J. Agr. Sci. Tech. (2017) Vol. 19: 1057-1066

Technological Alternatives with Low Consumptions to Regenerate the Degraded Grasslands

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ABSTRACT

This paper had as main objective the comparison of new technological solutions for degraded grassland using a grasslands regeneration machine and a trailed vindrover, with the conventional technologies. The grasslands regeneration machine performs several operations in one pass, as follows: soil tillage in narrow strips, direct seeding of an herb seed mixture into the vegetal cover and light compaction of the soil over the seeds for a proper contact, in order to obtain a good germination. The trailed vindrover is designed to the harvest and conditioning forage technology, running in a single pass operation of mowing, crushing and left on the ground to dry naturally. Experimental researches were carried out in two locations, namely National Institute of Research-Development for Machines and Installations designed for Agriculture and Food Industry- INMA Bucharest and Grasslands Research-Development Station- SCDP Vaslui, in the agricultural year 2014. For each technological link the following parameters were determined: fuel consumption per hour, fuel consumption per surface unit, hourly working capacity and labor consumption. Analyzing the comparative diagrams, it was observed that total average values of parameters obtained in the two locations in spring and late summer by applying the new technological variants were smaller than the ones obtained by applying conventional technologies. The new technological solutions for regeneration of degraded grasslands involve less fuel and labor consumption, being more environmentally friendly than conventional technologies used so far.

Keywords: Fuel consumption per surface unit, Grasslands regeneration machine, Labor consumption, Technological solutions.

[DOR: 20.1001.1.16807073.2017.19.5.9.2]

INTRODUCTION

Grasslands are ecosystems that respond fastest to the variability of rainfall, increasing aridity and persistent droughts that are expected to take place in the coming years especially for the most part of Africa, Southern Europe and the Middle East, America, Australia and Southeast Asia. A number of these regions have a large proportion of land covered by grassland (Smith *et al.*, 2013). Since 2008, when extreme weather conditions are manifested by floods and drought, fragile food systems, sensitivity to the vagaries of trade and price fluctuations have been to the fore, the role of agriculture, including research and development efforts forms the basis of back on the agenda at global, regional and national levels as an essential component of food security (Gathara *et al.*, 2006).

Because for a long period of time even the most basic grasslands maintenance measures were not applied, considering that you can get efficient production without technological inputs, now modern EU policies are formulated to solve the problem of biodiversity decline and destruction of

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grassland landscapes and sensitive habitats in Europe (Dragomir *et al.*, 2010).

Worldwide surveys were conducted to maintain phytocoenotic biodiversity of permanent grasslands, which have become increasingly degraded due to desertification, poor management of grazing, industrial development, pests and intensification of human activities in areas of pasture (Herrero *et al.*, 2013). Chaichi and Tow (2000b) showed that grazing pressure could significantly affect grassland availability as well as pod and seed yield. The restoration of degraded sites, where unvegetated gaps have been formed by longterm intensive grazing, is a concern for rangeland managers in these areas (Erfanzadeh *et al.*, 2014).

In terms of herbage and seed production, deferment of grazing could be beneficial only if the intensity of grazing does not severely damage the plant structure and photosynthetic area of the pasture during the vegetative and reproductive stages of growth (Chaichi and Tow, 2000a).

The research was conducted in time to understand the behaviour of grass growth by collecting daily data on minimum temperature, average and maximum rainfall, wind speed, humidity, radiation and pressure which were used to calculate an index of monthly moisture, evapotranspiration (Government EO No. 34, 2013), the amount of rainfall and number of days without rain (Field *et al.*, 2012). Maintaining the balance of grasslands grassy carpet is an art which aims at knowledge of plants, nutrient and moisture requirements thereof and applying differentiated technologies, adapted to the climatic and vegetation peculiarities based on scientific management, rational and balanced, respecting the environment and biodiversity using appropriate technical equipment (Harris, 2010).

Irrational management of grasslands has led, over time, the degradation through low density or disappearance of valuable species, invasion of non value grass and wood vegetation with mole-hills and erosion. To remove the effects of degradation and restoration of grasslands modern technology is needed to improve and utilise the grasslands (Mocanu and Hermenean, 2009 b).

