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Fertilization impact on natural and sown grassland floristic improvement

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The possibilities and ways of improving well-composed sown sward and natural sward were investigated during 2004–2005 at the Research Station of the Lithuanian University of Agriculture. The aim of the study was to determine the impact of monomial N, P and K fertilizers, their combinations and rates on improving the floristic composition of well-composed sown fodder sward as well as on natural sward of a poor nutrient value not improved for more than 10 years.

Data on the floristic composition of sown and natural swards are presented. The share of legumes in sown swards decreased and the share of grasses increased in the 3rd year after sowing, irrespective of the fertilizing background. The increase of legumes in these swards was not determined by any treatment. The share of grasses increased from 4 to 14%. The share of legumes was by 4–12% higher on the P and K background versus other treatments in 2005. In the 3rd year after sowing, the percentage of legumes decreased sequentially with increasing N rates. The biggest share of legumes remained in treatments with P medium rates, while the K background supported legume persistence to a lesser extent. The impact of fertilizer background on floristic composition was similar both in natural swards and in sown ones.

Key words: sown sward, floristic composition, natural sward, grasses, legumes, dry matter

INTRODUCTION

Meadows are great producers of organic matter, O_2, play an important role as an anti–erosion factor and anti-migration buffer for spreading the alien plant species (Kadziulienė, Slepetiene, 2004; Peter et al., 2008). Grasslands occupy about 42% (892,500 ha in total) of the agricultural area in Lithuania and have an economical importance for the successful development of husbandry. Grasslands and rangelands occupy more than 1.2 M ha in Lithuania (Daugėlienė, 2002). Such grass areas are responsible for more than 150 M ha in Europe (De Vliegher et al., 2000). Their proper management is essential for maintening the high productivity of grasslands. Improvement of grasslands is possible in different ways: by sowing and re-sowing, fertilizing, etc. Therefore, not all swards used for forage have been sown; part of cultured grasslands are created by improving natural ones by agrotechnical means (fertilization, weed destruction) (Daugėlienė, 2004; Daugėlienė, Butkutė, 2004; Daugėlienė, 2005; Hofman et al., 2001; Gutauskas, Šlepetienė, 2002; Jouven, Baumont, 2008; Kadziulienė, Slepetiene, 2004; Kadžiulis et al., 1974; Kadžiulis, Kadžiulienė, 2000; Katutis, 2003; Vasiliauskienė et al., 1996). The main plants in swards are perennial grasses of different families. They differ both by morphological characteristics and ecological features as well as by their nutrient and economic value.

Grasses (*Poaceae*) are among the most common plants in the world (Hofman et al., 2001; Sendžikaitė, 2002; Vasiliauskienė et al., 2007). Grasses are usually more fertile than legumes, if they are grown in soils with a high level of groundwater or where the period of vegetation is rainier. Grasses are the most important source of carbohydrates in forage (Hofman et al., 2001; Gutauskas, Šlepetienė, 2004, Jouven, Baumont, 2008).

Families of legumes (*Fabaceae*) are among the most important components of grassland phytocoenoses. Red, white and hybrid clovers, simple bird's-foot trefoil, lucerne are generally grown for forage. All legumes are of good nutritional value. They contain 1.5–2 times more crude and digestible protein than do grasses, therefore forages composed of legumes do not lack protein. There are slightly more crude fat and crude ashes in legumes, as well as less fiber and non-nitrogen extract substances (Glinski et al., 2002; Skuodienė, 1999; Tekeli, Ates, 2005). That is why legumes grown together with grasses improve the chemical composition of forages.

One of the main factors to form productive rangelands is supplying soil with nutritional matters. The experience of many countries proves that the most reliable way to increase the fertility of rangelands is fertilizing them with mineral fertilizers. Their suitable rates and combinations affect the harvest of pasture swards as well as their chemical and botanical composition (Daugėlienė, 2004, 2005; Daugėlienė, Butkutė, 2004; Gutauskas, Šlepetienė, 2002, 2004; Kadžiulis et al., 1974; Vasiliauskienė et al., 1996).

