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Structural Analysis of Seeding Process and Mineral Fertilizers Introduction in the Soil

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ABSTRACT

The article describes the farming systems in the form of interacting components "soilplant®fertilizer", state of physical and mechanical properties and process performance components - soil, plants and fertilizers, changing over the time. To realize the potential of crops (plants) to obtain maximum yield type, state, properties of the soil environment and the types, doses, methods of making fertilizer use have the important meaning. In this connection, the task of this system is the realization of the potential of crops to obtain the maximum yield or planned.

Key words: soil, seeds, plants, fertilizers, crop yields.

INTRODUCTION

The founder of Russian agrochemical science D.N. Pryanishnikov represents a system of agriculture in the form of a triangle, on the tops of which there is basic interacting with other objects of agricultural chemistry, "soil®plants®fertilizers" (figure 1).

The expediency of considering such system in the form of these components is quite competent. However it is necessary to take into account the state of physical and mechanical properties and processing performance of the system components that change over time. In addition, to realize the potential of crops (plants) to obtain maximum yield the important role is played by type, state, properties of the soil environment and the types, doses, methods of making fertilizer use.

In more detail this problem was studied by V.A. Chernovalov and V.P. Zabrodin[1, 2], who made analysis of the process of mineral fertilizers introduction on the field surface. To substantiate the technical means of the proposed process considering the existing agrochemical system in the form of the object "*soil®plant*" in its functional connections with the technical means of mineral fertilizers in the soil. Moreover, the interaction of components of the agrochemical, and more precisely the biological (BS) and technical systems (TS) in the fertilizer into the soil is considered as a system (Figure 2).

Main part

The objective of this system is to realize the potential possibilities of crops to obtain the maximum yield or planned one $Y(t)$. Feedback of biological system (BS) "soi*® plant*" is expressed in the fact that mineral fertilizers, contributing to realize the potential of crops, through plant affect the original condition of the soil. This influence is evident in the increasing biomass and root residues, which themselves then become fertilizer.

Vectors of external influences on biological (BS) $F_{BS}(t)$ and technical (TS) $F_{TS}(t)$ systems include factors affecting the efficiency of the biological system under conditions of use technical means of mineral fertilizers introduction. To realize the potential possibilities of crops the operator guided by information on the planned crop yield, the content of nutrients in the soil map of the agrochemical field (ACMF) and agronomic requirements (AR), forms a vector of control actions, configures technical means asking required dose and quality of making mineral fertilizers. The control unit (CU) which takes into account ACMF and AR generates control *U(t)* and input for the impact of soil *Q(t)* and plants *D(t).* The last ones monitor the implementation of the technological process of mineral fertilizers.

The given agrochemical system does not consider all the factors affecting the performance of the technological process of mineral fertilizers. Thus, the determining shortcomings of the system consist in the following:

- The main factors determining the process of mineral fertilizers *U(t)*, *Q(t)* and *D(t)* are uncertain and vary over the time;
- Used technical means do not take into account the feedback;
- Components of a biological system *"soil-plant"* must take into account the heterogeneity of the soil environment, as well as its physical and mechanical properties and technologicl indices.

To develop a structural model of agrochemical system of crop seeding and mineral fertilizers introduction in the soil it is required to complete with due regard to the following provisions:

- with any method of sowing seeds and mineral fertilizers soil environment, the plant (seeds) and mineral fertilizers should be the objects of agricultural chemistry;
- As components of agricultural chemistry interact with each other, they should be presented as a single system, which takes into account the biological and agronomic indices of the objects;
- When considering the technical means it is necessary to consider the interaction of the working bodies with soil environment, plants (seeds) and mineral fertilizers;
- to assess the quality of technical equipment functioning it is necessary to monitor and to control the process of sowing seeds and mineral fertilizers.

Considering the above mentioned provisions, the proposed structural diagram of the agrochemical system should include agrobiological (ABS), mechanical and technological (MTS), technical (TS) and agro technological (ATS) systems (Figure 3) which are discussed in more detail.

ÀBS - agrobiological system

If we start from figure 1, the main objects of the system are the agrobiological soil environment, seeds (plants) and mineral fertilizers, interacting with each other.

