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Estonian natural lucerne populations: yield ability and quality

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Abstract. With seeds collected in 2001–2002 from semi natural grasslands of Estonia, plot trials were established in 2003 in order to determine the ability of lucerne populations, their suitability for breeding purposes and prospective ways of use. In the sum of dry matter yields of the sowing year and three years of use, one natural population (Reigi) exceeded the standard variety by 6.0%, but in the crude protein yield it was within the experimental error inferior to the standard. From plant breeding perspective this population is of interest. However, it must be checked whether the location where seeds were collected was not a former sowing place of some existing foreign variety. The rest of the tested populations can be divided into two groups based on their growth rhythm and dry matter yield: 1) with modest regrowth, predominantly yellow-flowered forms of Medicago falcata L. type spreading by rhizomes deserve attention as initial material for breeding of specific varieties for landscape management. Particular longevity of the variety and low management costs are highly valued, but the biochemical composition of the yield (dry matter and crude protein yields account for 48.0–55.7% and 49.6–59.2% respectively, compared to the standard variety) is of minor importance, 2) yellow- and multicolour-flowered populations of M. media Pers., which dry matter and crude protein yields ranged between 65.8–92.0% and 64.5–86.2% respectively, in comparison with standard variety. The seeds of these populations can successfully be used for improvement of semi-natural grasslands on drought-sensitive light soils with neutral or alkaline reaction that are suitable for lucerne growth. Their advantage is winter hardiness, grazing resistance and longevity, and that is worth of considering while choosing initial material for breeding.

Key words: natural lucerne population, dry matter yield, crude protein yield, yield dynamics

INTRODUCTION

Despite of great progress in the field of genetics and the triumph of new breeding methods, plant breeders' interest in naturally growing species and populations has not disappeared in the last decades. In some cases the interest has increased instead. In case of lucerne, the reason has been considered to be the necessity to pay attention to grassland swards yield quality, species richness, longevity; grazing, winter, disease and pest resistance in breeding work (Smith & Kretschmer, 1989; Gau et al., 2000; Funtova, 2000; Zhuchenko, 2000; Pecetti et al., 2004). Natural lucerne populations possess special importance as herbage yield and quality securers in semi-natural grasslands. This is of special relevance in the context of rapid rise in energy and fertilizer prices (Maiorana et al., 2005). Natural lucerne populations are important in organic farming, where they are irreplaceable for improving yield, yield quality and edibility of semi-natural grasslands (and cultural grasslands) (Isselstein et al., 2005).

Natural lucerne populations have been investigated thoroughly in European states in last decades, most thoroughly in Italy. Some natural populations are used successfully in the local forage production in Italy, some of them are seen as initial material for future breeding (Torricelli et al., 2003).

Estonia is situated on the northern border of the area where it is economically profitable to cultivate *M. media* Pers. and *M. falcata* L. These species were introduced and used as cultivated crops approximately 150 years ago. Over the years more resistant imported lucerne populations have acclimatized and naturalized in Estonia and formed semi-natural grasslands of lucerne-red fescue (*Medicagini-Festucetum rubrae*) association. According to the latest inventory that was performed in 1978–1981, the mentioned above association was spread on 185 ha in North- and West-Estonia (Aug & Kokk, 1983). In some of the habitations lucerne has been growing continuously for more than 100 years.

Natural lucerne populations have been object of interest for breeders' ca 60 years in Estonia (Bender, 2007). One natural lucerne population ('Saaremaa kohalik') has been in use for forage production as a landrace, and in 1969–1992 it was included in the Estonian Variety List. One natural lucerne population (of Lithuanian origin) has been one of the parental components for the breeding of grazing resistant lucerne Juurlu (Bender et al., 2000).

In addition to forage production, natural lucerne populations could find more use in re-cultivation of the oil shale opencast-mine quarries (Leedu, 1998) and for plant cover in oil shale based recrements of the chemical industry in Estonia (Raave, 2005). Their perspective area of use could be in road building where they are capable, thanks to vigorous deep root system, of covering sandy-gravelly waysides, ditch shores and dug-through hillsides, while remaining green throughout summer.

