PRACTICAL ASPECTS OF USING RED CLOVER IN MIXTURES WITH GRASSES IN NEMORAL ZONE OF ROMANIA – A BRIEF OVERVIEW

Daniel **Dunea**[1], Niculae **Dincă**[2*]
[1]Valahia University of Târgovişte, Faculty of Environmental Engineering and Food Science, Aleea Sinaia, no.13, Târgovişte, Romania, 130004
[2]University of Agronomical Sciences and Veterinary Medicine Bucharest, Faculty of Agriculture, 59 Mărăşti Blvd., Sector 1, Bucharest, Romania
*e-mail: nicudinca@yahoo.com

Abstract

The paper presents a general guide for agricultural specialists who want to understand the basic principles of grassland renovation in the specific conditions of Romanian nemoral regions. Requirements of higher herbage yields than the potential productivity of natural grasslands situated in the nemoral areas of Romania have imposed the integration of temporary artificial grasslands as intensive forage systems in order to replace degraded or inefficient permanent pastures. Considering the vast regions occupied by natural hayfields in Romania (~1.4 mil. ha) from which the favorable area for potential red clover integration reaches 20-25%, it becomes important to investigate and identify an adequate substituting solution for the initial phytocenosis of the degraded permanent grasslands only in areas where the replacement of natural biodiversity is justified economically and ecologically. Improving the productivity of inefficient grasslands relies on an intensive crop system based on mixtures (legume - grass species), whose resource consumption particularities are physiologically, temporally, and morphologically complementary. Elaboration of mixed crop technologies tested in field experiments has proved the superiority of the legume-grass mixtures concerning the fodder quality and quantity, when compared to sole-cropped of the component species or to grasslands with low pastoral value. However, yield constancy was not always obtained due to seasonal fluctuations and incorrect management practices. Because of demonstrated efficiencies of using mixtures, it was hypothesized that the adequate intensive mixtures for the hilly areas of Romania consist in red clover-ryegrass, red clover-timothy, or red clover-meadow fescue in correlation with altitude. The choice is a result of their complementary characteristics and adaptability (similar growth rate, height and development, cutting frequency, cultivar tardiness etc.).

Keywords: grass-legume interaction, grassland renovation, forage quality, mixed canopy, competition capacity

1. INTRODUCTION

One of the efficient ways to improve forage yield and animal performance of the permanent grasslands is to renovate them periodically. Grassland renovation implies "renewing" existent grassland by introducing a better-yielding forage species and replacing of existent canopy. It usually involves destroying the sod, liming and fertilization according to the soil test, seeding a legume or legume-grass mixture, and weeds control (*Taylor and Quesenberry, 1996*).

The decision of grassland renovation should consider three elements: 1) botanical composition, 2) sward deterioration, and 3) condition of land.

Botanical composition provides information on the permanent grassland basic characteristics regarding the metabolizable energy, protein and minerals for an optimal animal nutrition. In the evaluation of plant community performance, the decision is made considering the legume and grass contents in sward, and the presence of unpalatable species. One of the major deficiencies of forage stands is the inability to maintain an adequate legume component (*Taylor and Quesenberry, 1996*). Less than 5% legumes and less than 60% good quality grasses recommend the renewing intervention. However, grasslands with an improper botanical composition can also be improved through proper fertilization, intensive cutting or grazing and adjustment of soil acidity. These options should be considered when the botanical composition is within optimal thresholds.

Quite often, *sward deterioration* is a result of the cumulative restrictions such as the incorrect management and the frost. Insufficient fertilizers, late cutting, intensive grazing and excessive soil moisture are several factors that affect a closed canopy.

Condition of Land is evaluated in terms of soil parameters and irregularity. Renovation becomes necessary when the land is uneven, the drainage is required and the mechanized operations are difficult. The land aero-hydric improvement will create optimal soil conditions for *Rhizobia* symbiotic processes with the legume species (*Samuil, 2010*).

The choice of grassland renovation must consider a well-balanced strategy and needs to be performed on a regular basis. Being a radical and expensive measure, the integration of an intensive forage system is justified if higher yields, better quality, and easier crop operations compensate the evaluated costs. Implementing artificial grasslands in critical conditions would diminish radically the efficiency of the system when compared with the previous swards. In some situations, it is preferable to maintain and ameliorate the existing grassland by correcting the causal factor. Nevertheless, the substituting system might manifest low adaptability in the eco-climatic and soil conditions compared to the initial phytocenosis.

2. PRINCIPLES OF ESTABLISHING TEMPORARY ARTIFICIAL GRASSLANDS FOR HAYFIELD USE USING RED CLOVER

The artificial grasslands, whether organic or conventional, have a major advantage in terms of yield and quality. Resown grasslands have a higher legume yield and, consequently a higher crude protein yield. Optimal herbage outcome must be at least three or four times higher than the old swards.

The Romanian grassland typology (*Motcă et al., 1994*) stipulates that the predominant zonal grasslands of nemoral areas consist of Rhode Island bent-grass series - *Agrostis tenuis*. Artificial hayfields are more profitable forage systems when introduced, although *Agrostis* grassland productivity may be improved from 1,622-2,205 kg DM ha^{-1} y^{-1} (natural potential) to 4,683-6,355 kg DM ha^{-1} y^{-1} by using 100 kg N ha^{-1} (*Puia et al, 1980*).

The integration of temporary artificial grassland, when used as hayfield starts with the sowing of a legume-grass mixture with species having significant pastoral values.