Soil environment

The heterogeneity of the soil environment is composed under the influence of natural factors and agrogenic and shown at different scales of investigation.

Micro varying of fertility is due to the formation of soil under the influence of the former natural vegetation, and more substantial variability - under the influence of physical and chemical processes. For such an object as soil environment it is required to know the fundamentals of its structure to be able to manage the process of handling (the deformation and destruction) of different soils. The soil environment is characterized by dispersion, which has a multi-level organization structure: elementary, aggregate and soil horizon. And what's more, the size of the properties, the shape of the structural units due to the ratio, the composition and arrangement of soil particles and aggregates, i.e. internal structure.

It is the internal structure of the soil and the quantification of its constituent individual particles and aggregates, as well as the nature of their relationship with each other are characterized by features of the soil environment. An example of the relationship between structure and function of the soil is its strength (resistance to external mechanical action on it). Strength characteristics of the soil environment, ultimately depends on its phase composition: Solid (S), liquid (L), gas (G), as well as on their relationship (R). Introduced by four components (S, L, G and R), soil environment is not uniquely determined. Different components allow us to consider the ratio of the soil environment as an object with the properties of the granular medium to solid[3, 4, 7, 8, 9, 10]. These considerations show that the questions describing soils differ from the usual problems of mechanics of fluids specific features and without taking them into account it is impossible to achieve success in quantitative forecasting methods of physical processes.

Another aspect of the soil environment is that there is a small region with the volume *Vs*, which can be regarded as an element of the solid soil environment. Selecting volume V_s is carried from the condition $V_b<V_s<V_u$. The lower limit of V_b depends on that a particular process is happening in it, and the upper V_u determines the character of the inhomogeneity of the structure. The volume V_s should be so large as compared with the V_b so that it is a solid element of the soil medium was sufficient to carry out the act of mass transfer.

For soils having a layered structure, the value of V_b and V_u will be different. So, if we consider the level of elementary particles, the V_b is determined by the amount of soil individual, and V_u - volume of microaggregates consisting of a set of individuals. At the macro level V_b is the volume of microaggregates and V_u- amount of macroaggregates, consisting of a set of microaggregates. On horizon level V_b - macroaggregates volume and V_u is volume of the soil environment. From these provisions it can be concluded that provided that the mechanical destruction of the soil is the result of overcoming the inter-aggregate bonds V_s is determined by the macro level. And, at the macro level the volume V_s is able to deform under the influence of various forces.

From these considerations there should be a number of important conclusions:

a) the definition of the scope of multi-level soil environment requires a system of packaging, and the choice of volume V_s depends on the nature of the problem being solved. It is necessary to know the quantitative characteristics of the phase composition of the soil environment;
b) to describe the structure and soil properties it is necessary to consider V_s at all levels;
c) provided that mechanical damage (crumbling) of the soil is the result of overcoming the inter-aggregate bonds, V_s is determined by the macro level. And, at the macro level the volume V_s is able to deform under the influence of various forces.

The quality of the mechanized tillage operations largely depends on the shape and parameters of the working bodies and the physical-mechanical and technological properties, figure 4. All the properties of the soil, except its mechanical structure are subject to considerable changes, due to weather conditions, change in crop rotation, soil mineral and organic fertilizers and views of prior treatment. These changes are both temporary, and continuous - even within a single field.

Mineral fertilizers

A significant impact on the functioning of the system has a state of fertilizer due to their physical, mechanical and technological properties. They can be classified by highlighting the following characteristics:

- Physical dimensions and weights (granulometry, humidity, density etc.);
- Friction (factors of external and internal friction angle of repose);
- Strength (resista nce to compression and the rate of side-pressures);
- Aerodynamic (coefficiency of vane, speed of hovering, friability and drillability).

From the totality of the characteristics there are the main properties of the fertilizer defining process of the unit, see Figure 4.

Seeds

Under the technological properties are meant only those properties of seeds which have a significant impact on the character and regularities of their seeding. These include the quality of seeds sown, and their physical and mechanical properties: shape, size, density and mass; frictiontional properties; the ability of seeds to resist certain types of deformation and so on.

Sowing qualities are as follows: the economic life, purity, germination, vigor, sowing suitability, humidity, weight of 1000 seeds, density and others.

