The influence of stands cultivation on persistency of different cultivars of *Medicago sativa* L.

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ABSTRACT

A polyfactorial field trial with alfalfa (*Medicago sativa* L.) cv. Palava, Jarka and Vlasta was established in Červený Újezd (altitude 405 m a.s.l., average year precipitation 493 mm per year, average year temperature 7.6°C, clay loam orthic luvisol) in the spring with a companion crop (spring wheat) in rows of a space of 125 mm, sowing rate 16 kg/ha of germinable seeds in the year 1998. The stands were cut 3 times per year, the control variant was left without a treatment, the rest were cultivated with a spike or a vibration harrow before the beginning of the vegetation season and after the first cut. The numbers of plants and stems per m^2 and dry mass yields were measured. The results were evaluated by four-factor analysis of variance Anova and by regression analysis. The harrowing of the stands resulted in a significantly lower amount of plants per m^2 in the end of the fourth year by 23–29%, on average a lower number of stems per m^2 (by 13% using double cultivation per year with the vibration harrow). The dry mass yield was significantly influenced only with cv. Jarka (by 5–11% higher in the cultivated fields). The moderately or relatively strong relationship between the plants amount and the time was exponential.

Keywords: *Medicago sativa* L.; cultivars; harrowing; stand density; yield capacity

The alfalfa is, besides the red clover, the most important legume cultivated on arable land in the Czech Republic. Its importance does not reside only in the production of forage with a good quality for high-production animals, but also in its function in the crops rotation. In the last several years, the average alfalfa yields decreased in the Czech Republic because of many reasons from 10 to 7.1–8 t/ha. With such yields, or lower ones, the forecrop value of the legume decreases more rapidly and it has its consequences in the economy of all the crops rotation.

The need of an effective soil surface cultivation of alfalfa fields for improving the conditions for overgrowing from underground buds was proved in various experiments, especially in older stands where the soil is more compact (Šantrůček 1989). A better cultivation effect of the vibration harrow in comparison with the spike harrow was described by Šantrůček et al. (2001). Their results show that harrowing does not result in significantly higher dry mass yields or plants density. Neither the amount of plants per m^2 was significantly influenced by cultivation during 3 years. The reason for the unsatisfactory results with alfalfa stands harrowing can be, besides the soil compaction, also damage to the plants that occurs under any crossing of the stands during the harvest or a treatment, including the cultivation with all types of harrows. It causes a higher consumption of reserve substances and a higher infestation with root and head diseases (Rechel et al. 1991a, b, Šantrůček and Svobodová 1992). Because of the risk of infestation with diseases, the cultivars with a higher tolerance are bred. The Czech cultivars Jarka and Vlasta (registered 1995) are two of them. It is possible to expect that their reaction on the stands cultivation can be different from that of the older cultivars and their tolerance to diseases will result in a slowlier decrease of the plants number and a better sprouting. Reaching high forage yields of alfalfa is a prerequisit for the economical effectiveness of its growing. Only dense and complete alfalfa stands can as well fulfil their ecological functions consisting of the soil quality improvement.

The aim of this study was to find whether harrowing can increase the yields of the recent alfalfa cultivars, and how it affects the stand density and persistency.

MATERIAL AND METHODS

A polyfactorial field experiment with three Czech cultivars of alfalfa (*Medicago sativa* L.) with different resistance against root and head diseases (Palava, Jarka, Vlasta) was conducted in Červený Újezd (405 m a.s.l., average precipitation 493 mm per year, average year temperature 7.6°C, clay loam orthic luvisol) in the years 1999–2001. The alfalfa was sown in the spring with a companion crop (spring wheat) in rows of a space of 125 mm, sowing rate 16 kg/ha of germinable seeds. The trial had four replications and the cut was three times per year.

