Agronomy Research **8** (Special Issue III), 711–720, 2010

Influence of cutting and management regimes on fodder galega for forage and seed production

J. Slepetys

Lithuanian Research Centre for Agriculture and Forestry, Institute of Agriculture, Instituto al. 1, Akademija, Kedainiai, LT-58344, Lithuania;
e-mail: jonas.slepetys@lzi.lt

Abstract. Field trials were designed to identify the most suitable time for the last cut and to ascertain whether it is possible to alleviate the consequences of improper timing of the cut by using the young and old sward under mixed management for forage and seed. Due to the autumn cut of the aftermath, a significant reduction in herbage dry matter yield and metabolizable energy was obtained in the first and second cuts in the following year. When autumn aftermath had been taken annually for four years, the productivity of the sward significantly declined when the cuts had been taken during the August 15 – October 15 period. The most unsuitable cutting time, when the greatest yield reduction occurred and the adverse effect of autumn aftermath cutting persisted longest, was found to be mid August – beginning of September. When the sward had been cut during the period middle August – beginning of September, a sharp, significant reduction occurred in the content of total and protein nitrogen, water-soluble carbohydrates and starch in roots. The greatest reduction in root mass in the 20 cm soil layer occurred in galega sward when it had been used for forage for four years. In the case of mixed management for forage and seed galega root mass was higher. When old sward of galega was used under mixed management for forage and seed, the negative effects of autumn aftermath cutting were alleviated or eliminated more rapidly.

Key words: *Galega orientalis*, forage production, last cut, seed yield

INTRODUCTION

Fodder galega is one of the less investigated perennial legume herbages. An interest in fodder galega has increase in Lithuania recently. Farmers are looking for new legumes characterized by longevity and high adaptability to growing conditions. As many as three new Lithuanian galega varieties 'Vidmantai', 'Laukiai' and 'Melsviai' have been registered in Lithuania over the recent years (Balezentiene, 2008). However, the Estonian galega variety 'Gale', which spread in Lithuania on a larger scale during the last three decades, still accounts for the largest production area. Although official statistics is not available, the collected data suggest that the total galega production area in Lithuania amounts to over 3 thousand hectares and tends to further increase. Galega production area in Estonia is much bigger – 5–6 thousand hectares (Raig et al., 2001a). Fodder galega is one of the longest-persisting plants in swards, notable for a high productivity without mineral fertilization (Virkajarvi & Varis, 1991; Adamovich, 2000). Attempts have been made to grow fodder galega on extensively used or

conserved soils, used-up quarries and in dug-off peat-bogs (Jankeviciene & Lukosevicius, 1999; Raig et al., 2001b; Slepetys, 2003). Fodder galega cultivation protects the soil from erosion and prevents the spread of weeds. Fodder galega can grow on a wide range of soils. It is important that ground water level is not high and soils are not acidic (Viil, 2001; Frame, 2005). According to soil requirements, fodder galega is very similar to lucerne. In Denmark, when cut in the first week of June, fodder galega had similar contents of crude protein and fibre. However, the forage lagged behind lucerne in organic matter and feed unit yield (Moller et al., 1997). Under more northern climatic conditions, research done in Estonia indicated that galega out yielded hybrid lucerne and persisted much longer in the sward. However, galega produced maximal yield very late, only in the 7^{th} –8^{th} years of use (Lillak & Laidna, 2000). Fodder galega has also some drawbacks, such as very slow development in the sowing year and in the first year of use, and sensitivity to frequent cutting or grazing (Parol & Viiralt, 2001).

Producers face many uncertainties concerning autumn aftermath cutting in swards. It is known that clover and especially lucerne are intolerant of early autumn cutting when they are still able to re-grow a little until the end of autumn vegetation. Re-growing grasses utilize nutrient reserves stored in roots. Due to this, plants exhibit poorer over-winter survival and perform worse after winter, which results in reduced sward productivity (Volenec, 1985; Barber et al., 1996; Halling, 1998). It was reported in Estonia, that if galega aftermath was cut at the end of August or beginning of September, a significant yield reduction occurred in the following year. Due to bad timing of the cut, galega developed much more slowly in the following year, the plants were shorter and produced fewer culms. In Estonia, it is recommended to cut galega late at the end of vegetation – in late September or in October. It has been warned about the bad consequences of galega cutting in August (Lillak & Laidna, 2000; Raig, 2001). The time of cutting should be undoubtedly linked to regional weather conditions. In Lithuania, compared with other legumes, research into fodder galega cultivation issues is scarce. According to the accepted clover and lucerne cultivation technology, September is inappropriate period for the last cut of legumes.