Physical and mechanical properties of seeds are as follows: the shape and the linear dimensions, nature of the surface and the coefficiency of friction, coefficiency of vane, speed of hovering, friability, elasticity, hardness, hygroscopic, heat capacity and thermal conductivity and others. In recent years seeds acquire such properties as osmotic and electromagnetic, color and hyaliness. With the passage of time with changing soil environmental conditions during the life of the seed change their physical properties change also.

MTS – mechanical & technological system

Multi-level structure of the soil environment, different scales of acts of its deformation and destruction determine a new approach to building a model of interaction with the working body of the soil environment [3,4,5,6,7,8]. And naturally develop models should include and take into account the ideas of physics and soil mechanics of destruction of modern media. Additionally, we require that the model and later theory, firstly, take into account the dispersion of the soil and its physical foundations of destruction, and secondly, to make recommendations on how to describe the phenomena occurring in the process of destruction, including engineering calculation methods, and thirdly, could propose methods and techniques create different models of soil with a given level of physical and mechanical properties of the soil environment. In constructing the model of destruction of the soil will be based on the following provisions:

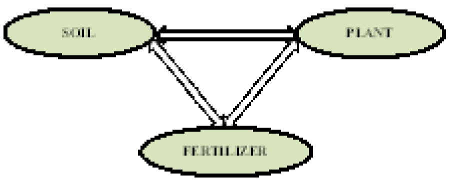

Fig. 1: System of Agrochemistry «soil→plant→fertilizers»

Suppose to proceed from the assumption that in the soil environment relatively homogeneous (solid) plot V_s can be isolated in which a cart-flow processes causing the deformation of the element are possible. Let's mark the strain tensor of solid soil environment as ε_i . As elastic, inelastic and plastic deformation can act. Element V_s is able to test any amount of these strains. Mentioned deformations occur under the action of a different nature, such as mechanical stresses,.

Deformation laws in this volume may not depend on the processes taking place at other levels of the soil environment. It allows to consider the development of deformation in V_s as a property of fundamental nature. Wherein analytical relations for the deformation must follow the principle of locality, i.e to make sense of the fundamental constants. In this amount of energy it can be inter-aggregate bonds.

The choice of the volume V_s, of the deformation act in it and study the laws of the deformation behavior of soil environment are key points in this issue. Success of the theoretical analysis depends on the rational choice of the scope of deformation act.

Suppose that any satisfactory approximation model is achieved if the properties are expressed in terms of volume V_s through average variables and such values as,, will be permanent. Statistical averaging is required to determine the parameters of the entire ensemble

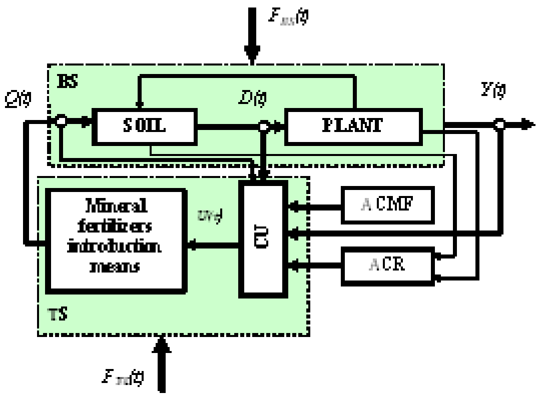

Fig. 2: Interaction of biological and technical systems during fertilizers introduction in the soil

volume V_u of the soil environment. It is essentially a tool to transfer to the description of the physical and mechanical properties of the soil in terms of mechanical engineering. Another important point is the assumption that the volume V_s is possible to consider as a mathematical point of a continuous medium. The average of its strains and stresses are now referred to the measured values having macroscopic contents. This allows use of the device of continuous and differentiable functions in a continuum. For such a space the basic laws governing the behavior of continuous media, such as the equilibrium equations and the equations for continuity for are formulated.