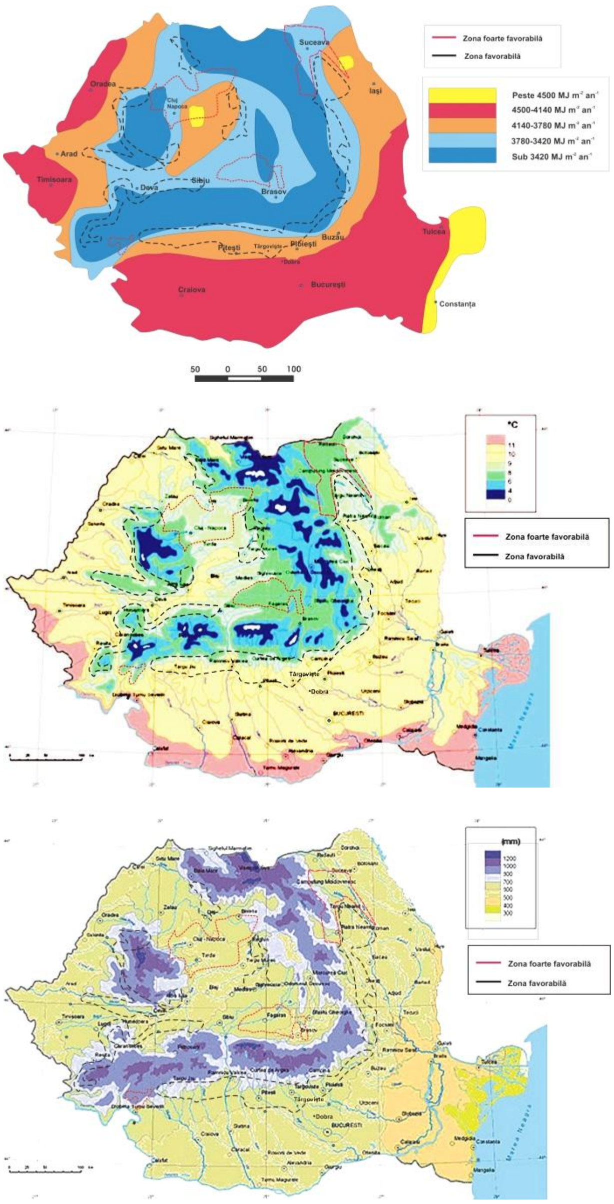


Fig. 1 Potential favorable areas of red clover cropping and annual global solar distribution (MJ m^2 y^{-1}), temperature (°C), and precipitations (mm) in Romania (meteorological maps from *NMA, 2006*)

Temporary grasslands allow to sow the preferred species and to keep up to date with the latest cultivars. Compared to grasses, legumes have a lower persistence in the established forage system. In fact, the limitative factors of legumes growth such as lime, phosphorus and potassium deficiencies, disease and insect damage, overgrazing or excessive cutting, drought, or grass and weed competition must be overviewed.

However, the productivity of legume species complements that of grasses, rising forage yields in mid- to late summer, when grass growth usually declines, and ameliorating nutritional quality of forage that results in improved animal performance (*Dunea et al., 2015*). Legumes are able to convert atmospheric nitrogen into crop available nitrogen and make it available to other plants in a way that minimizes nitrate losses and enhances soil quality. Grasses participation in a mixture usually lengthens the usable life of a sward because they persist longer and are more tolerant of mismanagement than legumes (*Taylor and Quesenberry, 1996*) .

Grasses also reduce the incidence of bloat, improve hay drying, and are stronger competitors with weeds than legumes.

The grassland renovation sustained by research and farmer experience shows that introducing the proper types of mixtures should provide benefits as follows:

⇒ *Diminishing of nitrogen fertilization, resulting lower costs and environmental protection.*

⇒ *Better seasonal distribution of forage (Legumes are more productive in mid-summer than cool-season grasses).*

⇒ *Increased forage protein content and quality.*

⇒ *Improved forage digestibility and palatability.*

⇒ *Higher mineral concentrations (especially Ca^{2+}, Mg^{2+}) that prevent animal health problems.*

⇒ *Improved livestock performance, such as daily gain, milk and wool production.*

⇒ *Improved beef breeding performance.*

For these reasons, such systems can enhance land-use efficiency and long-term productivity. Demands for high forage quantities and other economic pressures have stimulated the interest in temperate areas for mixed hayfields, managing them to maximize the total yearly crop production from a unit of land by mixing legumes and perennial grasses (*Dunea and Dincă, 2014*).

2.1 Why red clover?

Red clover constitutes the major forage species of humid climate areas from Romania, its importance residing in a high ecological plasticity, because it establishes rapidly and withstands more shading than other legumes (*Dunea and Motcă, 2007*). However, it is relatively short persistent and although useful in short-term mixtures (2-3 years), it cannot be relied on for long-term persistency.

Red clover occupies a medium position in terms of adaptability, surviving in a broad range of moderate soil types, pH, moisture, and climate conditions (*Savatti and Rotar, 2014*). It is relatively intolerant of heat and drought, and prone to winter injury, and disease, which combine to make red clover a short-lived legume, surviving 2 to 4 years, depending on management and climate.

Given the importance of clover in an intensive system, it is essential to choose high yielding varieties, which will persist under the intended sward use.

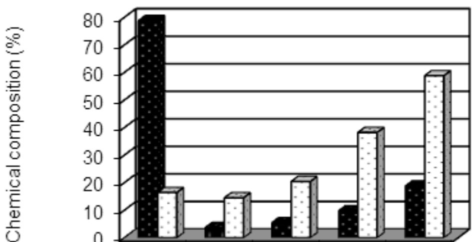
Experimental results (1975-1987) performed in different ecological areas of Romania with red clover soled crop and with clover-grass mixtures, indicated yields of 4,700-9,000 kg DM ha^{-1} (pure stands) and respectively of 7,800-14,800 kg DM ha^{-1}. In Poland, mixtures of red clover with meadow fescue and timothy provided more substantial yields than pure stands of components (*Taylor and Quesenberry, 1996*).

Mixtures of red clover with timothy provided 14,100 kg DM ha^{-1} with 75 kg ha^{-1} N (*Lesak and Sverakova, 1988*). At seven locations in France, yields of red clover in mixtures with annual ryegrass of orchardgrass, fertilized with 150 kg ha^{-1} N were similar to pure swards of the grasses fertilized with 300 kg ha^{-1} N (*Guy, 1989*). Research in USA (Kansas) has proved that red clover in association with four different perennial grasses yielded equal to or up to 1,000 kg ha^{-1} more than grass species fertilized with 90 kg ha^{-1} N (*Taylor and Quesenberry, 1996*).

