MECHANIZATION OF GRASSLAND FARMING BY TECHNOLOGICAL VARIANTS WITH MINIMAL INPUTS. A REVIEW

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MECANIZAREA LUCRĂRILOR AGRICOLE PE PAJIȘTI PRIN VARIANTE TEHNOLOGICE CU INPUTURI MINIME. REVIEW

Vasile MOCANU[1*)], Tudor Adrian ENE[1*)], Eugen MARIN[2)], Neluș-Evelin GHEORGHIȚĂ[3)]

[1)] Research-Development Institute for Grasslands, 500128 Brasov / Romania;

[2)] The National Institute of Research – Development for Machines and Installations Designed for Agriculture and Food Industry – INMA Bucharest / Romania

[3] University Polytechnic of Bucharest, Department of Biotechnical Systems, Faculty of Biotechnical Systems Engineering, 006042 Bucharest / Romania;

Correspondence: Tel: +40728941786; E-mail: vasmocanu@yahoo.com

Tel: +40735713143; E-mail: tudorene@yahoo.com

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ABSTRACT

Grassland farming plays a vital role in sustainable agricultural systems, providing forage resources for livestock production and contributing to environmental conservation. However, the labor-intensive nature of grassland management requires significant challenges for farmers. The adoption of appropriate mechanization technologies can improve efficiency, reduce labor requirements, and enhance overall productivity. This paper investigates the mechanization of grassland farming through technological variants with minimal inputs. The incorporation of sensor technologies and data analytics facilitates real-time monitoring of grass growth, enabling farmers to make decisions regarding grazing rotations and forage quality. Additionally, the utilization of smart sensors for soil moisture and nutrient content allows for targeted application of inputs, reducing waste and optimizing resource utilization. Overall, this article highlights the potential of mechanization and technological variants with minimal inputs to make efficient the grassland farming, improving productivity, sustainability and the livelihoods of farmers.

ABSTRACT

Gospodărirea pajiștilor joacă un rol vital în sistemele agricole durabile, oferind resurse furajere pentru animale și contribuind la conservarea mediului. Cu toate acestea, natura intensivă a forței de muncă pentru gestionarea pășunilor ridică provocări semnificative pentru fermieri. Adoptarea tehnologiilor adecvate de mecanizare poate îmbunătăți eficiența, poate reduce cerințele de muncă și poate crește productivitatea generală. Această lucrare analizează și promovează mecanizarea lucrărilor agricole pe pajiști prin variante tehnologice cu inputuri minime. Utilizarea tehnologiilor cu senzori și a analizei datelor facilitează monitorizarea în timp real a creșterii ierbii, permițând fermierilor să ia decizii cu privire la rotația pășunatului și la calitatea furajelor. În plus, utilizarea senzorilor inteligenți pentru umiditatea și conținutul de nutrienți ai solului permite aplicarea corectă a intrărilor, reducerea risipei și optimizarea utilizării resurselor. În general, acest articol evidențiază potențialul mecanizării și al variantelor tehnologice cu inputuri minime pentru eficientizarea valorificării pajiștilor, îmbunătățind productivitatea, durabilitatea acestora și mijloacele de trai ale fermierilor.

INTRODUCTION

According to FAO statistics, pastures—including open grasslands, herbaceous shrubs, and savannas—cover approximately 40 % of the Earth's land surface (*O'Mara, 2012; Wilsey, 2018*). Of this, 31.2 % are in America, 30.9% in Asia, 15.8% in Africa, 13.5% in Europe, and 8.6% in Oceania (*FAOSTAT, 2024*). Grasslands are among Earth's most valuable ecosystem complexes due to their vital ecological and socio-economic roles (*Hobohm et al., 2021*). They support biodiversity, provide habitats for countless species, and act as key regulators of the carbon and water cycles. In particular, permanent pastures serve as essential reservoirs of biodiversity and ecological stability, making them indispensable for nature conservation (*Dengler et al., 2014; Frenzel et al., 2024; Feurdean et al., 2018*).

Despite their importance, grasslands have significantly declined since the mid-20th century. This decline is largely driven by the intensification of extreme climatic events, such as prolonged droughts, heavy rainfall, and heatwaves, all of which have become more frequent due to global climate change (*Easterling et al., 2000; Pepin et al., 2022; Zhang et al., 2024*).

These adverse conditions have not only led to the degradation of permanent grasslands but have also critically impacted soil properties, including organic matter content, nutrient balance, and microbial activity. These factors are essential for maintaining grassland productivity and resilience (*Xinxia, 2024; Lu, 2024*).

Managing grasslands effectively presents a significant challenge for farmers. Balancing productivity with environmental sustainability requires adopting efficient strategies that optimize resource use and preserve ecosystem health (*Wróbel et al., 2023; Zhang et al., 2021; Wang et al., 2021*). Such approaches are crucial for ensuring consistent livestock productivity and improving forage quality, which is vital for meeting the nutritional needs of animals (*Chand et al., 2022*). At the same time, these practices must address environmental concerns, such as reducing greenhouse gas emissions linked to grazing and livestock activities (*Wan et al., 2024*) and preventing soil degradation through erosion, compaction, and nutrient depletion (*Bogunovic et al., 2022*). Technological advancements in monitoring and grazing systems provide promising solutions to these challenges, offering farmers tools to manage grasslands more effectively (*Liu & Shao, 2024*).

Beyond addressing immediate agricultural concerns, grassland management plays a broader role in tackling global socio-ecological issues. Proper management not only ensures the sustainability of rural livelihoods but also helps conserve areas unsuitable for conventional agriculture, thereby maintaining ecological balance (*Li et al., 2022; Dong et al., 2012*). Grasslands also provide valuable forage resources to support livestock production and enhance land use efficiency, which maximizes the productivity of available resources (*Anca, 2012; Buzhdygan et al., 2020*). By implementing effective strategies, farmers can contribute to preserving these critical ecosystems and preventing their overexploitation (*Peters et al., 2001*).

