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INNOVATIVE TECHNOLOGIES AND EQUIPMENT FOR THE MECHANIZATION OF SOIL WORKS WITH REDUCED IMPACT ON THE ENVIRONMENT. PRESENT AND PERSPECTIVE

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Abstract: Sustainable agriculture involves, first of all, the development of innovative mechanization technologies for tillage, the establishment and maintenance of agricultural crops that satisfy quantitatively and qualitatively the current needs of people without compromising the requirements or options of future generations and without causing irreversible damage to the environment. Ensuring a healthy and harmonious environment, as the quality of soil, water, air, vegetation and food depends on many factors, but the quality of the land and implicitly of the soil are decisive due to the excessive loosening of the soil, the removal of plant debris from the surface, excessive mineral fertilization, decreased content and degradation of soil organic matter. The paper presents research and perspectives on innovative technologies for mechanization of soil works without overturning the furrow and the establishment of crops by developing technical equipment for sustainable land use systems, which minimize soil degradation, prevent reducing biodiversity, restoring productive capacity and vital processes of degraded soils in order to increase the quality of life
Keywords: tillage without overturning the furrow, the establishment of vegetable crops, sustainable use

INTRODUCTION

Agriculture has a major contribution to the sustainable development of the economy and society, through the economic and social opportunities it gives to the current and future generations. This, apart from the fact that it represents the sector that ensures the food of mankind, constitutes the very basis of the existence of life. At the same time, however, agriculture must also assume the responsibility of protecting the soil and other environmental resources that it can degrade [1].

As estimated in some statistics, the population of the globe is continuously growing, estimating that by 2050 it will reach approximately 10 billion inhabitants, which will lead to an increase in the demand for food and raw materials [2], [5].

Under these conditions, through the pressure exerted by mankind due to the ever–increasing needs, the global capacity to produce food in agriculture will be greatly tested [3], [4]. In the future, the expansion of agriculture in a "horizontal" plan is no longer possible, due to the fact that worldwide the reserves of productive land are exhausted, and the uncultivated surface is no longer suitable for the development of high–performing, profitable, viable, sustainable agriculture [6].

The development of mechanized agricultural technologies, namely the use of increasingly larger and heavier tractors and machines, with advantages regarding productivity and economic efficiency, led to the appearance, intensification and expansion of some processes in the physical degradation of the soil, especially the destructuring and human compaction [7]. A particular problem is the one that occurs in areas with a drier climate, where intensive tillage and the removal of plant residues contribute to the loss of water from the soil, accentuating the processes of drought and desertification [8]. Among the most widespread negative processes of energy–intensive agriculture, we mention: the movement and deep leaching of nutrients and other chemical compounds causing the contamination of water resources, their translocation from the soil to the vegetative mass, and from here to the entire trophic chain; the excessive increase in soil compaction, the excess of surface water and the risk of erosion, the increase in emissions from the soil leading to the degradation and global warming of the atmosphere [8]. The negative influence of the agricultural technological system on the modification and reduction of biodiversity due to the excessive loosening of the soil, the removal of plant remains from the surface, the excessive mineral fertilization, the decrease in the content and the degradation of the organic matter in the soil cannot be neglected either [9].

Consequently, there must be major interest in the promotion of innovative mechanization technologies used within the technological itineraries, for systems for the sustainable use of agricultural lands, which prevent or minimize soil degradation, restore the productive capacity and vital processes of degraded soils [10].

MATERIALS & METHOD

The research materials and methods consist in the use of the reading sheets of the research phases from the research projects carried out within the research programs INNOVATION, PARTNERSHIPS IN THE PRIORITY AREAS, POC 2014–2020, ADER 2020, NUCLEU [11–19].