The aim of the present research was to determine the yield ability and herbage quality of natural lucerne populations in unexplored habitats, to estimate their breeding value and the prospective uses. The wider aim was to make a contribution to the program of expansion and popularization of lucerne as a genetic resource in Europe (Meglič et al., 2003).

MATERIALS AND METHODS

In 2001 and 2002 expeditions were organised to the regions of natural lucerne populations during which seeds were collected in amounts that enabled to establish a plot trial in July 2003 in order to study the ability of 15 populations. The trial was established on black fallow without a cover crop in four replications. The trial was laid on calcaric cambisol (K_0) soil with pH_{KCl} 6.2, humus concentration 2.1%, total nitrogen (N) 0.13%, P 230, K 229, Ca 1550 and Mg 77 mg kg^{-1}. Prior to the establishment and in the autumns of harvest years mineral fertilizers were applied at the rates of P 19 and K 67 kg ha^{-1}. The yield was determined in the year of sowing in one cut, in harvest years in three cuts. To estimate the quality of yield, the protein content in dry matter, the ratio of leaves and stems and the protein content of fractions were determined. As comparison the *M. media* Pers. varieties Jõgeva 118 (hay type, the standard), Karlu (rhizomatous, pasture type) and Juurlu (creeping-rooted, pasture type), all bred in Estonia, were used. The variety Juurlu has been bred by selections from a natural

population growing on the territory of Lithuania. Populations collected from the Estonian nature have been named after the place of gathering (Table 1). Statistical analyses were performed using the programme Agrobase 20.

RESULTS AND DISCUSSION

The varieties of *M. media* Pers. used in the trial gave in the sum of trial years almost equal dry matter and crude protein yields (Table 1, 2). The variety Karlu exceeded within the experimental error the standard variety in yield, the variety Juurlu was inferior to the standard in the yield. Similar trial results have been obtained with these varieties also earlier (Bender et al., 2000). The dry matter yields by cuts were also similar: the first cut yielded 55.5–57.1%, the second cut 28.1–30.1% and the third cut 11.2–12.5% of the annual yield.

Table 1. Dry matter yields of lucerne, t ha^{-1}.

Variety or natural population	Latitude	Longitude	2003	2004	2005	2006	Total 2003–2006	%
Jõgeva 118			1.65	15.10	12.48	12.44	41.67	100.0
Karlu			1.83	16.50	11.74	12.47	42.54	102.1
Juurlu			1.67	15.49	12.10	11.19	40.45	97.1
Reigi	58° 59' 00"	22° 30' 42"	2.55	14.86	14.50	12.27	44.18	106.0
Pühalepa	58° 52' 28"	22° 57' 28"	1.47	14.07	12.24	10.54	38.32	92.0
Sutlepa	59° 03' 47"	23° 36' 02"	1.36	13.60	11.10	11.65	37.71	90.5
Hanila	58° 37' 10"	23° 37' 43"	1.53	13.42	10.70	10.87	36.52	87.6
Orjaku	58° 48' 07"	22° 47' 09"	1.25	12.83	10.77	10.12	34.97	83.9
Saxby	59° 01' 11"	23° 08' 44"	1.20	10.67	11.37	10.62	33.86	81.3
Fällena	59° 01' 42"	23° 10' 19"	0.55	12.88	10.23	9.57	33.23	79.7
Hullo	58° 58' 49"	23° 15' 24"	0.43	11.19	10.85	10.58	33.05	79.3
Kersleti	59° 01' 24"	23° 08' 40"	1.33	10.85	10.55	9.99	32.72	78.5
Kärdla	58° 59' 27"	22° 46' 08"	0.47	12.16	9.99	9.81	32.43	77.8
Purtse	59° 24' 33"	27° 03' 03"	0.30	11.05	9.33	8.31	28.99	69.6
Kassari	58° 47' 28"	22° 50' 10"	0.50	9.13	9.03	8.77	27.43	65.8
Lasnamäe	59° 26' 57"	24° 48' 51"	0	8.08	7.47	7.64	23.19	55.7
Ridala	58° 54' 46"	23° 28' 02"	0	7.45	6.73	7.45	21.63	51.9
Padaorg	59° 26' 02"	26° 42' 45"	0	6.55	6.56	6.89	20.00	48.0
$LSD_{0,05}$			0.20	0.81	0.85	0.57	1.72	