Innovative technologies, particularly sensor systems and data analysis, are transforming grassland management. Although adopting these tools can be challenging for farmers, they offer significant benefits when implemented successfully (*Polichshuk et al., 2023; Bikker et al., 2014; Creighton et al., 2011*). For instance, the development and performance of small power electric tractors, as demonstrated by *Matache et al. (2020)*, highlight the potential of renewable energy-powered machinery to achieve efficient and environmentally friendly outcomes. These tractors not only reduce emissions but also provide cost-effective alternatives for operations like ploughing, aligning with sustainability goals. Similarly, advanced sensors enhance grazing quality by improving soil and vegetation monitoring, which positively impacts livestock foraging behavior (*Amorim et al., 2020; Kennedy et al., 2007*). Furthermore, smart sensors designed to monitor soil moisture and nutrients enable precise input applications, reduce waste, and improve crop yields through informed decision-making (*Krueger et al., 2021; Cao, 2024; Tadesse et al., 2021*).

Conservation-focused technologies have also proven effective in improving grasslands. These approaches significantly boost biomass production and species richness, enhancing ecosystem stability and resilience (*Hakimovich and Alishovich, 2023; Li et al., 2022; Hautier et al., 2014; Isbell et al., 2015; Wagg et al., 2017; Wang et al., 2019*). Importantly, such advancements preserve soil properties, ensuring long-term productivity and sustainability (*Maron et al., 2011*). These methods not only support environmental goals but also enhance the livelihoods of farmers by improving economic returns and ecological outcomes (*Xiong et al., 2023; Dong et al., 2023*).

Despite the availability of advanced technologies, many grassland management practices still rely on universal agricultural machinery designed for crops like cereals or industrial plants (*Huang and Fu, 2024; Collins et al., 2017*). While these tools have their benefits, they are often not tailored to the specific needs of grasslands, limiting their effectiveness. Developing specialized equipment for grassland restoration could significantly enhance the efficiency of such efforts (*Lyons et al., 2023; Tindale et al., 2024; Xie et al., 2023*).

Traditional methods for maintaining degraded grasslands have several shortcomings, including negative impacts on soil health such as erosion, nutrient imbalances, and biodiversity loss (*Mocanu et al., 2021; Baritz et al., 2018*). Inappropriate technologies can exacerbate these issues, leading to inefficiencies like increased fuel consumption and reduced soil carbon sequestration, both of which contribute to environmental degradation (*Song et al., 2023; Gorris et al., 2024; Ibrahim et al., 2010*). Recent studies, such as those examining the random vibrations of active cultivator components, underscore the importance of understanding mechanical dynamics to improve agricultural machinery performance and reliability. Such insights can guide the development of more efficient tools that better align with sustainable agricultural practices (*Cardei et al., 2023*). Addressing these challenges requires a shift toward sustainable, targeted interventions.

Grassland degradation is a global concern with widespread consequences. Tackling this issue and restoring these vital ecosystems is a priority for protecting biodiversity and ensuring the well-being of dependent communities (*Marușca et al., 2020; Oprea and Marușca, 2023*).

Strategies like overseeding and complete restoration using perennial grass and legume seeds have shown great potential in transforming low-yield grasslands into productive and resilient landscapes (*Marușca, T., 2022; Marin et al., 2023*).

The application of organic fertilizers, facilitated by specialized machinery, is another important component of grassland restoration. This approach improves soil fertility and supports sustainable vegetation growth, effectively combating degradation (*Ştefan et al., 2021; Ştefan et al., 2019*). Recent advancements in grassland technologies, developed through scientific research, offer practical solutions for improving the productivity and sustainability of these ecosystems while minimizing environmental impact.

Within this paper are presented new technologies for the maintenance and improvement of grasslands, which include efficient mechanization solutions with a reduced ecological impact, developed with minimal inputs and promoting a minimal soil processing system.

A. GRASSLANDS MANAGEMENT EQUIPMENT

1. Fertilizing equipment EF 2.5 type

The EF 2.5 fertilizing equipment (Figure 1), is used for the administration of solid mineral fertilizers simultaneously with the execution of other compatible operation for grassland farming.

1.1. Description

The EF 2.5 fertilizing equipment consists of the following main parts: assembled frame (pos.1, Fig.1); fertilizer boxes with metering devices and agitator drive shaft (pos. 2, Fig. 1); the mechanism of movement transmission to the fertilizer metering devices and agitator drive shaft of the equipment (pos.3 and 4, Fig.1) *(Mocanu and Hermenean, 2008)*.

1.2. Operation mode

When advancing the aggregate composed of the fertilizing equipment (mounted on the frontal three-point hitch of tractor), the pivoting drive wheel (pos. 3, Fig. 1), which runs on the ground, being kept in contact with the ground by an adjustable spring), transmits the rotational movement through two chain transmissions and a cardan shaft to the Northon type gearbox (pos. 4, Fig. 1).

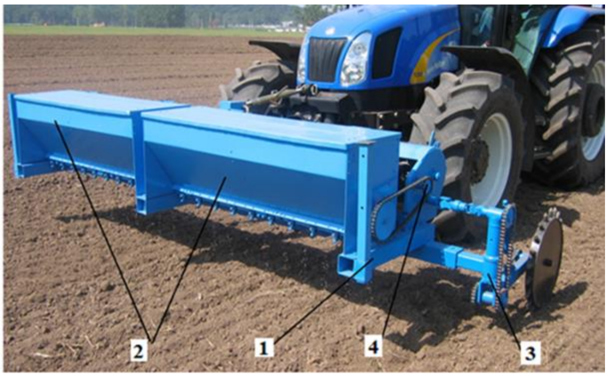


Fig. 1 - Fertilizing equipment EF 2.5 type
(Mocanu and Hermenean, 2008).

