Changes in the chemical composition of grass seed and stem during the period of ripening

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We investigated changes in the chemical composition in the seed and stems of five grass species occurring during ripening period. In the seed of *Poa pratensis, Festuca pratensis, Dactylis glomerata* the content of soluble carbohydrates, nonprotein nitrogen declined sharply, and the content of total and protein nitrogen and phosphorus was increasing until seed moisture declined to 45%. In the seed of *Lolium perenne* and *Phleum pratense,* similar changes occurred in these substances; however, due to uneven seed ripening it took a longer period for the seed moisture content to decline to 23%. The content of potassium in the seed of all grass species during the ripening stage consistently declined. Chemical composition of the seed ripened in swaths was similar to that of the direct-combined seed, when the seed moisture at harvesting had declined to 45%. However, the quality was better in seeds that ripened in swaths than in directly-combined seeds. In uncut stems and those laid in swaths the content of all study substances during the ripening period was on a steady decline due to their transport to seeds.

Key words: seed maturity, perennial grasses, chemical composition, seed moisture, seed quality

INTRODUCTION

In Lithuania, stands of perennial grasses occupied about 974 thousand hectares in the year 2000. This accounts for about 40% of the total crop area [1]. Grass species are predominant in swards. Renovation of swards requires large quantities of seed. The seed of grasses ripens unevenly, and when it ripens it shatters readily [2, 3]. Therefore, in order to minimise seed losses, it is necessary to harvest grasses as quickly as possible and to use various harvesting methods. However, a very premature cutting can incur heavy losses related to seed quality [4, 5]. Seed harvested very early is of low weight and low germination power. Such seed is not suitable for longer storage. It is very important to investigate the processes occurring during seed ripening period and to harvest the seed at the most suitable time. The development and growth of grasses starting from seed setting to complete ripeness is divided into three stages [6, 7]. During the first stage the seeds are developing and gaining weight fast. The seed moisture is about 75–80%. This stage continues from seed setting for 10–12 days. During the second stage, a rapid accumulation of dry matter in the seed and a gradual decline in moisture content to 40–45% occur. These processes take 10–14 days. During the third stage the dry matter content in seed no longer increases, however, a sharp decline in seed moisture content occurs. At the end of ripening, depending on relative air humidity, the seed moisture reaches 12–18%. The duration of this stage is very much dependent on grass species and the weather during the ripening period and varies from 6 to 18 days. The second and third seed development stages are very important to seed growers as they determine seed yield [6, 8]. The objective of our study was to investigate changes occurring in seed growth, seed and stem chemical composition during the seed ripening stage when harvesting seed by different methods.

MATERIALS AND METHODS

Four-year field trials were conducted in Dotnuva on a cultivated sod gleyic loam soil. Five main grasses of leys and cultivated pastures were involved: smooth-stalked meadow grass (*Poa pratensis* L.) cv. 'Danga', meadow fescue (*Festuca pratensis* Huds.) cv. 'Dotnuva I', cocksfoot (*Dactylis glomerata* L.) cv. 'Asta', perennial ryegrass (*Lolium perenne* L.) cv. 'Veja' and timothy (*Phleum pratense* L.) cv. 'Gintaras II'. Evaluation of seed ripeness was started on the 12–18th day from the start of the stand flowering and was continued every 2–4 days until the full ripeness of seed. Each time one part of the plot was threshed immediately after cutting, simulating direct combining. In the other part of the plot the cut grass was put in a thin swath, left for further seed ripening and threshed after 9–12 days. Here swath harvesting was simulated. Each harvesting datum was tested on 1 m^2 plots with 4 replications. The following data were established: seed moisture, 1000 seed weight of standard moisture, seed germination.

Samples for chemical analyses were taken four times: at a seed moisture of 55 ± 3%, 45 ± 3%, 23 ± 3% and 15 ± 3%. During the first three terms, analyses of seeds and stems harvested using direct and two-phase harvesting were done. Chemical analyses of low-growing grasses, smooth-stalked meadow grass and ryegrass, were done in the whole stem with leaves, analyses of timothy, cocksfoot and fescue involved the upper third of the stem. Soluble carbohydrates (mono-disaccharides) were determined by Bertran, total nitrogen by Kjeldhal, protein nitrogen by Barnstein, phosphorus by colorimetry methods, potassium was determined by flame photometry. Nonprotein nitrogen was calculated by deducing protein nitrogen from the total nitrogen. The data of chemical analyses are presented as per cent in dry matter.