The overall increased yields result due to the component crops, which differ enough in growth requirements by overlapping demands or diminishing critical constraints (*Dunea and Dincă, 2015*).

A red clover – grass mixture is appropriate to introduce as a functional group in the sown hayfield. A balance between advantages and disadvantages must be considered when mixed cropping systems are introduced in a certain area. It could define a better approach (proper design and operation) to the intensity of the cropping pattern, drawing as much as possible from the land resources, but without exceeding the normal thresholds. Otherwise, misapplied technologies for temporary hayfield in permanent grasslands can harm inherent land productivity and ecosystems stability.

Multiple uses of the red clover fodder as green forage, hay, and silage are increasing its feed value and economic potential (fig. 2).



	Moisture	Crude Protein	ADF	NDF	Nutritive Units
■Green forage	78.8	3.7	5.5	9.8	18.8
□Hay	16.4	14.5	20.4	38.2	58.8

Fig. 2 Chemical composition of red clover's green forage and hay (*Dunea and Motcă, 2007*)

Research in Australia, England, Poland, France and Romania has shown that red clover silage and hay can be used successfully for dairy and sheep production. Cows fed with red clover consumed only 1.22 times the DM and 1.09 times the digestible energy when compared to cows fed with perennial ryegrass. Cows yielded 1.9 kg d^{-1} more milk following the feeding with red clover (*Taylor and Quesenberry, 1996*).

In France, cows consuming 60% red clover silage and 40% maize silage, provided the same quantity of milk having lower fat content compared to those consuming only maize silage (*Hoden et al., 1987*).

In Romania, the hay traditionally produced from red clover-Italian ryegrass low-input hayfields supplied 55-62% from total feed required by the dairy cow. The hay digestibility was 50-70% (0.6-0.7 NU kg^{-1}) depending on its quality.

The move to organic production might be encouraged using such red clover-grass systems. "*Organic farming by poverty*" already affects the majority of Romanian farmers. The concentrate bill is a major variable cost on most dairy units. Although Romania's effort to encourage sustainable, organic farming practices provides valuable lessons for other Central and Eastern European (CEE) countries, modern organic farming practices to increase their farm outcome still need to be implemented (*Crowder, 2001*).

Dunea and Dincă (2014) suggested that the most suitable ecotype adapted for a nemoral area environment is medium red clover (taxonomy: *Trifolium pratense* L., ssp. *eupratense*, var. *sativum*, f. *intermedium*).

Several ecotypes, which combine precocious clover characteristics - f. *praecox* (partial flowering in the sowing year, fast growth rate, enhanced tillering and 2-3 harvests per year) with tardy clover forms - *f. serotinum* (mostly frost resistance), have developed through natural selection. A quantitative reaction characterizes their vernalization and photoperiod. Day length accelerates growth and development processes (*Motcă et al., 1994*). For these reasons, the red clover ecotypes cultivated in Romania are valuable biological germplasms still evolving and prone to amelioration. The germplasm collection comprises 10 wild ecotypes and 224 unclassified types (*IBPGR, 1991*). Red Clover of Transilvania and Red Clover of Suceava are the most important local populations.

Puia et al. (1980) reported that local populations generally had high yields and served as good sources for additional breeding and selection. The red clover cultivars Napoca –Tetra and F8 were developed from this program. Apollo–Tetra, another cultivar created in Romania (1990) showed better persistence, superior frost and disease resistance, and higher production potential.

The agricultural importance of red clover is based upon several characteristics as follows:

- ***Increased productivity***: In the favorable areas, with rainfalls higher than 600 mm y^{-1} red clover has a higher productivity than alfalfa (*Medicago sativa*) – 6,000-10,000 kg DM ha^{-1} y^{-1} (*Motcă et al., 1994*). Red clover is very high yielding producing 3 to 4 times the dry matter yield of white clover. Phytomass files of Duke report DM yields of 6,000–19,000 kg from countries such as Romania, Russia, and Switzerland (*Duke, 1981*). Finnish DM yields for 390 con-varieties ranged from 200–11,800 kg ha^{-1} (*Ravantti, 1980 cited by Taylor and Quesenberry, 1996*). In Belgium, DM yields were 7,000 kg ha^{-1} from pure clover, and nearly 13,000 kg ha^{-1} mixed with grasses (*Andries, 1982*). In Michigan, red clover con-varieties averaged 6,500–7,400 kg ha^{-1} compared with 10,300 kg ha^{-1} for alfalfa and 6,200 kg ha^{-1} for bird's foot trefoil.

- ***Production quality***: Red clover is generally intermediate between white clover (highest) and alfalfa in quality (*Buxton et al., 1985*). The chemical composition in both stages (hay and green forage) is similar to alfalfa, but the vitamins, mineral and microelements are sometimes substantial (fig. 3). Green forage of red clover is reported to contain 81% moisture, 4.0% protein, 0.7% fat, 2.6% fiber, 2.0% ash. Hay of red clover contains 12.0% moisture, 11.8% protein, 2.6% fat, 27.2% fiber, and 6.4% ash. Based on more than 500 analyses, *Miller (1958)* reported the hay contained on a moisture free basis: 8.3–24.7% protein (avg. 14.9%), 1.0–6.6% fat (avg. 2.9%), 12.5–39.3% crude fiber (avg. 30.1%), 3.1–14.0% ash (avg. 7.9), and 33.4–59.1% N-free extract (avg. 44.2). For green red clover forage he reported 12.4–34.87 protein (avg. 18.2), 3.2–5.9% fat (avg. 4.0%), 12.7–30.8% crude fiber (avg. 24.2), 7.0–13.6% ash (avg. 8.8), and 37.1–49.7% N-free extract (avg. 44.8%). The hay (dry matter averaging 87.7%) contained 0.97–2.29% Ca (avg. 1.61), 0.09–0.45% P (avg. 0.22), 0.57–2.67% K (avg. 17.6%), 0.24–0.81% Mg (avg. 0.45%), 0.001–0.185% Fe (avg. 0.013%), 9.9–17.6 ppm Cu (avg. 11.2 ppm), and 24.9–120.8 ppm Mn (avg. 65.6). The green forage contained 0.58–3.21% Ca (avg. 1.76), 0.24–0.53% P (avg. 0.29), 1.49–2.94% K (avg. 2.10%), 0.36–0.57% Mg (avg. 0.45), 0.016–0.032% Fe (avg. 0.03), 7.3-10-3 ppm Cu (avg. 8.8 ppm), 121–464 ppm Mn (avg. 159 ppm). The leaf-protein concentrate (59% protein) contains 6.4% arginine, 2.5% histidine, 5.4% threonine, 1.7% tryptophan, 9.5% leucine, 5.3% isoleucine, 1.7% methionine, 6.87 lysine, 6.1% phenylalanine, and 6.8% valine (*Miller, 1958*).

