PERFORMANCES EVALUATION OF DIRECT SEEDER FOR GRASSLANDS

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Abstract. The aim of this paper was to evaluate the performances of adirect seeder for grasslands, both in laboratory and in the field.The tests were conducted at the National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, during the spring season in 2014.The laboratory performance indices were: seed rate, seed rate instability and unevenness degree of seed distribution on the working width.The field qualitative and energetic indices were: average working depth on seedbed preparation, average width of the strips, average depth of seed incorporation on working width, standard deviation to the average depth of seeding on the working width, coefficient of variation of depth of seeding on the working width and uniformity of plant distribution in one row, fuel consumption per hour, hourly working capacity and fuel consumption per surface unit.The values of standard deviation to the average depth of seeding on the working width and the coefficient of variation of the depth of seeding on the working width were lower, when the seeder moved with the speed of 1.16 $m \cdot s^{-1}$. The higher uniformity of plant distribution in one row was obtained at the same working speed. The tested seeder for degraded grasslands showed good performances strictly connected to the proper adjustment of the working depth and seed rates and to the correct choice of the working speed.

Keywords: seeder, grasslands, overseeding, performance indices.

Introduction

Grassland is an important land type used in Europe, comprising approximately 35 % of the agricultural land area. There is large spatial variability in both grassland systems and productivity between European regions. Observed relations between grassland and crop variability suggest that similar factors explaining variability in crop productivity (i.e. climate and management) also affect grasslands [1]. 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 grassland landscapes and sensitive habitats in Europe [2].

Tisliar [3] studied a reaction of permanent grasslands to direct drilling of three grass/clover mixtures, without mineral fertilizer application and with application of medium nitrogen rate, with two machines for direct drilling – one with rolling discs and one with rotating blades. The seeder with rotating blades is better for agronomical requirements, such as faster seed germination, better sward canopy and higher yields, in direct drilling of the grass/clover mixtures into swards.

Lowther et al. [4] presented the results from an experimental strip seeder drill designed to mechanically remove competing vegetation. A seed mixture of *Medicago sativa*, *Lotus corniculatus*, *Dactylis glomerata* and *Festuca arundinacea* were drilled into undeveloped natural grassland with either a triple disc drill or a strip seeder drill in the absence or presence of herbicides. Their results demonstrate the agronomic superiority of the strip seeder drill for establishment of improved pasture species. Similarly, the results obtained by Woodman and Lowther [5] demonstrate serious limitations when conventional sowing methods are used to establish grasses into clover-developed tussock grasslands, and indicate the potential of the strip seeder drill technology for effective establishment.

The interaction between the seed rate and nitogen levels was only significant for dry matter for Sorghum fodder sown with the seed rate of 120 $kg \cdot ha^{-1}$ and 180 kg $N \cdot ha^{-1}$ resulted in significantly higher dry matter (%) than all other combinations [6]. Seed rates did not affect the straw yield of forage oats significantly [7].

Huguenin-Elie et. al [8]compared four kinds of seeders, a seed broadcaster with a roller, a seed broadcaster with a harrow, a drill seeder and a seeder with a rotary band cultivator, to assess the influence of the seeding method on the success of overseeding. The seeder with the rotary band cultivator gave slightly better results. Following their studies, the authors concluded that the seeding method only slightly influences the success of overseeding.

Mocanu et al. [9] presented new technological solutions for mechanization of improving the grassland working, using the special farming machinery: a direct drilling machine, a sowing machine and a complex aggregate composed by a rotary tiller-drill machine and fertilizer equipment. In comparison with usual technologies, the new technologies involve a lower specific fuel consumption with 8.63÷25.4 %, a lower work force consumption with 14.63÷58.11 % and the minimum passing number of the units.

The aim of this paper was to evaluate the performances of a direct seeder for grasslands, both in laboratory and in the field.

Materials and methods

In the year 2014, thedirect seeder for grasslands was developed at the National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest, Romania. The seeder is designed to the ecological technology for grassland surface regeneration, without deep soil mobilization, while retaining a certain percentage of the existing vegetation.

The direct seeder performs several operations in one pass as follows: soil tillage in narrow strips, direct seeding of herb seed mixture into the vegetal cover and light compaction of the soil over the seeds for a proper contact, in order to obtain good germination. Each section for soil tillage in narrow strips has on both sides two rotors, each one provided with flanges on which three pairs of “L” shape blades protected by shields are mounted. A view of the seeder for degraded grasslands is shown in Figure 1and brief specifications are given in Table 1.