Among natural populations population (Reigi) exceeded significantly the standard variety in the total dry matter yield of the trial years, but not in the total crude protein yield. The population had fast initial development in the year of sowing and good growth of aftermath in the second half of summer – dry matter yields were respectively by cuts 46.5, 33.3, and 14.5%. The analysis results of the yield structure indicated that the share of stems in the second and third cut of this population was higher than of the standard variety, but the crude protein content of leaves and stems was lower than the standard variety in all cuts (0.8–2.6% and 1.7–2.9% respectively) (Table 3).

Table 2. Crude protein yields of lucerne, kg ha^{-1}.

Variety or natural population	Latitude	Longitude	2003	2004	2005	2006	Total 2003–2006	%
Jõgeva 118			412	3008	2608	2762	8790	100.0
Karlu			451	3218	2413	2801	8883	101.1
Juurlu			436	2990	2473	2478	8377	95.3
Reigi	58° 59' 00"	22° 30' 42"	631	2839	2591	2526	8587	97.7
Sutlepa	59° 03' 47"	23° 36' 02"	261	2808	2145	2359	7573	86.2
Pühalepa	58° 52' 28"	22° 57' 28"	373	2590	2408	2179	7550	85.9
Hanila	58° 37' 10"	23° 37' 43"	370	2550	2129	2370	7419	84.4
Fällena	59° 01' 42"	23° 10' 19"	147	2858	2198	2019	7222	82.2
Orjaku	58° 48' 07"	22° 47' 09"	326	2604	2002	2156	7088	80.6
Kersleti	59° 01' 24"	23° 08' 40"	90	2239	2256	2160	6745	76.7
Hullo	58° 58' 49"	23° 15' 24"	114	2125	2108	2271	6618	75.3
Kärdla	58° 59' 27"	22° 46' 08"	109	2263	2055	2177	6604	75.1
Saxby	59° 01' 11"	23° 08' 44"	305	2078	1917	2039	6339	72.1
Purtse	59° 24' 33"	27° 03' 03"	76	1999	1864	1835	5774	65.7
Kassari	58° 47' 28"	22° 50' 10"	131	1881	1835	1819	5666	64.5
Lasnamäe	59° 26' 57"	24° 48' 51"	0	1702	1749	1750	5201	59.2
Ridala	58° 54' 46"	23° 28' 02"	0	1565	1324	1609	4498	51.2
Padaorg	59° 26'02"	26° 42' 45"	0	1307	1410	1642	4359	49.6
$LSD_{0,05}$			49	151	172	124	358	

The natural populations used in the trial were inferior to the standard variety in dry matter yield by 8.0–52.0% and in crude protein yield by 13.8%–50.4%. Based on the trial results these populations can be divided into two groups.

1. *M. falcata* L. populations Padaorg, Ridala and Lasnamäe were characterised by slower development in the year of sowing and smaller aftermath growth in the years of use. Of their dry matter yield 58.6–62.7% was harvested in the first cut, 29.3–32.8% in the second and only 8.0–9.2% in the third cut. By the autumn of the sowing year and

by the time of last cut of the following year of use they had not produced enough aftermaths to be harvested. Their yield was richer in leaves than that of the standard variety in all the cuts, but as to the crude protein content of leaves, they did not differ from the standard variety. The crude protein content of stems of these three populations was on the average of trial years similar to the standard variety in the yield of the first cut, exceeded this indicator in the second cut and remained below the respective indicator of the standard variety in the third cut.