The objectives of the study were to identify the most suitable time for the last cut of galega and to ascertain whether it is possible to alleviate the consequences of improper timing of the cut by using the young and old sward under mixed management for forage and seed.

MATERIALS AND METHODS

During 2000–2006, two field experiments were carried out on a sod gleyic loam soil (Epicalcari-Endohypogleic Cambisol in the central part of Lithuania $55^{0}23'$ N, $23^{0}51'$ E). The soil contained on average 2.63% of humus, 0.17 of N, 104 mg $kg^{-1}$of P, 125 mg kg^{-1} of K, pH was 7.0. In 1990 and 1998 fodder galega (cv. ‘Gale’) was sown at a seed rate of 10 kg ha^{-1} and at row spacing of 23 cm with a cover crop of spring barley. Experiments were set up in the swards of the second year of use (young sward) and the tenth year of use (old sward). Field experiments were continued for six years in two fodder galega swards from the second to the seventh and from the tenth to fifteenth year of use. Fodder galega did not receive any fertilization, and no chemicals were

used. The experiment was designed as a randomized complete block with 4 replications and a plot size of 2.5 m × 8.0 m. When used for forage, fodder galega was cut three times per season. The last cut was taken at different times every two weeks: on August 15, August 30, September 15, September 30, October 15, and October 30. In the control treatment fodder galega was cut twice in summer, autumn aftermath was not moved. When the sward was used under mixed management, use for forage was alternated with harvesting for seed year by year. After-effect was monitored for the last two experimental years. In 2004, all galega plots were cut for forage (2 cuts, autumn aftermath was not moved), and in 2005, the galega plots were left for seed. The first cut of galega was taken at the beginning of mass flowering, end of May –beginning of June, and the second at the end of first ten-day period of July, mass bud formation/beginning of flowering stage. A direct combine harvested fodder galega seed after 80±5% of pods had matured. The seeds were dried, cleaned and analysed for quality. Seed yield data were adjusted to 100% purity and 13% of moisture content.

Samples for determination of dry matter (DM) content, botanical and chemical composition were taken from cut herbage mass in 4 replicates. The botanical composition (grasses, legumes, other herbs) was measured after separation as DM weight. For an assessment of forage quality, chemical analyses of dry matter were performed for crude protein, by determining the amount of nitrogen (Kjeldahl method) and multiplying by 6.25, crude fibre by the Hennerberg-Stohmann method, crude fat by the Rushkovski method, crude ash, by combustion and digestibility of the dry mater in *vitro* using the pepsin-cellulose method. The differences in metabolizable energy were calculated on the basis of the chemical composition of DM, using digestibility coefficients and full value coefficients. Root samples were taken in November after the last cut. Two (20x20x20cm) topsoil monoliths were dug per each experimental plot. The dug monoliths were washed, galega and herbs' roots were separated, dried at 60°C, weighed, and prepared for chemical analysis. Soluble carbohydrates were determined spectrophotometrcally by anthrone method, and starch by using automatic polarimeter ADP410. The experimental data were processed by analysis of variance, applying the software ANOVA.

Weather conditions during the experimental years were different. In 2000, the summer was rainy and cool, and the autumn was warm and dry. Vegetation of swards lasted for one month longer than usual. In 2001, summer was warmer than usual but normally rainy. In 2002, the rainfall rate during the growing season in Lithuania was by 48% and in 2003 by 31% lower than the long-term mean (420 mm). Air temperature was by 1–2°C higher than usual (long-term mean 12.2°C). In 2004, summer was warm and rainy, conducive to sward growth and development. In 2005, the vegetation period was warm and dry and favourable to galega seed ripening and harvesting.