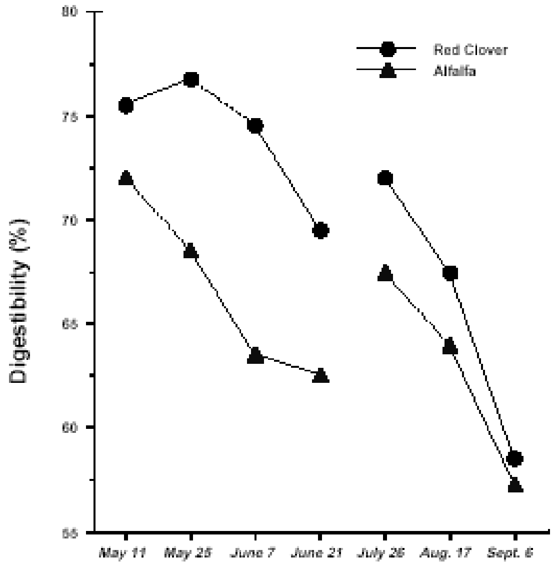


Fig. 3 Digestibility of red clover and alfalfa pure stands in function of plant maturity – 2 cuttings regime (*Buxton et al., 1985*).

Firstly, the protein contribution (1,500-2,000 kg nitric matter ha^{-1} y^{-1}) with essential amino acids promises to substitute the cattle feed prepared from carcasses of ruminants, which are responsible for appearance of the agent causing the BSE (Bovine Spongiform Encephalopathy). Secondly, red clover fodder reduces the potential for nitrate poisoning and grass tetany compared with pure grass stands.

- ***Enhanced digestibility***: Forage digestibility of red clover does not decline as rapidly with advancing maturity as alfalfa. This permits a longer interval over which high quality forage can be harvested (*Buxton et al., 1985*). Red clover in mixtures can improve overall forage quality.

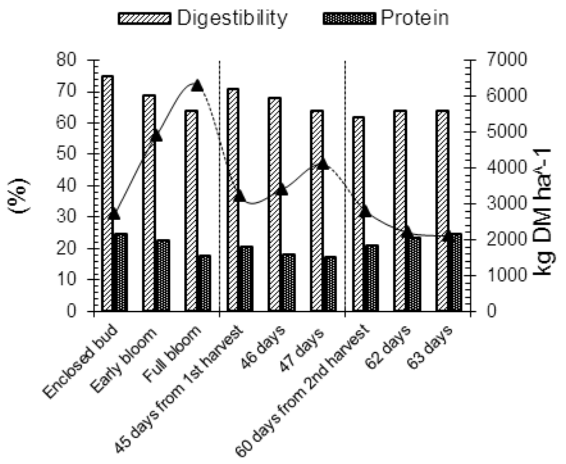


Fig. 4 Dry weight production (kg DM ha^{-1}), digestibility (%), and crude protein production (%) in function of harvesting time (3 cuttings regime) in a red clover soled crop (*Dunea and Motcă, 2007*)

Changes in plant morphological composition induce modifications in digestibility potential. It is important to identify the susceptible processes that influence the decreasing of leaf-stems ratio, its modulations under environmental factors, and their nitrogen content (*Dunea and Dincă, 2015*). Above ground biomass developmental stage is essential in choosing an appropriate cutting regime according to the management requirements (fig. 4).

- ***Soil ameliorating plant:*** Symbiotic processes with *Rhizobium trifolii* (at pH>5.5) provides 350 kg N ha^{-1} (maximal limit) in the second year at 10,000 kg DM ha^{-1} (about 2100 kg ha^{-1} crude protein in the crop). Annual nitrogen contribution in soil is estimated at 120-200 kg N ha^{-1} (*NRCS, 2001*). Red clover contributes to the improvement of soil structure due to the root characteristics (solubility capacity). It could also be merged as green manure to improve soil properties and increase yields of succeeding crops.
- ***Head-crop in rotation-of-crop***: The main role of red clover is in short term rotational conservation mixtures. In the rotation-of-crop system is chosen as a head crop being inserted in different crop systems (agricultural or forage systems). Many crop rotations are possible for red clover, the oldest being a 3-year rotation of corn, oats or wheat and red clover. A crop rotation using red clover, potatoes, winter wheat and winter oats uses the fertility from the red clover to grow a high value cash crop.
- ***Ecological indicator***: A forage species like red clover is a useful support to study the vegetative period of aboveground component development in relationship with climate limits. The perennial character (2-3 cycles × 3 years) allows better eco-physiological interpretation and long time series for analysis than annual crops. Furthermore, the presence of red clover in grassland is an indicator of soil-improved characteristics, and of pasture quality.
- ***Economic reliability***: Assuming that 21.5 million MT of hay are produced annually in US, the economic value of the red clover hay alone is worth \$1.4 billion per year or \$265 ha^{-1} (*Taylor and Quesenberry, 1996*). This number ignores other significant values of grassland in red clover.

2.2. Which grass species?

Selection of the accompanying grass for red clover in a forage mixture must rely on:

1) ecological area,
2) harvest technique (*grazing*, *mowing* or a *mixed management*), and
3) species complementary compatibility.

