PAERFOMANCE OF TEN LUCERNE VARIETIES DEPENDING ON CUTTING REGIME

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Abstract

The aim of the research (carried out in 2000–2004) was to compare the impact of three different cutting regimes and ten varieties on the lucerne (*Medicago* sp.) productivity, forage quality, stand longevity and regrowth intensity in spring and after cuts. Harvest management was as follows: traditional three-cut regime (cutting mainly by stage of plant development, providing stand longevity) – treatment 1; three-cut schedule using fixed time intervals – treatment 2; and four-cut schedule using fixed time intervals – treatment 3. Ten different, according to origin and fall dormancy type, lucerne varieties were used (3 local Baltic and 7 American). Results of the five years of lucerne usage showed that the best average lucerne dry matter (DM) yield was provided using treatment 1 ($p<0.01$). The effect of the used variety on obtained DM yield was more substantial if compared with that of the cutting regime. Treatments 2 and 3 appear more preferable, providing a substantially higher crude protein concentration measured in mg kg^{-1} of dry matter ($t > t_{crit}$). Regrowth intensity in spring and after cuts is connected with characteristics of a specific variety, mainly fall dormancy rating, and individuality of a specific season. Results of the research showed that lucerne stands could be used for up to 5 years even if the four-cut regime was applied, and high yields were obtained in spite of variable stand densities.

Key words: lucerne, variety, cutting regime, DM yield, quality, stand longevity, regrowth intensity

Introduction

Growing of lucerne (*Medicago sp.*) is important for obtaining high and excellent quality yields of hay or silage for cattle without application of nitrogen fertilisers, as well as for increasing crop diversity in crop rotation systems. It is comparatively expensive to establish lucerne stands de novo in Latvia. One of the most asked questions is: how long the stand can be kept. One of the reasons why farmers choose lucerne for forage production, besides high and qualitative yield, is its stand longevity. Cutting of lucerne may be scheduled using stages of plant development, fixed time intervals, crown bud development, or combination of these criteria (Scheaffer *et al.*, 1988). Traditionally, a three-cut schedule is recommended in Latvia, performing the 1st cut in the bud stage, 2nd cut in the stage of first flower (10% flower) and 3rd cut in the bud to first flower stage, but not earlier than 42 days after the 2nd cut. For better wintering and assuring better yield in the next season, October (October 1–10) is a better cutting time if compared with September (after September 20). Our findings in previous years (1994–2000) showed that three-cut schedule (1st cut – bud stage or the 1st ten-day period of June, 2nd cut – early to full bloom stage, generally before 31 July, 3rd cut – after 1 October) is very good for obtaining high yields and stand longevity, however it did not provide a presentable quality of forage in all the cases (Gaile, 2000). Foreign lucerne varieties are mainly used by Latvian farmers and, due to this, variety's winterhardiness (WH) is a trait with critical importance (Gaile, 2003). Traditionally fall dormancy (FD) score was used for predicting WH of a variety, but varieties with lower FD scores in fall are more dormant after cuts, too, and may have the disadvantage of lower yield potential. Nowadays possibility to use modern alfalfa varieties with high regrowth potential in spring and after cuts and sufficient WH provides a chance for choice of a more frequent cutting regime hence obtaining all the necessary characteristics – high yield, excellent quality of forage and long stand persistence.

The aim of the research was to compare impact of three different cutting regimes and ten varieties on the lucerne (*Medicago sp.*) productivity, forage quality, stand longevity and regrowth intensity in spring and after cuts.