RESULTS AND DISCUSSION

In the year of trial establishment, both swards of fodder galega, of the second and tenth years, contained few other plant species. Galega accounted for over 90% of the sward dry matter yield. Galega is a grass typically used for cutting, and the first cut produces the larger share of the total herbage yield. The first cut taken both in the old and the young sward accounted for 41.9–69.4% of the annual yield. Much less herbage

dry matter was obtained from the second cut – 16.0–25.7%. The third cut or autumn aftermath accounted for 8.2–33.6% The amount of autumn aftermath depended highly on weather conditions during the autumn period. In separate experimental years, dry matter yield of galega herbage of the third cut was very inconsistent and depended on weather conditions that occurred in the second half of summer and during the autumn season. The first two experimental years (2000 and 2001) were rainy, the other two (2002–2003) were dry. In the rainy years, the dry matter yield of the third cut of the old galega sward taken at the end of September amounted to 4.19 t ha^{-1} and was 60% higher than that of the young sward. However, in the drier years the herbage yield of both swards was low at the end of September (0.37–0.74 t ha^{-1}). The data averaged over the four years suggest that with a delay in the third cut timing from August 15 to the end of September, herbage dry matter yield increased from 0.74–0.91 t ha^{-1} to 1.43–2.00 t ha^{-1} (Table1). Metabolizable energy changed in proportion to the changes in fodder galega dry matter.

Table 1. Herbage yield and energy value of the third cut of galega. The data averaged over 4 years.

Date of the 3-rd cut	Sward of the 2nd–5th year of use			Sward of the 10th–13th year of use		
	Dry matter T ha^{-1}	Metabolizable energy		Dry matter T ha^{-1}	Metabolizable energy	
		GJ ha^{-1}	MJ kg^{-1}		GJ ha^{-1}	MJ kg^{-1}
15 August	0.74	7.55	10.23	0.91	9.42	10.39
30 August	1.06	10.23	9.86	1.69	16.20	9.62
15 September	1.39	13.58	9.62	1.95	19.33	9.99
30 September	1.43	13.66	9.75	2.00	19.61	9.82
15 October	1.26	12.02	9.58	1.72	16.12	9.49
30 October	1.21	11.44	9.60	1.77	16.51	9.63
$LSD_{0.05}$	0.30	2.72	0.35	0.55	5.17	0.35

When the cut was taken at the end of October, due to the shedding of leaves herbage yield declined and the quality of forage deteriorated (Table 2). A significant reduction in crude protein concentration occurred, the content of crude fibre increased in dry matter up to 328 g kg^{-1}. Averaged data indicate that *in vitro* dry matter digestibility of herbage of the third cut was low. This can be explained by the fact that galega herbage

Table 2. Dry matter quality indicators of galega herbage. The data averaged over 4 years.

Date of the 3-rd cut	Crude protein g kg^{-1}	Crude fibre G kg^{-1}	*In vitro* digestibility of dry matter %
15 August	189	302	63.0
30 August	166	302	60.0
15 September	163	311	58.6
30 September	157	313	58.6
15 October	150	316	57.2
30 October	143	328	54.6
$LSD_{0.05}$	18	28	5.3

had rather high content of fibre. Moreover, galega leaves turn brown due to frosts and part of the leaves are shed in autumn. In our research, at the last cut galega dry matterdigestibility declined by up to 54.6%. Compared with other legumes, poorer nutritive value of galega (higher fibre content) has been reported also by other researchers (Moller et al., 1997; Nissinen, 2000). However, galega herbage cut at budding stage contains more crude protein than that of red clover (Tuori et al., 2000; Frame, 2005).

In the first experimental year, two weeks after the last term of the third cut we determined water-soluble carbohydrate, starch, total and non-protein nitrogen contents in roots (Table3). When autumn aftermath was cut at different times, changes occurred in chemical composition of galega roots. Very important indicator showing plant preparedness for wintering is water-soluble carbohydrate content in roots. In the third cut taken at all terms a significant reduction in water-soluble carbohydrates in roots occurred. In autumn, while re-growing, galega utilized nutrient reserves. This was shown by significant reduction in starch and protein nitrogen content in roots, when aftermath was cut during the period from mid August to beginning of September, earlier cut galega re-grew more and utilized more nutrient reserves. The negative effects of autumn cutting on nutrient reserves in roots were also established for other legumes – lucerne and red clover (Halling, 1998; Barber, 1996).