The direct drilling (over-sowing) of the degraded grasslands can be applied where total tillage reseeding cannot be used and includes lower costs and energy consumption, lower seed rates and reduced loss of the exploitation period (Mocanu and Hermenean, 2009a).

In terms of area occupied by natural grasslands, Romania is ranked 5th in Europe after France, Britain, Spain and Germany (Samuil *et al.*, 2008). In the year 2014, a grasslands regeneration machine and a trailed vindrover were developed at National Institute of Research -Development for Machines and Installations designed for Agriculture and Food Industry- INMA Bucharest. These technical equipments were designed to the new technological variants, with low fuel and labor consumption and large productivity.

This paper had as main objective the comparison of new technological solutions for degraded grassland using the new equipments, with conventional technologies.

MATERIALS AND METHODS

Experimental researches were carried out in two different locations, namely: National Institute of Research - Development for Machines and Installations designed to Agriculture and Food Industry- INMA Bucharest and Grasslands Research-Development Station- SCDP Vaslui, in the agricultural year 2014. The geographical coordinates of the location of experimental plots were determined using GPS and are shown in Figure 1, using raster maps from the Google Earth archive. Bucharest is located in southeastern Romania, Vlăsiei Plain, which is part of the Romanian Plain. Climatic conditions in the area are characterized by an average temperature of 10.6°C and 595 mm total annual precipitation. Vaslui is located in North East, in the central Barlad Plateau. The

(a) (b)

Figure 1. Location of the experimental plots: (a) INMA Bucharest field (44° 29' 58.9" N, 26° 04' 14.3" E), (b): SCDP Vaslui field (46° 38′ 18″ N , 27° 43′ 45″ E).

climate is temperate-continental, with steppe regions. The average annual temperature is 9.4°C. Large amounts of rain fall during the warm season, with the peak in May and June, the annual average being 80.79 mm.

Improvement through overseeding of the degraded grasslands were done both in spring and in late summer, by creating two new technological variants and comparing them with two conventional technologies.

Both experimental fields consisted of permanent grasslands, with non-valuable species and low density of vegetation cover. The characteristics of the fields on which the experimental tests were carried out are shown in Table 1.

Experimental fields in the two locations were divided each into four equal plots (Figure 1). In every location, in spring a control plot P_1 was established by using conventional technology and a plot with the technological variant V_1.

On the control plot P_1, the conventional technology consisted of the following works: harrowing, seeding and rollers. The technical equipments used in the conventional technology were: the light disk harrow (GDU 3.4), the universal drill (SUP 29) and the smooth roller (TN 1.4).

The technological variant V_1 consisted of the following works: old vegetation and molehills cleaning and direct overseeding. The technical equipments used in the variant V_1 were: the machine for chopping vegetal residues and molehills clearing (MCP 2) and the grasslands regeneration machine (MSP).

In every location, in late summer a control plot P_2 was established with conventional technology and a plot by using the variant V_2. On the control plot P_2 the conventional technology consisted of: mowing old vegetation, disarrangement, furrow gathering and transportation all together and overseeding. The technical equipments used in the conventional technology were: the mower with rotating elements (CER 45), the rake (GRS 24), the forage harvester for selfloading wagon (RAF 4) and the grasslands regeneration machine (MSP).

The technological variant V_1 consisted of the following works: mowing, crushed and left in the furrow on the ground, furrow gathering and transportation all together and overseeding. The technical equipments used

Table 1. The characteristics of experimental fields.

Characteristic	INMA Bucharest	SCDP Vaslui
Soil type	Reddish brown	Cambic cernoziom
Field slope (Degree)	0	0÷2
The maximum height of the natural slopes or molehills (cm)	8	12
Degree of soil coverage with plants (%)	70	63
Average soil moisture in the layer 0-10 cm (%)	22 (In March) 17 (In September)	25 (In March) 18 (In September)

[DOR: 20.1001.1.16807073.2017.19.5.9.2]

in the variant V_2 were: The trailed vindrover (VF), the selfloading wagon for forage harvester (RAF 4) and the grasslands regeneration machine (MSP).

