Scientific Papers. Series A. Agronomy, Vol. LXVIII, No. 2, 2025
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

EXPERIMENTAL RESEARCH FOR PROMOTING A TECHNICAL EQUIPMENT FOR NARROW STRIP TILLAGE AND DIRECT SEEDING IN THE GRASS COVER OF A GRASS MIXTURE

Eugen MARIN[1], Vasile MOCANU[2], Tudor-Adrian ENE[2], Dragoş MANEA[1], Laurențiu-Constantin VLĂDUȚOIU[1], Alexandru IONESCU[1], Gheorghe STROESCU[1]

[1]National Institute of Research-Development for Machines and Installations Designed for Agriculture and Food Industry - INMA Bucharest, Romania
[2]Institute of Research-Development for Grasslands - ICDP Braşov, Romania

Corresponding author email: marineu61@yahoo.com

Abstract

Considering the imperative of improving the quality of life in the long term and under the pressure of increasing consumer demands for plant and animal agricultural products, there are scientific concerns in Western Europe and developed countries on other continents regarding rational grassland utilization technology. This paper presents the results of experimental research conducted under operational conditions on grassland quality restoration technology in the context of climate change, through narrow strip tillage and direct seeding into the grass cover of a grass mixture or even a single species, while preserving the existing vegetation entirely or to a certain extent.

Key words: *tillage, direct seeding, meadows.*

INTRODUCTION

Grasslands play a crucial role in capturing and storing carbon, which is why nowadays approximately one-third of the global terrestrial carbon stocks are found in soils, with plant diversity playing an essential role in storing and maintaining this carbon (Bai & Cotrufo, 2022).
Degradation of grasslands generated by climate change, including rising temperatures and decreasing precipitation, contributes to increased CO_2 emissions (Puche et al., 2023).
It is estimated that approximately half of the global natural grasslands are degraded in various forms by overgrazing, climate change, deforestation, or conversion to agricultural land (Bardgett et al., 2021).
Overseeding of grasslands plays a crucial role in capturing and storing carbon. By introducing fast-growing and highly resilient grass and legume species, organic matter production is stimulated, deeper and denser root systems help sequester carbon in the soil for the long term, and a denser vegetation cover protects the soil from erosion while improving its structure.
Overseeding is a sustainable and effective strategy for combating climate change, maintaining soil health, and increasing agricultural productivity (Barszczewski & Horaczek, 2024; Cardarelli et al., 2020; Bondaruk et al., 2020).
Grasslands suitable for overseeding include degraded areas where yields have decreased by approximately 10-90%, depending on the intensity of soil erosion and the degree of degradation, intensively used lands through grazing or mowing, fertile soils with sparse vegetation, as well as areas invaded by weeds or unproductive species that reduce their forage value (Durant & Doublet, 2022).
Overseeding can be performed using various types of agricultural machinery, depending on the land area, soil type, and plant species used. For instance, the grassland regeneration machine developed at National Institute of Research-Development for Machines and Installations Designed for Agriculture and Food Industry-INMA Bucharest, who has the oldest and the most prestigious researching activity in the domain of agricultural machinery and mechanization technologies in Romania, performs multiple operations in a single pass, including narrow strip tillage, direct seeding of a grass mixture, or even a single species, into the existing grass cover while preserving it either entirely or partially, and light soil compaction

over the seeds to ensure proper contact for optimal germination (Manea et al., 2017).
The Institute of Research-Development for Grasslands Brașov - ICDP Brașov, which coordinates the project *"ADER 15.3.2 - Research on the development and promotion of mechanized technologies for the reconstruction and maintenance of permanent grasslands, environmental protection, and biodiversity conservation using new specific equipment"*, has conducted, in collaboration with INMA Bucharest, field experiments (during the autumn season) on an experimental model of a grassland overseeding machine for degraded grasslands. The purpose of these tests was to ensure that the equipment operates according to technical specifications (https://www.madr.ro/attachments/article/504/ADER-1532-Faza-1.pdf).

MATERIALS AND METHODS

At Institute of Research-Development for Grasslands - ICDP Brașov, a technology has been developed for improving degraded grasslands through the direct overseeding of seeds into the soil using an experimental model of overseeding machine for degraded grasslands, without affecting the existing vegetation cover. This approach contributes to increasing forage production and conserving biodiversity (Mocanu et al., 2025).
The experimental model of overseeding machine for degraded grasslands (Fig. 1) consists of the following main components: assembled frame, furrow-opening equipment, seeding equipment, motion transmission mechanism for the seeding equipment, and furrow-compacting wheels (Marușca, 2008).