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Table 1. The dependence of the plant number per m^2 (y) on time factor (t)

Cultivar	Treatment	Curve equation $y = \exp(a - bt)$	R	R^2 (%)
Palava	no treatment	exp (5.60037 – 0.14796t)	–0.929**	86.39
	vibration 1	exp (5.67301 – 0.211236t)	–0.938**	88.04
	vibration 2	exp (5.47639 – 0.170125t)	–0.902*	81.38
	spike 2	exp (5.74221 – 0.204232t)	–0.871*	75.97
Jarka	no treatment	exp (5.46406 – 0.131358t)	–0.835*	69.70
	vibration 1	exp (5.65562 – 0.213759t)	–0.942**	88.71
	vibration 2	exp (5.44297 – 0.163239t)	–0.850*	72.30
	spike 2	exp (5.6832 – 0.191926t)	–0.864*	74.70
Vlasta	no treatment	exp (5.67518 – 0.16239t)	–0.951**	90.51
	vibration 1	exp (5.76317 – 0.229693t)	–0.900*	81.00
	vibration 2	exp (5.61939 – 0.198181t)	–0.869*	75.50
	spike 2	exp (5.76076 – 0.211705t)	–0.851*	72.38

y = number of plants per m^2; a, b = parameters of the equation; t (1 to 6) = order of marginal terms of vegetation (2nd–4th year); vibration 1, 2 – cultivation with vibration harrow 1, 2 times; spike 2 – cultivation with spike harrow 2 times

A part of the field was left without harrowing as a control, the rest of the area was cultivated with a spike or a vibration harrow to the depth of 70 mm before the beginning of the vegetation season and after the first cut, or by a vibration harrow only at the beginning of vegetation.

Dry mass yields (10 m^2 in each plot), the numbers of plants and stems per m^2 on randomly chosen squares (8 times 0.125 m^2) in the marginal terms of the vegetation years (spring and autumn of the 2nd–4th year) were measured. The results were evaluated by analysis of variance (ANOVA) and by regression analysis using the Statgraphics programme, version 4.0.

RESULTS AND DISCUSSION

One of the yield-creating elements, but along with it also a precondition of persistency of alfalfa swards that can be used also for non-production purposes (Svobodová et al. 2001) – so called green fallow for three to six years, is a number of plants per m^2. Harrowing of alfalfa stands from the second year of vegetation has been always a commonly used treatment of alfalfa in the Czech Republic with the aim of a better regrowing from the overground buds. But this treatment, besides an arguable soil surface aeration, damages the heads of the plants and causes their earlier dying out (Šantrůček 1989).

In this experiment, one and two cultivations with the vibration harrow per year resulted in a significantly lower **number of plants** (Table 2a, b) on average by 9.1 and 14.1% in comparison with the control variant. The influence was most marked in the fourth year of vegetation (by 29%). The influence of double vibration harrowing was significant from the second year of vegetation. The number of plants on the plots cultivated by the spike harrow was lower in comparison with the control variant from the fourth year (by 23%). The interaction between the cultivar used and the way of treatment was not found. The factor of the vegetation year had the highest influence on the number of plants.