For each technological link the following parameters were determined: Fuel consumption per hour (c), fuel Consumption per surface unit (C), hourly Working capacity (W_c) and labor Consumption (C_l) (Dobre, 2014).

The grasslands regeneration machine performs several operations in one pass, as follows: soil tillage in narrow strips, direct seeding of an herb seed mixture into the vegetal cover and light compaction of the soil over the seeds for a proper contact, in order to obtain a good germination. These technical features involve less fuel and labor consumption, being more environmentally friendly than conventional technologies, promoting a new technological solution.

The grasslands regeneration machine during tests on the experimental plots is shown in Figure 2 and brief technical specifications are given in Table 2.

The trailed vindrover is designed to the harvest and conditioning forage technology, running in a single pass operation of mowing, crushing and left on the ground to dry naturally. The trailed vindrover during tests on the experimental plots is shown in Figure 3 and brief technical specifications are given in Table 3.

RESULTS AND DISCUSSION

The average values of fuel consumption per hour, fuel consumption per surface unit, hourly working capacity and labor consumption, for the conventional technology applied on the control plot P_1 and the new variant V_1, in the two locations, are presented in Table 4.


(a)


(b)

Figure 2. The grasslands regeneration machine on experimental plots: (a*)* INMA Bucharest field, (b) SCDP Vaslui field.

Table 2. Brief specifications of the grasslands regeneration machine.

Parameter	Specification
Type	Tractor-operated mounted type
Power required (kW)	Min 33
Working width (m)	1.76
Number of strips and sown rows	8
Distance between strips (m)	0.22
Number of "*L*" shape blades	48
Diameter of blades rotor (m)	0.32
Diameter of wheels for soil compaction (m)	0.2

[DOR: 20.1001.1.16807073.2017.19.5.9.2]

(a)

(b)

Figure 3. The trailed vindrover on experimental plots: *(a)* INMA Bucharest field, (b) SCDP Vaslui field.

Table 3. Brief specifications of the trailed vindrover.

Parameter	Specification
Power required (kW)	33÷48
Working width (m)	2.7
Cutting unit type	Fingers and knives
PTO speed (rpm)	540

Table 4. Average values of parameters for every technological link, in spring.

Plot	Tractor	Equip	INMA Bucharest				SCDP Vaslui			
			c ($l\ h^{-1}$)	C ($l\ ha^{-1}$)	W_c ($ha\ h^{-1}$)	$\mathbf{C_l}$ (man hours ha^{-1})	c ($l\ h^{-1}$)	C ($l\ ha^{-1}$)	W_c ($ha\ h^{-1}$)	$\mathbf{C_l}$ (man hours ha^{-1})
P_1	U650M	GDU 3.4	12.81	6.1	2.10	0.47	11.20	6.4	1.75	0.57
	U650M	SUP 29	14.75	5.9	2.50	0.40	11.90	6.3	1.90	0.52
	U650M	TN 1.4	12.10	5.5	2.20	0.45	11.02	6.3	1.75	0.57
V_1	U650M	MCP 2	6.17	6.50	0.95	1.05	3.90	6.0	0.65	1.54
	TCE 50	MSP	9.78	7.41	1.32	0.75	9.35	12.8	0.73	1.37

The average values of fuel consumption per hour, fuel consumption per surface unit, hourly working capacity and labor consumption, for the conventional technology applied on the control plot P_2 and the new variant V_2, in the two locations are presented in Table 5.

In order to compare the results obtained by applying the new variants of mechanization (V_1 and V_2) to those obtained by applying conventional technologies (P_1 and P_2) in the two location and periods, diagrams were drawn and are shown in Figures 4 and 5.

