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Perennial fodder plants - potential feed sources in nutrition of rabbits

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Abstract. Temporary pastures throughout their multifunctionality play an important role in rabbit farming due to the both quantity and quality of provided fodder. Temporary or sown pastures, as they are named, can comprise one species (pure crop) or more perennial fodder plants (mixtures of grasses and legumes). Among the pure crops, the most frequently used in rabbit feed in Romania is alfalfa. The alternative of use of mixtures beside pure crops in fodder production for rabbits is interesting to be considered both from nutritional point of view and as agronomical advantages in comparison with pure crops. This paper presents comparative information regarding the production, quality and chemical composition of some species/mixtures of perennial fodder crops. Complex mixtures composed from 6, respectively 7 species (M7 and M8), revealed higher yields but lower values for cell walls content as compared with alfalfa. The same mixtures moderately fertilized (N60P70) can supply phosphorus and potassium needs in herbivorous nutrition.
Key Words: *Oryctolagus cuniculus*, pasture, alfalfa, plant cell walls, digestive physiology.

Introduction. Temporary pastures used in fodder production in Romania are represented both by pure crops of perennial fodder species, most frequently legume crops such as alfalfa and clover, and by mixture crops composed from several perennial fodder plants such as grasses and legumes. Mixtures composed from 2 or 3 species are considered simple while those composed from more than 3 species are considered complex mixtures. The alternative of use of mixtures beside pure crops in fodder production for rabbits is interesting to be considered due to agronomical advantages offered together by species within through their biological, ecological, morphological and biochemical features. In agreement with those above presented it can be mentioned: good adaptability of mixtures at extreme weather phenomena (drought, uneven distribution of rainfall); flexibility in hay production and small losses of leaves with legumes; easiness in crops rotation applying. The fodder provided by mixtures, from nutritional point of view, can be remarked through close content of fiber and protein with the fodder obtained from pure alfalfa crop while the presence of grasses in these mixtures can determine a better balance between carbohydrates and proteins. Among others advantages of perennial fodder crops which are common both to the pure crops and to the mixtures the following can be mentioned: the improving of soil' physical and chemical properties; the capacity to prevent erosion of sloping arable land (Pop et al 2013); the capacity to sequestrate the atmospheric CO_2, and not at least according to Pop (2003) such initiatives can help in land valorization in the hilly areas, which are not suitable for other crop production. In such investments should not be overlooked the specific water consumption/need of each species (Pop 2010; Pop et al 2007, 2004). In these conditions, testing of some mixtures in different ecological conditions and the study of their utilization in rabbits farming can provide useful information to the farmers for an economic efficient activity. Thus, the aim of this research is to present comparative information regarding the production, the quality and the chemical composition of some species/mixtures of perennial fodder crops. The presented data are both the result of own and other researches.

Material and Method. In order to provide information to the farmers from Transylvanian area concerning the use of perennial grasses and legumes mixtures as fodder sources, 8 complex mixtures (M) were testes in comparison with pure alfalfa crop – M1. *Medicago sativa* (*M.s.*); M2. *Medicago sativa*, *Trifolium alexandrinum*, *Dactylis glomerata*, *Lolium x hybridum*; M3. *Lotus corniculatus*, *Onobrychis viciifolia*, *Dactylis glomerata*, *Festuca pratensis*, *Bromus inermis*; M4. *Medicago sativa*, *Dactylis glomerata*, *Festuca arundinacea*, *Lolium perenne*; M5. *Trifolium pratense*, *Dactylis glomerata*, *Festulolium*, *Phleum pratense*, *Lolium perenne (L.p.)*; M6. *Lotus corniculatus*, *Phleum pratense*, *Dactylis glomerata*, *Festuca arundinacea*, *Festuca pratensis*; M7. *Trifolium pratense (T.p.)*, *Lotus corniculatus*, *Trifolium alexandrinum*, *Dactylis glomerata*, *Festuca pratensis*, *Lolium x hybridum (L. hybr.)*; M8. *Trifolium pratense*, *Trifolium repens (T.r.)*, *Dactylis glomerata (D.g.)*, *Festuca pratensis (F.p.)*, *Phleum pratense (Ph.p.)*, *Lolium x hybridum*, *Lolium perenne*; M9. *Medicago sativa*, *Trifolium repens*, *Bromus inermis*, *Festuca arundinacea*, *Lolium x hybridum* – using three fertilization levels (N0P0; N60P70 and N120P70 kg·ha^{-1}). The experiment was established in the field of Didactical and Experimental Station (DES) Cojocna of UASVM Cluj-Napoca in the end of March 2010. In the experimental field the soil is a luvic phaeozem with a neutral reaction (6.96), a high total nitrogen content (0.33%) and a good P (139 ppm) and K (171 ppm) supply. Three cuttings were harvested during the vegetative period in the heading-beginning of the flowering phenophase of legumes. The fresh matter yield of each variant was determined gravimetrically. The quality of the third cutting fodder was determined through the crude protein (CP) content using the Kjeldahl method and through the cell wall matrix (neutral detergent fiber-NDF, acid detergent fiber-ADF and acid detergent lignin-ADL), using the Van Soest method (Van Soest 1982).