RESULTS AND DISCUSSION

Changes in the chemical composition of seed and stems occurring during the ripening period in different years were similar, therefore we presented averaged three years' data. The highest content of soluble carbohydrates was determined at the first term of direct combining when seed moisture was about 55% (Table 1). After 4–12 days when grass seed moisture had declined to 45%, the content of soluble carbohydrates in smooth-stalked meadow grass seed declined 2.1-fold, in timothy seed 2.6 and in perennial ryegrass 4.1–4.2 times. This decline can be explained by the fact that soluble carbohydrates are used for starch synthesis and intensive respiration [4, 6, 9]. In

Table 1. **Content of soluble carbohydrates and phosphorus in seed and stems during ripening period, % in dry matter**

Grasses	Seed moisture, %							LSD_{05}
	55 ± 3		45 ± 3		23 ± 3		15 ± 3	
	D [x]	S [xx]	D	S	D	S	D	
	Soluble carbohydrates in seed							
Poa pratensis	4.31	1.94	2.05	1.23	1.44	1.06	1.21	1.46
Festuca pratensis	13.1	4.96	3.10	2.89	2.45	1.92	1.85	1.26
Dactylis glomerata	9.51	2.30	2.58	1.71	1.32	1.04	0.83	2.05
Lolium perenne	10.4	3.14	4.23	1.62	1.86	1.72	1.08	2.21
Phleum pratense	8.58	2.15	3.29	1.72	1.27	1.34	1.16	2.01
	Phosphorus in seed							
Poa pratensis	0.37	0.39	0.43	0.43	0.39	0.39	0.41	0.03
Festuca pratensis	0.27	0.35	0.41	0.41	0.43	0.43	0.42	0.05
Dactylis glomerata	0.31	0.40	0.47	0.49	0.45	0.46	0.44	0.04
Lolium perenne	0.28	0.35	0.33	0.35	0.39	0.37	0.37	0.05
Phleum pratense	0.34	0.48	0.45	0.45	0.44	0.45	0.46	0.03
	Phosphorus in stems							
Poa pratensis	0.13	0.13	0.14	0.14	0.11	0.12	0,11	0.03
Festuca pratensis	0.18	0.18	0.16	0.13	0.12	0.12	0.12	0.07
Dactylis glomerata	0.13	0.10	0.09	0.08	0.09	0.09	0.08	0.03
Lolium perenne	0.18	0.18	0.16	0.13	0.15	0.14	0.13	0.04
Phleum pratense	0.14	0.13	0.10	0.10	0.08	0.07	0.07	0.06
	Soluble carbohydrates in stems							
Poa pratensis	9.65	8.10	6.85	7.31	5.80	4.82	2.65	1.97
Festuca pratensis	15.5	9.00	7.54	5.87	3.58	2.79	2.51	4.14
Dactylis glomerata	8.28	2.23	1.51	0.82	0.50	0.42	0.18	1.54
Lolium perenne	21.2	17.4	14.1	11.4	10.2	7.15	7.58	3.64
Phleum pratense	9.48	4.61	6.95	5.78	2.91	2.14	1.28	2.33

[x] Direct harvesting.
[xx] Swath harvesting.

ripening seed of ryegrass and timothy, soluble carbohydrates further declined significantly until moisture content in seed declined from 45% to 23%. Reduction in the content of carbohydrates in the seed of other grasses during this period was already insignificant. A sharp reduction in the content of carbohydrates can be a reliable indicator to determine seed harvesting time [6]. When seeds contain a large amount of soluble carbohydrates they are not suitable for long-term storage: sugar is a good substrate for the propagation of pathogenic fungi [4]. In the seed harvested at the first time and ripened in swaths, the content of soluble carbohydrates was 2.3–4.1 times lower than in the direct-harvested seed. This difference declined at later harvesting terms and was insignificant. When the seed moisture was 45% and it was ripened in the swath, the content of soluble carbohydrates was similar to that in completely ripe seed harvested by direct combining.