Materials and Methods

Field experiments were carried out at the Research and Study farm 'Vecauce' of the Latvia University of Agriculture (LLU) (latitude: N 56° 28′, longitude: E 22° 53′) from 2000 to 2004 (lucerne was sown in 1999). Soil at the site was clay loam altered by cultivation with pH_{KCl} 6.3, containing available for plants P 198 mg kg^{-1}, K 224 mg kg^{-1} and with organic carbon content 15 g kg^{-1} of soil. Before sowing (1999), mineral fertilizers were given: 17.5 kg ha^{-1} of P and 33.2 kg ha^{-1} of K, but before the vegetative period started in the springs of usage years (2000–2004) – 34.9 kg ha^{-1} of P and 99.6 kg ha^{-1} of K. Ten lucerne varieties were used: seven varieties bred in North America (Table 1, Nos. 4–10), three varieties bred in the Baltic states (Skriveru – Latvia, Karlu – Estonia, Birute – Lithuania). The trial was arranged into 3 times replicated randomised blocks, plot size was 5 m^2. Cutting regimes were as follows: traditional three-cut schedule (1st cut – bud stage, June 5 and June 7 in 2004; 2nd cut – early to full bloom stage, July 24–25 depending on a year; 3rd cut – after October 1, October 1–2) – treatment 1; three-cut schedule using fixed time intervals (1st cut – May 25–June 1; 2nd cut – July 10; 3rd cut – August 20) – treatment 2; four-cut schedule using fixed time intervals – with 3 cuts mentioned above for treatment 2, and the 4th cut on October 10 – treatment 3. The yield was measured using direct accounting method: harvesting full plot and recasting per ha. Average yield samples per variety in amount of 0.5 kg were taken after harvest for yield quality analyses carried out in the Scientific Laboratory of Agronomy Research of LLU. Following quality analyses for every hybrid were carried out using standard methods: content of dry matter (DM) g kg^{-1} (Forage analyses met 2.2.1.1.), crude protein g kg^{-1} of DM (ISO 5983), NDF (Forage analyses met 2.2.1.1.) and ADF (Forage analyses met 4.1.), g kg^{-1} of DM, ash (ISO 5984), Ca (ISO 5490/2), P (ISO 6491), g kg^{-1} of DM (data are not presented). In addition, following observations were carried out during the vegetative period: regrowth intensity and dynamics in spring and after cuts, cm per 24 hours, measurements were taken on average after every 10 days; plant height in cm before the cuts; lodging resistance in points 1 to 5 (1 – without any lodging) before the cuts (data are not presented); stand density evaluated every year after the 1st cut visually in percent from that in the fall of establishment year; stand longevity measured by yield in specific years against the yield of first full harvest year. ANOVA procedures, correlation and regression analyses were used for processing the obtained experimental data.

Meteorological conditions were generally similar in all the wintering periods, but different – in vegetation periods. Conditions during vegetative seasons were registered by automatic PC-connected meteorological station Hardi-Metpole placed adjacent to the trial. The year 2000 was cool and wet, suitable for very high yield formation; 2001 – little warmer if compared with the meteorological norm in the region, and rainy; 2002 – atypically hot and very dry in August and September; 2003 – late, cool and dry spring, hot July and first part of August, and with mild temperatures and rainfalls in September; and 2004 – early, dry and cool spring followed by a cool and overly rich with precipitation summer, only August and September were warmer and less wet.

Results and Discussion

Results show that the best lucerne five years' average DM yield per season was obtained using treatment 1, i.e. traditional three-cut regime, where the cutting is organised mainly by stage of plant development ($p<0.01$; Table 1).

Table 1. Average five-year dry matter yield per season depending on variety characteristics and harvest regime, t ha^{-1}, 2000 to 2004

Variety – factor A	Harvest management – factor B			Average for A $\gamma_{0.05A} = 1.49$	FD (smaller value – marked dormancy)
	Treatment 1	Treatment 2	Treatment 3		
1. Skriveru	14.84	11.72	11.50	12.69	0.5
2. Karlu	15.56	11.82	12.33	13.24	0.5
3. Birute	17.62	16.60	17.08	17.10	1 … 2
4. Vernal	17.78	15.23	15.10	16.04	2
5. ABT – 205	18.53	17.78	17.53	17.94	2
6. WL-324	19.27	17.84	18.58	18.56	3
7. Spreador III	17.73	16.17	15.72	16.54	1
8. Alfagraze	18.25	15.34	15.35	16.31	2
9. DK – 121 HQ	16.32	15.20	16.09	15.87	2
10. Winterstar	18.85	16.76	16.16	17.26	2
Average for B $\gamma_{0.05B} = 0.77$	17.47	15.45	15.54	x	x

$\gamma_{0.05AB} = 2.58$.