Results and Discussion. An important goal in the choice of fodder plant mixtures as forage sources beside alfalfa is their capacity to provide equal or bigger forage yields than alfalfa. In the experiment established in Cojocna–Cluj during 2010-2011, the forage yields obtained in all studied mixtures were higher than the forage yield of alfalfa pure crop (Table 1). Significant yield increases were obtained in M7, M8, M5, M2, M4 and M9 mixtures.

Table 1

The influence of the mixture on DM yields 2010 – 2011 (t·ha-^{1})

Crop/Mixture (M)	*DM yield (t·ha^{-1})*	
M1	10.09	A
M3	10.44	A
M6	10.68	AB
M9	11.57	BC
M4	11.82	C
M2	12.26	C
M5	13.52	D
M8	14.42	DE
M7	15.37	E

TSD p=0.05.

Mixtures M7, M8 and M5 revealed the first highest three yields while the first and the second yield levels were recorded by the mixtures composed from 6 respectively 7 species.

Fodder plant mixtures should present, beside a good production capacity, a similar fodder quality as alfalfa in order to be a real fodder alternative to alfalfa. Among the fodder characteristics which prove its quality the crude protein, cell wall constituents (NDF, ADF, ADL) and fodder digestibility can be mentioned (Table 4). Lebas et al (1997), Chao & Li (2008) and Winkelmann & Lammers (2001) mentioned that the fodder for rabbits' feeding has to have in the ratio' structure sufficient fiber content. This

requirement is in accordance with the digestive physiology features of non-ruminant herbivorous animals (Carabaño et al 2010). According to Chao & Li (2008), the non-ruminant herbivorous animals present a high ingestion of plants with a high content in cell wall constituents.

In the first year of vegetation (2010) M7 mixture (30% legumes – *T. pratense*, *L. corniculatus*, *T. alexandrinum*) and M8 mixture (22% legumes – *T. pratense*, *Trifolium repens*) revealed through the highest CP content of fodder (Table 2). As compared with alfalfa fodder the two mixtures recorded higher CP contents in the unfertilized variants and in the fertilized with N60P70 dose variants. Nevertheless the CP content of alfalfa fodder (Table 3) varies between the limits mentioned by Mathieu 2003 (14–29%) and respects the requirement limits of a normal nutrition for rabbits (Gidenne & Lebas 2002). Regarding the fiber content of fodder in the first year of vegetation (2010) a higher content of NDF (cellulose, hemicellulose and lignin) in alfalfa fodder in comparison with the fodder of M7 and M8 mixtures in all variants, regardless the fertilization level, can be observed. The NDF values in alfalfa fodder in both unfertilized and fertilized with N60P70 dose variants (accessible to most farmers) varied between 53.90% and 55.47%, while in M7 and in M8 mixtures they were under 50% (Table 2).