By analyzing the comparative diagrams in Figure 4, it was observed that the total average values of parameters obtained in the location INMA Bucharest, by applying the new mechanization variants were smaller than the ones obtained by applying conventional technologies (e.g, in spring c: 15.95< 39.66 l h^{-1}, C: 13.91< 17.50 l ha^{-1}, W_c: 2.27< 6.8 ha h^{-1}). The results are in line with those obtained by Hermenean *et al.* (2003) and Mocanu *et al.* (2008, 2009), using similar technical equipments.

By analyzing the comparative diagrams in Figure 5, it was observed that total average values of parameters obtained in the location SCDP Vaslui, by applying the new mechanization variants were smaller than the ones obtained by applying conventional technologies (e.g, in late summer c: 28.70< 33.25 l h^{-1}, C: 24.2< 26.1 l ha^{-1}, W_c: 4.25< 5.96 ha h^{-1}, $\mathbf{C_l}$: 2.75> 3.24 man hours ha^{-1}). Similar results were reported by Tisliar (1993), Hermenean *et al.* (2003) and Huguenin-Elie *et al.* (2006).

Table 5. Average values of parameters for every technological link, in late summer.

Plot	Tractor	Equip	INMA Bucharest c (l h^{-1})	INMA Bucharest C (l ha^{-1})	INMA Bucharest W_c (ha h^{-1})	INMA Bucharest $\mathbf{C_l}$ (man hours ha^{-1})	SCDP Vaslui c (l h^{-1})	SCDP Vaslui C (l ha^{-1})	SCDP Vaslui W_c (ha h^{-1})	SCDP Vaslui $\mathbf{C_l}$ (man hours ha^{-1})
P_2	U445	CER 45	7.87	4.5	1.75	0.57	6.50	5.00	1.30	0.77
	U445	GRS 24	5.23	2.8	1.87	0.53	4.50	3.10	1.45	0.69
	U650M	RAF 4	16.27	4.42	3.68	0.27	12.90	5.20	2.48	0.41
	TCE 50	MSP	9.78	7.41	1.32	0.75	9.35	12.80	0.73	1.37
V_2	U650M	VF	9.13	5.4	1.69	0.59	6.45	6.20	1.04	0.97
	U650M	RAF 4	16.27	4.42	3.68	0.27	12.90	5.20	2.48	0.41
	TCE 50	MSP	9.78	7.41	1.32	0.75	9.35	12.80	0.73	1.37

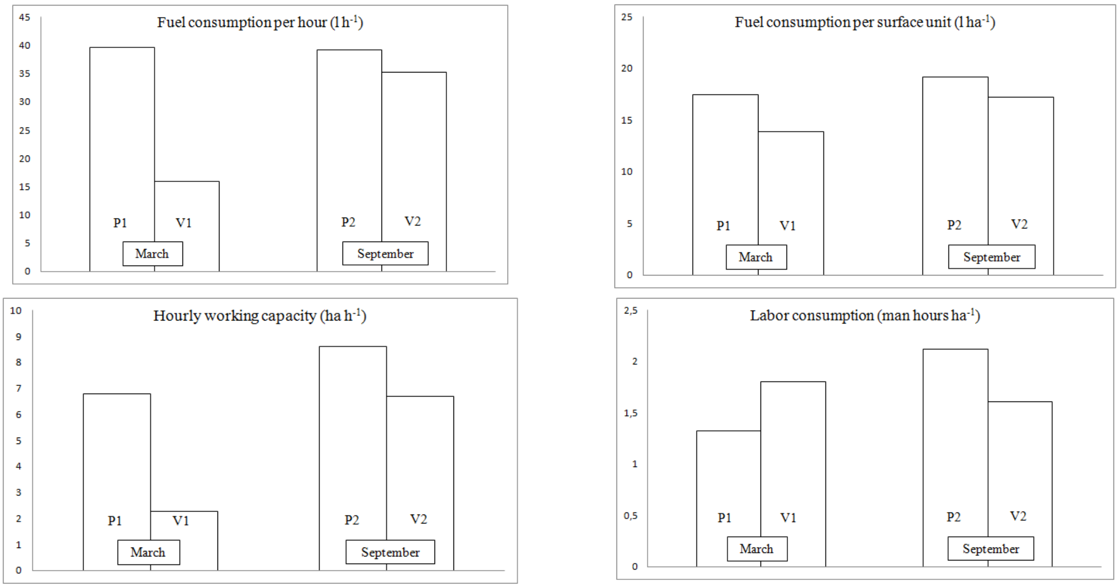

Figure 4. Comparative diagrams of total average values of the parameters obtained in the location INMA Bucharest, in spring and late summer.