This is in agreement with the findings of other researchers and our previous findings (Sheaffer *et al.*, 1988; Gaile, 2000). Comparing treatments 2 and 3, the four-cut schedule did not assure a substantial average DM yield increase. The DM yield was influenced substantially by both: the used variety as well as by cutting regime, but variety influence (41.23%) was more important than that of the chosen cutting regime (11.28%).

Two fall dormant varieties – Skriveru and Karlu – never provided a full 4th cut. On October 10, the plant height (PH) of these varieties in the four-cut nursery was 7–24 cm and 7–17 cm, respectively, depending on the year, and was very uneven within the specific year. The plant height of other 8 varieties was 23–44 cm and uniform within a specific year. Interconnection between the DM yield and PH can not be evaluated unambiguously. In some cases, tight positive correlation was found, in some cases – substantial, but week correlation, and in some cases – correlation was not found at all (Table 2). Data found in the literature confirms that PH not always correlated with the DM yield (Marinova *et al.*, 2004).

Table 2. Correlation between plant height (PH) before the cut and dry matter (DM) yield

Treatment	1st cut	2nd cut	3rd cut	4th cut
Treatment 1	0.050	0.223	0.537**	–
Treatment 2	0.904**	0.611**	0.429**	–
Treatment 3	0.887**	0.619**	0.363*	0.792**

** $p<0.01$; * $p<0.05$.

Very important for frequent lucerne cutting is its regrowth intensity in spring and after cuts. If the variety is very dormant, regrowth after cuts started with delay and it was not possible to obtain high DM yields during the short period between cuts as it was using treatments 2 and 3 where between 1st and 2nd cuts as well as between 2nd and 3rd cuts were only ~40 days. Two of Baltic local varieties ('Skrīveru' and 'Karlu') are characterized by very good winterhardiness.