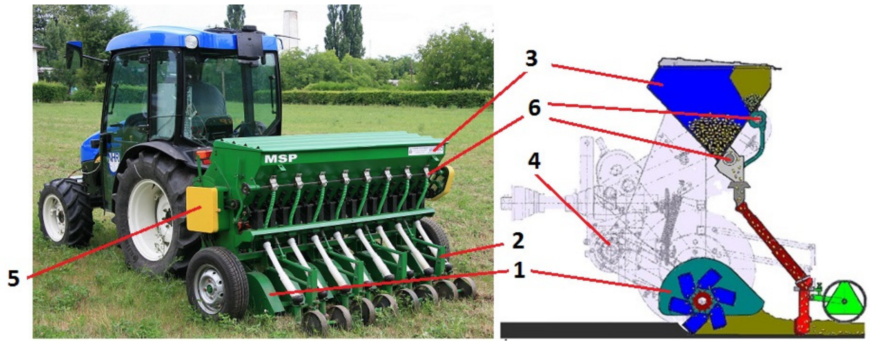

Fig. 1. **Direct seeder for grasslands used in the tests and the operating process:** 1 – section for soil tillage in narrow strips; 2 – section for seeding; 3 – seed box; 4 – transmission for the soil tillage sections; 5 – transmission for the seed metering devices; 6 – seed metering device

Table 1

Brief specifications of the seeder for degraded grasslands

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 blade rotor (m)	0.32
Diameter of wheels for soil compaction (m)	0.2

The performance of the direct seeder for grasslands was first tested in the laboratory. For this purpose an automated testing stand was used, which mainly consists of: an electric gear motor with variable speed continuously adjustable to simulate the working speed of the seeder; two bands provided with seed collection boxes, powered by two electric motors; an electronic scale for measuring the quantity of seeds collected from each individual metering device and the whole amount of seeds; an automated control and monitoring panel, having an PLC (programmable logic computer) and four frequency converters. Each sample was performed in three repetitions for three seed flows (minimum, medium and maximum), three working speeds (0.84 m·s^{-1}; 1.39 m·s^{-1}; 1.95 m·s^{-1}) and ten positions on graded sector of impulse gearbox adjustment lever. The seed usedwas *Trifolium repens,* whichhad the following physical characteristics: purity 98.5%; mass of 1000 seeds 2.1 g; specific mass 1.06 g·cm^{-3}. The following performance indices of the grassland seeder were determined: seed rate (*R*), seed rate instability (i_R) and unevenness degree (*U*) of seed distribution on the working width.

The performance of the direct seeder for grasslands was also evaluated in the field. The tests were conducted on the experimental field of the National Institute of Research – Development for Machines and Installations Designed to Agriculture and Food Industry – INMA Bucharest during the spring season of 2014. The experimental field consisted of natural grassland of *Lolium perenne.* The soil type was Stagnic preluvisol with thickness of Aohorizon 0-10 cm, brown dark colour, a loamy-sandy texture, glomerular structure and Bt(argic) horizon with thickness 10-70 cm. The soil humidities in the 0÷10 cm depth interval were 18÷22 %.The seed mixture for overseeding the natural grassland was *Poa pratensis* 8.4 kg·ha^{-1}, *Festucarubra* 12.6 kg·ha^{-1}, *Dactylis glomerata* 8.4 kg·ha^{-1}, *Lotus corniculatus* 6.3 kg·ha^{-1}, *Trifolium repens* 6.3 kg·ha^{-1}.

The tests were carried out for two working depths (2 cm and 6 cm) and three working speeds of 38.8 kW tractor (speed gear IB: 0.78 m·s^{-1}, speed gear IA: 1.16 m·s^{-1}and speed gear IIA: 2.09 m·s^{-1}). The field working speeds were chosen relatively close to the working speeds simulated in the laboratory tests (0.84 m·s^{-1}, 1.39 m·s^{-1}and 1.95 m·s^{-1}). The small differences between them were given by the tractor performances. According to the national standard requirements STAS 12836-90 [12], the values of the following were determined:

- the field qualitative indices: average working depth on seedbed preparation (A_{wd}), average width of the strips (A_{ws}),average depth of seed incorporation in one row (A_{sd}), average depth of seed incorporation on the working width (A_{sdw});
- statistical indicators: standard deviation to the average depth of seeding on the working width (D_{sd}), coefficient of variation of depth of seeding on the working width (C_{sd}), uniformity of plants distribution in one row (U_{pd});
- energetic indices: fuel consumption per hour (*q*), hourly working capacity (W_h), fuel consumption per surface unit (*Q*).