Nitrogen is necessary for young growing and re-growing grasses. On improving plant nutrition with nitrogen, grasses develop a greater leaf surface, become dark green, prolong their vegetation period, their yield accumulates more protein (Daugėlienė, Butkutė, 2004; Gutauskas, Šlepetienė, 2004; Kadžiulis et al., 1974). The efficiency of nitrogen mostly depends on meteorological conditions, as well as on soil characteristics, level of active phosphorus, potassium and microelement fertilizers. Phosphorus has a great significance for the synthesis of carbohydrates and protein, it is a component of cell nucleus and many enzymes. Due to potassium action, the positive physical and chemical characteristics of the protoplasm are maintained. Besides, as potassium decreases evaporation, swards become more resistant to droughts and diseases. The efficiency of potassium fertilizers depends also on meteorological conditions, soil qualities, application of nitrogen and phosphorus fertilizers. The impact of these factors decreases as the amount of potassium in soil increases (Daugėlienė, Butkutė, 2004; Vasiliauskienė et al., 1996).

The objective of the present investigation was to determine the impact of nutritive elements, their rates and combinations on the botanical composition, productivity and longevity of productive nutrient swards. The results of this investigation were compared with the results of an analogous investigation of the natural, pure nutritional value of swards not commonly used on the farms.

MATERIALS AND METHODS

Setup works (natural sward selected, plots boundaries sprayed with 6.0 l ha^{-1} of Roundup) of field trials started in 2002 at the Research Station of the Lithuanian University of Agriculture, on the light deeply carbonaceous washed light loam soil (*Bathihypogleyi–Calc(ar)ic Luvisol*). The soil was neutral, pH_{KCl} 7.1, with moderate humus (2.5%), phosphorus-rich (P_2O_5 180–240 mg kg^{-1} soil) and with a moderate potassium level (K_2O 120–150 mg kg^{-1} soil).

Fertilizing trials started in 2003. To achieve the objectives of the investigation, two trials were carried out. A natural sward not fertilized for 17 years was chosen for investigation. At the beginning of May 2003 a 3 m wide stripe of sward was sprayed with 6.0 l ha^{-1} of Roundup. After plants in the sprayed fields had died off, with a sowing machine 'Multidril' a mixture of forage grasses was sown in (25 kg ha^{-1}). The composition of the sown mixture: *Trifolium pratense* 'Liepsna' 20%; *Trifolium repens* 'Atoliai' 20%; *Lolium perenne* 'Sodrė' 15%; *Phleum pratense* 'Gintaras' 15%; *Festuca pratensis* 'Dotnuvos 1' 20%; *Poa pratensis* 'Lanka' 10%. The composition of the natural sward: 67% of grasses, 14% of legumes, and 19% of forbs. 2004 was the 2nd and 2005 – the 3rd year of trials.

The fertilization scheme was designed of two blocks with 18 systematical treatments (1 – control, $N_0P_0K_0$; 2 – N_{60}; 3 – N_{120}; 4 – N_{180}; 5 – N_{240}; 6 – $N_{180}P_{120}$; 7 – P_{40}; 8 – P_{80}; 9 – P_{120}; 10 – P_{160}; 11 – $P_{120}K_{150}$; 12 – $N_{180}K_{150}$; 13 – K_{50};14 – K_{100}; 15 – K_{150}; 16 – K_{200}; 17 – $N_{60}P_{40}K_{50}$; 18 – $N_{180}P_{120}K_{150}$) with three replications each. The total plot size was chosen 10 m^{-2} (2.0 × 5.0 m) of natural and 6 m^2 (2 × 3 m) of sown swards.

Monomial fertilizers ammonium saltpeter with 34.4% of N concentration, granulated super phosphate (P_2O_5 19%), potassium chloride (K_2O 60%) were used. P and K fertilizers were applied in early spring and N fertilizers at the beginning of the vegetation period and after the first harvesting. Swards were harvested twice. The share of botanic groups of swards was determined by weighing and calculating their proportion in the total mass of every plot and used for calculating the average mean of each treatment. The botanical composition of a sward and the content of dry matter (DM) were determined in 2004–2005. The investigation is in progress.

The temperature and precipitation rate were normal for sward growth in 2004. July was relatively dry (45 mm) and August was damp (136.2 mm) in 2005. The weather temperature was close to the annual average.

The data analyses of variance were performed using the statistical package ANOVA. Standard deviation (SD) and least significant difference (LSD_{05}) were calculated using every plot data of each treatment.