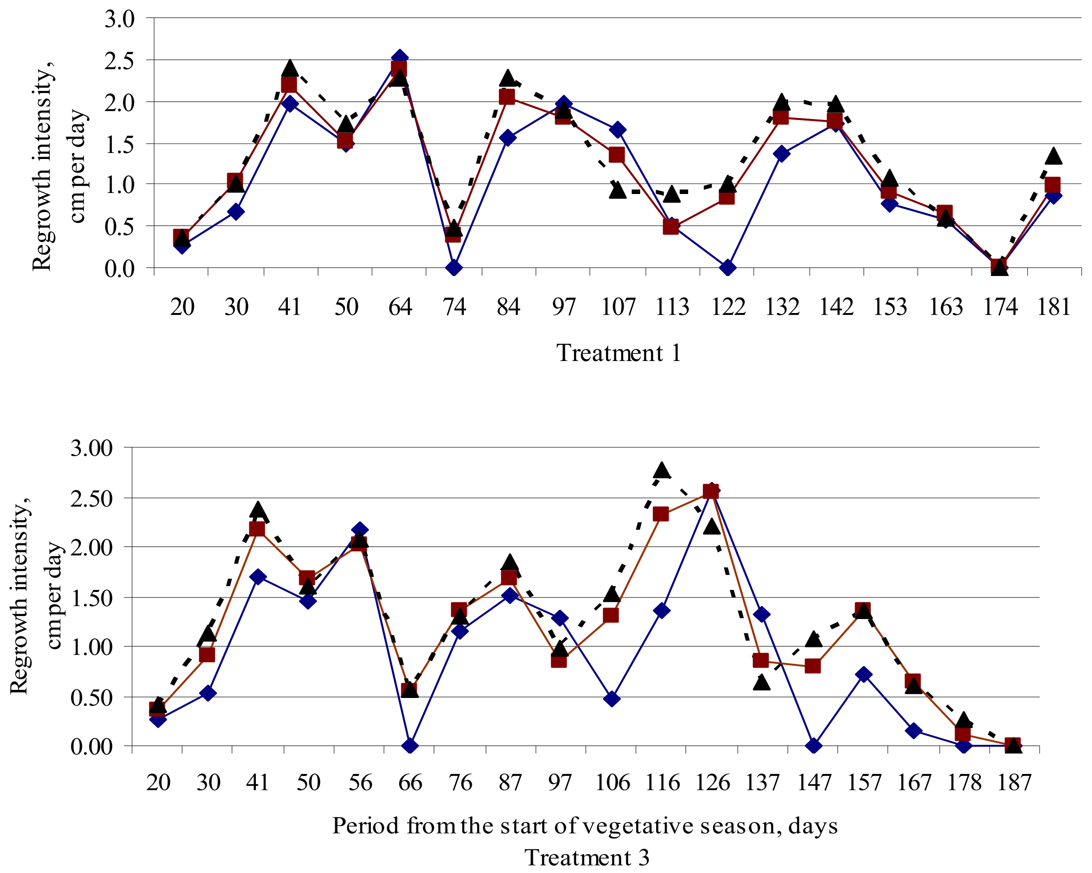

Figure 1. Changes of lucerne regrowth intensity in spring and after cuts per day depending on variety FD score and environmental conditions in 2002

FD= 0.5, on aver. FD =1-2, on aver. WL-324 (FD=3)

For treatment 1: 1st cut at 64th day, 2nd cut at 113th day and 3rd cut at 181st day from the start of vegetative season. For treatment 3: 1st cut at 56th day, 2nd cut at 97th day, 3rd cut at 137th and 4th cut at 187th day from the start of vegetative season.

However, for the mentioned two varieties, this trait is strongly related to low FD rating (Table 1) and, as said already before, these varieties never provided a full 4th cut. Regrowth intensity in spring and after cuts is substantially affected by the used variety ($p<0.05$).

Also a very important consideration is environmental effect on vegetative growth. Our previous findings from other trials showed that regrowth intensity of lucerne correlates with the average air temperature per period (Gaile and Kopmanis, 2001), which was approved by current research during 2000 to 2003 ($r = 0.442>r_{0.05}$). If cutting is done at fixed intervals, higher temperature provides better DM yield (Fick *et al.*, 1988) due to higher regrowth intensity during the period. As the best ocular-proof for the variety and air temperature influence on lucerne regrowth can serve the first 20 days after the cut. Performed measurements showed that sometimes due to low temperatures the regrowth score per first 10 days is zero, for instance, after the 2nd and 3rd cut in 2000 and after the 1st cut in 2001 for all the varieties, but dormant varieties could start to regrow only 10 or more days after the cut even at very good temperature conditions, for instance in 2002 (Fig. 1). Analyses of variance show a substantial effect ($p<0.05$) of both variety and environment on regrowth intensity of lucerne. Figure 1 illustrates both the variety as well as environment effect on regrowth intensity. For instance, two peaks in the middle of regrowth period before the 1st cut shows that regrowth intensity decreased due to the low air temperature. Figure 1 also shows that if the four-cut regime has been chosen for lucerne harvest, dormant varieties are far from suitability: after the 3rd cut regrowth is very weak if any. If we speak about varieties with higher FD ratings and a more intensive regrowth directly after the cut, meteorological conditions of a specific season could be the reason for choice of cutting regime, too.

Our results show that at average cutting frequency, DM yield decreases and forage quality increases, which is in conformity with the results of other scientists (Berardo *et al.*, 1994; Porqueddu *et al.*, 2003). The main interest of lucerne growers in Latvia is related to protein (CP). Treatments 2 and 3 appear more preferable, providing a similar and substantially higher CP concentration measured in g kg^{-1} of dry matter ($p<0.001$; Table 3) if compared with treatment 1.

Table 3. Average crude protein and NDF concentration depending on harvest regime and number of the cut, g kg^{-1}

Number of the cut	Harvest management and nutrition quality of lucerne					
	Crude protein, average from 2000 to 2004			NDF, average from 2000 to 2004		
	Treatment 1	Treatment 2	Treatment 3	Treatment 1	Treatment 2	Treatment 3
1st cut	201.46	220.31	221.51	416.03	382.61	375.86
2nd cut	189.08	202.68	200.05	482.91	435.29	430.67
3rd cut	183.65	202.62	202.52	436.41	443.41	449.35
4th cut	–	–	256.12	–	–	295.31

CP yield per ha per season depends mainly on DM yield per ha (De Falco *et al.*, 2003), and on CP concentration as well. On average during 4 experimental years, treatment 1 (3.379 t ha^{-1}) and treatment 3 (3.373 t ha^{-1}) showed almost the same CP yield, but treatment 2 (3.251 t ha^{-1}) – a substantially lower CP yield per ha ($\gamma_{0.05} = 0.05$). Lucerne DM yield remarkably decreased in the 5th year of usage if compared with the 4th year thus also affecting the CP yield per ha per season. However, the main conclusion remains the same – treatment 3 provided a similar CP yield per ha per season, but treatment 2 – a substantially lower CP yield per ha (Table 4).