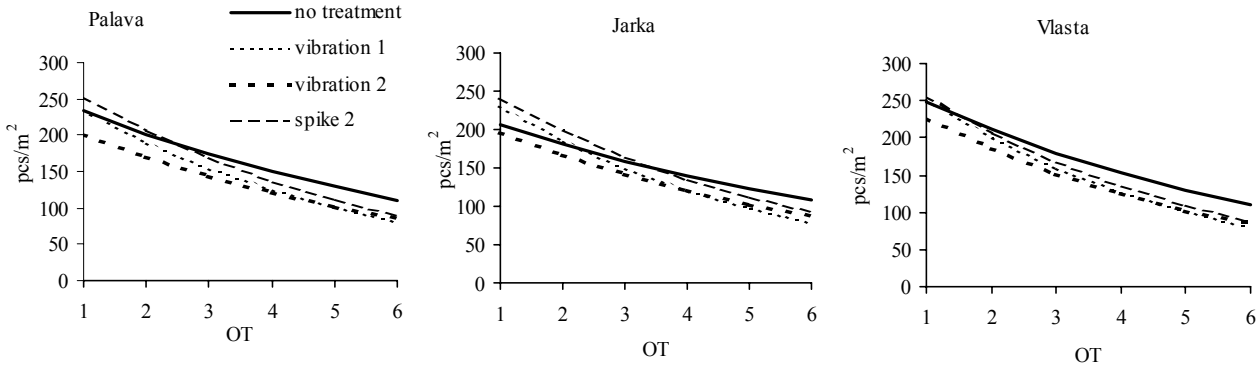

Figure 1. Number of alfalfa plants (pcs/m^2) – regression curves

OT – order of marginal terms of vegetation (2nd–4th year); vibration 1, 2 – cultivation with vibration harrow 1, 2 times; spike 2 – cultivation with spike harrow 2 times

Table 2a. Number of plants – ANOVA table

Source	*SS*	*mS*	*F*	*P*
		Main effects		
A: variant	28 155.3	9 385.09	19.52	0.0000
B: cultivar	6 188.36	3 094.18	6.44	0.0022
C: term	98 494.0	98 494.0	204.88	0.0000
D: year	572 052.0	286 026.0	594.97	0.0000
		Interactions		
AB	2 270.86	378.477	0.79	0.5814
AC	3 573.37	1 191.12	2.48	0.0641
AD	23 586.0	3 931.0	8.18	0.0000
BC	882.694	441.347	0.92	0.4018
BD	3 881.39	970.347	2.02	0.0955
CD	74 982.2	37 491.1	77.99	0.0000
ABC	4 116.08	686.014	1.43	0.2089
ABD	4 149.72	345.81	0.72	0.7305
ACD	4 523.25	753.875	1.57	0.1613
BCD	1 642.72	410.681	0.85	0.4934
Residual	63 458.0	480.742		

The dependency of the plant number on the time with the individual cultivars and ways of cultivation is expressed by exponential curves (Table 1). The course of the curves shows that the decrease of the plant number on the cultivated plots is quicker with all cultivars (Figure 1). The relationship is moderately or relatively strong, 72–90% of the variability is explained by the time factor, the probability of the relations presented is 95–99%.

The overground mass production is a criterion of alfalfa plants vitality. In the past, a higher stem creation was given as the aim of the alfalfa fields cultivation. Their number is one of the yield creating elements. But in this experiment, the **number of stems per m²** was not significantly higher on the cultivated plots with particular cultivars during the three years of vegetation. On the contrary, the total stem number in the second and third years (Table 3a, b) was significantly decreased by double cultivation with the vibration harrow, with Palava cultivar by 17.9%, with Jarka by 11.4%, and with Vlasta by 10.6%, respectively: the cultivation with the spike harrow had the weakest influence on the number of stems. Vlasta cultivar was characterised by a significantly higher number of stems (by 6.8%) than Palava. A significantly lower number of stems per m² was found in the fourth year of vegetation in all modifications of the treatment.

An increase of dry mass yield (Table 4a, b) by cultivation manifested itself more considerably in the second and third cuts. The total dry mass yield of Palava in three years was not significantly influenced by cultivation (lower in comparison with the non-treated control maximally by 5.1%). The total yield of the recent cultivar Jarka was significantly higher on one cultivation with the vibration harrow by 10%, and on double cultivation with the spike harrow by 11%. This cultivar was more yielding on average by 6% than Palava or Vlasta. By analysis of the factor interactions, it was found that the newer cul-

Table 2b. Average number of alfalfa plants (pcs/m²)

Treatment	Year of vegetation			
	2nd	3rd	4th	average
Control (no treatment)	210.7	166.8	116.7	164.7
Vibration harrow 1	198.2	168.5	82.5	149.8
Vibration harrow 2	174.8	164.7	83.5	141.0
Spike harrow 2	204.8	195.8	90.0	163.6
D_{min}		17.7		10.2

Vibration harrow 1 – cultivated with vibration harrow in spring; vibration harrow 2 – cultivated with vibration harrow in spring and after the first cut; spike harrow 2 – cultivated with spike harrow in spring and after the firts cut; control – without cultivation

