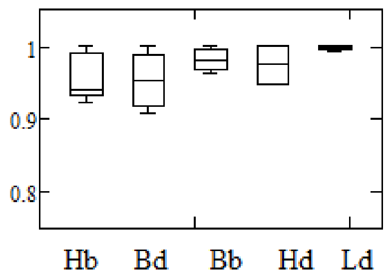


Fig. 4.98. Boxplot representation for the version with curved palettes (modified bearing structure)

4.5.3. Analysis of energy indices

In this subchapter is made the descriptive statistical analysis of the force resistant to the opening of water furrows.

The experimental data obtained for the tensile strength forces are presented in table form in the previous subchapters, and in this subchapter, they are presented graphically, in Fig. 4.99. - 4.102.

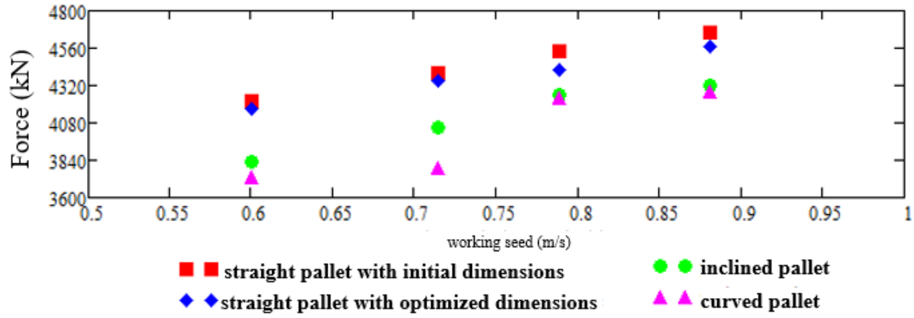


Fig. 4.99. Variation of the total tensile strength with the working speed, for the equipment with rotor (R_{rpddi}, R_{rpddo}, R_{rpi}, R_{rpc}).

4.6. Statistical and theoretical modelling of the processing-resistant force produced by the blade

Using the experimental data on the processing force of the main working body (palette), it is possible to try to obtain a theoretical-empirical relation for this resistance force.

$$R_{EDCBU} = R_{rar} + R_{pal} + R_{fr} + R_{rc} \quad (4.17)$$

$$R_{rar} = \mu G + \left(k + \varepsilon_g v^2\right)ab \quad (4.20)$$

$$R_p(a,b,v,t) = f \cdot g \cdot m_p + (k_1 + \varepsilon_1 v^2)A_p(a,b)\Theta(v,t) \quad (4.25)$$

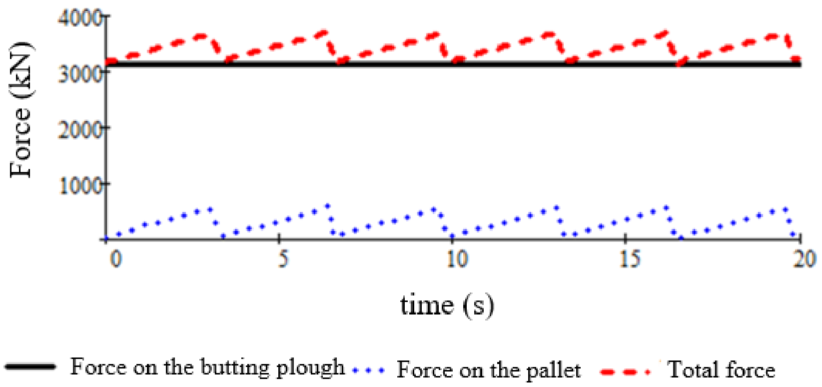


Fig. 4.109. Comparative variation of the total strength of its components over time

In fig. 4.110., the variation of the total tensile strength as a function of working depth and working speed is plotted for four values of the working width of the butting plough.