From the output of the gearbox, the movement is transmitted through a chain transmission to the agitator shaft of the fertilizer box (pos. 2, Fig. 1) whence, through a gear-driven transmission, the movement is transmitted to the axis of metering device that spread out the fertilizer directly on the ground. The Northon type gearbox allows adjusting the desired rate of fertilizer.

The pivoting drive wheel is a patented original construction that allows the movement to be transmitted even when the aggregate moves in a curve, for a left or right turning angle (inclination) of maximum 35 ^{0}, a value that exceeds the turning angle of the tractor steering wheels. The drive through this pivoting wheel has the great advantage that it gives the possibility to use the equipment even when moving the aggregate in a curve, a situation frequently encountered in the maintenance operations of grasslands by cleaning of weeds and worthless vegetation, in the preparation of the germinal bed, in reseeding degraded grasslands etc.

2. Fertilizing equipment EF 3.75 type; Sowing equipment ESR 3.75 type

The EF 3.75 fertilizing equipment (Fig. 2) is used for the administration of solid mineral fertilizers simultaneously with the execution of other compatible maintenance and improvement grassland farming operations *(Mocanu and Hermenean, 2008)*. The ESR 3.75 seeding equipment is the same as the EF 3.75, except that the fertilizer metering device is replaced with seed metering device for grassland plant seeds.

2.1. Description

The EF 3.75 fertilizer equipment is a modular agricultural equipment (with three modules) that can be used as a separate equipment carried on rear three-point hitch of tractor or mounted on the equipment for grassland levelling, thus forming a complex aggregate for cleaning and fertilizing the grasslands (Fig. 3). The ESR 3.75 seeding equipment is intended for the administration of forage plant seeds of grasslands (oversowing) simultaneously with the execution of cleaning operation of mole hills, animal dung, leveling the nano relief and grass sward aeration with the help of the equipment for grassland levelling (grassland planer, Fig. 3). The norm of forage plant seeds distributed can be varied from 6 to 300 kg/ha.

The EF 3.75 fertilizing equipment consists of the following main parts: assembled frame (pos.1, Fig. 2); fertilizer boxes (pos.2, Fig. 2); the movement transmission mechanism to metering devices and agitator drive shaft (pos. 3 and 4, Fig. 2).

2.2. Operation mode

When advancing the aggregate composed of the equipment (mounted on the rear three-point hitch of tractor), the pivoting drive wheel (pos. 3, Fig. 2), which runs on the ground (being kept in contact with the ground by an adjustable spring), transmits the rotational movement through one chain transmissions, two equal bevel gear transmissions and a coupling nut to the Norton type gearbox and further to the agitators and metering drive shaft of the devices for dosing the fertilizers (EF 3.75) or grass seeds (ESR 3.75).

Fig. 2 - Fertilizing equipment EF 3.75 type; Sowing equipment ESR 3.75 type
(Mocanu and Hermenean, 2008).

The pivoting drive wheel is another original construction, also patented, that allows the movement to be transmitted even when the aggregate moves in a curve, for a left or right turning angle (inclination) of maximum 35^0, a value that exceeds the turning angle of the tractor steering wheels.

Usually, this equipment is mounted on the grassland planer (Fig. 3), thus forming agricultural aggregates that perform several grassland farming operations in a single pass.

Fig. 3 - Grassland planer in aggregate with fertilizing equipment EF 3.75 type or sowing equipment ESR 3.75 type *(Mocanu and Hermenean, 2008)*.

Fertilizers or grass seed are distributed on the surface of the land, before the action of the active tools of the grassland planer start working. The action of the planer active tools produces the mixing (incorporation) of fertilizers (grass seeds) with soil, thus creating optimal conditions for plant growing.

3. Equipment for grassland levelling (grassland planer)

Grassland planer is intended for breaking up and spreading on the ground the mole hill, hummocks, droppings, micro uneven grounds and aerating the grassy carpet of grasslands *(Mocanu and Hermenean, 2008)*.

3.1. Description

The grassland planer (Fig. 4), is an equipment carried on the three-point hitch of drive tractors. It consists of the following main parts: the frame with the coupling triangle on the tractor (pos. 1, Fig. 4); 3 work devices (pos. 2, Fig. 4).

Each working section is equipped with two rows of vertical chisel-type knives (pos. 3, Fig. 4, b) and two rows of inclined horizontal blades (pos. 4, Fig. 4, b). The vertical chisel knives are adjustable for vertical position and can be inclined to the direction of advance. The two rows of inclined horizontal blades are mounted behind the chisel knives, in two different planes and with opposite inclinations.

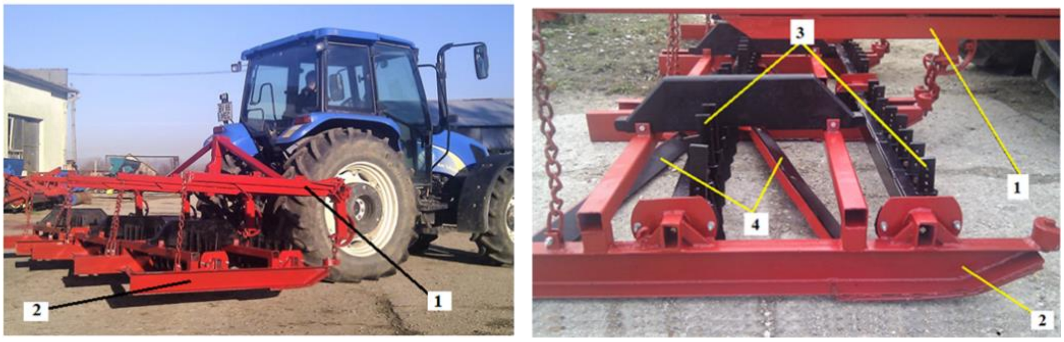


Fig. 4 - Grassland lever *(Mocanu et al., 2022)*.
a) aggregate view; b) detailed view of the work section

3.2. Operation mode

When advancing the aggregate, the chisel-type vertical knives perform the fragmentation of the hummocks, nano relief and droppings in the vertical-longitudinal plane, and the inclined horizontal blades perform the horizontal cutting and uniform spreading of the resulting fragments on the ground.