All grasses, except cocksfoot, at all harvesting terms contained higher levels of carbohydrates in stems with leaves than in seed. The content of carbohydrates consistently declined along with seed ripening. Part of soluble carbohydrates are transported from stems into developing seeds, however the larger part of them is turned into fibre [4, 9, 10]. Only the stems lying in swaths harvested at the first term, except smooth-stalked meadow grass which had a significantly lower content of soluble than direct-combined carbohydrates. Apparently, until the seed still grows intensively, part of carbohydrates even from cut stems gets into seed.

The content of total nitrogen in seed increased by 9–33% and protein nitrogen by 24–58%, while

Table 2. **Contents of total protein and nonprotein nitrogen in seed and stems during ripening, % in dry matter**

Grasses	Seed moisture, %							LSD_{05}
	55 ± 3		45 ± 3		23 ± 3		15 ± 3	
	D [x]	S [xx]	D	S	D	S	D	
	Total nitrogen in seed							
Poa pratensis	2.13	2.35	2.54	2.48	2.52	2.54	2.39	0.19
Festuca pratensis	1.75	2.12	2.18	2.21	2.19	2.19	2.26	0.16
Dactylis glomerata	2.09	2.61	2.78	2.82	2.90	2.80	2.93	0.20
Lolium perenne	1.63	1.94	1.78	1.97	1.95	2.01	1.99	0.19
Phleum pratense	1.97	2.93	2.61	2.69	2.84	2.83	2.88	0.16
	Protein nitrogen in seed							
Poa pratensis	1.78	2.09	2.32	2.32	2.30	2.27	2.22	0.17
Festuca pratensis	1.36	1.78	1.91	2.04	2.01	2.02	2.06	0.19
Dactylis glomerata	1.58	1.27	2.49	2.58	2.68	2.55	2.77	0.17
Lolium perenne	1.28	1.70	1.59	1.80	1.70	1.84	1.81	0.18
Phleum pratense	1.62	2.68	2.47	2.60	2.70	2.71	2.76	0.18
	Nonprotein nitrogen in seed							
Poa pratensis	0.35	0.26	0.22	0.16	0.22	0.28	0.18	0.07
Festuca pratensis	0.39	0.33	0.27	0.17	0.18	0.17	0.19	0.14
Dactylis glomerata	0.51	0.35	0.29	0.25	0.22	0.25	0.17	0.15
Lolium perenne	0.36	0.23	0.19	0.17	0.24	0.17	0.18	0.17
Phleum pratense	0.36	0.24	0.14	0.09	0.14	0.12	0.12	0.08
	Total nitrogen in stems							
Poa pratensis	0.63	0.57	0.59	0.61	0.51	0.55	0.42	0.13
Festuca pratensis	0.81	0.70	0.61	0.53	0.45	0.47	0.44	0.17
Dactylis glomerata	0.96	0.91	0.67	0.69	0.67	0.66	0.57	0.13
Lolium perenne	0.60	0.54	0.67	0.58	0.55	0.64	0.49	0.11
Phleum pratense	0.81	0.70	0.74	0.66	0.56	0.55	0.52	0.11
	Protein nitrogen in stems							
Poa pratensis	0.46	0.47	0.42	0.44	0.39	0.39	0.34	0.07
Festuca pratensis	0.69	0.54	0.41	0.43	0.34	0.37	0.36	0.13
Dactylis glomerata	0.82	0.74	0.44	0.49	0.52	0.51	0.47	0.11
Lolium perenne	0.49	0.44	0.45	0.42	0.42	0.46	0.41	0.08
Phleum pratense	0.71	0.55	0.63	0.56	0.45	0.44	0.44	0.13

[x] Direct harvesting.
[xx] Swath harvesting.

the seed moisture declined from 55 to 45% (Table 2). At a seed moisture 45% smooth-stalked meadow grass, fescue and cocksfoot seed contained the highest levels of total and protein nitrogen. With further seed ripening the content of these substances tended to increase, however insignificantly. In timothy and ryegrass seed the highest content accumulated later when the seed moisture was 23%. In the seed harvested at the first harvesting term and ripened in swaths, the content of total nitrogen increased by 10–49%, of protein nitrogen by 17–65% as compared with direct-harvested seed. At the other harvesting terms these differences were insignificant, except the seed of perennial ryegrass.