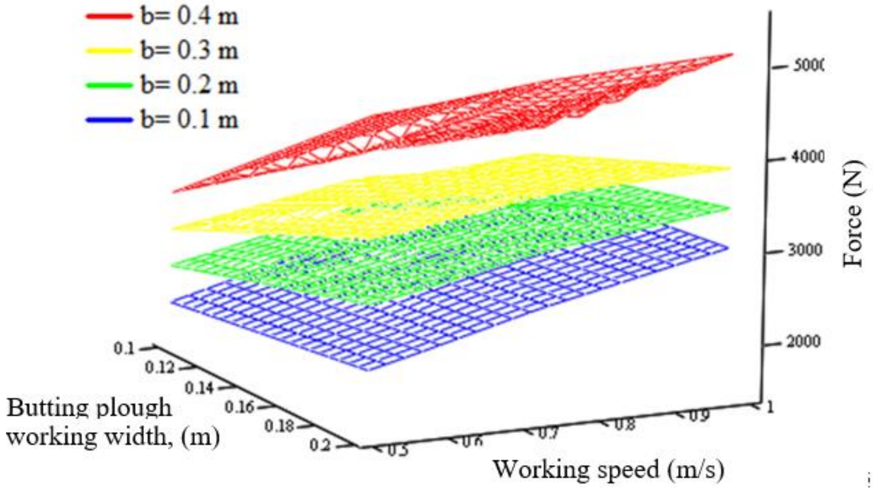


Fig. 4.110. Representation of the total tensile strength of EDCBU, as a function of depth and working speed, for four values of the working width of the butting plough.

Chapter 5. RESEARCH ON THE STRUCTURAL ANALYSIS OF THE EQUIPMENT FOR OPENING AND PARTITIONING WATER FURROWS USING THE FINITE ELEMENT METHOD

5.1. General consideration

Structural analysis is a modern tool in the research of physical phenomena and the design of industrial, civil or other products. In the field of agricultural machinery, in recent years, there have been many works related to the design of equipment used in agriculture or the structural modelling of physical processes in agriculture.

5.2. Structural analysis of the carrier structure of the equipment for opening and partitioning water furrows-EDCBU

The simplified load-bearing structure of the EDCBU equipment is represented graphically in Fig.5.1. The structural model is constructed with 3D unidimensional elements, meaning, physically, Timoshenko bar models [124, 143]. For linear-elastic static analysis, the only necessary characteristics of the structure material are: the modulus of linear elasticity, *E*, with the value $2.1{\cdot}10^{11}$ Pa [21, 36]; he transverse contraction coefficient *ν*, with the value 0.29 [21, 36]; steel density with the value 7850 kg/m^3.

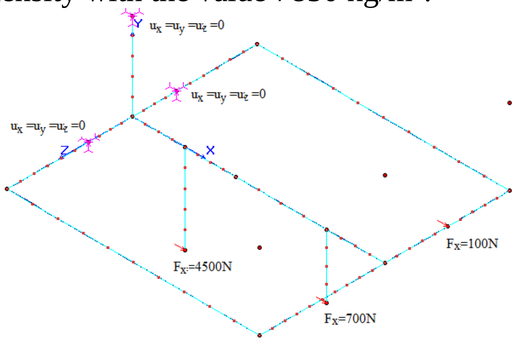


Fig. 5.2. Structural model of the load-bearing structure of EDCBU equipment (geometry, loads and bearing or contact with the environment)

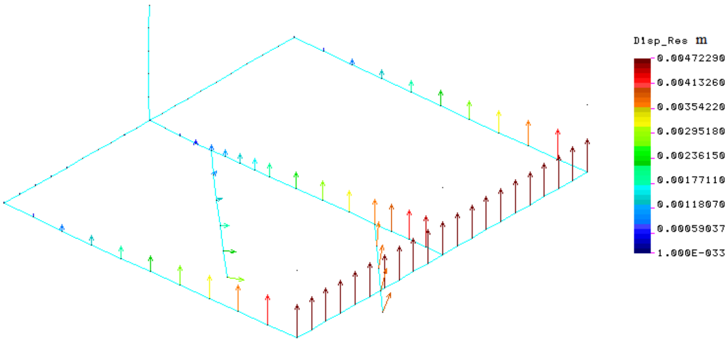


Fig. 5.3. Distribution of the resulting relative displacement field in the load-bearing structure of the EDCBU

Static analysis also provides reaction forces at the points of support of the structure, on the three axes and the resultant. The reaction values are given in table 5.1.