For the depth of seed incorporation the measurements were carried out "in green", that is, after the plants emergence, in all rows of passages, on three working speeds and three repetitions. According to the agronomic requirements specified in the national standard SR 13238-2:1994 [11], acceptance condition (repeatability) is the depth of seed incorporation that can vary within:

$$|D_{sd}| \leq 0.2\times A_{sdw}, \text{ cm} \quad (1)$$

$$|C_{sd}| \leq 20, \%. \quad (2)$$

Uniformity of plant distribution in one rowwas also determined "in green", by counting the plants in areas with a length of 5 cm. Measurements were performed on three rows from each passing through a length of 2 meters, three repetitions located in three areas of the experimental plot (the end and the middle). Experimental data processing was carried out by developing a MathCad application. The software developed could determine the following statistical indicators: average number of plants per meter, average distance between the plants in the row and uniformity of plant distribution in 5 cm length sectors for the three working speeds.

Results and discussion

The results of performance indices in the laboratory are presented in Table 2. Analyzing the data presented in Table 2, it was observed that the seed rate range is 0.7÷28.7 kg·ha^{-1}, completely covering the agro technique request, which is 2.1÷15.0 kg·ha^{-1} for *Trifolium repens* seed. The values of seed rate instability and unevenness degree of seed distribution were smaller than the maximum permitted values, which are 5 % for the first one and 8 % for the second [11]. Values close to the upper limit were observed for the minimum working speed and the first two positions of the adjustment lever (e.g., U = 7.90 % at working speed of 0.84 m·s^{-1} and lever position L_1). Therefore, it is better to avoid this working regime. Table 3 presents the results obtained for the field performance indices. Analyzing the data presented in Table 3, it was observed that the direct seeder for grasslands performed average working depth on seedbed preparation and average depth of seed incorporation in one row of 1.80÷6.20 cm. This working depth range completely covers the agro technique request for all herb seeds. Similar results were reported by Tisliar [3], Hermenean et al. [10] and Huguenin-Elie et al. [8].

In order to validate the experimental data, the experimental values of standard deviation to the average depth of seeding on the working width and the coefficient of variation of the depth of seeding on the working width with the maximum values obtained by applying equation (1) were compared.