Figure 1. Experimental model of overseeding machine for degraded grasslands

During the experiments to determine operational indices, a TL 100A New Holland tractor, available at ICDPP Brașov, was used, with the experimental model of overseeding machine for degraded grasslands coupled to it.
When the tractor-overseeding machine unit is in operation, the rimmed discs of the furrow-opening sections vertically and longitudinally fracture the old sod, the coulters create the furrow and place the forage plant seeds at the desired depth, as distributed by the machine's seeding equipment, while the compacting wheels ensure proper seed-to-soil contact along each seeded row (Mocanu & Hermenean, 2008).
Table 1 presents the main technical characteristics of the experimental model of overseeding machine for degraded grasslands (Marușca, 2008).

Table 1. The main technical characteristics of the equipment used in the experiment

Characteristic	UM	Value
Working width	m	2.55
Working depth	cm	0.5...4
Number of processed rows	pcs.	17
Minimum row spacing	cm	15
Terrain contour following range per processed row	cm	± 10
Volume of the perennial grass seed compartment	dm^3	55
Seeding rate adjustment for perennial grasses	-	Northon gearbox with 72 steps
Seeding rate adjustment for perennial legumes	-	adjustable grooved cylinder length
Mass	kg	1175

The tests were conducted on the experimental fields of ICDP Brașov in accordance with a specific testing procedure.
The average climatic data recorded at the experimental research location were as follows: in August 2024, the average daily temperature was 13°C, and the average precipitation was 74 mm; in September 2024, the average daily temperature was 9°C, and the average precipitation was 56 mm.
The determination of operational indices was carried out through field experimental research on a grassland plot characterized by low herbaceous vegetation cover, poor floristic composition, and a low percentage of clover, alfalfa, and ryegrass.
For the seeds used in the experiments, the following physical and mechanical characteristics were determined: purity degree, thousand-seed weight, hectoliter mass, and

moisture content. The measurements were performed using an electronic balance with an accuracy of ±0.1 grams, in three repetitions. The average values obtained are presented in Table 2.

Table 2. Physical and mechanical characteristics of the seeds used in the experiments

Seed name	Degree of purity %	Thousand-seed weight g	Hectoliter mass g/dm^3	Moisture content %
Trifolium repens	99.02	0.62	70.63	9.5
Lolium perenne	97.32	1.72	28.05	8.8

The additional equipment used to determine the soil characteristics of the experimental field included: a FIELDSCOUT SC 900 digital electronic penetrometer for measuring soil penetration resistance (Kumar, 2023) a portable Extech MO750 soil moisture meter for the direct measurement of soil water content, expressed as a percentage of soil volume (Hilal et al., 2022).
Table 3 presents the characteristics of the experimental field, where the tests were conducted using the experimental model of overseeding machine for degraded grasslands, coupled with the TL 100A New Holland tractor.

Table 3 Characteristics of the experimental field

No.	Characteristic	UM	Value
1	Soil type	-	podzolic
2	Degree of soil coverage with vegetation	%	82
3	Average plant height	cm	4.8
4	Plant mass	g/m2	46
5	Soil moisture at 0…10 cm depth	%	11.8
6	Soil penetration resistance at 10 cm depth	MPa	2750

The calculation of the slippage (δ) of TL 100A New Holland tractor's drive wheels which occurs due to the traction power transmission process, was performed using Equation (1). The slippage was determined by measuring the average working speed (v_l) over a specific distance (s) and counting the number of loaded (n_s) and unloaded (n_g) wheel rotations during the tests.

$$\delta = \frac{(n_s - n_g)}{n_s} \times 100, \% \text{ (Persu et al., 2020)} \quad (1)$$

The traction force was determined using the tensometric method, which involved the use of strain gauges, a data acquisition system, and a computer equipped with specialized software packages. The stored data were retrieved and processed using specialized software, after which the average values of the traction force were determined by eliminating transition regimes recorded during the experimental research (Persu et al., 2020).
The traction power (P_{tr}) was calculated based on the travel speed (v_l) and the traction force (F_{tr}) (Marin et al., 2012).
The determination of operational indices, including effective working time, time losses, actual working capacity, and fuel consumption per hectare, for the experimental model of overseeding machine for degraded grasslands coupled with the TL 100A New Holland tractor, allowed for the evaluation of its performance and efficiency in the agricultural process. This assessment aimed to ensure maximum economic benefits under the specific conditions of each farm (Hunt, 2008).
The fuel consumption per hectare was determined by directly measuring the volume of fuel consumed. This process involved: completely filling the fuel tank before the overseeding operation, performing the overseeding task on a determined area, and refilling the tank after the operation to measure the volume of fuel added (Voicu et al., 2020).