Table 5.1.
Reaction values at tractor attachment points for the load-bearing structure of the EDCBU.

Point	Ox Reaction, [N]	Oy Reaction, [N]	Oz Reaction, [N]	Resultant, [N]
Coupling to the right tie rod	-5115	-843.1	5.7	5184
Coupling to the central tie rod	5072	168.6	0.0	5345
Coupling to the left tie rod	-5258	-843.1	-5.7	5325
Total	-5300	0.0	0.0	5300

5.3. 3D structural analysis of the frame of the equipment for opening and partitioning water furrows-EDCBU

The geometry of the structural model of the load-bearing structure of EDCBU taken from the drawings of the CAD model is presented in fig. 5.24.

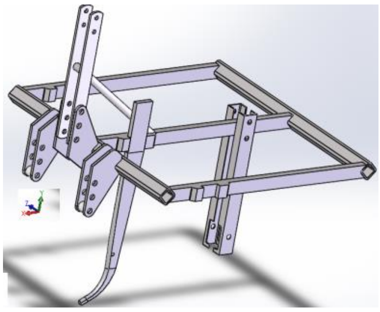


Fig. 5.24. Geometry of the structural model of EDCBU

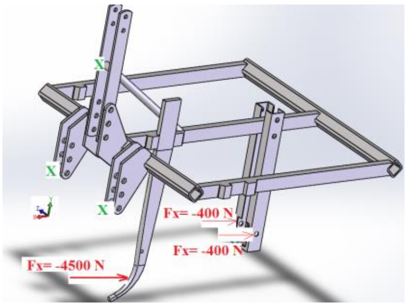


Fig. 5.25. Structural model of EBCDU (geometry, contact with the environment - bearing and loading)

The values of the equivalent stress field at the boundary of the structural model of EDCBU are represented by the distribution in fig. 5.31. The high values are located in the butting plough support and in the bearing areas (connection to the tractor tie rods).

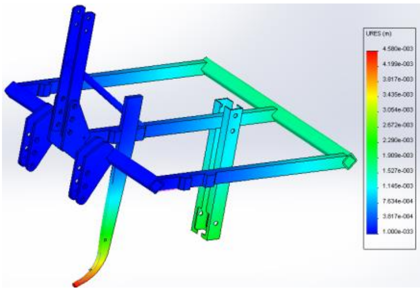


Fig. 5.26. Distribution of relative displacements for the structural model of the EDCBU

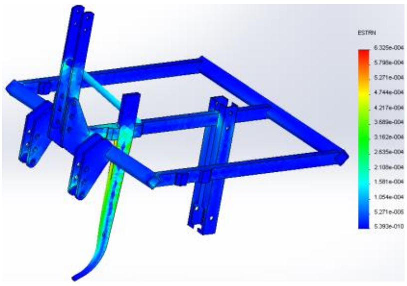


Fig. 5.30. Distribution of total specific deformations at the boundary of the structural model of the EDCBU

5.4. 3D structural analysis for the palette support and the palette

The structural model used for the linear static analysis of the ECDBU substructure formed by the palette and support or the load-bearing substructure of the palette, is presented in fig. 5.32. This geometric model of the physical object is obtained from the CAD model for the execution of the physical structure. The support is made as in fig.5.32, and the loading of the structure is done as in fig. 5.33.

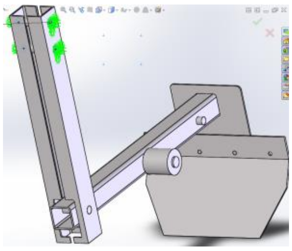


Fig. 5.32. Structural model with support

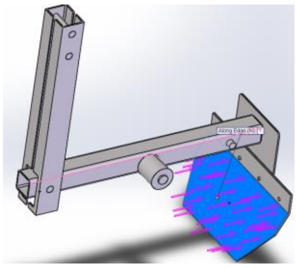


Fig. 5.33. Structural model with loading

The main results of the analysis are: the relative displacement field (deformation), the specific deformation field, the stress field and the safety factor.