4. The harrow with rigid tines GCF 4.0 type

The harrow with rigid tines (Fig. 5) is used for aerating the grasslands after winter period, as well as for cleaning/spreading manure after the end of each grazing cycle *(Mocanu et al., 2022)*.

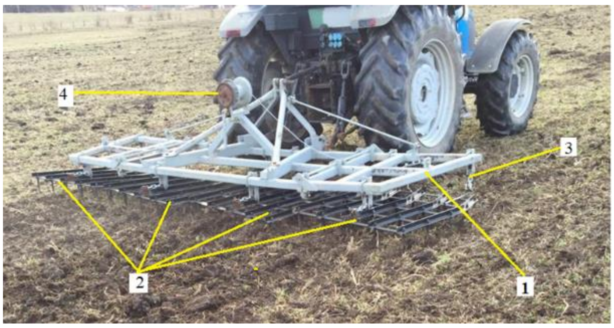


Fig. 5 - Harrow with rigid tines *(Mocanu et al., 2022)*

4.1. Description

The machine is an agricultural machine of the type carried on the rear three-point hitch mechanism of drive tractors. This complete harrow consists of tines grouped together in a frame and 4 of these frames grouped together.

The main component parts of the harrow with fixed tines are: assembled frame (pos. 1, Fig. 5); 4 individual harrows with a working width of 1 m (pos. 2, Fig. 5) linked to the frame with support chains (pos. 3, Fig. 5).

To reduce the gauge width during transport, the machine is equipped with a mechanism (pos. 4, Fig. 5) for lifting and descending the side harrows for transport and operation position respectively.

4.2. Operation mode

When advancing the aggregate, the rigid tines of harrows performs a superficial tillage, allowing aeration of the grassy carpet and spreading of animal dung and mole hills after each grazing cycle. It is generally a simple operation, but with a great effect for grassy plant growing.

5. Planer-grader equipment, RGP-2,0 type

Planer-grader equipment, RGP-2,0 type, is intended for the cleaning of annual and multi-annual hummocks, of animal dung and the micro-leveling of the land of degraded permanent pastures *(Mocanu et al., 2022)*.

5.1. Description

The machine is a semi-carried agricultural machine during transport and respectively trailed during the operation.

The main components of the levelling-grader equipment, RGP-2,0 type (Fig. 6), are: assembly frame (1), left levelling blades (2), right levelling blade (3), posterior levelling blade (4), front disc battery (5), left side disc battery (6), right side disc battery (7) the mechanism of lifting-descending for posterior leveling blade (8), hydraulic (9).

5.2. Operation mode

During operation, the aggregate formed by the tractor and the planer-grader equipment for grassland, the battery with frontal discs fragment in vertical-longitudinal plane the annual, multiannual earth hummocks, mole-hills and the animal manure.

Alternative left and right movement of the fragmented material, thanks to leveling blades, and under the action of the lateral disc batteries, intensifies the process of cutting it, being evenly distributed on the surface of the ground by the rear leveling blade.

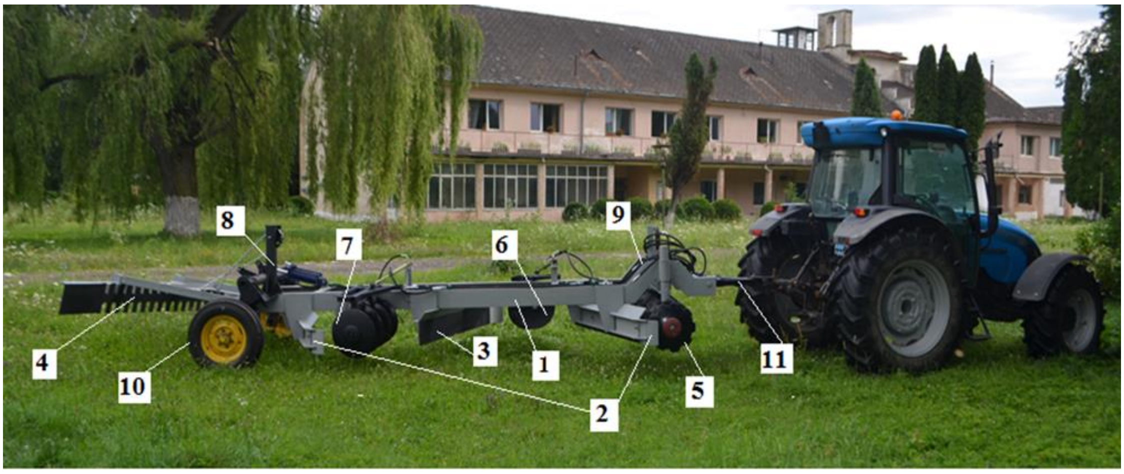


Fig. 6 - Side view of the aggregate tractor and planer-grader equipment RGP-2.0 type
(Mocanu et al., 2022)

6. Rotary toppers for cleaning the grasslands

They are intended for cutting, chopping and spreading on the ground the hillocks, mole hills and worthless vegetation from pastures or green areas in parks and recreational or sports grounds or on the side of roads. The MCP-2 and MCP 2.5 type rotary cleaning machines are representative (Fig. 7) *(Ştefănescu et al., 1982; Pop et al., 1994)*.

2.6.1. Description

The MCP-2 and MCP 2.5 grassland rotary cleaning equipment (Fig. 7) are machines carried on the three-point hitch mechanisms of drive tractors, have the active working tools of the vertical rotor type with articulated knives and are operated from the power take-off of tractors.

