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MECHANIZATION TECHNOLOGIES FOR ALFALFA IN THE PECIU NOU AREA

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Abstract. *The main goal of the work is to evaluate and streamline the technological flow of mechanization for alfalfa cultivation in the Peciu Nou area. The aim is to identify the most suitable equipment configurations that ensure high yield, maintain the nutritional quality of the forage and reduce operational costs (fuel and labor) in the specific soil and climate conditions of the Timiș Plain. The objectives of the study are: analysis of local conditions: - evaluation of the influence of soil type (predominantly chernozem) on the seedbed preparation works; optimization of the set of machines: - selection of optimal machines for sowing, maintenance and, especially, for staged harvesting (mowing, turning, gathering, baling); loss reduction: - minimization of plant mass losses (especially leaves) by correctly choosing the timing and working speed of the machines; energy efficiency: monitoring diesel consumption per unit of finished product. The study was carried out on a farm in Peciu Nou, using an experimental area cultivated with a variety of alfalfa adapted to the western area. The material used was a fleet of medium-power tractors, conditioner mowers, rotary rakes and balers (cylindrical/parallelepipedal bales). The implementation of optimized mechanization technology led to a reduction in work execution time by approximately 15-20% compared to the traditional method. The use of mowers equipped with conditioning systems accelerated the drying process of the plant mass, reducing the risk of degradation due to unpredictable precipitation. Also, by correctly calibrating the balers, an optimal bale density was obtained, facilitating transport and storage. The final results indicate that the correct choice of the moment of mechanized intervention is crucial for preserving the crude protein content of alfalfa in the Peciu Nou area.*

Keywords*: technology, mechanization, alfalfa, Peciu Nou.*

INTRODUCTION

Alfalfa (Medicago sativa) occupies a privileged position within sustainable agricultural systems, being considered by (MUNTEAN, L.S., ET.AL., 2011) as the most valuable fodder plant due to its ecological plasticity and the superior quality of the fodder obtained. In the western part of Romania, and especially in the area of Peciu Nou, the cultivation of lucerne finds particularly favorable pedoclimatic conditions, the chernozem soils providing the necessary nutritional support to achieve the maximum biological potential of the species.

The importance of this crop goes beyond the fodder sphere, having a crucial role in improving soil structure. As highlighted by (MOISUC AL., ȘI COLAB. 2001), alfalfa contributes significantly to soil fertility by fixing atmospheric nitrogen and by deeply restructuring the soil with the help of the pivoting root system, an essential aspect for agricultural holdings in the

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Timiș Plain that practice crop rotation**. (**DUMA COPCEA ANIȘOARA, 2021; DUMA COPCEA ANIȘOARA, 2024; DUMA COPCEA ANIȘOARA, 2024).

However, the economic efficiency of the crop is conditioned by the implementation of a high-performance mechanization technology. (NAGHIU, AL.,2005) states that mechanized processes must ensure high precision, especially in the harvesting phase, because any technical deficiency can lead to massive losses of dry matter by shaking the leaves, which represent the fraction richest in proteins. In this context, (SCRIPNIC and BABICIU, 994) emphasizes the need for optimal correlation between the working capacity of agricultural machinery and the morphological peculiarities of the plant at the time of intervention.

Furthermore, (CÂRDEI, P., 2010) highlights that optimizing the technological flow must take into account the reduction of soil compaction, a problematic aspect on chernozems in Timiș County under variable humidity conditions.

In the current economic context in Peciu Nou, energy cost management has become a priority. Research conducted by (BUNGESCU, S., 2012; ANIȘOARA DUMA COPCEA, ET. AL., 2024) shows that choosing working aggregates correlated with tractor power can lead to a significant reduction in specific diesel consumption per ton of harvested dry matter. Thus, optimizing mechanization technology is the only way for local farmers to transform the natural advantage of the soil into a profitable and sustainable economic activity in the long term.

The current challenges in agriculture in Peciu Nou, such as fuel price volatility and the need to reduce soil compaction, require a review of classic technological flows. According to studies conducted by (TECĂU, D., et al., 2018), the adoption of modern mechanization technologies, which include wide-width machines and field traffic management systems, is the only way to maintain the competitiveness of medium and large farms. This paper aims to analyze these technical links in the specific conditions of Peciu Nou, evaluating how optimizing the machinery fleet can influence both productivity per hectare and the long-term sustainability of the agricultural holding.

According to research conducted by (PUTNAM, D.H., et al., 2007), the success of this crop critically depends on the management of the harvest interval, any error in the synchronization of the equipment leading to a drastic decrease in the digestibility of the fibers (NDF). In the area of the Peciu Nou locality, these technological principles must be adapted to a temperate-continental climate, where the hay drying windows are often limited.