RESULTS & DISCUSSION

In this paper, some of the research carried out within INMA Bucharest are presented, which concern innovative technologies for the mechanization of soil works and the establishment of vegetable crops (grass cereals and fallow plants) in accordance with sustainable agriculture:

A. Technical equipment with active bodies trained for the work of loosening the soil in depth, EAA

The technical equipment (Figure 1) is intended for deep loosening works, in order to reduce the primary or secondary compaction, primarily of podzolic, reddish brown

soils, vertisols, lacustrine soils and heavy alluvial soils. It can also be used on chernozems, brown soils and medium alluvial soils. It cannot be used for the execution of deep loosening works on sandy soils, soils with gravel and superficial hard rock, on flood lands and with ground water at a depth of less than 1 m depth, lands with a slope of more than 15% and on lands with slips.

Figure 1. Technical equipment with active bodies trained for the work of loosening the soil in depth

The main subassemblies of the technical equipment with active bodies driven for the work of loosening the soil in depth are the frame provided at the front with a yoke and hydraulic cylinder for coupling to the tractor's three–point suspension mechanism; the active working organ of the oscillating vertical knife type with vibrating chisel tip; the transmission consisting of cardan shaft and conical reducer with two left–right outputs; elastic couplings with bolts; right wheel and left wheel for adjusting the working depth; the support leg for stationary support; roller for aggressive shredding, placement and additional levelling of clods.

B. Multifunctional aggregate for working the soil, MATINA

The multifunctional aggregate for working the soil (Figure 2) promotes the conservative farming system, a system that ensures quantitatively and qualitatively competitive productions with those obtained in the classical system, but with low costs and high profit, under the conditions in which it is ensured:

- accumulation and storage in the soil of the entire amount of water from precipitation during the summer and autumn;
- accumulation in the soil of a large amount of nitrates by intensifying nitrification processes;
- obtaining a layer of loose soil, but at the same time settled to ensure a good rooting of the plants and to avoid the process of removing shoes;
- obtaining a germinative bed without lumps, so that the seed can make as intimate contact with the soil as possible to sprout in the shortest possible time.

The aggregate consists of the following main assemblies: battery with chisel organs; battery with independent discs; rod roller; monobeam chassis with transport train.

The battery with chisel organs loosens the soil in depth with loosening organs, to facilitate the penetration of plant roots more easily, in depth, for the necessary nutrients and water.

The battery with chisel organs consists of a metal frame on which five active organs are mounted (two organs on the front pipe and three organs on the rear pipe).

Figure 2. Multifunctional aggregate for working the soil in agricultural holdings

The battery with independent discs performs the preparation of the germinal bed with specific working organs, of the type of crenellated spherical discs.

The battery with independent discs is composed of a metal frame and two half–batteries, the front one with the active part of the discs oriented to the left and the rear one with the active part of the discs oriented to the right.

The roller with rods ensures a shredding and a slight levelling off the ground processed by the crenelated discs, being located behind them and it consists of a frame, an elastic adjustment system and the roller with rods.

The monobeam chassis with transport train constitutes the skeleton on which all the components of the aggregate mentioned above are mounted. It is composed of a crossbar, an elastic system for adjusting and maintaining the horizontality of the chassis, monobeam frame with built–in hydraulic pipes, hydraulic cylinder for the transport train.

C. Multifunctional equipment for working the soil in agricultural holdings, SCAR–ART

The multifunctional equipment for tilling the soil in agricultural holdings (Figure 3) promotes the conservative farming system, a system that ensures quantitatively and qualitatively competitive productions with those obtained in the classical system, but with low costs and high profit, under the conditions of improving the properties of the soil.

The operations performed in a single pass are as follows:

- intensive decompaction of soil layers;
- breaking the hardpan;
- soil preparation at working depths of 10–14 cm with independent disc–type working bodies;
- crushing the lumps on the surface.

The equipment additionally executes the subsoil of the soil at working depths of 0.20–0.25 m, without overturning the slices processed in the aggregate with the 150–200 HP tractors.