The main component parts of the rotary toppers MCP 2.0 and MCP 2.5 are: machine casing (pos. 1, Fig. 7), with the coupling frame to the tractor, with the grill with fingers and the support devices; the rotor with the active working tools (pos. 2, Fig. 7); support and adjustment wheels (pos. 3, Fig. 7); movement transmission system (pos. 4, Fig. 7).

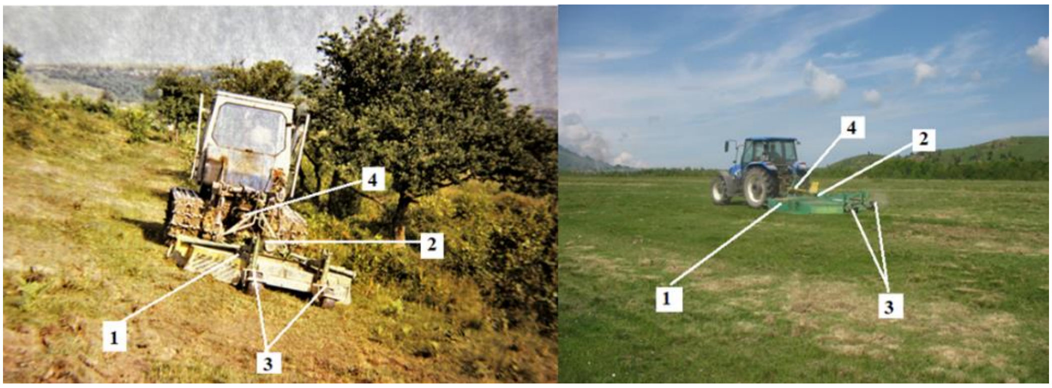


Fig. 7 - Rotary toppers for cleaning the grasslands *(Pop et al., 1994)*

a) MCP 2.0 type; b) MCP 2.5 type

6.2. Operation mode

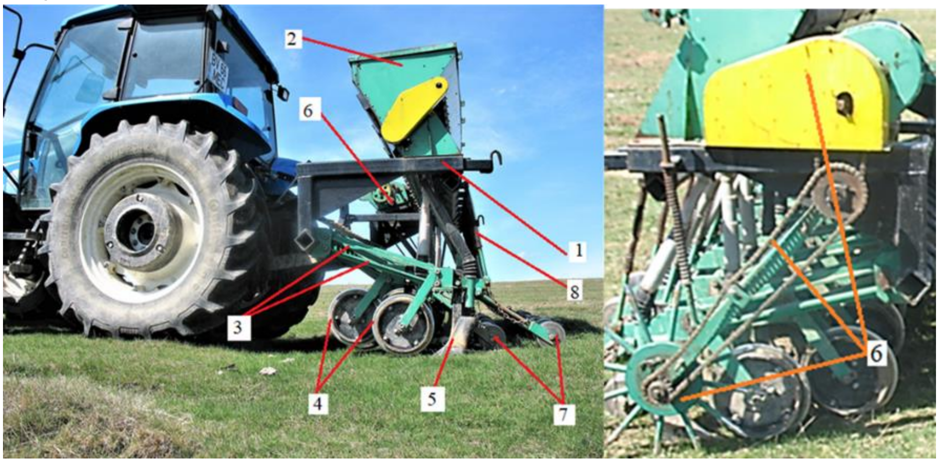
When the aggregate is moving forward, the knives on the rotating rotor cut and shred the hummocks and worthless vegetation. The "Z"-shaped knives cut hillocks and worthless vegetation, and the "J"-shaped ones shred them and spread the fragments on the ground *(Hermenean and Mocanu, 1986)*. The finger grate allows the passage and spreading on the ground only of the fragments that have the appropriate shredding sizes (less than 10 cm), the larger ones being further chopped until the passing size is obtained, which facilitates obtaining the desired degree of shredding.

7. Direct drilling seeder MSPD 2.5 type

Direct drilling seeder MSPD 2.5 type (Fig. 8) is intended for oversowing of degraded grasslands by opening furrows, metering, distributing and introducing the grassy seeds in the opened furrows and settling the sown row *(Hermenean et al., 2003; Hermenean and Mocanu, 2002)*.

7.1. Description

The machine is rear mounted on the drive tractor. The main component parts of the direct drilling seeder MSPD 2,5 type are: assembled frame (pos. 1, Fig. 8); equipment for opening the seed slots (pos. 3, 4, 5, Fig. 8); sowing equipment (pos. 2, Fig. 8); movement transmission mechanism to the sowing equipment (pos. 6, Fig. 8); press wheels for settling the sown slots (pos. 7, Fig. 8) *(Hermenean et al., 2003; Hermenean and Mocanu, 2002)*.



a) b)

Fig. 8 - Side view of direct drilling seeder MSPD2.5 type

(Hermenean et al., 2003; Hermenean and Mocanu, 2002)

a) -left side; b) right side

7.2. Operation mode

When the tractor-oversowing machine aggregate is working, the rimmed discs of the furrow opening sections (pos. 4, Fig. 8) fractionate the old sward in a vertical-longitudinal plane, and the coulters (pos.5, Fig. 8) open the slot and insert, at the desired depth, the seed of the grassland fodder plants distributed by the sowing equipment of the machine. The press wheels achieve intimate contact between the seed and the soil, on each seeded row. The mounting on the frame of the slot opening sections by parallelogram drag arms (pos.3, Fig. 7) allows, on the one hand, to maintain the constant angle of attack of the coulter during work, and on the other hand to copy the unevenness of the land within the limits of ± 10 cm. The loading springs (pos. 8, Fig. 7) achieves the force necessary to maintain the pressure and penetration on/into the soil of the rimmed disc wheels and the coulters. The rim on the disc wheels allows a constant sowing depth of the seeds during work time *(Hermenean et al., 2006; Hermenean et al., 2006)*.