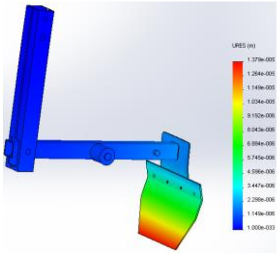


Fig. 5.35. Distribution of the resulting relative displacements in the structural model

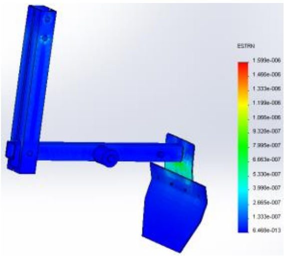


Fig. 5.40. Equivalent strain distribution (Von Mises) in the structural model

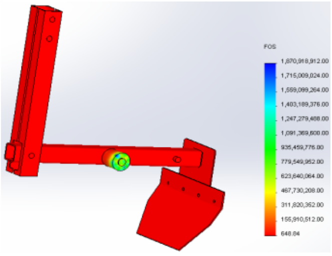


Fig. 5.41. Distribution of safety factor values in the structural model of the EDCBU substructure

5.5.3. Analysis of the curved hoe working body

Figure 5.51. presents the model of the curved hoe on which the forces and fixings can be highlighted. Figure 5.52. presents the discredited model, whose network has a number of 23148 nodes and 11426 elements. The network has a maximum element size of 22.806 mm and a minimum of 4.56121 mm with a maximum mesh ratio of 14.774.

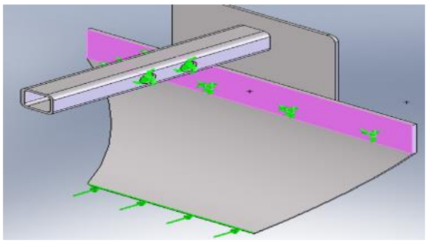


Fig. 5.51. Curved hoe model

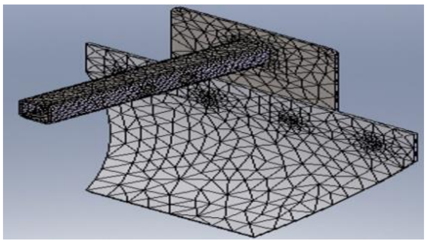


Fig.5.52. The discretized model of the curved hoe

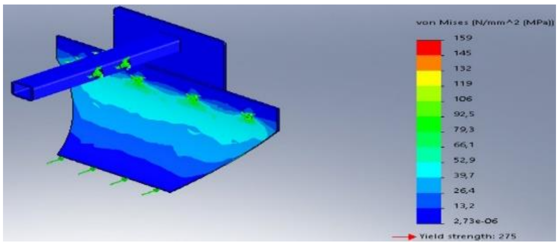


Fig. 5.53. distribution of equivalent strains

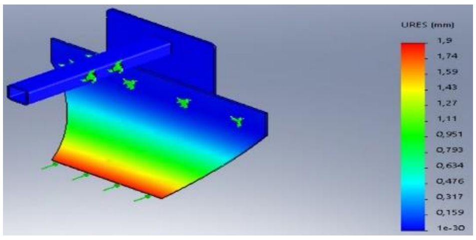


Fig. 5.54. Distribution of total displacements

5.6. 3D structural analysis for the rotor with palettes working body

5.6.4. Analysis of the rotor with curved blades working member

Figure 5.71. presents the geometric model of the rotor with curved palettes and in figure 5.72. is presented the discretized model of the rotor with curved palettes whose network has 67238 nodes and 32208 elements, with the element size of 10.7165 mm.