Table 3. Chemical indicators of galega roots, (%) in dry matter. The sward of the second year of use, middle of Novemeber.

Date of the 3-rd cut	Water-soluble carbohydrates	Starch	Total N	Protein N
No cut	8.56	25.6	2.35	1.35
15 August	7.53	16.2	1.76	1.02
30 August	7.72	17.3	1.63	1.08
15 September	7.80	18.9	1.96	1.18
30 September	7.81	22.2	1.93	1.26
15 October	7.80	22.1	2.29	1.33
30 October	7.79	23.0	2.54	1.55
$LSD_{0.05}$	0.70	3.5	0.34	0.21

The swards of galega of the second year of use cut three times produced 6.51 t ha^{-1} DM, and that of the tenth year of use 11.28 t ha^{-1} DM. When the sward was cut twice, significantly less herbage was obtained compared with the sward cut three times. The next year due to the autumn aftermath cutting, a significant reduction occurred in dry matter yield of herbage obtained during the first and second cut. Due to the autumn cutting, in the old sward herbage yield of the first two cuts declined more (30–39%) than in the young sward (Table 4 and 5). Metabolizable energy and crude protein yield changed in proportion to the changes in fodder galega dry matter. Galega, which is cut at the end of August or at the beginning of September starts to re-grow again and as a result, the plants were worn out and were not capable to form rhizomes and also above ground organs (shoots). This causes an essential decrease in the yield of the following year, also inhibition of plant development (Raig et al., 2001). In our research, the marked negative effect of late cut (end of October) can be explained by long vegetation of galega, which in 2000 lasted until mid December. In 2001, seed yield declined when

Table 4. Annual dry matter yield of herbage (t ha^{-1}) and seed yield (kg ha^{-1}) of galega sward of the 2^{nd}–7^{th} year of use.

Date of 3-rd cut	2000	2001		2002		2003	2004	2005
	3f	**S**		**3f**	**2f**	**S**	**2f**	**S**
No cut	3.66	494			5.07	500	3.68	476
15 Aug	4.71	492		4.42	4.19	198	2.51	292
30 Aug	5.59	377		4.48	4.24	299	2.83	318
15 Sept	6.52	449		4.72	4.37	311	2.84	306
30 Sept	6.26	426		5.24	4.84	419	3.15	314
15 Oct	6.32	482		5.07	4.64	389	2.97	314
30 Oct	5.97	503		4.72	4.51	450	3.36	442
$LSD_{0.05}$	**0.67**	**63.7**		**0.46**	**0.47**	**70.2**	**0.39**	**46.0**
	3f	**3f**	**2f**	**3f**	**2f**	**3f**	**2f**	**S**
No cut	3.66	6.69	6.69	5.73	5.73	4.25	2.65	533
15 Aug	4.71	6.36	4.95	3.84	3.46	2.67	1.44	328
30 Aug	5.59	5.86	3.93	3.56	3.34	3.08	1.54	358
15 Sept	6.52	6.96	4.86	4.32	3.93	3.40	1.76	349
30 Sept	6.26	7.37	5.46	4.99	4.33	3.63	2.04	386
15 Oct	6.32	7.43	5.70	5.35	4.95	3.60	2.45	496
30 Oct	5.97	7.97	6.07	5.18	5.01	4.63	2.80	534
$LSD_{0.05}$	**0.67**	**0.42**	**0.34**	**0.51**	**0.53**	**0.47**	**0.30**	**53.5**

Table 5. Dry matter yield of herbage (t ha^{-1}) and seed yield (kg ha^{-1}) of galega sward of the 10^{th}–15^{th} year of use.