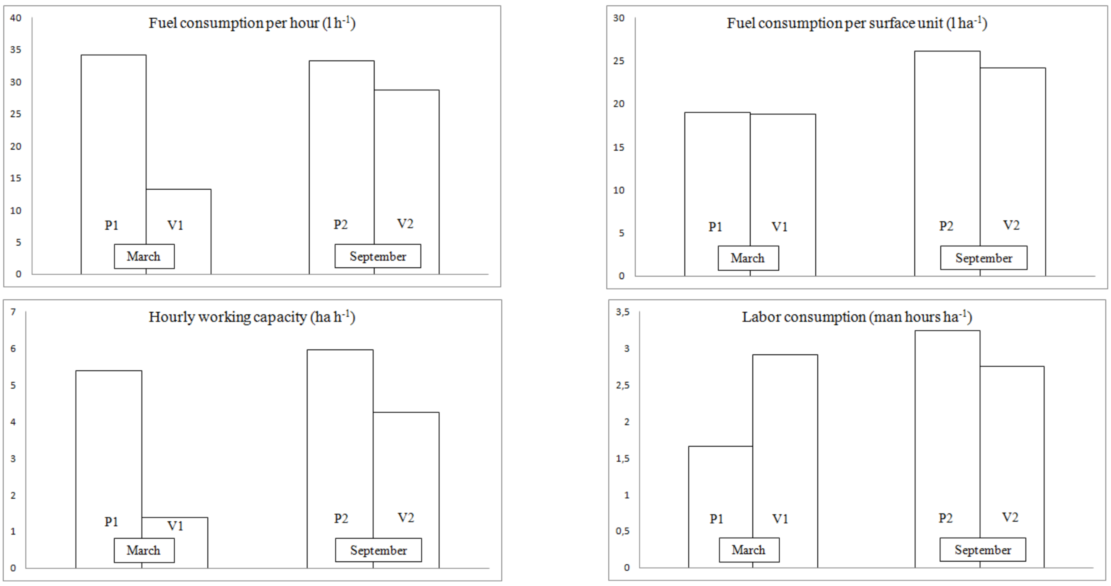

Figure 5. Comparative diagrams of total average values of the parameters obtained in the location SCDP Vaslui, in spring and late summer.

An exception to this rule was represented by the total average value of labor consumption in spring for the new mechanization variants, in both locations, which is bigger than the traditional one (**C**$_l$: 1.8> 1.32 man hours ha^{-1} at INMA Bucharest, **C**$_l$: 2.91> 1.66 man hours ha^{-1} at SCDP Vaslui). This could be explained by the low productivity of the machine for chopping vegetal residues and molehills clearing MCP 2 (e.g 0.65 ha h^{-1}). For decreasing the labor consumption in spring, a machine with a bigger hourly working capacity could be used. A Previous study by Mocanu *et al.* (2009) showed that utilization of new technologies for mechanization of works to improve the degraded grassland provides the decreasing of labor consumption with 2.27-6.98 man hours ha^{-1}.

The total fuel consumption per surface unit for conventional technologies varies between 17.50-26.10 l ha^{-1}. The total fuel consumption per surface unit for the new mechanization variants varies between 13.91-24.20 l ha^{-1}. The total labor consumption for conventional technologies varies between 1.32-3.24 man hours ha^{-1}. The total labor consumption for the new mechanization variants varies between 1.61-2.91 man hours ha^{-1}.

Statistical Analysis

The rational approximation function *f(m,s)*, which has the general form (1), was defined for the studied parameters, both in the case of conventional technologies and for the new technological variants proposed.

$$f(m,s) = a + b \cdot m + c \cdot s + d \cdot m \cdot s \qquad (1)$$

Where, *a, b, c, d* represent the function coefficients; *m* is the soil moisture; *s* is the field slope.