RESULTS AND DISCUSSION

Amelioration of the natural sward. Grasses comprised on average 71% in the natural sward in 2004, and 72% of them remained after a year (Fig. 1). No significant changes were determined in grasses share of the sward structure applying N_{60} in the 2nd and 3rd years of investigation. Applying a double N rate, the share of grasses increased by 3 and 6% in 2004 and 2005, respectively, versus control. Increasing the rate of nitrogen up to 180 kg ha^{-1} resulted in an increased share of grasses by 3% and 8% in 2004 and 2005, respectively versus control. The greatest nitrogen rate (240 kg ha^{-1}) increased the share of grasses in the natural sward by 5% and 11% in 2004 and 2005, respectively. The $N_{180}P_{120}$ fertilization background resulted in the rise of grasses. Applying $N_{180}K_{150}$ increased the share of grasses by 1% and 5% respectively, in 2004 and 2005. Fertilization with nitrogen alone brought about increasing tendencies in the share of grasses in the natural sward composition, possibly because grasses use nitrogen fertilizers in a better way. Using phosphorus together with nitrogen also increased the share of grasses in the 3rd year, however, less in comparison with applying the high rates of nitrogen alone.

In the backgrounds containing phosphorus, the decreasing tendencies of legumes were observed. This was better visible in the 3rd than in the 2nd year of investigation. Potassium is an important nutrient matter for grasses. In a background where 200 kg ha^{-1} (the highest rate in this investigation) was used, in the third year of research a significant increase in legumes was achieved as compared with the control treatment. As the amounts of potassium were increased in different treatments, a slight increasing tendency in legumes was observed. The highest $N_{180}P_{120}K_{150}$ rates gave a statistically significant increase in legumes in the natural sward in 2005.

Table 1. **Impact of fertilization on the share of grasses, legumes and forbs in natural sward (mean ± SD, p < 0.05)**

Treatment	Grasses		Legumes		Forbs	
	2004	2005	2004	2005	2004	2005
Control	71	69	13	17	16	14
N_{60}	70	70	15	17	15	13
N_{120}	74	77	12	11	14	12
N_{180}	73	78	13	12	14	10
N_{240}	76	80	12	10	12	10
$N_{180}P_{120}$	76	76	15	15	9	9
P_{40}	73	70	15	12	12	18
P_{80}	70	65	15	17	15	18
P_{120}	72	65	16	20	12	15
P_{160}	68	60	18	20	14	20
$P_{120}K_{150}$	69	71	18	19	13	10
$N_{180}K_{150}$	72	74	15	14	13	12
K_{50}	67	68	10	15	23	17
K_{100}	68	71	14	20	18	9
K_{150}	73	72	11	19	16	9
K_{200}	71	79	11	18	18	3
$N_{60}P_{40}K_{50}$	72	74	12	14	16	12
$N_{180}P_{120}K_{150}$	72	80	13	13	15	7
LSD_{05} / R_{05}	3.78	3.49	0.87	0.72	0.83	0.57

Fertilization background had a greater effect on legumes than on grasses in the natural sward (Fig. 1). Forage should be composed at least of 40% of legumes for fully providing with protein (Hofman et al., 2001). The ratio of legumes was 13% (2004) and 17% (2005) in the treatment without fertilizers. A small N_{60} rate increased the share of legumes by 2% only in the 2nd year and did not have any impact in the 3rd year. A double N_{120} rate had a negative effect on legumes in the natural sward. This was demonstrated by data of both years. The N_{180} fertilizing background decreased the share of legumes by 5% only in the 3rd year and did not have any influence in the 2nd year. The greatest N_{240} kg ha^{-1} rate applied during the experiment decreased the share of legumes by 1% in the 2nd and by 10% in the 3rd year. Applying nitrogen fertilizers together with phosphorus increased the rate of legumes by 2% in the 2nd and decreased by 2% in the 3rd year.

The background of nitrogen and potassium ($N_{180}K_{150}$) had a similar influence, only in 2005 legumes decreased by 3% versus the control treatment. Phosphorus fertilizers showed a positive influence on legumes in the natural sward. As the rates of phosphorus fertilizers increased, legumes showed increasing tendencies both in the 2nd and the 3rd year. However, the same number of legumes was found after separate treatments had been fertilized with P_{120} and P_{160} in 2005. The background of $P_{120}K_{150}$ statistically significantly increased the quantities of legumes in 2004. A significant increase of legumes was also determined in the treatments fertilized with K_{100}, K_{150} and K_{200}. The share of legumes increased by 3%, 2% and 1%, respectively, in 2005. The share of legumes was closer to the control treatment and fluctuated less under NPK treatments.