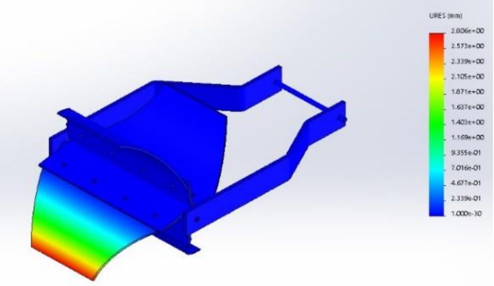


Fig. 5.74. Distribution of total displacements

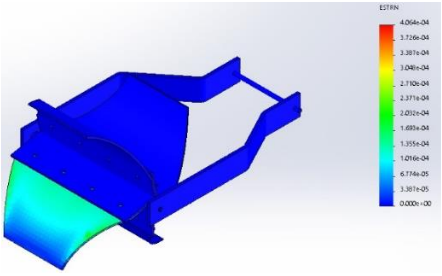


Fig. 5.75. Distribution of specific deformations

Chapter 6. CONCLUSIONS. ORIGINAL CONTRIBUTIONS. PERSPECTIVES

6.1. Conclusions

1. Soil capacity is limited and the demand for natural resources from society is increasing. Climate change, soil, water and air pollution, erosion and desertification, the reduction of wetlands and tropical forest systems, the disappearance or threat on the existence of a number of plant and animal species, the rapid reduction of non-renewable natural resources have begun to have a negative impact on the socio-economic development and quality of life of people in vast regions of the planet.

2. Water has been identified as one of the scarce resources that can severely restrict and even compromise agricultural production and productivity unless it is carefully managed and conserved.

3. Soil works are conducted to create the right environment for plant development by enriching it in water, heat, air, nutrients, loosening the soil, thus regenerating its production capacity.

4. One of the mechanical works used to combat water stagnation or uncontrolled leakage is soil modelling work. Soil surface modelling works are performed to facilitate the management of water along the row of plants or its uniform storage.

5. By compartmentalizing the furrows, the excess water is retained by the furrow dam to continue the infiltration, reducing the amount of water that would be lost, but also the erosion produced by water runoff.

6. When making continuous or interrupted furrows, the aim is to obtain an enlarged section of the furrow necessary for the accumulation and transport of as large a volume of water as possible.

7. Discontinued water furrows are needed on lands with unevenness or slopes that cause water to drain and accumulate in micro-depressions. By practicing partitioned furrows on sloping lands, the prevention or reduction of puddles at the bottom of the cultivated land takes place, but also the reduction of the phenomenon of wind erosion.

8. In weeding crops, the opening and partitioning of water furrows is done simultaneously with sowing and hoeing, making this operation even more efficient.

9. For the most efficient use of water, a diverse range of equipment has been created to correspond to different types of crops such as: fodder plant crops and straw cereals but also for weeding crops and vine plantations. By using these types of equipment in crop technology, considerable production increases have been obtained, reaching up to 20%.

10. For weeding crops and vine plantations, the efficiency of the equipment depends on the degree of preparation of the field. Recently, the application of herbicides in the technology of more and more crops has made it possible to use the equipment with better results. The increased interest in this equipment makes the industry to design and build a range as diverse as possible.

11. Analysing the constructive solutions presented, it is observed that in most cases the equipment necessary to make the compartmentalized furrows is not expensive and can be attached to the respective cultivation equipment. The main role of this equipment is to create storage accumulation dams with maximum volume, low energy consumption and low cost.

12. The additional forces required for the use of the equipment for opening and partitioning water furrows, resulting from the measurements made during the tests, represent approximately 12% of the total value of the force required for the hoeing work, which justifies the efficiency of using this equipment, taking into account the reduced cost of the equipment.

13. Following the determination of the qualitative indices, there is a significant difference between the values of the dimensions of the furrows obtained with the initial version and those

obtained with the optimized version, this having a major influence on the volume of water to be stored by the compartmented furrow.

14. In the case of the distance between the furrows for the equipment equipped with the cam-tappet control system, a higher accuracy was obtained than for the equipment equipped with a rotor with partitioning palettes.

15. The tensile strength generated by the equipment for opening and partitioning water furrows during operation can be mathematically modelled in many ways. The model built within the thesis has a series of constants or model parameters that allow its calibration to the experimental data known for the equipment.