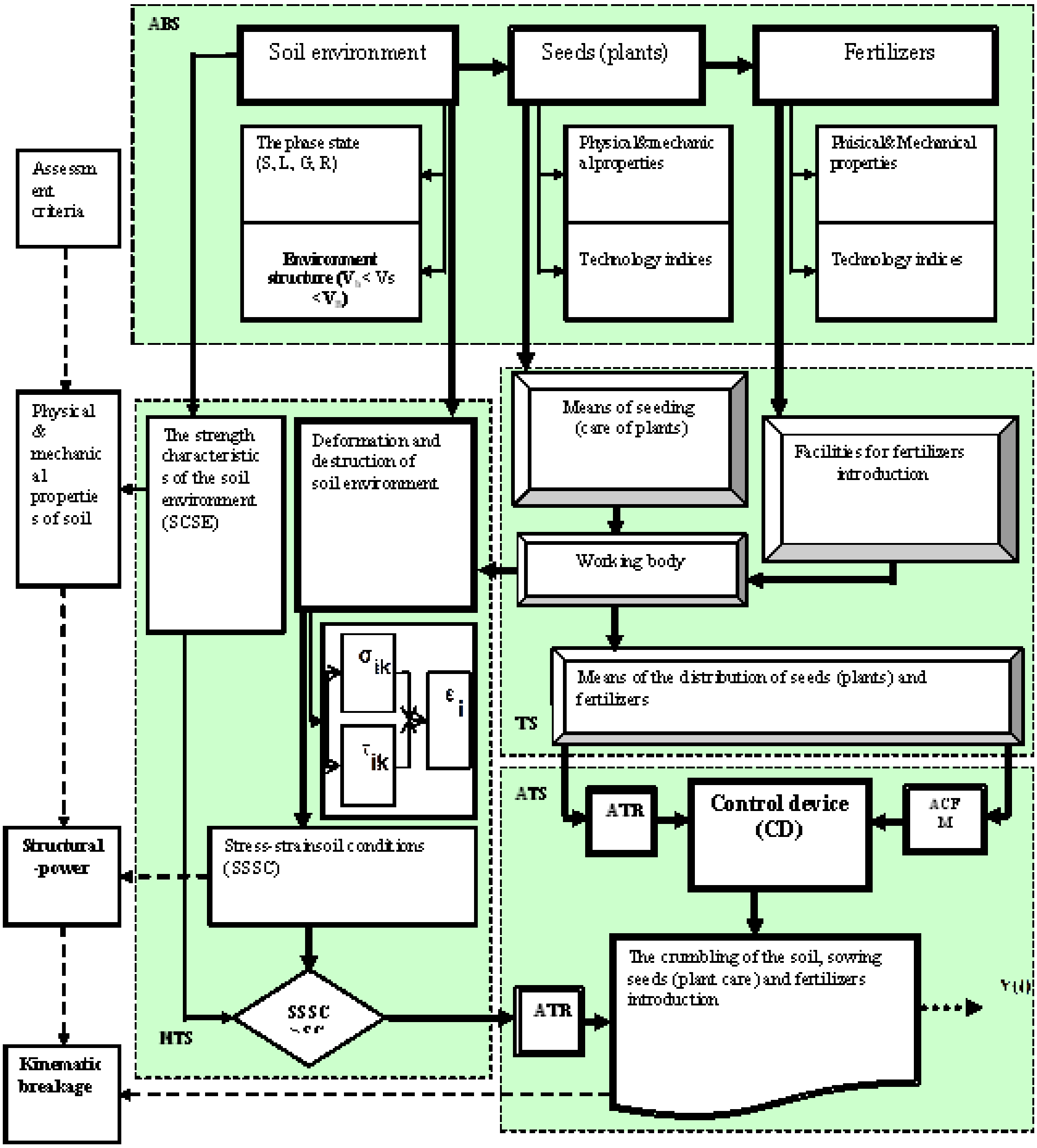

Fig. 3: The block diagram of the process of seeding and application of mineral fertilizers in the soil

Thus in this model the physical and mechanical aspects of deformation are assigned to different macro levels: physical - the lower V_b, mechanical - upper V_u.

It is obvious that between different macrolevel objects V_s there are interactions. Thus, in any volume V_s plastic deformation is developed, and in the other - an elastic. This leads to a redistribution of stresses between the first and second volumes. The nature of this redistribution depends on many factors: the mutual arrangement of the volume V_s in averaging V_u relative to each other, their relative orientation in space, and so on. For an accurate calculation of the soil environment such interactions are virtually impossible. However, if each volume V_s experiencing the same effects from the others and has the same orientation in space, it becomes possible to consider an ideal model, e.g., model of a continuous medium.