2. The remaining yellow- and multicolour-flowered populations of *M. media* Pers. (total yield of dry matter and crude protein in comparison with the standard variety 65.8–92.0% and 64.5–86.2%) are valuable because of their longevity. Among them there are forms spreading by rhizomes that are important initial material for breeding pasture varieties of lucerne.

Table 3. Yield quality of natural lucerne populations on the average of 2004–2006, %.

Variety or natural population	I cut			II cut			III cut		
	Leaves in yield	Crude protein in		Leaves in yield	Crude protein in		Leaves in yield	Crude protein in	
		leaves	Stems		leaves	stems		leaves	Stems
Jõgeva 118	39.8	29.2	16.1	51.1	28.6	14.1	62.1	28.3	15.6
Karlu	38.1	28.7	16.1	51.1	28.3	13.8	61.4	27.4	15.9
Juurlu	40.6	29.0	16.4	54.6	28.4	13.8	62.5	28.2	17.0
Reigi	39.7	27.2	14.4	44.3	26.0	13.2	49.7	27.5	13.3
Pühalepa	41.7	28.6	15.7	51.1	27.7	13.0	62.3	28.4	15.5
Sutlepa	38.9	28.3	16.1	52.6	27.1	13.8	64.8	27.6	16.1
Hanila	40.4	28.2	14.8	52.9	27.6	14.3	66.0	27.8	15.8
Orjaku	41.8	28.3	15.3	53.4	27.1	13.4	55.5	27.0	16.0
Saxby	41.5	27.4	13.3	45.5	25.5	11.4	44.9	26.3	13.1
Fällena	43.4	28.9	15.5	55.2	28.4	15.4	65.0	28.8	17.2
Hullo	44.1	28.1	15.8	54.0	27.9	14.5	58.1	27.8	16.4
Kersletti	42.3	27.9	14.3	52.6	27.8	13.4	64.1	27.2	15.6
Kärdla	41.3	27.6	14.8	52.6	27.6	13.9	62.7	28.2	16.6
Purtse	43.2	27.8	14.4	54.2	27.6	13.3	65.8	28.4	17.2
Kassari	45.7	28.0	14.8	50.8	26.1	13.6	61.2	26.6	15.0
Lasnamäe	52.6	27.8	16.8	62.6	28.9	16.0	72.9	25.8	13.8
Ridala	49.3	28.1	16.1	61.0	28.5	15.7	68.7	25.7	13.1
Padaorg	53.4	28.4	15.5	60.6	28.7	16.0	59.6	27.3	14.4

CONCLUSIONS

As the result of the comparative trials with natural populations of lucerne that were conducted in 2003–2006 the following prospective uses can be recommended.

The lucerne population collected from Reigi on the island Hiiumaa needs additional post-control trials. It may be a past sowing of some West-European variety. In earlier similar trials no populations were found in the Estonian nature that would have exceeded varieties in dry matter yield (Bender & Tamm 1997; Bender 2000).

In order to increase the yield ability of semi natural grasslands and improve the yield, top sowing of seeds of natural lucerne populations growing in Pühalepa, Sutlepa and Hanila can be recommended. Their yield ability remains below the standard variety, but it is compensated by the fact that the plant cover maintains its yield ability for a long time. The research so far has indicated that the top sowing of lucerne is successful and the plant cover persists and retains its competitive ability only in growth places that are suitable for the species. Preferable are neutral or alkaline soils, light texture and drying of soils during the vegetation period. Longevity is favoured by softer maritime climate and high phosphorous content of the soil (Lemetti et al., 2001).

M. falcata L. populations Lasnamäe, Ridala and Padaorg are prospective in landscape design in particular for growing along the roadsides, on ditch banks and mountain slopes. Their plant cover is very decorative during flowering and because of modest aftermath growth the costs of cutting are also low.

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