Figure 3. Multifunctional equipment for working the soil in agricultural holdings

D. Decompactor for deficient soils with simultaneous administration of nutrients, DECOM FERTI

The technical equipment (Figure 4) is composed of two main assemblies: DECOM, which through the specific working organs (chassis, active organs with reversible chisel knives, rollers with claws, working depth adjustment wheel) achieves the loosening and improvement of soil permeability in the purpose of storing and conserving water and FERTI which, through the distribution system and the conducting tubes, brings improvements to the complex functions of the soil by adding nutrients (solid chemical fertilizers), in order to achieve the most favorable conditions for plant nutrition to obtain spores (quantitative and qualitative) of agricultural production. The application of basic fertilizers (NPK) is carried out in such a way as to harmonize with the needs of the crop plant and the properties of the soils to be applied to ensure maximum efficiency and reduce the risk of losses or blockages through different processes.

Figure 4. Decompactor for deficient soils with simultaneous administration of nutrients

E. Harrow with independent disks, GD4

The harrow with independent discs (Figure 5) executes in one pass:

- weeding;
- the preparation of the seedbed for the purpose of sowing grassy cereals and grassy plants at working depths between 10–14 cm.

It is used summer–autumn (in certain situations spring) on fresh ploughing, in all types of soil located on flat land or with a slope of up to 6º.

Weeding is carried out immediately after harvesting grassy or leguminous cereals because the soil remains free (unshaded) and water evaporation intensifies. This reduces the rate of water evaporation from the soil by breaking capillarity. Moreover, weeding ensures the mechanical destruction of weeds, stimulates the germination of the seeds left on the ground so that they can be destroyed chemically or mechanically, and last but not least, it ensures the leveling of the soil.

The seedbed made by the harrow with independent discs, GD4 complies with the following rules:

- the attack angle of the disks is the same for all batteries;
- the front batteries work at the same depth as the rear ones;
- the work speed corresponds to the agrotechnical requirements.

Figure 5. Harrow with independent disks

F. Chisel, PC13

The chisel (Figure 6) is intended for the execution of the soil work without overturning the furrow, on all soils with a maximum clay content of 32%, in order to establish cereal crops, especially grass cereals with disc seeders, within the input technologies reduced. The use of the chisel is mandatory on saline lands or those with a tendency to become saline, those with a thin fertile layer, and those subject to wind erosion.

Figure 6. Chisel, PC 13

G. Technical equipment with working bodies for preparing the soil and sowing grassy cereals, SGR

The technical equipment (Figure 10) is intended for soil preparation and sowing that uses working organs for the establishment of grassy cereal crops, grain legumes, fodder plants, in prepared (Variant I) or semi–prepared land (crusted land that requires further loosening of the layer on the surface for sowing), as well as on land where basic soil processing, sowing and subsequent compaction are carried out in a single work cycle (Variant II).

The technical equipment with working organs for preparing the germinative bed and sowing, SGR by equipping vertical rotors with tooth knives is used for sowing grassy cereals in semi–prepared land for sowing. The vertical rotors with tooth knives process the soil, worked by ploughing, at depths of up to 8 cm, thus creating a suitable germinative bed for sowing.

The technical equipment with working organs for preparing the germinative bed and sowing, SGR by equipping vertical rotors with blade knives is used for sowing grassy cereals in unprepared land for sowing. The vertical rotors with blade knives work the soil at depths of up to 12 cm, thus creating a suitable germinative bed for sowing.

The technical equipment with working bodies for preparing the soil and sowing grassy cereals, SGR (Figure 11) works in aggregate with the 150 HP tractors on wheels equipped with category 3 hydraulic lifters according to SR ISO 730–1+C1.