This approach is important not only to describe the interaction between the volumes V_s, but also to use a phased model of soil degradation: deformation and fracture . In this model, the process is formed, where the properties of the soil is as follows. Tension rises microtension which is capable to develop and accumulate microcracks in the soil environment. The last ones cause physical aspects of micro destruction. As a result, there is a macroscopic strain which is determined by orientational and spatial averaging. The critical value is determined by the stress-strain state (SSS). If you exceed the strength characteristics of (SSS) soil macroscopic decoupling appears, i.e the soil is destroyed (crumbled) to form surfaces.

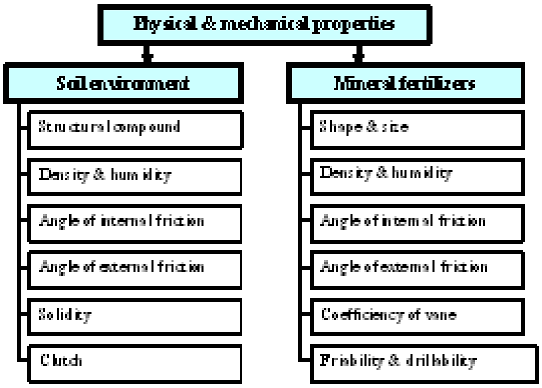

Fig. 4: Physical and mechanical properties

Ultimately, the study of the questions describing the state of the soil environment, as well as the acts of its deformation and destruction determines the construction of the rheological model. In the classical approach, the first step is the preparation of the equations of the stress - strain state (SSS) of the soil prior to its destruction, and the second stage - the establishment of an acceptable theory of the strength of the soil. For example, the state of stress in the class of the deformable soil is well described by the model of the body of Maxwell or Voigt, and the destruction of the soil - the theory of Mohr-Coulomb strength.

Multiscale acts of deformation and fracture requires consideration of their connectivity. The problem of connectivity is fundamental and draws the physical aspects of the destruction of the soil environment. The values and are the input and output parameters of process failure and determined by the properties of the soil environment rather than the individual elements. This means the impossibility of reducing the macroscopic properties of a deformable soil properties destroying element or group of newly formed surfaces. Therefore it is impossible to identify the mechanical micro - and macrodeformation with macrodestruction. With regard to the soil it is advisable to simplify the connectivity factor, leading to the logical nature of operations and going to the general indicators. So, it is possible to use the efficiency of destruction of the soil if to carry the energy expended on the formation of a surface to the energy of a bygone strain on the soil.

While using this approach for the study of the deformation and destruction of the soil it is necessary to perform the two failure criteria: structural and power (the level of micro-cracks) and kinematics-breakage (at the macroscopic level of destruction). For example, in the first case, the soil can act as a deformable medium and is characterized by levels of stress - strain state. To describe it the methods of continuum mechanics can be used. In the second case, the description of the methods applied to destroy the soil mechanics of a discrete environment. Moreover, to determine the problem whether the element of the soil was destroyed, it is necessary to know the conditions of its transition to the destroyed state, i.e to failure criteria. Multi-level structure of the soil environment involves the consideration of the local and global failure criteria. Local criterion refers to an element of the soil, the global - to the system.

CONCLUSION

In conclusion we note that the material presented should be perceived as an illustration of the general principle of constructing the model of deformation and destruction of the soil. The reason for that are the physical processes occurring in the soil which does not always fit into a single scheme and application-specific tasks can be modified in the direction of simplicity and complexity. Therefore, the working formulas should reflect the nature of the implementation of acts of deformation and failure for each solved task. The main advantage of the proposed approach to the construction of a model of destruction of the soil is the possibility of the physical interpretation of the phenomenological parameters of the model.

ÒS - technical system

The used seeding technology and the methods of application of mineral fertilizers and means for their implementation are defining parameters of the technical system. The components of the system for different technologies of cultivation of agricultural crops may contain various technical means. If we limit the scope of solved problems in this paper, for example, in relation to the process of growing crops, all used drills and tools for subsurface mineral fertilizers should have the technical tools to do the following:

- selection of seeds (fertilizer) from the hopper through the hole;
- dispensing seeds (fertilizer) by sowing apparatus;
- distribution of the dose received by the rows (to the sleeves of seed tubes);
- seed portion transport (fertilizer) from the sowing to the working body;
- furrow formation and embedding of the seeds (fertilizer) into the soil by working organs.