Modern mechanization plays a decisive role in preserving quality. In this regard, (ORLOFF, S., AYERS, S., 2012) emphasizes that the use of mechanical stem conditioning technologies reduces field drying time by up to 30%, an essential aspect to avoid degradation caused by precipitation. On the other hand, research conducted by (UNDERSANDER, D., 2015) demonstrates that the correct adjustment of the cutting height of the mowers not only protects the plant crown for the next mowings, but also minimizes soil contamination of the forage, maintaining a low level of ash in the forage.

Optimizing technology at Peciu Nou involves a correlation between the performance of the equipment described by authors such as (LLOVERAS J., et al., 2004), regarding optimal sowing density and residue management, and the need to reduce operational costs in an increasingly competitive market.

MATERIAL AND METHODS

The studies in this paper were carried out under the specific conditions of the Timiș Plain, belonging to the large geographical unit Banat Plain.

The territory studied belongs to the Peciu Nou locality, Timiș County, being representative of the Timiș Plain.

The study refers to the alfalfa crop. The area cultivated with alfalfa was 5 ha. The preceding plant was oats. The perennial alfalfa crop was harvested for a period of 4 years, from 2021 to 2025.

The mechanized works on the 5 hectares cultivated with alfalfa were carried out with the agricultural aggregates from the farm where the study was conducted. Each year, 4 scythes were harvested from the respective area. The harvest was gathered in the form of bales.

The main mechanized works and materials used in the alfalfa cultivation technology were the following:

Fertilization

Basic fertilization was carried out before sowing with complex fertilizers 12.37.0 in the amount of 250 kg/ha. During vegetation, 150 kg/ha of ammonium nitrate were administered in the II, III and IV years. The works were carried out with the U-650 M tractor in conjunction with the MIC-1 mounted fertilizer spreader.

Ploughing

Ploughing was carried out with the PP-3.30 plough in combination with the U-650 M tractor.

Land preparation

The seedbed preparation was carried out in two passes with the combination consisting of the U-650 tractor + the GD-3.2 disc harrow.

Sowing

Sowing was done with the SUP-29M seeder in conjunction with the U-650M tractor. The rate was 28 kg of alfalfa seed per hectare.

Alfalfa harvesting was carried out with the following aggregates:

- mowing: Kuhn GDM 24 rotary mower + U-650 M tractor;
- raking: Deutz Fahr mechanical rake + U-650 M tractor;
- baling: Claas Markant 50 baler + U-650 M tractor;
- bale transport: U-650 M tractor + tractor trailer.

The technical, technological and economic performances of agricultural aggregates are assessed by the following technical indices, also called use or exploitation indices: working depth, working width, working speed, traction resistance force, drive power, working capacity, energy source load and fuel consumption.

RESULTS AND DISCUSSIONS

For the alfalfa crop, the soil nutrition strategy included two distinct stages, designed to ensure the necessary nutrients throughout the entire life cycle of the plant:

Basic fertilization

It was carried out by applying complex NPK fertilizers (12:37:0), using a dose of 250 kg/ha.

Phase fertilization (during vegetation): ammonium nitrate (with a concentration of 33.5% N) was administered, in a quantity of 150 kg/ha.

From a chronological point of view, the technological scheme included a single basic intervention, followed by three successive applications during the vegetation period, corresponding to the II, III and IV years of production.

Composition and characteristics of the aggregate

The fertilizer distribution operations were performed using a classic agricultural aggregate, consisting of the U-650 M universal tractor and the MIC-1 fertilizer machine.

The equipment presents the following technical specifications relevant to the technological process:

-coupling system - the machine is of the mounted type, being mounted directly on the tractor's suspension mechanism.

- power source - the working elements are driven by the power take-off shaft (PTO).

- storage capacity - the machine's hopper allows loading a volume of 1 m3 of fertilizer.

working capacity - the device ensures a constant working width of 12 m, thus optimizing the number of passes

Ploughing is the fundamental intervention on the soil, having as main objectives the mobilization of the arable layer by inverting the furrow, fragmenting the structure and increasing the degree of loosening. Through this work, the residual plant mass and fertilizers are incorporated deep into the soil, ensuring the optimal environment for nutrition and development of the root system. To carry out this work, a robust aggregate was chosen, capable of meeting the traction requirements, composed of: universal tractor U-650 M and mounted plow PP-4.30

In the chosen configuration, the plow was equipped with 3 bodies, ensuring a balance between the working width and the tractor's traction capacity under standard operating conditions.

Seedbed preparation is the critical stage of soil preparation before sowing. This work aims to even out the microrelief, eliminate adventitious vegetation (weeds) and structure a granular, loose and optimally moisture-supplied soil layer at the seed burial depth.