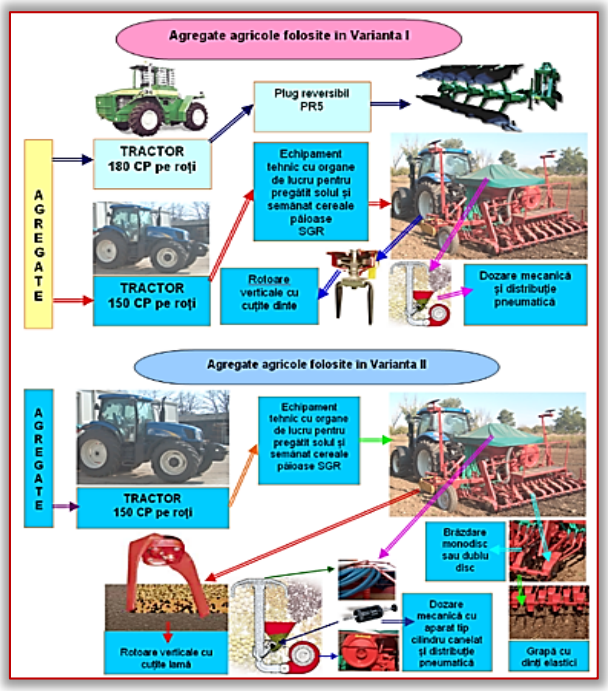

Figure 10. Technical equipment with working bodies for preparing the soil and sowing grassy cereals

Figure 11. Technical equipment with working bodies for preparing the soil and sowing grassy cereals SGR

The technical equipment with working bodies for preparing the soil and sowing consists of a harrow with vertical rotors (Figure 12), which can work independently to work the soil or to prepare the seed bed, and a mechanical–pneumatic seeder (Figure 13) which can he worked independently sowing grassy cereals.

Figure 12. Harrow with vertical rotors

Figure 13. Mechanical–pneumatic seeder

H. The technical equipment for tilling the soil in strips, sowing weeds, fertilizing and distributing insecticides, ELS 4

The technical equipment for working the soil in strips, sowing weeds, fertilizing and distributing insecticides (Figure 14) can be used independently in one pass for processing, mobilizing, and loosening the soil on an area called a "narrow strip" and in another pass for sowing crops of creeping plants (corn–by–corn sowing, sunflower, etc.) simultaneously with the administration of chemical fertilizers and insecticides or simultaneously when tilling the soil in "narrow strips", sowing creeping plants, fertilizing, distributing granulated insecticides, incorporating into the soil, covering and light compaction is achieved in a single pass.

Figure 14. The technical equipment for tilling the soil in strips, sowing weeds, fertilizing and distributing insecticides

The technical equipment consists of a front frame, a coupling bar, some side bars, some bolts, some supports, some clamps, some nuts, a rear frame, a central tie rod, some bolts secured with a pin and an elastic safety, some left/right wheels for support, some working sections equipped with two notched discs mounted at an angle, a straight notched disc, a chisel knife, two notched spherical discs, some sowing sections that have seed distribution devices driven

from a support wheel and right–hand drive by means of a chain–wheel drive, some boxes for chemical fertilizers and some boxes for granulated insecticides having in their composition dispensers driven from a left–hand support wheel by means of a chain–wheel drive, some coulters for incorporated fertilizers and insecticides, some left/right track markers operated by means of a hydraulic device IC and a vacuum installation which consists of an exhauster driven from the tractor's power take–off by means of cardan transmissions, a bearing and a multi–belt transmission.

I. Equipment to work the soil in the substrate adapted to conservative technology in the context of climate change, CONSOL

The tillage equipment adapted to conservative technology (Figure 15) is of the type carried on the three–point suspension mechanism mounted on the rear of 220–240 HP wheeled tractors, category 3, SR ISO 730:2012 and is intended to perform soil work from the arable substrate (without turning the furrow) and removing the impermeable layer of soil (hardpan) between the layer and the arable substrate.