Date of 3-rd cut	2000	2001		2002		2003	2004	2005
	3f	**3f**	**2f**	**3f**	**2f**	**S**	**2f**	**S**
No cut	7.65	9.07	9.07	6.14	6.14	622	8.98	962
15 Aug	8.76	8.82	7.14	4.76	4.30	387	8.77	816
30 Aug	10.38	8.51	5.52	4.36	4.04	283	7.57	836
15 Sept	11.49	8.80	6.14	4.43	4.05	317	8.82	814
30 Sept	11.84	9.28	6.71	4.89	4.41	536	9.02	943
15 Oct	11.50	8.78	6.74	5.54	5.08	561	9.22	898
30 Oct	11.18	8.82	6.38	5.72	5.47	643	8.77	959
$LSD_{0.05}$	**0.95**	**0.77**	**0.70**	**0.61**	**0.59**	**113**	**0.51**	**101**
	3f	**S**		**3f**	**2f**	**S**	**2f**	**S**
No cut	7.65	586		6.09	6.09	843	8.25	627
15 Aug	8.76	783		5.53	5.07	539	8.03	667
30 Aug	10.38	456		6.21	5.67	553	8.01	647
15 Sept	11.49	539		5.82	5.38	684	7.85	672
30 Sept	11.84	604		7.04	6.20	737	8.42	638
15 Oct	11.50	732		6.31	5.62	786	8.33	664
30 Oct	11.18	769		6.16	5.70	808	7.91	714
$LSD_{0.05}$	**0.95**	**110**		**0.51**	**0.51**	**152**	**0.47**	**57.3**

F – sward used for forage; 2f – 2 cuts; 3f – 3 cuts; s – sward used for seed

autumn aftermath had been cut in the end of August and September in the young sward. In the old sward, seed yield declined only when the cut was taken at the end of

August. Late autumn aftermath cut even increased galega seed yield in the following year. This can be explained by high luxuriance of the old sward. Galega sward worsened by the autumn cut lodged less, and consequently produced a higher seed yield.

In the young sward, when autumn aftermath had been cut annually for four successive years, the sward productivity significantly declined when the cuts were taken during the period 15 August – 15 October. The herbage yield obtained per three cuts was significantly lower than that of two cuts. The extra yield of the third crop did not compensate the losses resulting from sward productivity reduction. When the sward was used under mixed management for forage and seed, the negative effect of the third cut persisted, but was weaker, especially in the old sward. When the young sward had been used under mixed management for five years, galega accounted for 69–80% of the sward. In the old sward, more than 72–85% of galega persisted. In the swards that had been used only for forage the content of galega was lower 58–79% (young sward) and 65–80% (old sward). The greatest damage to the sward was done when autumn aftermath was cut during the period from 15 August to beginning of September.

In the fifth experimental year autumn aftermath was not cut and herbage yield was determined from the two cuts in the young (6 years of use) and the old (14 years of use) galega swards. Here we monitored the effects of autumn aftermath cutting. Significantly lower herbage yield was obtained when galega autumn aftermath was taken during the period 15 August – 15 October. However, when galega had been left twice for seed production, dry matter yield, when cut twice increased by 1.03 t ha^{-1}. When cut three times, herbage yield was equal to that obtained in two cuts, or was slightly lower when galega had been cut for the last time at the end of October. In Estonia, the later cutting at the end of growing period in October had favourable effect on galega growth and the spring yield of the following year (Raig, 2001). However, the sward there was cut only twice and the effect of the last cut was compared when the cut was taken on September 12 and October 23. In our experiments in the old galega sward, herbage dry matter yields were nearly three times higher than those in the young sward. In the old swards, where galega was used under mixed management, leaving it every second year for seed, we did not establish any negative effect in the fifth experimental year. The old galega sward, when used under mixed management, produced rather stable yields and could be used as energy crop. When seed was harvested, about 4–7 t ha^{-1} of dry thrashing residues were left, which could be used for biofuel. The use of galega for biofuel was investigated in Estonia and Latvia and some promising results were obtained (Lillak et al., 2007; Adamovics et al., 2009).