Forbs are an inevitable part of every natural sward (Howman et al., 2001; Vasiliauskienė et al., 2007). Forbs ranged from 16% in the 2nd year and 14% in the 3rd year in the control treatment of natural sward.

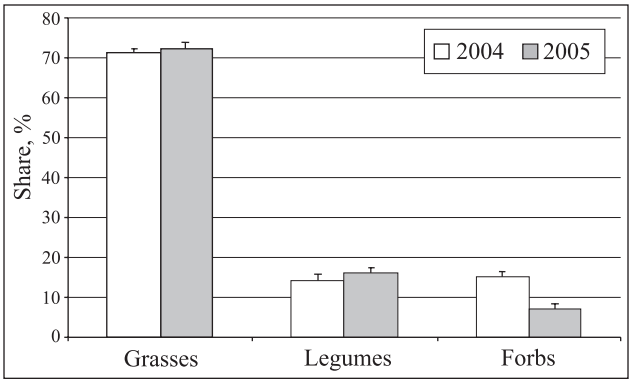

Fig. 1. Fluctuation of main floristic groups in natural swards in 2004–2005 (mean ± SD, p < 0.05)

The share of forbs decreased by 1% in a treatment with N_{60} versus control both in 2004 and 2005. The tendencies of forbs decrease remained with increasing the N rate to 120 kg ha^{-1}. The share of forbs decreased by 4% and by 2% under N_{180} kg in 2004–2005. Under the greatest rate (N_{240}) the share of forbs decreased also. The greatest P rates in this investigation significantly increased the quantity of forbs, especially in the 2nd year. According to references (Daugėlienė, Butkutė, 2004; Gutauskas, Šlepetienė, 2004) and the obtained data, the quantity of forbs decreased both in the 2nd and the 3rd year under PK treatments.

Amelioration of sown swards. According to the obtained data on the botanical composition of the sown sward in 2004, the ratio of grasses and legumes changed by 5–10% versus the composition of the natural mixture (Fig. 2). In agreement with Vasiliauskienė (2005), Daugėlienė (2002, 2004), an increase of grasses was observed in all treatments with N fertilizers. Legumes made 29–40% of the total composition of the sward in 2004. We observed in the 2nd year that legumes reacted negatively to the N background.

Table 2. **Impact of fertilization on the share of grasses, legumes and forbs in sown sward (p < 0.05)**

Treatment	Grasses		Legumes		Forbs	
	2004	2005	2004	2005	2004	2005
Control	58	65	35	27	7	8
N_{60}	62	66	33	22	5	12
N_{120}	63	76	33	19	4	5
N_{180}	67	73	30	14	3	13
N_{240}	68	85	29	10	3	5
$N_{180}P_{120}$	65	84	33	13	2	3
P_{40}	60	67	33	26	7	7
P_{80}	60	68	32	27	8	5
P_{120}	58	68	36	26	6	6
P_{160}	58	70	37	22	5	8
$P_{120}K_{150}$	59	69	37	22	4	9
$N_{180}K_{150}$	68	74	30	23	2	3
K_{50}	55	73	35	20	10	7
K_{100}	50	71	40	20	10	9
K_{150}	53	70	39	22	8	8
K_{200}	53	69	40	24	7	7
$N_{60}P_{40}K_{50}$	58	70	38	20	4	10
$N_{180}P_{120}K_{150}$	63	77	36	18	1	5
LSD_{05} / R_{05}	3.79	3.67	0.71	0.69	0.21	0.19

The share of legumes was by 6% and 17% lower than in the treatment with 240 kg ha^{-1} of N versus the control treatment ($N_0P_0K_0$) in 2004 and 2005, respectively. The background of P (from 120 kg ha^{-1}) and K influenced legumes in a positive way, and their share grew up. The rate legumes increased by 5% in treatments fertilized with K_{100} and K_{200} in the 2nd year after sowing versus the control treatment. On average, 1–5% of forbs were found in all treatments during the study period.