During the ripening period, the content of total and protein nitrogen in stems declined. Significant differences were obtained only between the earliest and the last harvesting periods. Reduction of nitrogen in stems and an increase in protein nitrogen in seed can be explained by transport of nitrogen compounds into seed and their utilisation for protein synthesis [4, 7, 11]. This is confirmed by a reduction of nonprotein nitrogen content in seed.

Phosphorus content in seed increased sharply in line with the reduction in seed moisture to 45%. During further seed ripening, phosphorus content changed inconsiderably. A consistent reduction was observed in stems.

The highest content of potassium accumulated in seed when seed moisture declined to 45%. During further ripening of seed the potassium content in them declined significantly. This can be explained by a relatively faster accumulation of carbohydrates in the seed and a possible leaching of potassium [6, 10]. This is also confirmed by a trend showing that in the seed ripened in swaths there was a lower content of potassium than in the direct-harvested seed. The stems that were laid in swaths also had a lower content of potassium.

Seed development and suitability for sowing is best demonstrated by 1000 seed weight and germination (Table 3). Thus 1000 seed weight data show that intensive accumulation of organic and mineral substances occurred until before ripening of grass seeds, until the seed moisture declined to 45%. When the seed is ripened longer, its weight increase is not high. Seed ripened in swaths are of a significantly higher weight and germination capacity as compared with direct-harvested seed, when the cut is taken at milk ripeness stage, at a seed moisture content of over 45%. Therefore it can be concluded that when early cutting into swaths is used, it is possible to start seed harvesting earlier and to obtain high quality seed.

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Table 3. **Variation in 1000 seed weight and germination during ripening period**

Grasses	Seed moisture, %							LSD_{05}
	55 ± 3		45 ± 3		23 ± 3		15 ± 3	
	D [x]	S [xx]	D	S	D	S	D	
	1000 seed weight, g							
Poa pratensis	0.28	0.30	0.37	0.38	0.38	0.39	0.39	0.01
Festuca pratensis	1.26	1.47	2.02	2.03	2.17	2.14	2.18	0.04
Dactylis glomerata	0.71	0.79	1.05	1.05	1.16	1.14	1.15	0.02
Lolium perenne	1.44	1.65	1.92	1.99	2.15	2.17	2.15	0.04
Phleum pratense	0.30	0.34	0.40	0.39	0.47	0.47	0.47	0.01
	Germination, %							
Poa pratensis	22	55	57	76	80	84	81	3.0
Festuca pratensis	47	86	93	93	95	93	95	2.0
Dactylis glomerata	35	75	75	87	91	93	94	3.0
Lolium perenne	67	81	87	97	95	97	97	2.0
Phleum pratense	24	84	76	84	97	95	96	2.0

[x] Direct harvesting.
[xx] Swath harvesting.

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VARPINIŲ ŽOLIŲ SĖKLŲ IR STIEBŲ CHEMINĖS SUDĖTIES POKYČIAI BRENDIMO METU

S a n t r a u k a

Ištirti cheminės sudėties pokyčiai brendimo metu penkių varpinių žolių sėklose ir stiebuose. Pievinės miglės, tikrojo eraičino, paprastosios šunažolės sėklose tirpių angliavandenių, nebaltyminio azoto kiekis staigiai mažėjo, o bendrojo ir baltyminio azoto ir fosforo kiekis didėjo tol, kol sėklų drėgnumas sumažėjo iki 45%. Daugiametės svidrės ir pašarinių motiejukų sėklose šių medžiagų pokyčiai vyko panašiai, tačiau dėl nevienodo sėklų brendimo užtruko ilgiau, kol sėklų drėgnumas sumažėjo iki 23%. Kalio kiekis visų žolių sėklose brendimo metu nuosekliai mažėjo. Sėklų, brendusių pradalgėse, cheminė sudėtis buvo panaši, kaip ir sėklų tiesiogiai nuimtų, kai sėklų drėgnumas pjovimo metu buvo sumažėjęs iki 45%. Tačiau pradalgėse brendusios sėklos kokybės rodikliai buvo geresni negu tiesiog iškultų sėklų. Nenupjautuose ir paguldytuose į pradalges stiebuose visų tirtų medžiagų kiekiai brendimo metu nuosekliai mažėjo dėl jų pernešimo į sėklas.