Table 2

The influence of mixture and fertilization on the CP content and the cell wall constituents of fodder (% of DM)

Crop/Mixture (M)	*Level of fertilization (F)*	*CP %*	*NDF %*	*ADF %*	*ADL %*
M1	F1	14.83	55.47	37.05	4.71
	F2	15.56	53.90	35.97	4.09
	F3	18.44	49.82	33.91	4.00
M5	F1	14.02	55.12	34.75	3.35
	F2	15.45	55.08	34.20	3.30
	F3	16.33	54.80	32.30	3.20
M7	F1	17.39	49.12	34.36	4.86
	F2	19.02	48.47	31.71	4.21
	F3	18.27	48.76	34.00	4.60
M8	F1	20.40	43.25	29.40	3.50
	F2	20.29	46.58	30.72	3.42
	F3	20.89	44.88	30.02	3.52

Table 3

Current levels of fiber in a complete feed for the growing rabbit according to the analytical method (version of Gidenne & Lebas 2002)

Fiber determination criteria	*%DM*
Acid Detergent Fiber (ADF)	16
Neutral Detergent Fiber (NDF)	27
Other feed constituents	
Crude protein	13 – 18

The NDF content of fodder for a complete nutrition in growing rabbits is usually about 27% of DM (Gidenne & Lebas 2002). In agreement with the American system of evaluation of alfalfa fodder quality (Table 6), the NDF contents of the studied mixtures' fodder indicate an acceptable to good quality. The ADF values (cellulose and lignin) of fodder from M5, M7 and M8 mixtures (unfertilized and fertilized with N60P70 kg·ha^{-1}) were smaller (34.75%-30.72%) than those of alfalfa (37.05%-35.97%). Gidenne & Lebas (2002) recommend for a complete nutrition of rabbits an ADF value of 16% of DM. The lignin content of mixtures' fodder was smaller in M5 and M8 mixtures (ADL values between 3.20–3.52) compared with alfalfa fodder (ADL values between 4.00–4.71).

According to the researches of Carlier et al (1998), Gidenne & Lebas (2002) (Table 4), and Gidenne et al (2010), lignin is the cellular wall constituent with the smallest digestibility.

In the second year of vegetation (2011) an increase of brute protein content of alfalfa fodder, both compared with alfalfa fodder in 2010 and compared with mixtures' fodder, was observed. The fiber content of alfalfa fodder revealed high NDF and ADL levels in unfertilized and with N60P70 fertilized variants, compared with mixtures' fodder (Table 5). The highest lignin content was recorded in alfalfa fodder regardless the fertilization level. According to the evaluation grid for alfalfa fodder quality (Table 6) the NDF content of alfalfa in unfertilized and with N60P70 fertilized variants indicates an average forage value of fodder. Among the mixtures with near yields (M5 and M8), M8 mixture remarks both with a high crude protein content and with small NDF content of fodder obtained in unfertilized and with N60P70 fertilized variants.

Table 4

Whole tract digestibility coefficient of fiber fractions (%) in the growing rabbit (version of Gidenne & Lebas 2002)

Class of dietary fiber	*Mean*
Lignin (ADL)	10 - 15
Cellulose (ADF-ADL)	15 - 18
Hemicellulose (NDF-ADF)	25 - 35

Table 5

The influence of mixture and fertilization on the crude protein content and NDF, ADF, ADL content of cellular walls (% of DM) 2011

Crop/Mixture (M)	*Level of fertilization (F)*	*CP %*	*NDF %*	*ADF %*	*ADL %*
M1	F1	19.98	51.45	39.44	5.60
	F2	20.85	50.92	38.28	5.31
	F3	21.41	45.58	37.30	5.52
M5	F1	16.85	48.97	38.96	4.20
	F2	19.42	49.13	37.94	4.14
	F3	20.87	48.29	38.61	4.25
M7	F1	17.79	51.11	42.19	4.32
	F2	19.09	48.82	40.82	4.21
	F3	19.91	49.10	41.80	4.70
M8	F1	19.40	48.10	40.08	4.41
	F2	19.73	45.31	29.89	2.49
	F3	20.17	45.35	31.22	3.16

Table 6

Grid of quality used in USA for alfalfa hay (Mathieu 2003, adapted by Sima 2015)

Parameters (% of DM)	*Nutritive value of fodder Relative feed value*		
	High	*Average*	*Acceptable*
NDF	40 - 46	47 - 53	54 - 60
ADF	31 - 35	36 - 40	41 - 42
CP	17 - 19	14 - 16	11 - 13