The botanical composition of the sown sward varied more in 2005 than in 2004. The share of grasses increased from 4% to 14% in all treatments. No increase in the share of legumes was observed in the 3rd year after sowing in any treatment, irrespectively of the fertilizing background. The increase in the share of grasses was found in treatments with a greater rate of N (treatment No. 5), as well as NP and NPK. The share of legumes decreased from 4% to 18% in different fertilizing backgrounds. The share of legumes remained by 5% to 12% higher in treatments with P and K backgrounds than in other treatments in 2005 (Tekeli, Ates, 2005). The least ratio (10% versus control) of legumes was determined in the treatment fertilized with the greatest rate of N_{240} in 2005.

Forbs accounted for 15% of the swards in 2004 (Fig. 1). The largest amounts of them were found in treatments fertilized with K_{50} and K_{100} (by 3% more than in the control treatment). Fertilization with phosphorus and potassium alone did not have any significant influence on forbs in 2004. The share of forbs decreased by 6% in treatments fertilized with NK, NP and NPK versus the control sward. Forbs were found increased in five treatments versus control in 2005. Treatments N_{180}, N_{60} and $N_{60}P_{40}K_{50}$ were especially indicative due to the increased amount of forbs as compared to both the control treatment and investigations of the 1st and the 2nd years.

The better botanical composition persisted in sown swards due to the larger share (17–18%) of legumes in natural (Fig. 2) and sown (Fig. 5) swards during 2004–2005.

The botanical composition of both test swards fluctuated differently during 2004–2005. The common tendencies of botanical changes showed that the natural swards of a purer composition improved their constitution in comparison with sown ones by

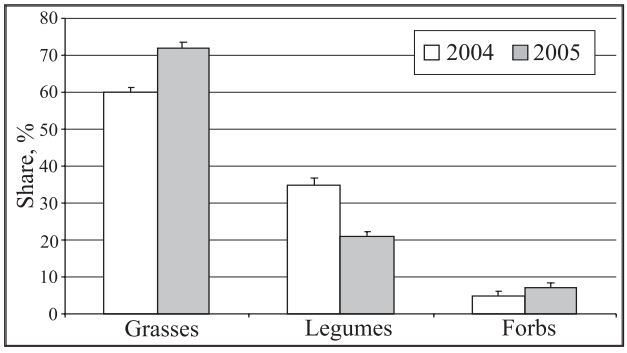

Fig. 2. Fluctuation of main floristic groups in sown swards during 2004–2005 (mean ± SD, $p < 0.05$)

reducing the share of grasses and increasing that of legumes by 1% and 2%, respectively. The share of grasses increased by 4% and the share of legumes decreased by 4%; consequently, the floristic composition of sown swards declined, contrary to changes in the natural swards during the study period.

Larger amounts of DM accumulated in sown swards than in natural ones, except for the treatment fertilized with the greatest rate of N_{2400} in 2005 (Fig. 3). The highest content of DM was observed in treatments fertilized with $N_{180}P_{120}K_{150}$ as well as in the treatment fertilized with the biggest rates of N or NP both in sown and in natural swards.

CONCLUSIONS

Different tendencies of floristic composition fluctuation were determined during 2004–2005 as well as under different ways of grassland management. Floristic composition was more stable in natural swards than in sown ones. Grasses comprised 71%, legumes 13%, forbs 16% on average in natural unfertilized extensive swards in 2004. The dynamics of legumes determined different accordingly swards and year. The decrease of legumes reached even 10% in sown swards, but legumes increased in natural swards in 2005. The share of forbs increased both in natural and sown swards in the 2nd year. Different fertilizers