RESULTS AND DISCUSSIONS

The determination of soil penetration resistance provided an accurate assessment of soil compaction. The average value of 1374 kPa, measured in situ, indicated that it was close to the upper permissible limit - as values above 2000 kPa significantly hinder root penetration, compromising plant growth.
By analyzing soil moisture in the experimental area, the presence of water in the soil was confirmed, which is beneficial for seed germination and emergence processes, particularly for *Trifolium repens* and *Lolium perenne*.
The soil penetration resistance of 1394 kPa (approximately 1.39 MPa) combined with a volumetric moisture content of 17% in podzolic soil suggests relatively high compaction, which could hinder the root development of *Trifolium repens* and *Lolium perenne* seeds. This compaction, along with low moisture levels, may negatively impact germination, as seeds could struggle to penetrate the soil, leading to uneven emergence and reduced plant development.

To improve germination conditions, a lighter compaction roller was used on the overseeding machine during the overseeding process to prevent excessive soil compaction.
Table 4 presents the average values of soil penetration resistance and soil moisture obtained in the 0...10 cm layer.

Tabel 4 Average values of soil characteristics in the experimental field

No.	Characteristic	UM	Value
1	Average soil penetration resistance	kPa	1374
2	Average soil moisture	%	17

Table 5 presents the average values of energy indices (average working speed and wheel slip of the tractor in the unit) recorded for two speed levels of the tractor during uphill and downhill travel. Slip of the tractor's drive wheels uphill increased in second gear, because the tractor needed more torque at the wheels, as a result of the increase in speed and forward resistance and downhill it was reduced in both cases, due to the lower mechanical load on the transmission.
By using the second gear, a moderate increase in working speed is achieved, with a relatively small impact on slip of the tractor's drive wheels, especially downhill. Conversely uphill, increased of tractor's drive wheels slip may indicate a possible reduction in energy efficiency, caused by difficult terrain conditions.

Table 5 Average working speed and wheel slip of the tractor unit

Speed level	Average working speed uphill, (km/h)	Average working speed downhill, (km/h)	Slip of the tractor's drive wheels uphill (%)	Slip of the tractor's drive wheels downhill (%)
V_1	6.08	6.24	18.79	14.25
V_2	6.79	6.95	19.39	14.95

Table 6 presents the average values of traction force (F_{tr}) and traction power (P_{tr}) recorded for two speed levels of the tractor unit during uphill and downhill travel.

Table 6 Average values of traction force and traction power

	Average traction force	Average traction power	
	uphill	uphill	
	[daN]	[CP]	[kW]
V_1	379.29	8.54	6.28
V_2	423.74	10.66	7.84
	downhill	downhill	
V_1	334.84	7.74	5.69
V_2	389.23	10.02	7.37

An example of the data acquisition visualization panel used for determining the traction force is shown in Figure 2.

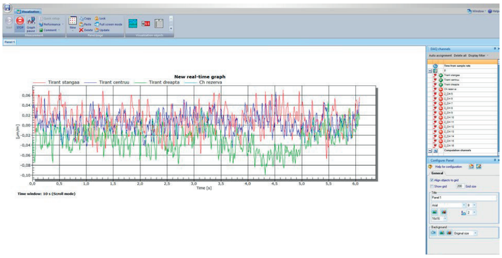

Figure 2. View of the data acquisition process for measuring traction resistance

In Figure 3, a graphical representation is shown of the variation of the determined indices at two speed levels for the experimental model of overseeding machine for degraded grasslands coupled with the TL 100A New Holland tractor on the ICDP Brașov experimental field during uphill travel.

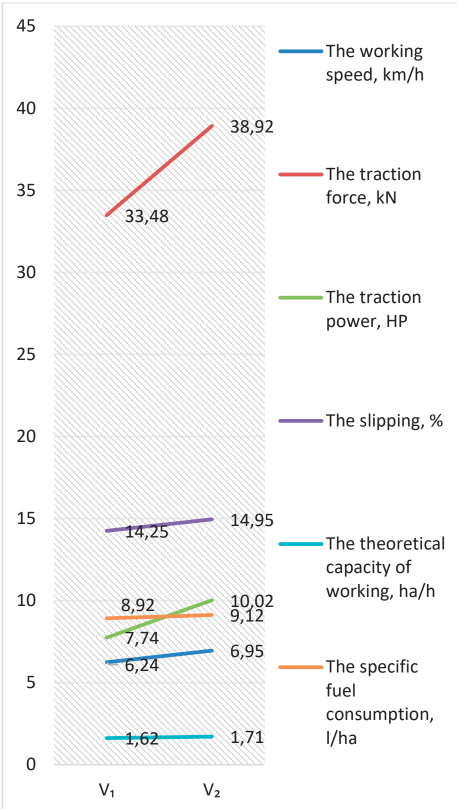

Figure 3. Graphical representation of the variation of the determined indices during uphill travel