Table 3a. Number of stems – ANOVA table

Source	*SS*	*mS*	*F*	*P*
		Main effects		
A: variant	507 574	169 191	43.67	0.0000
B: cultivar	227 172	113 586	29.32	0.0000
C: cut	1.366E7	1.366E7	3 527.99	0.0000
D: year	7.511E6	3.755E6	969.41	0.0000
		Interactions		
AB	44 120	7 353	1.90	0.1080
AC	85 735	28 578	7.38	0.0006
AD	1 540 001	25 666	6.63	0.0001
BC	29 316	14 658	3.78	0.0323
BD	17 988	4 497	1.16	0.3443
CD	2.520E6	1.260E6	325.33	0.0000
ABC	57 162	9 602	2.48	0.0414
ABD	123 360	10 280	2.65	0.0117
ACD	249 295	41 549	10.72	0.0000
BCD	34 294	8 573	2.21	0.0870
ABCD	135 854	11 321	2.92	0.0063
Residual	139 469	3 874		

tivars (Vlasta and Jarka) produced more overground mass in the first year (by 7–13%) and in the first cuts (by 5–10%) than Palava. The highest average yields (by 6% more in comparison with the control – Table 4a, b) were reached on the plots cultivated two times per year with the spike harrow.

It was found, by regression analysis of the dates of the fourth vegetation year, that the dry mass yield depends only very little on the number of stems. A statistically significant moderate relationship ($R = 0.56$) was found only in the second cut in the fourth year of vegetation ($R^2 = 30.8\%$).

The stands were not infested with weeds but this can be expected later if the thin stands are used for more years.

The results proved the conclusions of our previous experiments. It is possible in some cases to reach a higher number of stems per plant by harrowing or by other

Table 3b. Number of stems (pcs/m^2, %)

Treatment/Cultivar	Palava	Jarka	Vlasta	Average	
Control (no treatment)	810.9	773.2	839.9	808.0	
Vibration harrow 1	753.2	759.6	792.7	768.5	
Vibration harrow 2	665.6	685.3	751.1	700.7	
Spike harrow 2	783.2	762.2	849.6	798.3	
D_{min}		51.5		29.8	
Treatment		relatively (control = 100%)			
Control (no treatment)	100	100	100	100	
Vibration harrow 1	92.9	98.2	94.4	95.1	
Vibration harrow 2	82.1	88.6	89.4	86.7	
Spike harrow 2	96.6	98.6	101.1	98.8	
Treatment/year, cut	year of vegetation			cut	
	2nd	3rd	4th	1nd	3rd
Control (no treatment)	904.9	960.4	558.7	975.4	561.5
Vibration harrow 1	895.0	878.7	531.8	897.0	504.4
Vibration harrow 2	803.7	783.8	514.6	1 038.7	557.9
Spike harrow 2	940.4	897.6	557.0	1 035.8	580.2
D_{min}		51.53			42.1

Table 4a. Dry mass yield – ANOVA table

Source	*SS*	*mS*	*F*	*P*
		Main effects		
A: variant	4.77	1.59	9.27	0.0000
B: cultivar	5.38	2.69	15.70	0.0000
C: cut	1 057.38	528.69	3 082.59	0.0000
D: year	49.84	24.91	145.29	0.0000
		Interactions		
AB	5.84	0.97	5.68	0.0001
AC	9.15	1.52	8.90	0.0000
AD	6.09	1.01	5.92	0.0000
BC	4.59	1.14	6.70	0.0001
BD	2.61	0.65	3.81	0.0073
CD	69.37	17.34	101.13	0.0000
ABC	4.51	0.37	2.19	0.0208
ABD	4.57	0.38	2.22	0.0192
ACD	11.29	0.94	5.49	0.0000
BCD	5.93	0.74	4.32	0.0003
ABCD	15.92	0.66	3.87	0.0000
Residual	12.3486	0.171509		

ways of alfalfa stands cultivation but the total number of stems per m^2 depends also on the number of plants. The weight of one stem manifests itself in the dry mass yield. In this experiment, the increase of the yield by cultivation represented 2–4 t alfalfa hay per hectare in three years with 3–6 cultivations altogether with only one of