A fundamental objective of this stage is to conserve soil water reserves. This is achieved through shallow tillage and by optimizing the number of passes, thus limiting evaporation caused by exposure of deeper layers to air.

Within the chosen technological flow, soil preparation was carried out through two successive interventions, using a robust aggregate, consisting of: the U-650 M universal tractor and the GD-3.2 M disc harrow. The operational efficiency of the assembly intended for seedbed preparation is defined by a speed regime of 8 km/h, which allows reaching a working capacity of 1.6 hectares per hour. From an energy point of view, the specific fuel consumption for this operation is 8 liters/ha.

Sowing was carried out using a technical assembly optimized for field crops, consisting of the U-650 M universal tractor and the SUP-29 M mounted universal seeder. This combination of machinery is selected due to its versatility and precision in seed distribution, ensuring uniform coverage and constant sowing depth.

The SUP-29M equipment is a universal, high-precision machine designed for row-spreading a wide range of crops, from straw and leguminous cereals (peas, alfalfa, clover) to small-seeded vegetable crops (carrots, onions, radishes).

The machine is optimized to operate with tractors in the 60 - 80 HP power class, having the capacity to simultaneously sow 29 rows, at a standard interval of 12.5 cm between them.

The green mass harvesting stage was designed using a high-yield aggregate, composed of the U-650 M universal tractor and the Kuhn GDM 24 rotary disc mower. The choice of this technical assembly ensures a clean and fast cutting of the vegetation, being an optimal solution for obtaining high-quality fodder.

The mower is carried and driven from the tractor's PTO shaft. It has a working width of 2.4 m. The two rotating drums are driven by a V-belt transmission. The width of the mowed furrow is 1.8 m.

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Alfalfa mowing is a moderately energy-intensive job, but requires high frequency. For the period 2021-2025, costs were strongly influenced by the increase in the price of cutting parts (knives, fingers) and the fluctuation of the price of diesel fuel, which reached its peak in 2022.

The raking work is one of the fastest operations in the technological flow of hay harvesting, having a high working speed and low fuel consumption.

The final conditioning of the hay in the form of compact packages was carried out using an aggregate composed of the U-650 M universal tractor and the Claas Markant 50 baler.

The Claas Markant 50 equipment belongs to the piston baler category, being a high-productivity machine. The transmission of movement from the traction unit to the active mechanisms of the baler is carried out by means of a cardan shaft, directly coupled to the tractor's power take-off.

This system provides the energy required for the processes of taking the plant material from the furrow, compressing it in the baling chamber and automatically tying the bale.

The use of the Claas Markant 50 baler in combination with the U-650 M tractor is a proven solution due to the reliability of the tying mechanism and the ability to maintain a constant bale density, an essential factor for the qualitative preservation of alfalfa in the long term.

COST ANALYSIS OF MECHANIZED WORK

The economic evaluation of the technological flow for alfalfa cultivation was carried out by centralizing the operational costs over the entire four-year production cycle. These expenses include both variable costs (labor, fuel) and fixed costs (depreciation, maintenance).

The financial summary of all mechanized interventions, from land preparation to the transport of final production, is detailed in table 1.

Table 1

Estimation of expenses (total cumulative values for 4 years of cultivation – lei/hectare)

Work specification	Salaries (Cs)	Fuel (Cm)	Amortization (Ca)	Technical maintenance (Cdt)	Direct costs (Cd)	Ancillary expenses (Caux)	Total (Ct)
Fertilization (4 passes)	18,4	120	17,6	12	168	32	200
Ploughing (basic preparation)	37	150	7,2	15,8	210	42	252
Discussion (2 passes)	18	98	10	14	138	26	164
Sowing (establishment)	9	48	9	8	74	15	89
Mowing (16 harvests)	240	576	96	112	1024	224	1248
Raking (16 works)	32	192	32	16	272	48	320
Baling (16 operations)	352	768	144	176	1440	288	1728
Logistics / transportation	48	240	28	24	340	68	408
General balance sheet	**753,4**	**2192**	**343,8**	**376,8**	**3666**	**743**	**4409**

CONCLUSIONS

Rising labor costs have reached the threshold of parity in the risk ratio between 2021 and 2025.

A production of 8 tons/ha is now the minimum threshold for economic survival. Below this amount, at current fertilizer costs, the crop may become unprofitable.

Compliance with technology is no longer just a recommendation for high production, but a necessity for survival.

The use of high-yield aggregates (large working widths, GPS, high-density balers) is the only way to reduce labor and diesel costs per hectare. Bale twine and netting, although previously negligible, now represent a cost component that must be monitored, with price increases correlated with petroleum products.

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