In Figure 4, a graphical representation is shown of the variation of the determined indices at two speed levels for the experimental model of overseeding machine for degraded grasslands coupled with the TL 100A New Holland tractor on the ICDP Brașov experimental field during downhill travel.

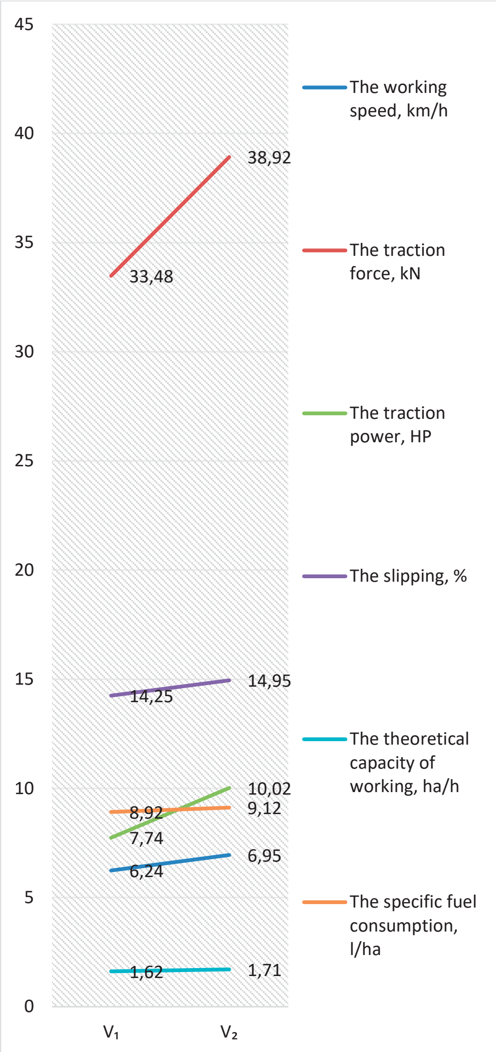

Figure 4. Graphical representation of the variation of the determined indices during downhill travel

Table 7 presents the results of the operational indices during the working process of the experimental model of overseeding machine for degraded grasslands, coupled with the TL 100A New Holland tractor, on the ICDP Brașov experimental field over an area of 1 hectare.

Table 7. Technological parameters during work coupled with TL 100A New Holland

Specification	**UM**	**Value**
Fertilization type	-	NPK
Average displacement speed	km/h	1.52
Surface	ha	1
Real working time, T_1	min	39.2
Working hourly capacity at real time, W_{ef}	ha/h	1.53
Capacity of working per hour at shift time W_{07}	ha/h	1.32
Coefficient of technological safety, K_{41}	-	0.99
Coefficient of technological safety, K_{42}	-	1.0
Coefficient of reliability, K_4	-	0.93
Coefficient of using the shift time, K_{07}	-	0.86
Fuel consumption per hectare	l/ha	9.10

During operational experiments conducted over an area of 1 hectare, the experimental model performed well throughout the testing period. Under these conditions, it achieved: an operational safety coefficient of 0.99, a performance-based hourly working capacity of 1.32 ha/h, and a fuel consumption rate of 9.10 l/ha.

Figure 5 presents two aspects from the operational experiments conducted on the experimental field owned by ICDP Brașov.

Figure 5. Aspects from the operational experiments conducted in field conditions

CONCLUSIONS

From an operational perspective, the overseeding machine for degraded grasslands successfully met the technological parameters, which are in compliance with the agrotechnical requirements for the overseeding work.

During the tests, the experimental model of overseeding machine for degraded grasslands, coupled with the TL 100A New Holland tractor, demonstrated good performance, achieving an average working capacity of 1.53 ha/h and an average fuel consumption of 9.10 l/ha.

The experimental research confirmed the functionality of the technical solutions implemented in the design of the experimental model, ensuring that a competitive piece of equipment can be offered to stakeholders. This equipment is designed to improve degraded permanent grasslands with low-inputs through surface measures.