Table 4b. Dry mass yields (t/ha)

Cultivar	Treatment	Average of cuts (2^{nd}–4^{th} year)			Total DMY (2^{nd}–4^{th} year)	
		1^{st} cut	2^{nd} cut	3^{rd} cut	t/ha	relatively (%)
Palava	control	5.60	5.09	2.01	38.09	100
	vibration harrow 1	5.32	4.59	2.13	36.14	95
	vibration harrow 2	5.65	4.79	2.22	37.98	100
	spike harrow 2	5.41	5.28	2.13	38.46	101
Jarka	control	6.17	4.55	1.76	37.43	100
	vibration harrow 1	6.10	5.28	2.33	41.10	110
	vibration harrow 2	6.18	4.55	2.34	39.23	105
	spike harrow 2	5.83	5.59	2.42	41.54	111
Vlasta	control	5.86	4.64	1.96	37.37	100
	vibration harrow 1	5.42	4.62	1.75	35.37	95
	vibration harrow 2	5.89	4.78	2.16	38.48	103
	spike harrow 2	5.94	5.15	2.13	39.66	106
D_{min}			0.486		2.70	7
Palava		5.50	4.94	2.12	37.66	100
Jarka		6.07	4.99	2.21	39.82	106
Vlasta		5.81	4.80	2.00	37.82	100
D_{min}			0.238		1.35	
Control (no treatment)		5.88	4.76	1.91	37.63	100
Vibration harrow 1		5.61	4.83	2.07	37.53	100
Vibration harrow 2		5.91	4.70	2.24	38.57	102
Spike harrow 2		5.73	5.34	2.23	39.88	106
D_{min}			0.28		1.56	

the cultivars used. It was proved that the reaction on the cultivation of different alfalfa varieties, especially bred for a higher tolerance to diseases, can vary. The influence of the root and head diseases on the yields and plants persistency under different stand managements is not so clear and the results will be published in our next works. It is necessary to know the properties of the varieties for the decision on the best stand management, and to consider the economical efficiency of the treatments in relation to the actual prices and yields required.

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ABSTRAKT

Vliv kultivace porostů různých odrůd vojtěšky seté (*Medicago sativa* L.) na jejich vytrvalost

Parcelový polyfaktoriální pokus s vojtěškou setou (*Medicago sativa* L.), odrůdami Palava, Jarka a Vlasta byl založen v řepařské výrobní oblasti 405 m n. m., roční úhrn srážek 493 mm, průměrná roční teplota 7,6°C, na jílovitohlinité hnědozemi v roce 1998 na jaře do krycí plodiny (jarní pšenice), do řádků s roztečí 125 mm, výsevek 16 kg klíčivých semen na ha. Porost byl využíván trojsečně, kontrolní varianta byla ponechána bez ošetření, ostatní byly vláčeny hřebovými nebo vibračními branami na jaře a po první seči. Byl sledován počet rostlin a lodyh na m^2 a výnos nadzemní biomasy. Výsledky byly statisticky vyhodnoceny čtyřrozměrnou analýzou rozptylu Anova a analýzou regrese. Na kultivovaných plochách byl zaznamenán průkazně nižší počet rostlin na m^2 na konci čtvrtého roku vegetace o 23–29 % ve srovnání s kontrolou a v průměru nižší počet lodyh na m^2 (o 13 % při dvojnásobné kultivaci vibračními branami). Výnos nadzemní biomasy byl průkazně ovlivněn pouze u odrůdy Jarka (o 5–11 % vyšší na kultivovaných plochách). Těsná až velmi těsná závislost počtu rostlin na čase měla exponenciální průběh.

Klíčová slova: vojtěška setá; odrůdy; kultivace; hustota porostu; výnosová schopnost

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