Figure 15. Equipment for working the soil in the substrate adapted to conservative technology

The farmer using the advanced management method, which involves collecting and storing on–site weather data from a wireless weather station and receiving this information in real–time on a computer/smartphone by the farmer, can make an instant decision on the conservative work of soil, thus saving time and labor for additional checks on the farm. The conservation work is carried out with the technical equipment to work the soil in the substrate and allows the maintenance of plant remains on the soil surface or close to the soil surface and/or keeping the soil surface loose and granular, in order to reduce erosion and improve soil–water relations. During work, to avoid overlaps and replace ground marking, the operator (machinist) uses a MATRIX® 570GS manual guidance system, which consists of a console, an RXA–30 26 dB antenna, and a RealView camera with night vision. With such a system, overlaps are eliminated and the number of people needed for a job is reduced. Basically, markings are no longer used, and compasses or other methods are no longer used.

J. Weeding equipment for working in rows and between the vine trunks, EPV 2.2

Weeding equipment for working in rows and between vine trunks (Figure 16) is intended for the mechanized execution of soil mobilization work between vine stumps simultaneously with the execution of cultivation work on the interval between the rows, in plantations with management vines on the stem, vertical, with tutus at each hub.

Figure 16. Weeding equipment for working in rows and between the vine trunks, EPV 2.2

The process of tilling the soil between the hubs consists of the translational movement of the knife–type active organ with a long side wing, lifting a strip of soil and shredding it simultaneously with cutting the roots of weeds. During the movement of the active organ on the row of hubs, the feeler rod touches the hubs at a height of 10–15 cm above the ground and through the lever system transmits the command to withdraw the active organ to the hydraulic distributor. Retraction is done progressively according to the stroke of the probe. After passing the hub, the feeler rod returns to its initial position under the action of a spring, also commanding the return of the active organ to the row of hubs. In this way, by withdrawing and returning the active organ, the area between the stumps is processed on the vine row with the exception of an area around the stumps and trellis posts.

K. Spraying machine in vine plantations, MSR

The spraying machine (Figure 17) is intended for spraying with the recovery of the working substance in vine plantations planted at a distance between rows of 2–2.2 meters. The liquid that does not adhere to the leaf surface is transferred back to the reservoir and reused for work in order to obtain a significant saving of active substance and reduce environmental pollution compared to the conventional application of treatments in vine plantations.

Figure 17. Spraying machine in vine plantations

The machine is of the type carried by a wheeled or tracked tractor, with a power of 45 HP, equipped with a three–point suspension mechanism, mounted at the rear, category 1 according to SR ISO 730–1+C1:2000, for work in vineyards planted at a distance between rows of 2–2.2 meters. The technological process of the machine's operation is carried

out in the following order: from the PTO shaft (APP) of the tractor, through the universal joint shaft, the shaft of the M135s Imovilli pump is driven in rotation. The liquid in the polyethylene tank is absorbed by the pump through the suction filter and sent to the flow and pressure regulator. From the flow and pressure regulator, the working liquid is sent to the ramps with nozzles mounted on the central panels and the stg/dr panels, and from here to the plants. The dispersed working fluid passes through the foliage of the plants. A part of the drops are deposited on the leaves, and the rest drips on the panels and reaches the accumulation tanks located in the lower part of the panels. Here it is filtered and transported through the solution recovery system with electric direct current pumps to the liquid tank for reuse. The machine is fed through the filling mouth of the tank, in which the filling filter is fixed. The liquid level in the tank is visualized on the level indicator located on the outside of the tank. Emptying the liquid from the tank is done through the 3–way tap located at the bottom of it.

CONCLUSIONS

- The research results allow useful recommendations for farmers who implement innovative mechanization technologies for soil work, the establishment and maintenance of agricultural crops that can contribute to a better protection and conservation of soil resources.
- Innovative technologies and equipment for the mechanization of soil work in field crops with low impact on the environment represent alternatives to the conventional system of soil work through the effects of conservation of soil properties and assured productions.
- The EU Soil Strategy for 2030 supports investments in preventing and restoring soil degradation because they are economically justified.

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