A stable herbage production in clover mixtures with perennial grasses requires an understanding of the factors that determine the performances of red clover in artificial grasslands. An important factor is the composition of legume - grass mixtures having significant influence upon production potential, fertilization system, exploitation mode, evolution of botanical composition and duration of economical exploitation (*Motcă et al., 1994*).

The basic guidelines used in Romanian forage systems to conceive the grass-legume mixture composition are presented below:

a. *Cropping duration and grassland use* is influenced by species vivacity (persistence) - especially by the vivacity of legumes. Extension of the period for profitable exploitation is preferred when new temporary hayfields are replacing degraded grasslands.
The economical cropping duration of red clover is maximum 3-4 years. Mowing is the adequate practice to use in short-term forage systems. Long-term grasslands are managed profitably under grazing or mixed regime (mowing-grazing alternance).

b. *Number of species in mixtures* – Generally, the recommended number of species in mixture depends on the duration and the intensity of crop system. For 2-3 years intensive systems, 2-3 species are introduced conversely, 3-5 species for 4-6 year system (table 1).

Table 1 Selection of the number of species in mixtures considering management practice and plant height

Duration (years)	**Number of species**	**Utilization**	**Grass (%)***			**Legumes (%)***		
			Total	**Tall height**	**Short height**	**Total**	**Tall height**	**Short height**
2-3	**2-3**	*MOWING*	30	30	-	70	70	-
4-6	**3-5**	*MOWING*	60	60	-	40	40	-
		MIXED	60	50	10	40	30	10
>6	**4-6**	*GRAZING*	70	50	20	30	-	30
		MIXED	70	60	10	30	10	20

* - % from seed quantity of pure stand

The most common option for an intensive legume-grass cropping system is using the simple mixtures, because the insurance of high productions relies on several species, which detain a better adaptability – viability and better capacity of concurrence (Dunea, 2015).

The complex mixtures present interest in an extensive cropping technology (without fertilization, irrigation and traditional exploiting techniques) or in improper environmental conditions (table 2). Integration of complex mixtures becomes a practical issue when the aim is the maintenance of variability in a bio-top corresponding to a *phytocenosis.*

The complex mixtures will complete numerous existent ecological niches.

Table 2 Influence of mixture complexity on dry matter production of artificial grasslands in Romania (*Bărbulescu et al., 1991*).

Mixture	**Irrigated**		**Not irrigated**	
	N100*		N100**	
	(kg/ha)	(%)	(kg/ha)	(%)
Simple	13,190	100	5,480	100
Complex	11,810	89	6,420	123

Fertilization levels: * - 50 P_2O_5/50 K_2O
** - 40 P_2O_5/30 K_2O

Mixture complexity increases with altitude due to reductions in availability of resources. Botanical composition of intended mixtures must be similar to the composition pattern of permanent grasslands. In Switzerland, complex mixtures with 7-9 species are recommended for extensive systems situated at high altitudes (Alps) or drought affected areas (*Charles et al., 1988*).

However, an intermediate structure of 4-5 species will have a positive effect to improve forage palatability, if it is introduced even in intensive systems. From this number 1-2 species might be legumes in these situations:

- when conceiving the complex mixtures;
- when anticipating valuable yields in the red clover system after the second year of cropping;

- when the persistence of red clover reduces drastically – the second legume replaces the extinction of red clover maintaining the percentage of legumes in the grassland (i.e. white clover or bird's foot trefoil);
- when a mixed management (mowing-grazing) in grasslands is planned – a legume for mowing (alfalfa - *Medicago sativa*, sainfoin - *Onobrychis viciifolia*, red clover - *Trifolium pratense*), and a legume for grazing (white clover – *Trifolium repens*, bird's foot trefoil - *Lotus corniculatus*).

c. *Grass - legume percentage of participation in mixtures* is expressed as percentage from seed quantity used in pure stand.

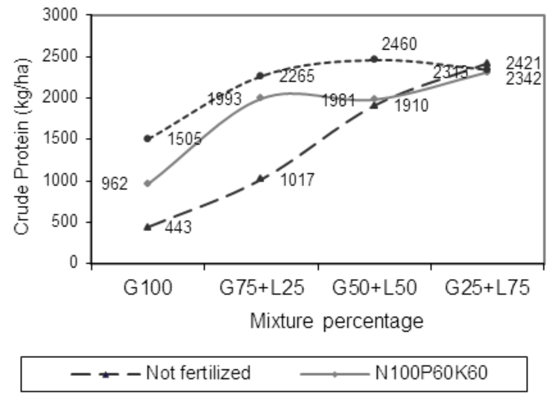
The percentage depends on intended duration and use of the grasslands as well as on biological characteristics of species. Therefore, the legume percentage dominates in short-period mixtures because of the faster development rate and shorter persistence when compared with grass species. They assure overall yields in the first 2-3 years of life. Experimental results (average of 4 and 7 years in different sites) showed that rising the legumes percentage in mixtures up to 75% without fertilization, has provided better dry matter productions (× 3.4) than grass pure stands (*Barbulescu et al., 1991*).
Nitrogen fertilization diminishes the contribution of red clover to the final yield especially at elevated nitrogen inputs (Table 3). Same effect is present on production of crude protein (fig. 6). Furthermore, the legumes determine the improvement of calcium (Ca^{2+})/Phosphorous (P_2O_5) ratio in forage up to 50% (*Motcă et al., 1994*).

The nitrogen input is minimized in function of legumes' participation in the temporary grassland. The same level of dry matter and primary protein is obtained by using 75% legumes in the mixture.

This method should be considered as a substitution of 100 kg N ha^{-1} to achieve 10,000 kg DM ha^{-1} and 1300-1400 kg Protein ha^{-1}.

On the average of 4 years, the nitrogen fixed by legumes is present in the yield at levels of 12 kg/1000 kg DM.

A.



B.

