

QUANTIFICATION OF THE BIOLOGICALLY-FIXED NITROGEN IN TEMPORARY PASTURES, WITH THE METHOD OF NITROGEN BALANCE

CUANTIFICAREA AZOTULUI FIXAT BIOLOGIC LA PAJIȘTILE TEMPORARE PRIN METODA BILANȚULUI AZOTULUI

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Abstract: The simple associations of *Festuca pratensis* and some of the legume species (*Medicago sativa*, *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*) fix biological nitrogen between 57-133 kg/ha, in the first year of vegetation, and between 175-242 kg/ha, in the second year of vegetation. The amount of fixed nitrogen for 1% participation of legume species in the floristic structure was 2.36 kg/ha/year, and the amount of fixed nitrogen that remained in the soil ranged between 54-102 kg/ha.

Rezumat: Amestecurile simple de *Festuca pratensis* și unele specii de leguminoase (*Medicago sativa*, *Trifolium pratense*, *Trifolium repens*, *Lotus corniculatus*) fixează azot biologic între 57-133 kg/ha, în primul an de vegetație și între 175-242 kg/ha în anul al doilea. Cantitatea de azot fixat pentru 1% participare a leguminoaselor în structura floristică a fost de 2,36 kg/ha/an, iar cantitatea de azot fixat rămasă în sol variază între 54-102 kg/ha.

Key words: graminaceous, legume, fixed nitrogen, floristic structure

Cuvinte cheie: graminee, leguminoase, azot fixat, structura floristică

INTRODUCTION

The amount of nitrogen fixed in pasture crops represents a variable function, determined by several parameters: the degree of soil provision with nitrogen, the proportion of legume species in the floristic structure of the vegetal cover, the technology level applied, the method of utilization, local natural conditions, etc.

The estimation of the nitrogen amounts fixed in permanent and temporary pastures differs from one country to another and from one type of pasture to another, depending on the floristic structure (CARLSSON and DANELL – HUSS, 2003; DANELL – HUSS et al., 2007; HANSEN and VINTHER, 2001; HANSEN et al., 2002; LEDGARD and STEELE, 1992; VINTHER et al., 2000).

METHOD OF RESEARCH

The researches were performed at U.S.A.M.V.B. Timișoara, during 2005-2007, on a cambic chernozem-type soil, slightly gleyed. The experimental device was consisted of the following variants: V1= *Medicago sativa* (100%); V2= *Trifolium pratense* (100%); V3= *Trifolium repens* (100%); V4= *Lotus corniculatus* (100%);

V5= *Medicago s.* + *Festuca pratensis* (60% + 40%); V6= *Trifolium p.* + *Festuca p.* (60% + 40%); V7= *Trifolium r.* + *Festuca p.* (60% + 40%); V8= *Lotus c.* + *Festuca p.* (60% + 40%); V9= *Festuca pratensis* (100%).

Before planting, we applied complex fertilizers (15 : 15 : 15) in an amount of 200 kg/ha.

Every year of vegetation, we determined the dry matter yield and took samples of vegetal material in order to analyze the total nitrogen content.

To estimate the amount of biologically-fixed nitrogen (BFN), we applied the method of nitrogen balance, by using a reference graminaceous crop (KRISTENSEN et al., 2004; GRANSTEDT, 1992), according to the formula:

$$\text{NFB(kg/ha)} = \text{Nt (pure crop or association)} - \text{Nt (reference crop)}$$

The quantification of the amount of fixed nitrogen that was transferred to the graminaceous species within the association was carried out according to the methodology elaborated by SIMPSON (1976), who considers that 25.3% of the total fixed nitrogen amount is transferred to these graminaceous plants.

RESULTS

Taking into consideration the importance of the nitrogen-based nutrition for plants, the estimation of the amount of nitrogen fixed by all legume species has a great practical importance for all agricultural ecosystems, natural and cultivated.

The studies regarding the indirect determination of the amount of fixed nitrogen, with the help of the method of total nitrogen balance, showed that there are considerable differences between the legume species studied, indifferently of the cultivation method.