ACKNOWLEDGEMENTS

The results presented in this article were obtained with the support of MADR through the "Sectoral Plan - ADER 2026", financing contract no. 15.3.2 / 17.07.2023, ADER project 15.3.2. Research on the development and promotion of mechanized technologies for the reconstruction and maintenance of permanent grasslands, environmental protection, and biodiversity conservation using new specific equipment, managed by the Research - Development Institute for Grasslands Brasov-Mechanization Laboratory.

REFERENCES

Bai, Y., & Cotrufo, M. F. (2022). Grassland soil carbon sequestration: Current understanding, challenges, and solutions. *Science*, *377*(6606), 603-608.

Bardgett, R. D., Bullock, J. M., Lavorel, S., Manning, P., Schaffner, U., Ostle, N., ... & Shi, H. (2021). Combatting global grassland degradation. *Nature Reviews Earth & Environment*, *2*(10), 720-735.

Barszczewski, J., & Horaczek, T. (2024). Assessment of the effectiveness of overseeding methods for hardwood meadows under various pluviothermal conditions. *Journal of Water and Land Development*, 91-101.

Bondaruk, V., Lezama, F., Del Pino, A., & Piñeiro, G. (2020). Overseeding legumes in natural grasslands: Impacts on root biomass and soil organic matter of commercial farms. *Science of the Total Environment*, *743*, 140771.

Durant, D., & Doublet, C. (2022). Effect of Oversowing and Fertilization on Species Composition, Yield and Nutritional Quality of Forages on a Permanent Wet Meadow. *J. Agric. Sci*, *14*, 23.

Hilal, Y. Y., Khessro, M. K., van Dam, J., & Mahdi, K. (2022). Automatic water control system and environment sensors in a greenhouse. *Water, 14(7*), 1166

Hunt, D. (2008). *Farm power and machinery management*. Waveland Press.

Kumar, V. (2023). Prediction of hardpan zones in the soil profile using field scout SC 900 cone penetrometer, *International Journal of Statistics and Applied Mathematics 2023; SP-8(4),* 478-483

Jiang, Q., Cao, M., Wang, Y., & Wang, J. (2020). Estimating soil penetration resistance of paddy soils in the plastic state using physical properties. *Agronomy, 10(12),* 1914.

Manea, D., Voicu, G., Paraschiv, G., & Cardei, P. (2017). Technological Alternatives with Low Consumptions to Regenerate the Degraded Grasslands. *Journal of Agricultural Science and Technology*, *19*(5), 1057-1066.

Marin E., Sorica C., Manea D., (2012), The establishing of corn with the equipment for soil tillage and sowing in narrow strips, *40. Symposium "Actual Tasks on Agricultural Engineering", Opatija, Croatia*, 231-241 ref. 9

Marușca T., (2008). Ecological reconstruction of degraded grasslands, *Transilvania University Press of Brașov, 108 pages*, ISBN 978-973-598-310-9

Mateescu, M., Marin, E., Păun, A., Manea, D., Gheorghe, G., & Neacșu, F. (2015). Innovative technology for works mechanization of modeling and direct seeding in field for onion crop, *International Symposium of ISB-INMA TEH. Agricultural and Mechanical Engineering, Bucharest, Romania, 29-31 October 2015*, 169-176 ref. 15

Mocanu, V., Ene, T., Marin, E., Gheorghiță, N.-E. (2025). Mechanization of grassland farming by technological variants with minimal inputs. *A review. INMATEH Agricultural Engineering, Vol 74(3),* 954-970.

Mocanu, V., & Hermenean, I. (2008). *Technologies for low-input mechanization of grassland maintenance and improvement*. *Transilvania University Press, 100 pages*, ISBD: II 78880.

Persu, C., Gheorghe, G., Găgeanu, I., Cujbescu, D., Fogoraș, A., & Lateș, D. (2020). Influence on quality and energy indices for a reversible plow equipped with electric vibrators. *" Annals of the University of Craiova-Agriculture Montanology Cadastre Series"*, *50*(2), 453-457.

Puche, N. J., Kirschbaum, M. U. F., Viovy, N., & Chabbi, A. (2023). Potential impacts of climate change on the productivity and soil carbon stocks of managed grasslands. *Plos one*, *18*(4), e0283370.

Voicu, G., Constantin, G. A., Matache, M. G., Tudor, P., & Poenaru, I. C. (2020). Research on tensile strength and specific fuel consumption for a Miscanthus rhizome planter in different equipping conditions at the four row. *Scientific Papers. Series A. Agronomy*, *63*(1).

***https://www.madr.ro/attachments/article/504/ADER-1532-Faza-1.pdf