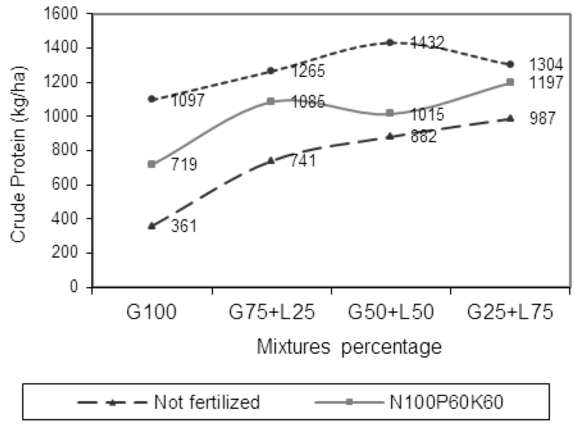


Fig. 5 Influence of grass-legume ratio on crude protein production: a) 2nd year from sowing; b) Average of 4 years; Grass species - G: orchardgrass (*Dactylis glomerata*); Legumes' mixture - L: red clover (*Trifolium pratense* - 80%) and bird's foot trefoil (*Lotus Corniculatus* - 20%); (*Barbulescu et al., 1991*).

The exported biological nitrogen reached 24 kg/1000 kg DM in the second year (maximum productivity of red clover). A quarter from total symbiotic nitrogen is remaining in the soil layer (*Moga, 1993*).

d. *Selection of the species in mixture* – Bio-ecology, production capacity, feed and economical values are important elements to be considered when choosing the species. The selection of forages for hay, pasture, and conservation is an important decision requiring knowledge of species complementary compatibility.

Table 3 Influence of grass-legume ratio on dry matter production (*Barbulescu et al., 1991*)

Grass (%)	Legume (%)	No fertilization		60 P_2O_5, 60-80 K_2O			
				N100		N200	
		(kg/ha)	(%)	(kg/ha)	(%)	(kg/ha)	(%)
100	-	2,140	**100**	6,870	**100**	8,930	**100**
75	***25***	6,100	**285**	8,180	**119**	9,330	**104**
50	***50***	6,820	**318**	8,380	**122**	10,030	**112**
25	***75***	7,290	**340**	9,060	**132**	9,640	**108**

Furthermore, managerial aspects such as intended use of forages, nutritional and dry matter requirements of livestock to be fed, seasonal feed needs, harvest and storage capabilities and seasonal labor availability should be envisaged.

- Species complementary compatibility in binary mixtures implies temporal, morphological, and physiological similitude of both participating plants.
- The competition capacity and the specific quality index are considered as primary indicators for such complex trait. Evaluation of competitiveness is presented excluding the first year of cropping when the majority of species are included in II and III groups (table 4). Alfalfa and ryegrass species are exceptions because of their fast growth rate and improved competitiveness (*Puia et al., 1980*).

The competitiveness can be improved for weak species by correcting the plant densities (using a higher quantity of seeds) depending on the class of concurrence. This will maintain the initial structure of botanical composition during several years of cropping. An increase of 30% seeds is required for the class II species when they are mixed with class I species (table 4).

From the interactions, affecting persistence determined by abiotic and biotic stresses, quoted as having pregnant influence are plant-to-plant competition and weed to plant competition (*Kropff and van Laar, 1993*).

The most productive mixture for high-input hayfields includes red clover and Italian ryegrass, which provides enhanced yields even without N fertilization (fig. 6).

Table 4 Evaluation of the competition capacity for several grass species and legumes (excluding the first year of cropping)

Concurrence class	Grass Species	Legume species
I. High capacity of competition	*Arrhenatherum elatius* *Dactylis glomerata* *Festuca arundinacea* *Lolium multiflorum*	*Medicago sativa*
II. Moderate capacity of competition	*Alopecurus pratensis* *Bromus inermis* *Lolium perenne*	*Trifolium pratense*
III. Weak capacity of competition	*Agropyron cristatum ssp.pectinatum* *Agrostis stolonifera* *Festuca pratensis* *Festuca rubra* *Phleum pratense* *Poa pratensis* *Typhoides arundinacea*	*Lotus corniculatus* *Onobrychis viciifolia* *Trifolium hybridum* *Trifolium repens*

Most researchers pointed out a moderate competitiveness for red clover. *Motcă et al. (1994)* recommended as successful binary mixtures for short-term grasslands (2-3 years), the association of red clover (10-15 kg ha^{-1}) with Italian ryegrass (4-5 kg ha^{-1}). A mixture with tetraploid red clover (10-15 kg ha^{-1}) and timothy (4-5 kg) was suggested for a 4 years grassland system.

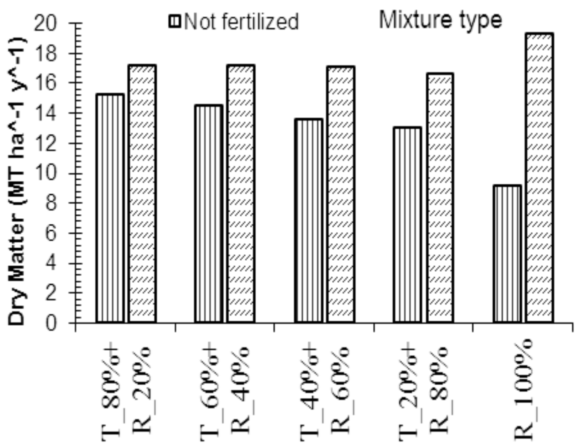


Fig. 6 Influence of *Italian ryegrass (R)- red clover (T)* percentage and nitrogen fertilization on total dry matter production in the first year of cropping - average of 6 locations situated in different ecological areas (*Moga, 1993*).

Optimal sowing ratios for such mixture are considered using 60-80% red clover (12-16 kg ha^{-1}) and 20-40% Italian ryegrass (5-10 kg ha^{-1}).

Moga (1993) recommended also the Italian ryegrass introduction (3-4 kg ha^{-1}) in a mixture of red clover (14 kg ha^{-1}) – orchardgrass (12 kg ha^{-1}) as a reliable solution to improve productivity. Such alternative brought 8-13% gains to the final yield because the resulted dense sward competed successfully with the weeds and low quality grasses.