A proper nutrition for rabbit is determined by the microelements' content of fodder. Among the macro elements (calcium, phosphorus, magnesium, sodium, potassium, chloride and sulphur) only calcium, phosphorus and sodium are taken into account in

rabbits' diet (Mateos et al 2010). Rabbit meat is rich in potassium (400 mg/100 g according to Mateos et al [2010]; 388 mg/100 g according to Hermida et al [2006]) and phosphorus (400 mg/100 g according to Mateos et al [2010]; 388 mg/100 g according to Hermida et al [2006]) and it is poor in sodium (37 and 49.5 mg/100 g according to Hernandez & Zotte [2010]; 60 mg/100 g according to Hermida et al [2006]; 55 mg/100 g according to Mateos et al [2010]; 40.5 mg/100 g according to Nistor et al [2013]). Due to the ratio between potassium and sodium, the rabbit meat is recommended in hypertension diets (Hermida et al 2006). Also, the high phosphorus content of meat provides approximately 30% of the recommended daily intake for 100 g consumption (Hermida et al 2006).

Considering both the importance of phosphorus and potassium in rabbit nutrition, generally in herbivorous nutrition, and the possibility of using of some perennial species in rabbit feed (Bura 2001; Bud et al 2011; Fenner et al 1999; Lebas 2004) we considered interesting to determine the P and K content of some of the species within the tested mixtures (Table 7).

The high content in P and K of species within the mixtures recommends them as good sources of these macro elements in the rabbits' diet. *F. pratensis* within mixtures 7 and 8, in the unfertilized and with N60P70 fertilized variants, revealed the highest content in P of forage, among the studied species. *T. pratense* and *M. sativa* revealed the lowest P content of forage. Among the legumes the highest values were recorded with *T. repens.* Regarding the K content of forage all the studied species revealed an optimum content for herbivorous nutrition.

Table 7

The content in P and K of forage of some perennial grasses and legumes species within the tested mixtures

Current No.	*Crop/Mixture (M)*	*Species*		*% DM*	
				P	*K*
1	M 5,7,8	*Dactylis glomerata*	F1	0.547	3.83
			F2	0.473	4.12
			F3	0.463	5.29
2	M 7,8	*Festuca pratensis*	F1	0.557	3.62
			F2	0.559	3.91
			F3	0.491	4.24
3	M 7,8	*Lolium x hybridum*	F1	0.331	2.64
			F2	0.331	2.92
			F3	0.333	2.83
4	M 5,8	*Lolium perenne*	F1	0.471	3.01
			F2	0.485	3.75
			F3	0.486	3.87
5	M 5,8	*Phleum pratense*	F1	0.384	3.56
			F2	0.406	3.73
			F3	0.472	3.57
6	M 5,7,8	*Trifolium pratense*	F1	0.278	2.78
			F2	0.289	2.95
			F3	0.290	2.96
7	M 8	*Trifolium repens*	F1	0.421	2.44
			F2	0.400	2.19
			F3	0.454	2.44
8	M 1	*Medicago sativa*	F1	0.312	2.67
			F2	0.311	3.00
			F3	0.278	2.67

The P and K content in the alfalfa forage are within the limits indicated by other researchers (Oprea 1999; Mathieu 2003). Thus, Mathieu (2003) mentioned for alfalfa forage 0.2% – 0.35% DM for P content and 1.2% - 2.3% DM for K content.

Table 8

Phosphorus and potassium contents of forage for herbivorous (Oprea 1999)

Content level (%)/Macroelements	*P*	*K*
Optimum	0.35 – 0.45	1.5 – 2.00
Deficiency	0.20	1.00

Conclusions. The complex mixtures M7, M8 and M5 provided significant yield increases in comparison with the pure alfalfa crop. The mixtures M7 and M8 revealed lower values for cell walls content as compared with alfalfa. Even for the both above mentioned mixtures a careful completion with other forage supplies, to achieve the optimum level of fiber for rabbits, is compulsory. The mixtures M7 and M8 moderately fertilized (N60P70) are recommended for farmers, while the species within them can provide phosphorus and potassium needs in herbivorous nutrition.

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References

Bud I., Vlădău V.-V., Petrescu-Mag I. V., 2011 Creşterea iepurilor. Editura Ceres, Bucureşti pp. 69-78; 201-219.

Bura M., 2001 Proiect tehnologic pentru creşterea iepurilor de casă. Colecţia revistei Ferma, pp. 43-48.

Carabaño R., Piquer J., Menoyo D., Badiola I., 2010 The digestive system of the rabbit. In: Nutition of the rabbit. Second edition, de Blas C., Wiseman J. (eds), pp. 1-18, CAB International.