8. Combined grassland rotary tiller-drill machine MCT 2.5 M type

The MCT 2.5 combined machine is intended for the destruction of the old vegetal carpet and preparing seedbed, simultaneously with the sowing of grassland fodder plants.

By improving some of the components, the new modernized machine MCT 2.5 M type allows the removal of all the deficiencies reported in the old variant machine. Thus, a higher quality of the work can be obtained, the number of passes required for a good seedbed preparation is reduced etc. *(Hermenean et al., 1994)*.

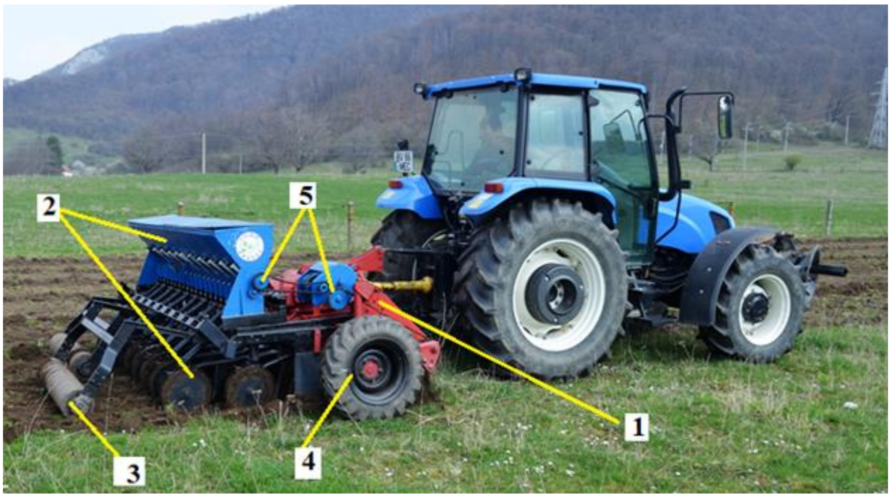


Fig. 9 - Combined grassland rotary tiller-drill machine MCT 2.5 M type
(Hermenean et al., 1994)

8.1. Description

The machine is rear mounted on the drive tractor and operated from the power take-off of tractors. The improved combined machine MCT 2.5 M type (Fig. 9), consists of the following main parts: equipment for destroying the old sward and preparing the seedbed, rotary milling type (pos.1, Fig. 9); sowing equipment (pos. 2, Fig. 9); 2 light rollers for pressing the soil after sowing (pos. 3, Fig. 9); running wheels (pos. 4, Fig. 9); mechanism for transmission of movement to the sowing equipment (pos. 5, Fig. 9).

8.2. Operation mode

During work, the rotary milling equipment, which is driven by the independent power take-off of 1000 rpm. of the tractor, destroys the old vegetal carpet and prepares the seedbed. The sowing equipment, which is driven from the right wheel of the machine, distributes the adjusted seed rate and introduces it into the soil with the help of the double disc coulters. The use of double disc coulters eliminates the deficiency of the old coulters, namely that of clogging caused by large fragments of soil and no shredded sward. The light rollers mounted on the back of the sowing equipment allow rolling after sowing, thus creating optimal conditions for seed germination. The use of two articulated rollers allows better copying of the ground on the working width.

B. GRASSLANDS MANAGEMENT TECHNOLOGIES

1. The purpose of new technologies

The purpose of the new technologies for the mechanization of grassland maintenance and improvement operations consists in: creating favorable conditions for developing the valuable fodder plants; increasing the fodder quantity and quality; limiting or removing the phenomenon of degradation of the vegetal carpet; reducing and stopping the phenomenon of erosion on grasslands located on sloping land; conservation and restoration of grassland biodiversity; making available favorable conditions for the mechanization of grassland farming and in particular those for harvesting fodder; reducing the physical effort and labor required for the maintenance and improvement of degraded pastures; reducing the degree of the environment pollution (soil, air, water) as a result of reducing the specific fuel consumption and the passes number of the aggregates; increasing economic efficiency by reducing the cost per improved surface unit; promoting an ecological agriculture and improving the eco-landscape beauty by reducing the phenomenon of erosion and re-introducing the degraded surfaces into an agro-pastoral circuit *(Hermenean and Mocanu, 2009; Mocanu and Hermenean, 2013)*.

2. Technologies for maintenance of grasslands

The maintenance of grasslands consists of: cleaning the hillocks and worthless vegetation, fertilizing during the years of exploitation, cleaning the plant residues after each grazing cycle.

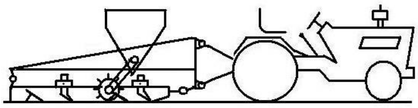
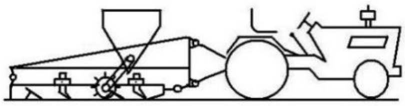
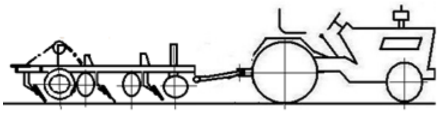
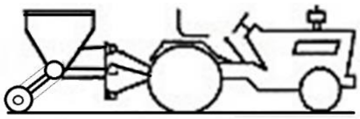
Depending on the degree of cover with anthill, mole hills, hummocks, grassy and non-valuable woody vegetation and their sizes, the following situations are found in practice:

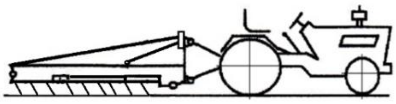
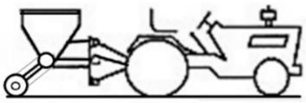
a- grassland is invaded by hillocks and animal droppings after each grazing cycle;
b- grassland is invaded by large hillocks and with a high cover degree per hectare;
c- grassland is invaded by weeds and worthless vegetation with a diameter that does not exceed 4 cm;
d- grassland area includes the plant residues after the end of a grazing cycle.