Italian ryegrass (*Lolium multiflorum* Lam.) or annual ryegrass presents low winter hardiness and therefore behave as an annual species except in mild winters or with proper snow cover. Over-seeding is required due to decreased perennial persistence, which complicates management practices and increases overall costs of crop maintenance. It has potential, as an annual forage crop, to provide high quality fodder for dairy cattle. It produces high yields and maintains productivity through the mid-summer water deficit better than most other cool season grasses in the first year of cropping.

It is easy to establish and grows rapidly.

It is recommended also for use as a companion crop with red clover when establishing new temporary grasslands. Adding it to a mixture with red clover and a more persistent grass, like timothy or orchardgrass, will provide rapid growth and high quality forage in the seeding year. The ryegrass will disappear in 1 to 3 years leaving behind the other grasses and legumes. Hence, Italian ryegrass is a valuable second grass introduced to enrich productivity in a red-clover grass hayfield.

The hybrid ryegrass (Italian type) maintains Italian ryegrass qualities and excludes its short viability. Intermediate, or short rotation ryegrass (*Lolium hybridum*, Hausskn.), is the result of a cross between annual and perennial ryegrass. As such, in comparison with perennial ryegrass, a hybrid has more extended growing season and higher production.

Persistence and winter hardiness are less than perennial ryegrass but better than Italian ryegrass. Its recommended use would be for hay/haylage or grazing production (*Barbulescu et al., 1991*).

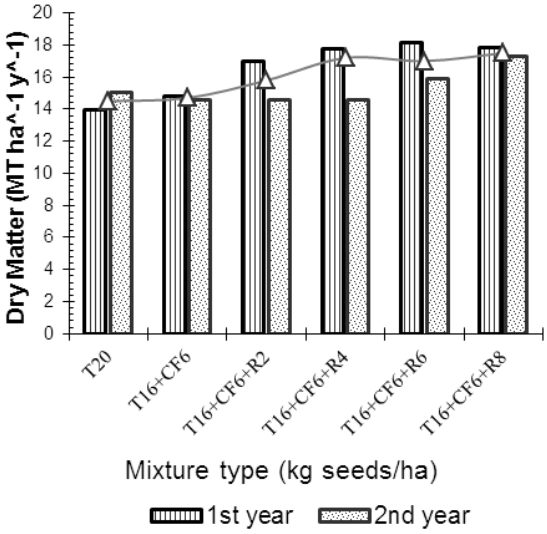


Fig. 7 Influence of *grass* - *red clover* sowing ratio on total dry matter production when differentiating graduation of ryegrass seed are added - Grass species: orchardgrass–CF (*Dactylis glomerata*); hybrid ryegrass-R (*Lolium hybridum*); Legumes: red clover-T (*Trifolium pratense*) (Moga, 1993).

In Romania, the combination of various quantities of hybrid ryegrass seeds in the orchardgrass - red clover mixture provided a better productivity on two years average (almost 4,000 kg ha^{-1} DM – 17-19% gains), when compared to simple mixtures or clover pure stands, due to an active and dynamic competition against weeds (fig. 7).

Hybrid ryegrass (*Lolium hybridum* Hausskn.) is the adequate species in conceiving mixtures for intensive forage systems, either mowed or grazed during two or three years on fertile soils (*Dunea et al, 2015*).

In association with red clover or alfalfa, it provides significant yields owing to its complementary traits such as early growth, high dry matter accumulation, diseases resistance, palatability, and persistence (*Dunea, 2008*).

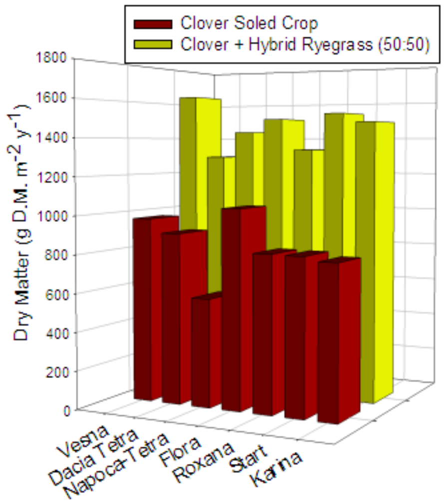


Fig. 8 Total forage production (g D.M. m^{-2}) of clover cultivars (Karina – white clover; other cultivars – red clover) in pure crops and in mixtures of the first year of cropping with hybrid ryegrass (Zefir cultivar) using a participation ratio of 50:50 (*Dunea, 2006*)

e. *Selecting the cultivars for each species*
Clover species and cultivars may differ in their competitiveness with grass species (fig. 8).

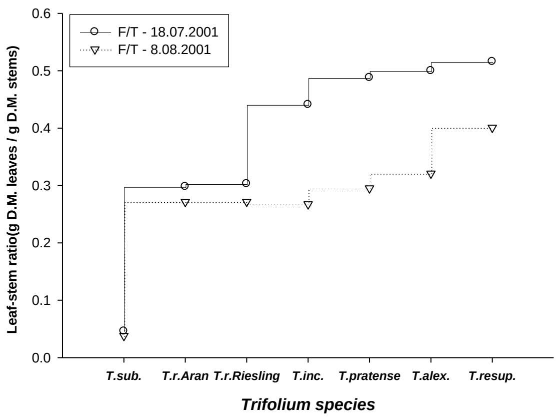


Fig. 9 Leaf stem ratio – qualitative indicator for the forage of the main *Trifolium* species at 100 daye after sowing (T.sub. – *T. subterraneum* cv. Mount baker; T.r.Aran - *T.repens* cv. Aran; T.r.Riesling - *T.repens* cv. Riesling; T.inc. – *T. incarnatum* cv. Contea; T.pratense – *T.pratense* cv. Violetta; T.alex. – *T. alexandrinum* cv. Alex; T.resup. – *T. resupinatum* cv. Accadia) (*Dunea, 2015*).