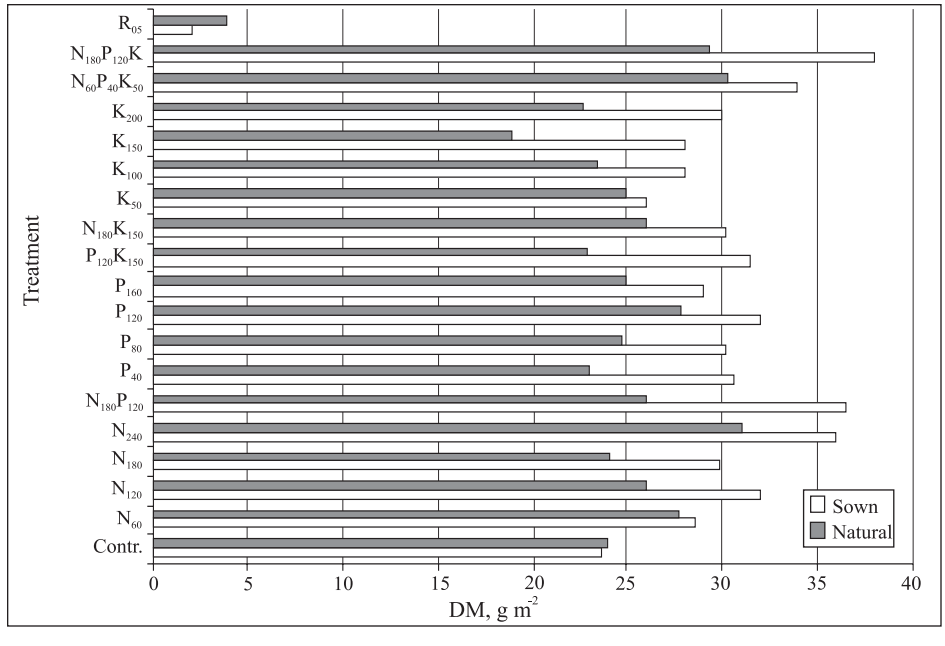

Fig. 3. DM (g m^{-2}) accumulation in different swards in 2005

have a different effect on floristic composition. Nitrogen fertilizers increased the share of grasses in the total yield by 6–12%; $N_{120–240}$ diminished the share of legumes. Phosphorus fertilizers increased the share of legumes, whereas the botanical composition of the sward varied insignificantly in combination with N and K. The most effective means for maintaining a suitable composition of a sown sward is balanced fertilization with NPK.

The tendencies of the botanical composition changes determined differences both test swards during 2004–2005. The natural swards have improved their constitution by reducing the share of grasses and increasing that of legumes. The composition of sown swards declined due to a decrease of legume share on average by 8% during the study period.

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TRĄŠŲ POVEIKIS NATŪRALAUS IR SĖTINIO ŽOLYNO FLORISTINĖS SUDĖTIES GERINIMUI

Santrauka

Tręšimo bandymas pradėtas 2003 m. Žolyno botaniniai ir sausosios medžiagos derliaus tyrimai atlikti 2004–2005 m. Lietuvos žemės ūkio universiteto Bandymų stotyje, giliai glėjiško karbonatinio išplautžemio lengvo priemolio dirvožemyje (*Bathihypogleyi–Calc(ar)ic Luvisol*). Dirvožemis neutralios reakcijos – pH_{HCl} 7,1, vidutinio humusingumo (2,5%), fosforingas (P_2O_5 180–240 mg kg^{-1} dirvos) ir vidutinio kalingumo (K_2O 120–150 mg kg^{-1} dirvos). Tirta vienanarių N, P, K trąšų, jų derinių ir normų įtaka pašariniam, geros botaninės sudėties sėtiniam žolynui ir natūraliam, daugiau nei 10 metų negerintam, menkos pašarinės vertės žolynui.

Gauti bandymų rezultatai parodė, jog trečiais metais po žolių mišinio sėjos, pastebėtas ankštinių sumažėjimas, o varpinių pagausėjimas, nepaisant tręšimo fono. Ankštinių pagausėjimo nenustatyta nei viename variante. Visuose tirtuose variantuose varpinių pagausėjo nuo 4 iki 14%, su P ir K fonu – ankštinių 2005 m. išliko nuo 4 iki 12% daugiau nei kituose variantuose. Didėjant N trąšų normai variantuose, trečiais metais po sėjos žolyne nuosekliai mažėjo ankštinių žolių. Daugiausia ankštinių išliko variantuose, vidutiniškai tręštuose P, mažiau ankštiniams išlikti padėjo K fonas. Natūraliame žolyne tręšimo fono įtaka botaninei sudėčiai turi panašias tendencijas kaip ir sėtiniame.

Raktažodžiai: sėtinis žolynas, botaninė sudėtis, natūralus žolynas, varpinės žolės, ankštinės žolės, sausosios medžiagos