The variety affected the average 5-year CP yield per season to a high degree – by 38%, and both, the best DM and CP yield per ha was obtained from WL-324, ABT-205, Birute and Winterstar plots (Tables 1 and 4). Digestibility and dry matter intake of forage is adversely related to ADF (acid detergent fibre) and NDF (neutral detergent fibre) concentration, respectively. NDF concentration was substantially higher ($p<0.05$) using treatment 1 in 1st and 2nd cut, though the difference is not proven statistically for the 3rd cut (Table 3). ADF concentration during the five years could not be evaluated unambiguously: in some years ADF concentration was substantially higher using treatment 1, but on average during the experimental period it was not statistically proven at the 95% confidence level. Responsible for these unexplained differences in lucerne quality could be environmental factors that vary from cut to cut, from season to season.

Table 4. Average five-year crude protein yield per season depending on variety characteristics and harvest regime, t ha^{-1}, 2000 to 2004

Variety – factor A	Harvest management – factor B			Average for A
	Treatment 1	Treatment 2	Treatment 3	$\gamma_{0.05A} = 0.265$
1. Skriveru	3.029	2.637	2.499	2.721
2.Karlu	3.205	2.653	2.708	2.855
3. Birute	3.419	3.422	3.598	3.479
4. Vernal	3.307	3.003	3.085	3.132
5. ABT – 205	3.475	3.584	3.667	3.575
6. WL-324	3.550	3.492	3.794	3.612
7. Spreador III	3.332	3.216	3.195	3.248
8. Alfagraze	3.479	3.139	3.176	3.265
9. DK – 121 HQ	3.145	3.120	3.413	3.226
10. Winterstar	3.568	3.412	3.416	3.465
Average for B; $\gamma_{0.05B} = 0.145$	3.351	3.168	3.255	x

$\gamma_{0.05AB} = 0.459$.

Longevity of lucerne stands could be affected by different aspects: suitability of a variety to specific conditions, soil characteristics, different stress conditions and cutting regime, including cutting height, frequency and critical rest period in the fall (Sheaffer *et al.*, 1988). During four years of usage, high DM yields were obtained and the stand density in 2003 was still above 75%. In the fifth year of usage, 2004, a remarkable stand density decrease was observed (on average by 25%), but it was similar for all three cutting regimes.

Variety effect was substantial ($p<0.01$). The average remainder stand density in 2004 was 53.3, 53.8 and 53.5% for used treatment, respectively. It is well known that severe reduction in plant population is possible before significant yield reduction occurs because decrease of plant population is often compensated for by an increased stem number and DM weight per plant (Sheaffer *et al.*, 1988). In the fifth year of usage (2004) in our experiment, a week correlation between total DM yield per season and stand density was already noted ($p = 0.05$). At the same time, obtained DM yield still was high (10.20 to 16.72 t ha^{-1} on average per variety) and achieved from 70.25 to 84.96% from that in the 1st year of usage (Table 5).

Table 5. Dry matter yield per season in 2004 if compared with that in 2000 depending on variety characteristics and harvest regime, %

Variety – factor A	Harvest management – factor B			Average for A
	Treatment 1	Treatment 2	Treatment 3	$\gamma_{0.05A} = 7.29$
1. Skriveru	64.71	72.53	73.51	70.25
2.Karlu	90.76	83.50	80.63	84.96
3. Birute	60.67	69.88	76.46	69.01
4. Vernal	77.48	67.72	66.16	70.45
5. ABT – 205	86.88	81.32	80.69	82.96
6. WL-324	86.19	76.59	78.64	80.47
7. Spreador III	78.63	69.51	67.55	71.89
8. Alfagraze	82.63	70.68	71.59	74.96
9. DK – 121 HQ	79.74	71.22	69.72	73.56
10. Winterstar	85.83	74.67	75.21	78.57
Average for B $\gamma_{0.05B} = 4.00$	79.35	73.76	74.02	x

$\gamma_{0.05AB} = 12.64$.