16. From a practical point of view (for the design of the load-bearing structure and the calculation of the power source), it is enough to estimate the maximum value of the tensile strength. In this case it is not necessary to model the variation in time of the resistant force generated by the palette. If, however, problems related to the dynamics of the unit are addressed (variation of the traction force, oscillating effects on the quality of the work, resonant work regimes) a model of the type offered in this paper is necessary. However, the fineness aspects (even the oscillating characteristics) can have (depending on the soil quality) effects that are difficult to anticipate due to the random nature of many of the soil properties. However, these problems require a large volume of experimental tests and a high level of statistical data processing.

17. The experimental models presented, which have achieved very good working indices (the device equipped with the palette rotor and the equipment with cam – tappet control system), are easy to make, simple, robust and cheap.

18. The results of the theoretical and experimental researches undertaken by the author on the study of the bodies for opening and partitioning water furrows justify the opportunity of the doctoral topic approached, for the current stage of development of the equipment.

6.2. Original contributions

1. This paper is one of the few works that addresses the overall process of opening and partitioning of water furrows, bringing a series of data on the current state of the works that try to use water as efficiently as possible in agriculture.

2. Through the topic approached in this paper, original contributions are made to the study of the working processes of the equipment for opening and partitioning water furrows, the author making experimental devices with novelty character, studied compared to the existing ones.

3. The elaboration of the theoretical study on the working bodies that achieve the opening and compartmentalization of the water furrows, the optimization of the dimensions of the body that achieves the compartmentation of the furrows, the determination of the quantitative and qualitative indices of this work.

4. In order to achieve a new control system for the working bodies, in order to achieve compartmentalized furrows, a rigid memory is synthesized. As the cam mechanisms have the great advantage that they can perform particularly complicated transmission functions, in order to obtain an optimal furrow shape, for the furrow compartmenting equipment, a study is made on the cam mechanisms following which a mechanism with rotating cam and rotating tappet with roller is chosen. The cam-tappet mechanism has the advantage that it allows the working parts of the equipment to shape the furrow as the designer wants. Based on the study, the new control mechanism of the working body was designed, executed and tested, the qualitative indices obtained from the tests confirmed the theoretical statements regarding the accuracy of the distance between the furrows.

5. The mathematical model presented has a minimal novelty character by the fact that it simulates a tensile strength with two components, one of them having a dynamic, oscillating character, according to the control of the drive mechanism.

6.3. Perspectives

1. The work constitutes a serious basis for further research in order to develop the theory and improve new construction solutions for equipment for opening and compartmentalizing water furrows.

2. By continuing the study, we can analyse the possibility of providing the equipment with a gearbox with which we can achieve variable distances between dams, which would increase the efficiency of using this equipment depending on the slope of the terrain.

3. Due to the declining cost price of electrical and automation systems, studies can be performed for a new constructive cam drive version, replacing the spur wheel and mechanical transmission from the spur wheel, which is a cumbersome and energy consuming construction.

4. The study presented and the experimental model achieved can be the basis for the realization of an equipment for opening and partitioning water furrow that could successfully compete with the existing equipment on the market at the moment.

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	descriptions, elaboration of internal regulations -Direct management of the sale-offer and negotiation activity -Leading the labour protection and PSI activity, administrative problems, car fleet.
Skills acquired in the workplace	-a good knowledge of quality control processes
Certificates and attestations	Certificate of graduation of the psycho-pedagogical module Certificate of completion of the ESSENTIAL SOLIDWORKS training course Certificate of completion of the advanced training course in the field of Hydraulic Drives
Membership in prestigious academic associations	member of the Romanian Society of Agricultural Mechanical Engineers (SIMAR) member of the European Society of Agricultural Engineers (EurAgEng)
Scientific activity	member of 20 scientific research projects first author or co-author of over 25 scientific papers 2 patent applications.
Driver's license	B and C

Date: 8.07.2021 **Eng. Remus-Marius OPRESCU**

WORKS IN THE FIELD OF THE THESIS

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