In the sixth experimental year, galega swards were left for seed. The vegetation season was warm and dry and conducive to galega seed ripening and harvesting. Seed yield was very high. Autumn aftermath cutting (15 August – 15 October) significantly reduced the number of generative shoots, stem height and thickness, and the number of pods, but had lesser effect on seed quality indicators. In the young sward, even when applying mixed management for forage and seed the negative effect of autumn aftermath cutting persisted and the seed yield declined. When using the most luxuriant oldest sward for forage and seed (cutting it for forage every second year) the negative effect of autumn aftermath cutting disappeared.

As a result, it is expedient to cut younger galega crops twice and if due to more rational distribution of herbage, it is desired to cut the crop three times, the last cut should be taken at the end of October.

Autumn aftermath cutting of galega tended to reduce root weight (Table 6). Management method had some influence on the formation of root mass in the top 20 cm soil layer. The lowest content of roots (4.22–7.55 t ha^{-1}) accumulated in the sward used for five years where galega had been continuously used for forage.

Table 6. Root weight of galega and herbs t ha^{-1} in the 20 cm soil layer in the sward of the fifth year of use.

Date of 3-rd cut	Management method			
	For forage only		Mixed for forage and seed	
	Galega	Herbs	Galega	Herbs
No cut	7.28	1.47	8.84	0.75
15 August	4.25	3.27	5.67	1.51
30 August	4.21	2.10	7.88	1.52
15 September	5.79	1.64	6.58	1.22
30 September	4.82	2.31	7.98	0.89
15 October	5.53	0.60	9.71	0.97
30 October	7.55	0.27	8.81	0.95
$LSD_{0.05}$	**1.82**	**0.73**	**1.57**	**0.43**

The root content of herbs (*Taraxacum officinale*) prevailed was also the highest here by 0.27–3.27 t ha^{-1}. The highest content of roots of other grasses and the lowest content of galega roots was in the treatments where autumn aftermath was continuously cut on August 15 and 30. When the use for forage was alternated by use for seed, the topsoil contained more galega roots. The highest content of roots of other grasses was found in the treatments where autumn aftermath was cut during the period of August 15 to September 15. In the old sward used for 13 years, galega accumulated similar amount of roots (6.64–9.09 t ha^{-1}) to that in the younger sward. When alternating management methods, galega root mass did not decline significantly even when galega had been cut at the most unfavourable time – mid-August. The root weights of grasses were lower than those in younger galega swards. As a result, we can conclude that in the old galega sward with dense root system, it is difficult for other plants to get established.

The highest content of humus 2.80–3.01% accumulated in the old sward. In the young sward, which had been used under mixed management for forage and seed, humus content was higher (2.50–2.65%) than in the sward used for forage (2.28–2.34%). This shows that mixed management method determines root mass increase and due to death of part of roots during mineralization process organic matter turns into humus.

CONCLUSIONS

When autumn aftermath had been continuously cut every year, the productivity of galega significantly declined when the cut had been taken during the period August 15

– October 15. The herbage yield produced per three cuts was significantly lower compared with that produced per two cuts. The herbage yield of the third cut did not compensate the losses that occurred due to the reduction in sward productivity. Under mixed management of the sward for forage and seed, the negative effect of the third cut was not determined in the old sward, while in he younger sward this negative effect persisted but it was less severe. The highest reduction in the seed yield occurred when autumn aftermath had been cut during the period from August 15 to September 30. The most unsuitable cutting period, when the adverse effects of autumn aftermath cutting persisted the longest, was mid-August – beginning of September.

Having cut autumn aftermath, due to nutrient reserves used for re-growth, a reduction in total and protein nitrogen, water-soluble carbohydrates and starch occurred in galega roots. The greatest reduction occurred when galega had been cut during the period mid August – beginning of September. Galega root mass in the top 20 cm soil layer declined most in the young sward, when galega had been used for forage for four years. Under mixed management for forage and seed galega root mass was higher.

Fodder galega is very sensitive to autumn aftermath cutting. It is more expedient to use young galega swards for seed or cut only twice per season, and if autumn aftermath is needed, it should be taken in the middle or end of October, towards the end of the growing season, so that it does not re-grow. When the old sward of galega was used under mixed management for forage and seed the negative effects of autumn aftermath cutting were alleviated or eliminated more rapidly.