Our experiment has shown that in very good lucerne management conditions, including appropriate variety and soil selection as well as nutrition management, stand could be used up to five years even if the four-cut regime is used.

Conclusions

A significantly higher average dry matter yield was obtained using traditional three-cut harvest regime (treatment 1). Though, on the other hand, using treatment 3 for less dormant varieties (WL-324, ABT-205, Birute) it is possible to obtain similar yield if compared with treatment 1, but with better quality. Average effect of cutting regime on stand density decrease during the five years was insignificant. Even in the fifth year of usage, high DM yield per season was obtained using all three cutting regimes, but yield reduction was greater for treatments 2 and 3 if compared with the 1st year yield. Regrowth intensity in spring and after cuts was highly dependent on variety characteristics, and for the four-cut regime less dormant varieties starting to regrow directly after the cut should be used. Consequently, all three cutting regimes could be successfully used under Latvia's conditions with a prerequisite that peculiarities of a specific variety and season are taken into account.

References

1. Berardo, N., Gnocchi, G. *et al* (1994) The role of the cutting regime in the lucerne nutritive value improvement. Fibre and crude protein content. In: Proceedings of EUCARPIA Lucerne Section Meeting "Management and breeding of perennial lucerne for diversified purposes." – National Institute for Agricultural Research (INRA) Forage Plant Breeding Station, Lusignan, France, 135–138.
2. De Falco, E., Landi, G. *et al* (2003) Harvest management effects on Lucerne (*Medicago sativa* L.) forage production and quality in a hilly environment in southern Italy. In: Kirilov, A., Todorov, N., Katerov, I. (Eds.) Grassland science in Europe. Volume 8. Proceedings of the 12th Symposium of the European Grassland Federation, Pleven, Bulgaria, 348–351.
3. Fick, G. W., Holt, D.A. *et al* (1988) Environmental Physiology and Crop Growth. In: Hanson, A. A. (Ed.), Alfalfa and Alfalfa Improvement. ASA, CSSA, SSSA, Madison, Wisconsin, USA, 163–194.
4. Gaile, Z. (2000) Investigations of alfalfa performance and quality at Research and Study farm "Vecauce" (1993–1999). In: Bender, A. (Ed.) Proceedings of International Conference "Collaboration on Plant Breeding in the Baltic Sea Region, Jogeva Plant Breeding Institute, Estonia, 218–225.
5. Gaile, Z., Kopmanis, J. (2001) Performance and regrowth of alfalfa depending on agrometeorological conditions of season. In: Lapins, D. (Executive Ed.) Proceedings in Agronomy, Latvia University of Agriculture, Jelgava, Latvia, 191–195.
6. Gaile, Z. (2003) Evaluation of winterhardiness in lucerne in Latvian conditions using an accelerated test. In: Kirilov, A., Todorov, N., Katerov, I. (Eds.) Grassland science in Europe. Volume 8. Proceedings of the 12th Symposium of the European Grassland Federation, Pleven, Bulgaria, 365–368.
7. Marinova, D., Petkova, D., Yanheva, Ch. (2004) Influence of the multifoliolate trait on quantity and quality of lucerne (*M. sativa* L.) forage. In: Luscher, A. *et al* (Eds.) Grassland science in Europe. Volume 9. Proceedings of the 20th General Meeting of the European Grassland Federation, Lucern, Switzerland, 927–929.
8. Porqueddu, C., Parente, G., Elsaesse, M. Potential of grasslands. In: Kirilov, A., Todorov, N., Katerov, I. (Eds.) Grassland science in Europe. Volume 8. Proceedings of the 12th Symposium of the European Grassland Federation, Pleven, Bulgaria, 11–20.
9. Scheaffer, C. C., Lacefield, G. D., Marble, V. L. (1988) Cutting Schedules and Stands. In: Hanson, A. A. (Ed.), Alfalfa and Alfalfa Improvement. ASA, CSSA, SSSA, Madison, Wisconsin, USA, 411–437.