The values for soil moisture *m* and field slope *s* in the two locations (INMA Bucharest and SCDP Vaslui) and periods (March and September) were presented in Table 1 above.

In order to determine the coefficients *a, b, c* and *d* the method of least squares was used (Bretscher, 1995; Björck, 1996; Rao *et al.*, 1999). The algorithm for calculating the coefficients was developed in Mathcad software.

The function to be minimized, according to the method of least squares, has the following form:

$$F(a,b,c,d) = \sum_{i=1}^{n} \left(a + b \cdot m_i + c \cdot s_i + d \cdot m_i \cdot s_i - p_i\right)^2 \qquad (2)$$

Where *p* is the vector of model parameters (fuel consumption per surface unit or labor consumption), both for the conventional technologies and for the new technological variants. In this case, *n*= 4.

The calculation of the coefficients *a, b, c* and *d* for each of the studied parameters was done by solving the linear system of Equations (3), by canceling the first order partial derivatives:

$$\frac{\partial F}{\partial a} = 0; \frac{\partial F}{\partial b} = 0; \frac{\partial F}{\partial c} = 0; \frac{\partial F}{\partial d} = 0 \qquad (3)$$

Having the coefficient values calculated, the rational approximation function (1), was applied to experimental data for fuel consumption per surface unit (C_1, C_2) and labor consumption (C_{l1}, C_{l2}), both for the conventional technologies and for the new technological variants, becomes:

$$\begin{cases} C_1(m,s) = 24.1 - 0.3 \cdot m + 9.961 \cdot s - 0.348 \cdot m \cdot s \\ C_2(m,s) = 35.426 - 0.978 \cdot m + 3.348 \cdot s - 0.0008857 \cdot m \cdot s \end{cases} \qquad (4)$$

$$\begin{cases} C_{l1}(m,s) = 2.816 - 0.058 \cdot m + 1.052 \cdot s - 0.046 \cdot m \cdot s \\ C_{l2}(m,s) = 6.684 - 0.222 \cdot m - 0.501 \cdot s + 0.03 \cdot m \cdot s \end{cases} \qquad (5)$$

Fuel consumption per surface unit decreases with soil moisture, both for conventional technologies and for the new technological variants (Figure 6). Decreased fuel consumption with soil moisture is more pronounced in the new variants (the slope of soil moisture is higher). The soil moisture is higher, even if new variants consumption is substantially reduced compared to conventional technologies.

Depending on the field slope, the fuel consumption per surface unit increases both for the conventional technologies and for the

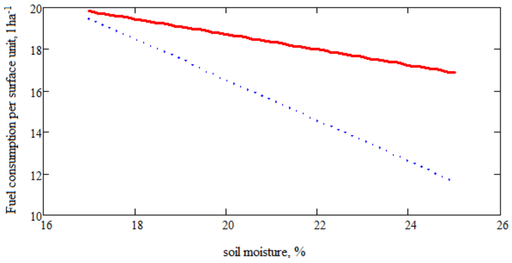

Figure 6. The variation of fuel consumption per surface unit, depending on the soil moisture

new technological variants. The growth slopes of the consumption curves are almost equal (approximately parallel) (Figure 7).

In relation to the soil moisture, the labor consumption decreases, the apparent match in its extreme right in the studied range of moisture. The labor consumption decrease is faster for the new variants, however, at low moistures, this parameter is significantly in favor of conventional technologies (Figure 8).

In relation to the average field slope, the labor consumption increases in all variants, faster for the conventional technologies. It was observed that around value 1.2 for the field slope, the labor consumption becomes the same in all variants. Before this value, the new technological variants are larger labor consuming, and the upper slope values of 1.2, the conventional technologies are the most intensive labor consuming (Figure 9).