Table 2

Values of the performance indices in laboratory*

Working speed, $m \cdot s^{-1}$	Lever position	Seed flow								
		minimum			medium			maximum		
		R, $kg \cdot ha^{-1}$	i_R, %	*U*, %	*R*, $kg \cdot ha^{-1}$	i_R, %	*U*, %	*R*, $kg \cdot ha^{-1}$	i_R, %	*U*, %
0.84	L_1	0.9	4.6	7.90	1.5	5.0	7.60	4.1	1.7	8.00
	L_2	1.4	1.3	6.38	2.8	0.9	7.12	6.8	0.3	6.45
	L_3	2.0	1.0	6.18	4.1	0.6	6.62	9.6	0.7	6.40
	L_4	2.5	1.9	6.63	5.3	0.8	5.46	12.2	0.3	6.35
	L_5	3.1	1.8	6.18	6.4	0.4	5.42	15.0	0.7	5.52
	L_6	3.6	1.4	5.32	7.7	0.4	4.64	17.8	0.3	6.29
	L_7	4.2	2.0	5.81	9.1	1.0	3.28	20.5	1.3	7.56
	L_8	4.9	2.0	7.09	10.6	0.6	5.62	22.7	0.1	4.70
	L_9	5.6	2.1	4.03	12.1	0.6	5.67	26.0	0.3	2.70
	L_{10}	6.5	2.4	7.33	14.1	0.3	5.72	29.0	0.1	6.32
1.39	L_1	0.7	1.3	5.14	1.7	1.1	5.55	3.7	2.3	6.66
	L_2	1.3	1.9	6.55	3.2	1.6	2.73	6.3	1.1	3.46
	L_3	1.9	0.2	3.88	4.7	1.1	3.61	8.8	1.6	5.22
	L_4	2.4	0.7	7.52	5.3	1.5	3.13	11.1	0.3	3.89
	L_5	2.9	2.0	6.80	6.6	0.4	2.73	13.4	0.2	3.90
	L_6	3.3	0.8	3.86	8.0	0.5	4.47	16.7	0.4	2.34
	L_7	4.0	1.2	5.03	9.2	0.4	5.20	19.9	0.5	3.27
	L_8	4.6	1.1	6.60	10.2	0.1	5.55	21.9	0.3	1.08
	L_9	5.3	0.8	5.48	11.7	0.6	4.14	25.2	0.1	2.63
	L_{10}	5.9	0.4	8.97	13.4	0.5	4.23	28.7	0.3	6.15
1.95	L_1	0.8	4.8	7.60	1.8	1.9	3.68	3.6	2.5	5.00
	L_2	1.3	3.7	7.03	3.0	2.0	3.43	6.4	1.3	4.92
	L_3	1.9	2.3	5.82	4.1	0.8	3.06	9.1	1.2	5.24
	L_4	2.4	1.1	5.64	5.4	0.9	3.26	11.8	0.6	4.78
	L_5	2.9	3.1	5.08	6.4	0.4	2.91	14.5	0.3	4.48
	L_6	3.7	1.9	6.89	8.0	0.3	1.13	17.9	0.8	5.48
	L_7	3.9	1.1	5.34	9.4	0.5	1.53	21.0	0.6	5.62
	L_8	4.6	1.1	5.53	11.1	0.4	0.96	24.1	0.2	5.83
	L_9	5.3	1.7	4.08	12.0	0.6	1.22	25.7	0.3	5.41
	L_{10}	5.8	0.4	5.82	13.1	0.9	3.24	27.5	1.2	6.28

*R – seed rate; i_R – seed rate instability; U – unevenness degree of seed distribution on the working width

Table 3

Average values of the field qualitative indices

Working speed, $m \cdot s^{-1}$	Minimum working depth (2 cm)					Maximum working depth (6 cm)				
	A_{wd}, cm	A_{ws}, cm	A_{sdw}, cm	D_{sd}, cm	C_{sd}, %	A_{wd}, cm	A_{ws}, cm	A_{sdw}, cm	D_{sd}, cm	C_{sd}, %
0.78	2.40	7.85	2.40	0.170	7.00	6.20	7.95	6.20	0.168	2.71
1.16	2.20	7.60	2.20	0.150	6.82	6.10	7.55	6.10	0.145	2.38
2.09	1.80	7.25	1.80	0.160	8.89	5.80	7.40	5.80	0.156	2.69

From the results shown in Table 3 and Figure 2, it was noticed that the average values of standard deviation to the average depth of seeding on the working width D_{sd} (0.170 < 0.48; 0.150 < 0.44; 0.160 < 0.36 cm) and the coefficient of variation of the depth of seeding on the working width C_{sd} ($C_{sd} \leq 20$ %), at the three working speeds and two working depths (2 cm and 6 cm) comply with the agro requirements specified in the national standard SR 13238-2:1994 [11]. However, it was found that these values were lower, when the seeder moved with the speed of 1.16 m·s^{-1}. This is an important observation for choosing the working speed so as to achieve a constant working depth and thus a uniform plant emergence.

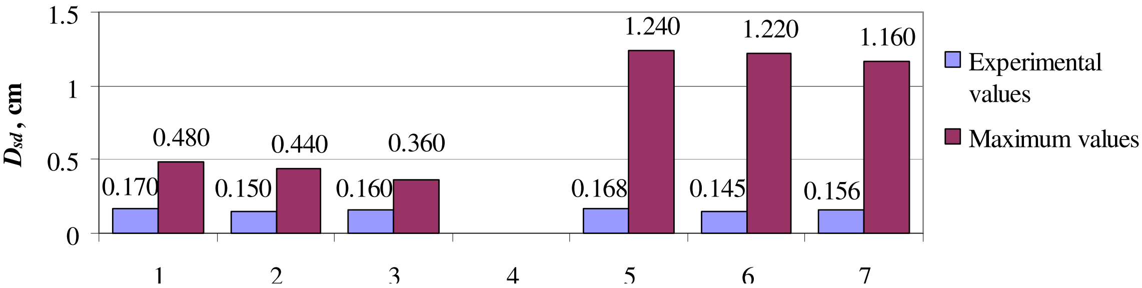

Fig. 2. **Standard deviation to the average depth of seeding on the working width:** comparison between experimental values and maximum values obtained by applying equation (1)

Table 4 shows the results of the investigation on the number of 5 cm length sectors, where 0÷10 plants and uniformity of plant distribution were found.