Carlier L., Puia I., Rotar I., 1998 For a better grass production. Risoprint Publishing House, Cluj-Napoca, Romania.

Chao H. Y., Li F. C. 2008 Effect of level of fibre on performance and digestion traits in growing rabbits. Animal Feed Science and Technology 144:279–291.

Fenner M., Hanley M. E., Lawrence R., 1999 Comparison of seedling and adult palatability in annual and perennial plants. Functional Ecology 13:546-551.

Gidenne T., Lebas F., 2002 Role of dietary fiber in rabbit nutrition and in digestive troubles prevention. 2nd Rabbit Congress of the Americas, Habana City, Cuba, June 19-22.

Gidenne T., Lebas F., Fortun-Lamothe L., 2010 Feeding behaviour of rabbits. In: Nutrition of the rabbit. 2nd edition, de Blas C., Wiseman J., (eds), pp. 233-252, CAB International, UK.

Hermida M., Gonzalez M., Miranda M., Rodriguez-Otero J. L., 2006, Mineral analysis in rabbit meat from Galicia (NW Spain). Meat Science 73:635–639.

Hernández P., Zotte A. D., 2010 Influence of diet on rabbit meat quality. In: Nutrition of the rabbit. 2nd edition, de Blas C., Wiseman J., (eds), pp. 163-178, CAB International, UK.

Lebas F., 2004 Reflections on rabbit nutrition with a special emphasis on feed ingredients utilization. Proceedings of the 8th World Rabbit Congress, 7-10 September, Puebla, Mexico, pp. 686-736.

Lebas F., Coudert P., de Rochambeau H., Thébault R. G., 1997 The rabbit: husbandry, health and production. FAO Animal Production and Health Series 21:30-62.

Mateos G. G., Rebollar P. G., de Blas C., 2010 Minerals, vitamins and additives. In: Nutrition of the rabbit. 2nd edition, de Blas C., Wiseman J., (eds), CAB International, UK.

Mathieu M., 2003 Luzerne - culture, récolte, conservation utilisation. Editions France Agricole.

Nistor E., Bampidis V. A., Păcală N., Pentea M., Tozer J., Prundeanu H., 2013 Nutrient content of rabbit meat as compared to chicken, beef and pork meat. J Anim Prod Adv 3(4):172-176.
Oprea G., 1999 Contribuţii în aprecierea valorii nutritive a unor amestecuri intensive de graminee şi leguminoase perene. Academia de Ştiinţe Agricole şi Silvice Gheorghe Ionescu Şişeşti, Teză de doctorat, Bucureşti, Romania.
Pop N., 2010 Research regarding the water consumption and production of *Medicago sativa* on the sloping terrain in Chinteni, Cluj County. Agricultura - Stiinta si Practica 3-4:75-76.
Pop N., 2003 Valorisations of land areas by growing fodder plants in the collinar zone of Cluj County, Romania. Bulletin of USAVM Cluj-Napoca, Horticultura 60:160.
Pop N., Budiu V., Ortelecan M., Dirja M., Luca E., Gotea I., Hoban A., Luput I., 2007 Topographical and pedologycal studies regarding the water consumption at some leguminous fodder plants located in an experimental field in Chinteni, Cluj County. Bulletin of USAMV Cluj-Napoca 64(1-2):662-667.
Pop N., Budiu V., Ciotlaus A., Ortelecan M., Luput I., 2004 Some remarks on the relation to water consumption and production in the culture of *Medicago sativa* on a slopy terrain. Bulletin of USAMV Cluj -Napoca, Horticultura 61:310-315.
Pop N., Ortelecan M., Salagean T., Aciu C., 2013 Research on water consumption and production of red clover on an erosional arranged land in Chinteni, Cluj County. Lucrari Stiintifice, Seria Agronomie, Iasi, Romania, 56(2):117.
Van Soest P. J., 1982 Nutritional ecology of the ruminant: Ruminant metabolism, nutritional strategies, the cellulolytic fermentation and the chemistry of forages and plant fibers. O and B Books Publisher, Corvallis, OR.
Winkelmann J., Lammers H.-J., 2001 Creşterea iepurilor de casă. Editura M.A.S.T., pp. 25-37.

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