REFERENCES

Adamovics, A., Dubrovskis, V. & Plume, I. 2009. Biogas production from energy grasses. *Grassland Science in Europe*, Brno, **14,** 339–341.

Adamovich, A. 2000. Productive longevity of eastern galega (*Galega orientalis* Lam.)/grass sward. *Grassland Science in Europe*, Alborg, **5,** 100–103.

Balezentiene, L. 2008. Bio-morphological peculiarities of new cultivars of fodder galega (*Galega orientalis* Lam.). *Agronomijas Vestis*, **10,** 82–87.

Barber, L.D., Joern, B.C., Volenec, J.J. & Cunningham, S.N. 1996. Supplemental nitrogen effects on alfalfa regrowth and nitrogen mobilization from roots. *Crop Science*, **36**, 1217–1233.

Frame, J. 2005. Forage legumes for temperate grasslands. FAO, Science Publishers, INC, pp. 73–78.

Halling, M.A. 1988. Growth of timothy and red clover in relation to weather and time of autumn cutting. 2. Storage of carbohydrates in autumn and spring. *Swedish Journal of Agricultural Research*, **18**, 161–170.

Jankevicienė, D. & Lukosevius, L. 1999. Cultivation of fodder galega on a cultivated low peat. *Zemdirbyste –Agriculture* **68**, 161–167.

Lillak, R. & Laidna, T. 2000. Productivity of long-term forage legumes depending on growing conditions. *Sodininkystė ir daržininkystė*, Babtai, **19** (3) 2, 62–72.

Lillak, R., Meripold, H., Viil, P., Vosa, T., Laidna, T. & Kodis, I. 2007. Fodder galega (*Galega orientalis* Lam.) potential as a bioenergy crop. *Agronomy*, pp. 75–78.

Moller, E., Hostrup, S.B. & Boelt, B. 1997. Yield and quality of fodder galega (*Galega orientalis* Lam.) at different harvest managements compared with lucerne (*Medicago sativa* L.). *Acta Agricultural Scandinavica.* Soil and Plant Science. **47,** 89–97.

Nissinen, O., Hakkola, H., & Tuori, M. 2000. New forage legumes for cultivation in Finland. In: Viiralt, R., Lillak, R. & Michelson, M. (eds.). *Conventional and ecological grassland management.* Tartu, pp. 162–166.

Parol, A. & Viiralt, R. 2001. Grazing trials with fodder galega carried out in Estonian Agricultural University. In: Nommsalu, H. (ed.). *Fodder galega*, Saku, pp. 114–119.

Raig, H. 2001. Cutting time and frequency. In: Nommsalu, H. (ed.). *Fodder galega*, Saku, pp. 55–57.

Raig, H., Metlitskaja, J., Meripold, H. & Nommsalu, H. 2001a. The history of adaptation and introduction of fodder galega. In: Nommsalu, H. (ed.). *Fodder galega,* Saku, pp. 6–22.

Raig, H., Nommsalu, H., Meripold, H. & Metlitskaja, H. 2001b.The possibilities of using fodder galega in recultivating oil-shale open pits. In: Nommsalu, H. (ed.). *Fodder galega*, Saku, pp. 130–133.

Tuori, M., Syrjala–Qvist, L., Bertilsson, J. & Wilkins R. 2000. Milk production based on leguminous silage: Red clover and fodder galega in Finland. *Grassland Science in Europe*, Alborg, **5**, 356–358.

Slepetys, J. 2003. Longevity of fodder galega grovn for forage and seed on a low moor soil with a removed peat layer. *Zemdirbyste – Agriculture* **84** (4), 92–103.

Vill, P. 2001. The yielding ability of fodder galega on sod-calcareous and gley soils. In: Nommsalu, H. (ed.) *Fodder galega*, Saku, pp. 59–60.

Virkajarvi, P. & Varis, E. 1991. The effect of cutting times on goat's rue. (*Galega orientalis* Lam.) leys. *Journal of Agricultural Science in Finland*, **63**, 391–402.

Volenec, J.J. 1985. Leaf area expansion and shoot elongation of diverse alfalfa germplasm. *Crop Science*, **25**, 822–827.