Table 4

The number of sectors with length of 5 cm and uniformity of plants distribution

Working speed, m·s^{-1}	**Number of plants in a sector**											**Total sectors**	**U_{pd}, %**
	0	1	2	3	**4**	**5**	**6**	**7**	8	9	10		
	Average number of 5 cm length sectors (on three rows and three repetitions on each row)												
0.78	0.0	0.0	0.0	4.1	**22.0**	**24.7**	**34.6**	**28.1**	3.4	3.1	0.0	120	91.10
1.16	0.0	0.0	0.0	2.4	**22.1**	**25.6**	**36.8**	**28.8**	2.3	2.0	0.0	120	94.70
2.09	0.0	0.0	0.0	6.3	**24.6**	**25.4**	**26.1**	**24.8**	6.6	6.1	0.0	120	84.09

Uniformity of plant distribution in one row is given by the total number of 5 cm length sectors, where there are 4÷7 plants over the total number of 5 cm length sectors, and it was calculated using the computer application developed in MathCad. From the results presented in Table 4 it was noticed that the higher uniformity of plant distribution in one row (94.70 %) was obtained at the working speed of 1.16 m·s^{-1}. Table 5 reports the average values of the main energetic indices observed in the field tests.

Table 5

Average values of the field energetic indices

Working speed, m·s^{-1}	**Working depth**					
	2 cm			**6 cm**		
	q, l·h^{-1}	**W_h, ha·h^{-1}**	**Q, l·ha^{-1}**	**q, l·h^{-1}**	**W_h, ha·h^{-1}**	**Q, l·ha^{-1}**
0.78	8.75	0.49	17.85	9.95	0.49	20.30
1.16	9.35	0.73	12.80	11.65	0.73	15.95
2.09	9.79	1.32	7.41	12.10	1.32	9.16

Analyzing the energetic indices presented in Table 5, it results that thedirect seeder for grasslands powered by the 36.8 kW tractor performs higher hourly working capacity (W_h) of 1.32 ha·h^{-1} with lowest fuel consumption per surface unit (Q) of 7.41 l·ha^{-1} for minimum working depth of 2 cm and 9.16 l·ha^{-1}for maximum working depth of 6 cm, in the second speed gear. But if we consider the remarks above, regarding the field qualitative indices, which were optimum at the working speed of 1.16 m·s^{-1} (speed gear IA) it might be concluded that thedirect seeder for grasslands performs the hourly working capacity of 0.73 ha·h^{-1} with the fuel consumption per surface unit of 12.80 l·ha^{-1} for the minimum working depth and 15.95 l·ha^{-1} for the maximum working depth. The results are in line with those obtained by Hermenean et al. [10] and Mocanu et al.[9].

Conclusions

1. The tested seeder for degraded grasslands showed good performances in narrow strips soil tillage and overseeding operations, strictly connected to the proper adjustment of the working depth and seed rates and to the correct choice of the working speed.
2. Under laboratory tests the performance indices of the seed rate, seed rate instability and unevenness degree of seed distribution on the working width were 0.7÷28.7 kg·ha^{-1}, 0.1÷5.0 % and 1.08÷8.0 %. Values close to the upper limit were observed for the minimum working speed and the first two positions of the adjustment lever, it was concluded that it is better to avoid this working regime.
3. Under the field tests of the direct seeder for grasslands, it was found that the values of standard deviation to the average depth of seeding on the working width and the coefficient of variation of the depth of seeding on the working width were lower, when the seeder moved with the speed of 1.16 m·s^{-1}; in the same time, the higher uniformity of plant distribution in one row was obtained at the same working speed.
4. The direct seeder for grasslands performed the hourly working capacity of 0.73 ha·h^{-1} with the fuel consumption per surface unit of 12.80 l·ha^{-1} for the minimum working depth and 15.95 l·ha^{-1} for the maximum working depth.

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