Table 1

Estimated amount of nitrogen fixed in the legume species planted in pure crop or associations with graminaceous, under conditions of unfertilization with nitrogen (first year of production)

Variant	Total N amount in the forage biomass yield (kg/ha)	Estimated amount of fixed N (kg/ha)	Nitrogen fixed according to legume proportion (kg/% of participation)	Fixed N efficiency (kg fixed N/t DM)	
<i>Medicago sativa</i> (100%)	222	169	1,69	27,1	
<i>Trifolium pratense</i> (100%)	176	123	1,23	22,5	
<i>Trifolium repens</i> (100%)	142	89	0,89	21,2	
<i>Lotus corniculatus</i> (100%)	151	98	0,98	18,7	
<i>Medicago s.</i> (60%) + <i>Festuca p.</i> (40%)	219	166	2,18	22,4	
<i>Trifolium p.</i> (60%) + <i>Festuca p.</i> (40%)	181	128	2,87	19,4	
<i>Trifolium r.</i> (60%) + <i>Festuca p.</i> (40%)	139	86	2,95	16,5	
<i>Lotus c.</i> (60%) + <i>Festuca p.</i> (40%)	174	121	2,94	17,7	
<i>Festuca pratensis</i> (100%)	53	-	-	-	
Mean fixed nitrogen amount	Legume species (pure)	173	120	1,19	22,3
	Association	178	125	2,73	19,0

In the first year of production, in the crops planted at the end of summer, under conditions of unfertilization with nitrogen, we observed rather big differences between the legumes species studied in terms of nitrogen fixation capacity.

So, in the case of the legume planted in pure crop, alfalfa fixes the biggest nitrogen amount, respectively 169 kg/ha. The other species fix nitrogen amounts that are 40-80% smaller, respectively 123 kg/ha in red clover, 98 kg/ha in birds foot trefoil and 89 kg/ha in white clover. In the case of the association with the orchard fescue, the amount of fixed nitrogen ranges between 86-166 kg/ha, depending on the legume species in the association (Table 1).

On an average in the first year of vegetation, under conditions of unfertilization with nitrogen, the perennial legume fix between 120-125 kg/ha, and, successive to the application of nitrogen-based fertilizers, the estimated amount of fixed nitrogen is 68-90 kg/ha.

To estimate the capacity of atmospheric nitrogen fixation, we may also use other indices assessing this capacity: the amount of nitrogen fixed according to the legume proportion in the floristic composition of the vegetal cover and the amount of fixed nitrogen according to the dry matter production obtained. From this viewpoint, in the first year of vegetation, we obtained between 0.98-1.69 kg fixed nitrogen in the pure crop and between 2.18-2.95 kg fixed nitrogen in the association, for each percentage of legume participation. The biggest amount, 1.69 kg fixed nitrogen/1% participation, was obtained in alfalfa.

The efficientization of the process of nitrogen fixation may be also made evident by reporting the amount of fixed nitrogen to the dry matter yield achieved from the legume species planted in pure crop or in association with graminaceous species. This method of assessment led to the conclusion that, for one ton of D.M. obtained, the pure legume crops fix between 18.7-27.1 kg N, and the associated crops fix between 16.5-22.4 kg N.

In the second year of vegetation, in the case of the pure crops of perennial legume, the amount of fixed nitrogen was 258 kg/ha in alfalfa, 218 kg/ha red clover, 190 kg/ha in birds foot trefoil and 140 kg/ha in white clover (Table 2).

Table 2

Estimated amount of nitrogen fixed in the legume species cultivated in pure crop and in association with graminaceous, under conditions of unfertilization (the second year of production)

Variant	Total N amount in the forage biomass yield (kg/ha)	Estimated amount of fixed N (kg/ha)	Nitrogen fixed according to the legume proportion (kg/% of participation)	Efficiency of fixed N (kg fixed N /t DM)
<i>Medicago sativa</i> (100%)	297	258	2,58	31,7
<i>Trifolium pratense</i> (100%)	257	218	2,18	29,1
<i>Trifolium repens</i> (100%)	179	140	1,40	27,3
<i>Lotus corniculatus</i> (100%)	229	190	1,90	25,9
<i>Medicago s.</i> (60%) + <i>Festuca p.</i> (40%)	281	242	2,75	27,2
<i>Trifolium p.</i> (60%) + <i>Festuca p.</i> (40%)	235	196	2,64	24,1
<i>Trifolium r.</i> (60%) + <i>Festuca p.</i> (40%)	167	128	1,47	21,5
<i>Lotus c.</i> (60%) + <i>Festuca p.</i> (40%)	214	175	2,57	22,6
<i>Festuca pratensis</i> (100%)	39	-	-	-
Mean fixed nitrogen amount	Legume species (pure)	240	2,01	28,5
	Association	224	185	23,8

In the legume associations with *Festuca pratensis*, the amounts of fixed nitrogen were between 128-242 kg/ha, and we remarked the association consisted of *Medicago sativa* + *Festuca pratensis*, which produced the biggest amount of fixed nitrogen (242 kg/ha).