ÀÒS – agrarian and technological system

The main purpose of this system is to manage the actuators used technical means in accordance with agro-technical requirements (ATR) and agrochemical (ACHR) requirements. The efficiency of the units at sowing seeds and mineral fertilizers are largely dependent on the availability of technical means and ways to customize the actuators, point-of setting working bodies, timeliness of the performing these operations, depending on the changing needs and conditions. To ensure high-quality performance in carrying out the technological processes of seeding and mineral fertilizers it is necessary to make technological adjustments. In particular the setting on the dosing rate (dose) of seed and fertilizer distribution and setup the parameters of distribution working bodies. The need to equip machinery by control systems (CS) is especially evident in the technology of differentiated seeding and making different kinds of fertilizer.Taking into account the heterogeneity of the soil medium (fertility) even within a single field the control device is required to have a wide range of process adjustment. The task is complicated by the application of provision controls of soils with necessary soil nutrients according to information obtained from the agrochemical field maps (ACFM) as the required dose (normal) make of various mineral fertilizers. In addition, the consequence of the change of soil properties in different areas of the field with respect to time is a wide variation in quality parameters of technological operations of tillage. When processing at the middle even within the physical ripening of the soil, not all the areas in the degree of crumbling meet agrotechnical requirements. For homogeneous quality indicators that meet agrotechnical requirements across the entire field, the working bodies of tillers should be able to change the impact on the soil and the management of work due to changes in its technology and design parameters.

Inferences

Thus from the above given material it's possible to do the following conclusions:

1. It is shown that existing processes of sowing seeds and fertilizer it is required to be improved in the direction of their adaptation to the needs of crops in rates (doses) of their introduction.
2. It is proved that for any method of sowing seeds and mineral fertilizers as objects of agricultural chemistry should be soil

environment, the plant (seeds) and mineral fertilizers interacting with each other.

3. A block diagram (model) of an agrochemical, including agrobiological (ABS), Mechanics and Technology (MTS) Technical (TS) and the Agriculture technology (ATS) system is offered.
4. The components of the agrochemical systems and their interrelationships, justifying the indicators characterizing the process of planting seeds and mineral fertilizers in the soil are considered.

REFERENCES

1. Chernovalov, V.A., Problems of improving the machinery for fertilizers introduction. *Mechanization and electrification of agriculture. Journal,* **5**:17 - 18 (2000).
2. Zabrodin, V.P., The mechanization of the adaptive processes of mineral fertilizers. Zernograd, pp:384 (2004).
3. Kapov, S.N., Mechanical and technological basis for the development of energy-efficient tillers. M.S. thesis, Chelyabinsk (1999).
4. Voronin, A.D., Fundamentals of Soil Physics. MGU, pp: 214 (1986).
5. Kulen, A., and H. Kuipers, Modern agricultural mechanics. M.: *Agropromizdat*, pp: 349 (1986).
6. Zelenin, A.N., Fundamentals of mechanical destruction of soils. M.: Engineering, pp:375 (1968).
7. Aduov, M.A., Scientific and technological bases of creation of technical means for sowing grain seeds and mineral fertilizers (on the sample of the northern zone of Kazahstan. M. S. thesis, Almaty (2008).
8. Aduov, M.A., S.N., Kapov and S.A., Nukusheva, Model of soil environment as object of mechanical tillage. *Life Sci J,* **11**(12s): 156-161 (2014).
9. Aduov, M.A., S.N., Kapov, S.A., Nukusheva and M.R., Rakhimzhanov. Components of coulter tractive resistance for subsoil throwing about seeds planting. *Life Sci J.* **11**(5s):67-71 (2014).
10. Mesik, I., I., Sestak, Z., Kisis, A., Zgoreles and A. Jurisik, Metod of soil sampling based on circular probe apparatus. III International Scientific Congress. Agricultural Machinery, 22-25 June, Varna, Bulgaria, *Proceedings,* **3**: 16-18 (2015).