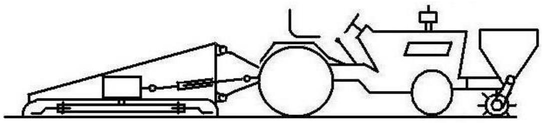
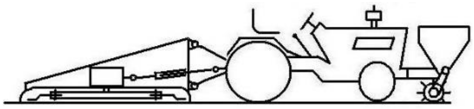
The new maintenance technologies, shown schematically in table 1, use combined aggregates that perform two or three operations in a single pass, namely: cleaning of mole hill, hillocks and chemical fertilization; cleaning of worthless vegetation, of hillocks and chemical fertilization; cleaning of the plant residues after grazing and phased chemical fertilization.

Table 1

New technological variants for maintenance of grasslands *(Mocanu and Hermenean, 2013)*

a. Grassland is invaded by hillocks and animal droppings after each grazing cycle			
Operations and recommended aggregates	Working capacity [ha/daily operating time]	Necessary labor force [man hour/ha]	Fuel consumption [l/ha]
Cleaning of mole hill, anthill, animal droppings, grass sward aeration and chemical fertilization  Wheel tractor of 48-60 kW (65-80 HP) + Grassland lever + Equipment for fertilizing EF 3.75 type	8.0	1.00	4.6
b. Grassland is invaded by large hillocks and with a high cover degree per hectare			
Variant b1			
Cleaning of mole hill, anthill, animal droppings, grass sward aeration and chemical fertilization  Wheel tractor of 48-60 kW (65-80 HP) + Grassland lever + Equipment for fertilizing EF 3.75 type - two perpendicular passes with the administration of chemical fertilizers on the second pass	4.5	1.78	8.8
Variant b2			
Cleaning of mole hills, large hillocks, animal droppings  Wheel tractor of 48-60 kW (65-80 HP) + Planer-grader equipment. RGP-2.0 type	5.6-8.2	1.02-1.42	12.5-16.5
Chemical fertilization of grassland  Wheel tractor of 25-33 kW (35-45 HP) + Equipment for fertilizing EF 3.75 type	12.0-14.5	0.55-0.66	3.5-4.5
Total variant b2	x	1.57-2.08	16.0-21.0

Variant b3			
Cleaning of mole hill, anthill, animal droppings, grass sward aeration  Wheel tractor of 25-33 kW (35-45 HP) + Harrow with rigid tines GCF 4.0 type	11.2-18.0	 0.44-0.72	3.8-6.1
Chemical fertilization of grassland  Wheel tractor of 25-33 kW (35-45 HP) + Equipment for fertilizing EF 3.75 type	12.0-14.5	 0.55-0.66	3.5-4.5
Total variant b3	x	0.99-1.38	7.3-10.6

c. Grassland is invaded by weeds and worthless vegetation with a diameter that does not exceed 4 cm;			
Cleaning of worthless vegetation, hillocks and fertilizing with chemical fertilizers  Wheel tractor of 60 -74 kW(80-100CP) + Rotary toppers for cleaning the grasslands MCP 2.5 type+ Equipment for fertilizing EF 2.5 type	3.8-4.5	 1.78-2.10	15.0-21.0
d. Grassland area includes the plant residues after the end of a grazing cycle			
Cleaning of refused plants after grazing and periodic chemical fertilization  Wheel tractor of 60 -74 kW(80-100CP) + Rotary toppers for cleaning the grasslands MCP 2.5 type+ Equipment for fertilizing EF 2.5 type	7	 1.14	8.50

3. Technologies for improving the degraded grasslands by oversowing method

Oversowing improvement technologies are part of the category of technologies for improving degraded pastures by surface operations focused on creating better seed growing conditions for valuable grassland plants, without destroying the existing vegetal sward. They are simple, easy to apply and in most cases, less expensive *(Mocanu et al., 2021; Dragos et al., 2023; Mitev, 2023)*.

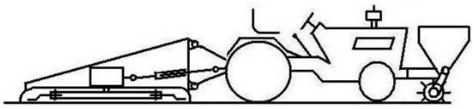
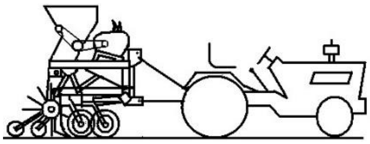
Oversowing operation consists of introducing the seeds of valuable perennial grasses and/or legumes into the old vegetal carpet by partial processing of sward *(Cujbescu et al., 2021; Ene et al., 2023)*.

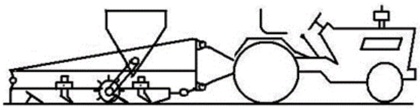
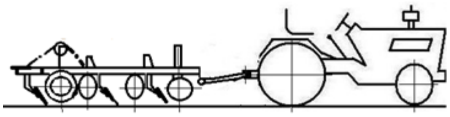
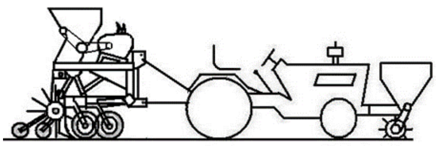
In general, in order to meet the agro-technical requirements, this is done with special overseeding machines *(Hermenean and Mocanu, 2009; Ene et al., 2023)*. The grasslands indicated for overseeding are those surfaces characterized by: a low level of vegetation cover; inappropriate floristic composition (weedy); reduced edaphic volume; peaty or heavy soils on which processing by ploughing is difficult *(Ungureanu et al., 2019)* lands exposed to erosion and landslides; land without vegetation after: worthless woody vegetation control; destruction of hillocks; removing stones; levelling operation; paddocking surfaces; the surfaces on which, for the protection of the environment, total soil processing works are not indicated (by ploughing, deep milling etc.) *(Vlăduț et al., 2023)*.