According to legume percentage of participation in the vegetal cover, their contribution to the achievement of the amount of fixed nitrogen at the level of 1% participation is 2.58 kg/ha/year in alfalfa, 2.18 kg/ha/year in red clover, 1.90 kg/ha/year in birds foot trefoil and 1.40 kg/ha/year in white clover. In the case of the legume and graminaceous crops, the

mean amount of fixed nitrogen for 1% participation of legume species in the floristic structure is 2.36 kg/ha/year.

If we correlate the amount of fixed nitrogen with the DM yield, we may observe that there is a direct relationship of interdependence between these two variables. This aspect was made evident by the results obtained in the first year of vegetation and in the second year of vegetation as well. In the last year of research, we obtained a mean value of 28.5 kg fixed nitrogen for a ton of DM, in the legume species cultivated in pure crop, and 23.8 kg fixed nitrogen in the associated crops of legume species with *Festuca pratensis*.

The researches performed aimed at the determination of the proportion of fixed nitrogen in the amount of total nitrogen obtained in legume crops or associations, too. This determination index of the atmospheric nitrogen fixation lead us to a global assessment of this process; relying on this, we can estimate the amount of nitrogen fixed in natural and cultivated ecosystems, due to the legume contribution.

Table 3

Proportion of fixed nitrogen (in the total amount of produced nitrogen) and the amount of nitrogen transferred to the graminaceous species within the association

Variant	Proportion of fixed N in total amount of produced N (%)		N amount transferred to graminaceous (kg/ha) *	
	Year I	Year II	Year I	Year II
<i>Medicago sativa</i> (100%)	76	87	-	-
<i>Trifolium pratense</i> (100%)	70	85	-	-
<i>Trifolium repens</i> (100%)	63	78	-	-
<i>Lotus corniculatus</i> (100%)	65	83	-	-
<i>Medicago s.</i> (60%) + <i>Festuca p.</i> (40%)	76	86	55	71
<i>Trifolium p.</i> (60%) + <i>Festuca p.</i> (40%)	71	83	46	59
<i>Trifolium r.</i> (60%) + <i>Festuca p.</i> (40%)	62	77	35	42
<i>Lotus c.</i> (60%) + <i>Festuca p.</i> (40%)	69	82	44	54
Mean				
Legume species	68	83	-	-
Associations	70	82	45	56

In the legume species planted in pure crop, the proportion of fixed nitrogen in the total nitrogen amount ranges between 63-76%, in the first year of vegetation, and between 78-87%, in the second year. In the legume crops cultivated in association with *Festuca pratensis*, the proportion of fixed nitrogen in the total nitrogen amount ranges between 62-76%, in the first year, and between 77-86%, in the second year of vegetation (Table 3). These values are concordant with other researches performed, especially by Spatz and Benz (2001), who prove, with the technique of the radioactive ¹⁵N through dissolution, that the proportion of fixed nitrogen differs from one year to another in the total nitrogen amount available in the white clover plants: 91.8% in the first year, 80.4% in the second and 52.3% in the third year of vegetation.

To assess the nitrogen amount transferred to the graminaceous within the association, we considered the estimations made by SIMPSON (1976), who proved that only 25.3% of the total nitrogen produced is transferred to the graminaceous species. Relying on this observation, our determinations made evident that, in the first year of vegetation, between 35-55 kg/ha of the total nitrogen produced is transferred to the graminaceous species, and 42-71 kg/ha in the second year (Table 3).

CONCLUSIONS

- In the first year of vegetation, perennial legume species fix a mean value of 120-125 kg/ha, and in the second year of vegetation between 140-258 kg/ha;
- In the first year of vegetation, for each percentage of legume participation, we obtained between 0.98-1.69 kg fixed nitrogen in the pure crop and between 2.18-2.95 kg fixed nitrogen in the association.
- For one ton of DM obtained, the pure legume crops fix between 18.7-27.1 kg N, and the associations fix between 16.5-22.4 kg N.
- In the first year of vegetation, between 35-55 kg/ha of the total amount of nitrogen produced is transferred to the graminaceous species, and between 42-71 kg/ha in the second year.
- In the legume species cultivated in pure crop, the proportion of fixed nitrogen in the total nitrogen produced ranges between 63-76%, in the first year of vegetation, and between 78-87%, in the second year.

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