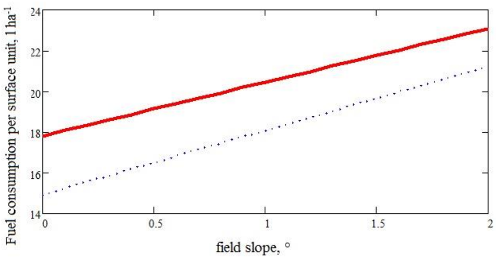

Figure 7. The variation of fuel consumption per surface unit, depending on the field slope.

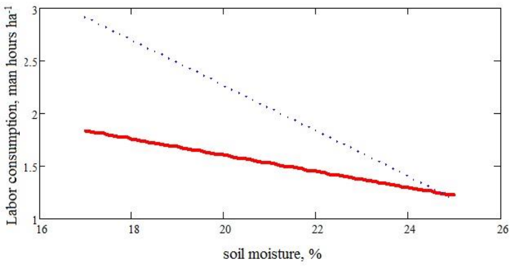

Figure 8. The variation of labor consumption, depending on the soil moisture.

CONCLUSIONS

The results obtained with the new technological alternatives for regeneration of degraded grasslands in spring and late summer are cheaper and more environmentally friendly than conventional technologies used so far. In comparison with conventional technologies, the new technological variants described in this paper involve a lower fuel consumption per surface unit with 7.28-20.5%, a lower labor consumption with 15.12-24.05% and the minimum passes number. By lowering fuel consumption per hour and fuel consumption per surface unit, the new technological variants have a reduced environmental impact.

ACKNOWLEDGEMENTS

The work has been funded by the Sectoral Operational Programme Human Resources Development 2007-2013 of the Ministry of European Funds through the Financial Agreement POSDRU/159/1.5/S/134398.

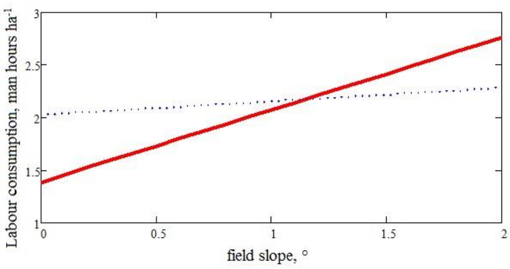

Figure 9. The variation of labor consumption, depending on the field slope

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فناوری‌های جایگزین با مصرف کمتر برای بازسازی مراتع تخریب شده

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چکیده

هدف اصلی این مقاله، مقایسه راه حل های فن آوری جدید برای احیای مراتع تخریب شده با استفاده از یک دستگاه بازساز و vindrover با فن اوری های متعارف است. این ماشین ها چندین عملیات را در یک مرحله کاری انجام می دهند مانند: خاکورزی خاک در نوار باریک، کشت مستقیم مخلوط دانه گیاهان در پوشش گیاهی و تراکم نور خاک روی بذر برای یک تماس مناسب را به منظور به دست آوردن یک جوانه زنی خوب انجام می دهد. Vindrover برای برداشت و تهویه علوفه طراحی شده و در یک مرحله کار، زدن، خرد کردن و هوادهی تا خشک شدن را انجام می دهد. مطالعات در دو منطقه در سال کشاورزی ۲۰۱۴ انجام شد: موسسه تحقیقات ملی – توسعه ماشین الات کشاورزی- INMA SCDP Vaslui -Development Station -Bucharest and Grasslands Research. برای هر لینک فن آوری پارامترهای زیر تعیین شد: مصرف سوخت در ساعت، مصرف سوخت در واحد سطح، ظرفیت ساعت کاری و مصرف نیروی کار. با تجزیه و تحلیل نمودارمقایسه ای، مشاهده شد که مقدار میانگین کلی پارامترهای بدست آمده در این دو منطقه در بهار و تابستان توسط انواع فراوری های جدید از مقداری که توسط فناوری های متعارف گرفته شده بود، کمتر بود. راه حل های تکنولوژیکی جدید برای بازسازی مراتع تخریب شده شامل سوخت و مصرف نیروی کار کمتر ، که سازگاری بیشتر با محیط زیست نسبت به فن آوری های معمولی دارند، می شود.

[DOR: 20.1001.1.16807073.2017.19.5.9.2]