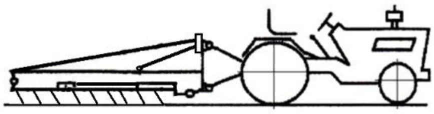
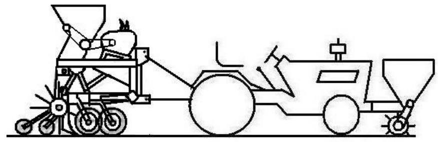
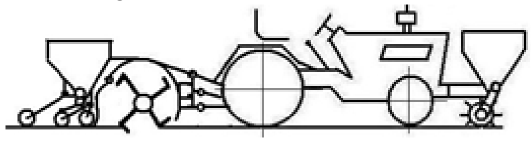
Table 2 shows the options for mechanizing the operation within the new technology for oversowing the degraded grasslands.

Table 2

New technological variants for improving degraded grasslands by oversowing method *(Mocanu and Hermenean, 2013)*

Operations and recommended aggregates	Working capacity [ha/daily operating time]	Necessary labor force [man hour/ha]	Fuel consumption [l/ha]
Variant 1. Grassland is invaded by hillocks and worthless vegetation with a diameter that does not exceed 4 cm			
Controlling the competition of the old sward by cleaning of worthless vegetation, hillocks, micro unevenness, droppings and chemical fertilization (phosphorus and potassium)  Wheel tractor of 60 -74 kW(80-100CP) + Rotary toppers for cleaning the grasslands MCP 2.5 type+ Equipment for fertilizing EF 2.5 type	3.8-4.5	 1.78-2.10	15.0-21.0
Actual overseeding  Wheel tractor of 60 -74 kW(80-100CP) + Direct drilling seeder MSPD 2.5 type	8-10.5	 0.76-1.00	7.5-8.5
Total Variant 1	x	2.54-3.10	22.5-29.5

Variant 2. Grassland is invaded by mole hill, anthill, animal droppings			
Cleaning of mole hill, anthill, animal droppings, grass sward aeration and oversowing operation  Wheel tractor of 48-60 kW (65-80 HP) + Grassland lever+ Equipment for seeding ESR 3.75 type - two perpendicular passes with the administration of seed mixture on the first pass	4.5	 1.78	8.8
Variant 3. Grassland is invaded by mole hills, large hillocks, animal droppings			
Cleaning of mole hills, large hillocks, animal droppings  Wheel tractor of 48-60 kW (65-80 HP) + Planer-grader equipment, RGP-2.0 type	5.6-8.2	 1.02-1.42	12.5-16.5
Actual oversowing and chemical fertilization (phosphorus and potassium)  Wheel tractor of 60 -74 kW(80-100CP) + Direct drilling seeder MSPD 2.5 type + Equipment for fertilizing EF 2.5 type	7.0-9.0	 0.88-1.14	8.5-9.5
Total Variant 3	x	1.90-2.56	21.0-26.0

Variant 4. Grassland is invaded by mole hill, anthill, animal droppings			
Cleaning of mole hill, anthill, animal droppings, grass sward aeration  Wheel tractor of 25-33 kW (35-45 HP) + Harrow with rigid tines GCF 4.0 type	11.2-18.0	 0.44-0.72	3.8-6.1
Actual oversowing and chemical fertilization (phosphorus and potassium)  Wheel tractor of 60 -74 kW(80-100CP) + Direct drilling seeder MSPD 2.5 type + Equipment for fertilizing EF 2.5 type	8-10.5	 0.76-1.00	7.5-8.5
Total Variant 4	x	1.2-1.72	11.3-14.6
Variant 5. Degraded grasslands with thin fertile soil layer and thin sward			
Decreasing competition from old sward, the seedbed preparing by a low disturbance of soil, oversowing, rolling after sowing and fertilization with chemical fertilizers  Wheel tractor of 60 -74 kW(80-100CP) + Combined grassland rotary tiller-drill machine MCT 2.5 M type + Equipment for fertilizing EF 2.5 type	3.2-3.6	 2.22-2.50	25-30

These agricultural aggregates, depending on the needs, execute through a single pass, either the cleaning operations of hillocks and worthless vegetation along with chemical fertilization, or the cleaning of plant residues resulted after grazing simultaneously with periodical chemical fertilization.

CONCLUSIONS

New technologies or technological sequences for the mechanization of the maintenance and improvement of degraded grasslands, presented in this paper, are based on the composition of complex aggregates, using machines and equipment specific to the mechanization of grassland farming.

Compared to the classic technology, the new technology of mechanization of grassland improvement works by oversowing method use complex aggregates that perform two operations in a single pass, which allows reducing the number of passes of the aggregates. Thus, at the same time with execution of cleaning the hummocks, the old vegetation and to reduce the competition of the old sward before the actual oversowing, the fertilization with chemical fertilizers is also performed.

Compared to classic technologies, the new technologies and technological solutions for mechanization of the maintenance works and those for the improvement of degraded grasslands require lower fuel and work force consumptions with a lower number of passes of the aggregates.

Thus, fuel consumption is reduced by:

- 3.0-3.5 l/ha for grassland maintenance operations;
- 10.7 l/ha for improvement operation by oversowing the degraded grasslands;

By using the new technologies labor consumption is reduced with:

- 0.49 -1.176 man hours/ha for grassland maintenance operation;
- 2.316 man hours/ha for the improvement operations by oversowing;

When using the new technological variants, the number of passes of the aggregates for carrying out the operations under study is reduced as follows:

• for grassland maintenance operation from 2 passes to one pass;

• for the improvement operations by oversowing method from 4 passes to 2 passes;

By reducing fuel consumption and the number of passes, the new technologies and the technological sequences for mechanization of grassland farming have a reduced ecological impact, environmental pollution (air, water, soil) is lower, and the cost is reduced proportionally, the inputs being reduced.

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