A mixture must be formed from varieties characterized through similar growth rate and development (an appropriate precocity index). Several parameters are important to take into account when selecting cultivars (emergence, ground cover, winter hardiness, dry matter yields, competitive ability, and disease resistance).

Leaf-stem ratio is an important parameter that provides information regarding fodder quality (fig. 9).

3. CONCLUSIONS

In the current context, the Law of grasslands (O.U.G. 34/2013) was recently issued in Romania, allowing farmers to grant the concession of the grasslands. This will ensure the required animal feeding and will maintain the interest of farmers for the rational management of the leased grassland, being known that overgrazing threatens the floristic diversity of grasslands and causes the extinction of some species. Consequently, it is necessary to develop a suitable decision-making information instrument, which will help farmers for the grazing rationalization to avoid further degradation of grasslands and irreparable damage to their ecological status.

The paper presents a general guide for agricultural specialists who want to understand the basic principles of grassland renovation in the specific conditions of Romanian nemoral regions. It could also provide a framework for students in grassland and forage sciences disciplines to gain more integrated, quantitative insight into the complexity of grass-legume associations.

4. References

[1] Andries A., The role of red clover in Belgian forage production: Changes and perspectives. Fourrages 90. 2737, 1982.

[2] Barbulescu C., Puia I., Motcă Gh., Moisiuc Al., Cultura pajistilor si a plantelor furajere, Editura Didactica si Pedagogica, Bucuresti, 1991.

[3] Buxton D.R., Hornstein J.S., Wedin W.F., Marten G.C., Forage quality in stratified canopies of alfalfa, birdsfoot trefoil, and red clover, Crop Sci. 25:273-279, 1985.

[4] Charles J. P., Lehmann J., Fourrages, 58, 1989.

[5] Crowder C., Romania hopes organic agriculture make business sense, 2001, Regional

Environmental Center for Central and Eastern Europe.http://greenhorizon.rec.org/bulletin/Bull102/romania.html

[6] Duke J.A., Handbook of legumes of world economic importance, Plenum Press, New York, 1981.

[7] Dunea D., Bioconversion efficiency in grass-legume forage systems, LAP Lambert Academic Publishing, Germany, Saarbrucken, ISBN 978-3-659-79200-7, 256 pag., 2015.

[8] Dunea D., Dincă N., Contributions to the Development of a Crop Growth Model for Assessing Grass-Legumes Interactions, Bulletin USAMV CN series Agriculture, 72(2), 388-396, 2015.

[9] Dunea D., Frăsin L.B.N., Dincă N., Ecophysiological Responses of White Clover-Hybrid Ryegrass Mixture to Foliar Fertilisation, Notulae Botanicae Horti Agrobotanici Cluj-Napoca 43 (1), 173-178, 2015.

[10] Dunea D., Dincă N., Improving land utilization using intensive grass-clover mixtures in forage production systems, Romanian Agricultural Research, 31, 2014.

[11] Dunea D., Persistence assessment of red clover (*Trifolium pratense* L.) in Targoviste plain. Scientific Papers Animal Science and Biotechnologies, University of Agricultural Sciences and Veterinary Medicine of Banat Timisoara, Vol. 41, Ed. AGROPRINT, 293-302, 2008.

[12] Dunea D., Motcă Gh., Forage quality assessments of red clover (*Trifolium pratense* L.) through near infrared spectroscopy, Lucrari Stiintifice - Zootehnie si Biotehnologii, Universitatea de Ştiinţe Agricole şi Medicină Veterinară a Banatului Timişoara, Vol. I, Ed. AGROPRINT, Timişoara, 274-283, 2007.

[13] Dunea D., Cercetări privind bioconversia energiei solare la *Trifolium pratense* L. în câmpia piemontană a Târgoviştei, Teză de doctorat, Universitatea de Ştiinţe Agronomice şi Medicină Veterinară, Bucureşti. 29-32; 163-166, 2006.

[14] Guy P., Essais multilocaux d'associations trèfle violet-graminée, Fourrages 117, 29-47, 1989.

[15] Hoden A., Marquis B., De La Foye F.X., Ensilages de mais et de tréfle violet pour vaches laitiéres. Bulletin Techique Centre de Recherches Zoologiques et Veterinaires de Theix (INRA) 67, 33-37, 1987.

[16] International Board for Plant Genetic Resources (IBPGR), IBPGR annual report 1991, Online at: http://www.bioversityinternational.org/e-library/publications/detail/ibpgr-annual-report-1991/

[17] Kropff M.J., van Laar H.H., Modelling crop-weed interactions. CAB International Wallingford, 1993.

[18] Lesak J., Sverakova J., Results of agrotechnical trials with clover/grass mixtures, Rostlinna Vyroba 34(11), 1221-1229, 1988.

[19] Miller D.F., Composition of cereal grains and forages. National Academy of Sciences, National Research Council, Washington, DC. Publ. 585, 1958.

[20] Motcă Gh., Oancea I, Geamanu Lidia Ivona, Pajistile Romaniei, Editura tehnica Agricola, Bucuresti, 1994.

[21] Moga I., Cultura leguminoaselor perene, Editura CERES, Bucuresti, 1993.

[22] NRCS, 2001, RED CLOVER *Trifolium pratense* L. Plant Symbol = TRPR2, Plant fact sheet http://plants.usda.gov/factsheet/pdf/fs_trpr2.pdf

[23] Puia I., Barbulescu C., Pavel C., Oprin C., Producerea si pastrarea furajelor, Editura Didactica si Pedagogica, 1980.

[24] Samuil, C., Producerea şi conservarea furajelor, Editura Ion Ionescu de la Brad Iaşi, 2010.

[25] Savatti M., Rotar I., Monografia trifoiului roşu (*Trifolium pratense* L.), AcademicPres, Cluj-Napoca, 2014.

[26] Taylor N.L., Quesenberry K.H., Red Clover Science, Kluwer Academic Publishers, Dordrecht, 1996.