DIVERSILIENCE - Diversifying Organic Crop Production to Increase Resilience

D3.2 – Farmer-participatory design and assessment of multispecies forage intercrops

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Abstract

Mixtures of forage species are frequently found to produce more biomass and be less infested by weeds, pests and diseases than pure stands of only one forage species. This is particularly true for mixtures including different functional groups, particularly both grasses and legumes. The presented experiments were aimed at testing and identifying forage mixtures with good performance in Romania and Norway, respectively.

In Romania, the research was focused on mixtures of alfalfa with perennial grasses and dill, and their performance in terms of yield, weeds and alfalfa weevil infestation. The Norwegian experiment aimed at testing the effect of 1) replacing the commonly cultivated red clover with the currently not cultivated bird's foot trefoil in grass-legume and grass-legume-herb mixtures, and 2) adding bird's foot trefoil, or the not commonly cultivated herbs chicory and ribwort plantain to a mixture of timothy, perennial ryegrass and red clover.

The alfalfa–dill-Festuca, alfalfa–dill-Dactilys and alfalfa–dill-Phleum mixtures generally performed better than the alfalfa–Phleum mixture, representing valuable alternatives for forage production in Romania. In these mixtures, no attack by *Hypera variabilis* was reported, which is all the more recommended for the organic farming system. Bird's foot trefoil, cv. Leo, did not perform as well in as red clover in forage mixtures in Norway, in terms of DM yield and protein concentration, but increased the concentration of NDF and metabolizable energy. Addition of bird's foot trefoil, chicory, cv.Puna II, or ribwort plantain, cv. Ceres Tonic, to grass-red clover mixtures did not have a significant effect on DM yield or forage quality.

Introduction

Mixtures of forage species are frequently found to produce more biomass and be less infested by weeds, pests and diseases than pure stands of only one forage species. This is particularly true for mixtures including different functional groups, particularly both grasses and legumes. The presented experiments were aimed at testing and identifying forage mixtures with good performance in one location in Romania and one in Norway.

In Romania, the research was focused on alfalfa and mixtures of alfalfa with perennial grasses and dill, and their performance in terms of yield, weeds and alfalfa weevil infestation. The alfalfa weevil (*Hypera variabilis*) has spread to almost all areas of alfalfa in Romania and cause significant crop losses if no control measures is made.

The Norwegian experiment is part of a series of similar experiments organized in the LegacyNet network (legacynet.ie), and the data will later be subjected to multi-site analyses. We here present a simple analysis of a subset of the treatments, aimed at testing the effect of 1) replacing the commonly cultivated red clover with the currently not cultivated bird's foot trefoil in grass-legume and grass-legume-herb mixtures, and 2) adding bird's foot trefoil, or the not commonly cultivated herbs chicory and ribwort plantain to a mixture of timothy, perennial ryegrass and red clover.

Materials and methods

The experiment in Romania

Experiments were carried out with different perennial and annual fodder species in the experimental field of the Ecological Agriculture center from National Agricultural Research and Development Institute Fundulea situated in south-east of Romania. The experimental treatments consisted of forage mixture crops including 10 alfalfa (*Medicago sativa*) synthetic cultivars and 5 registered alfalfa cultivars, perennial grasses (one variety of cocksfoot (*Dactylis glomerata,* Marius variety), tall fescue (*Festuca arundinacea,* Adela variety) and timothy (*Phleum pratense,* Tirom variety), and dill (*Anethum graveolens)* (Table 1). Biomass yield and infestation by weeds and alfalfa seed weevil were recorded.

Table 1. Experimental mixtures at species level (species compositions). For each of these there were 15 subvariants in which the alfalfa component was represented by one of 15 different populations or varieties (see Table 4).

Alfalfa
Alfalfa + Festuca
Alfalfa + Phleum
Alfalfa + Dactylis
Alfalfa + Anethum
Alfalfa + Anethum + Festuca
Alfalfa + Anethum + Phleum
Alfalfa + Anethum + Dactylis

The experiment in Norway

An experiment with different species compositions of the three functional groups grasses, legumes and herbs with the number of functional groups varying from 1 to 3 and the number of species varying from 1 to 6, were sown at Ås, Norway, in May 2022 in a simplex design with one plot for many of the species compositions and 3 replicate 10.5 m^2 plots of some, all randomly distributed (Table 2). Plots were fertilized with organic chicken manure (70 t N ha^{-1} in 2022 and 100 t N ha^{-1} in 2023). The plots were harvested once in 2022 and three times in 2023 and dry matter yield, species proportions and forage quality measures (by near-infrared spectroscopy) were recorded.

Here, we conducted simple analyses of variance of replicated or pooled data without any correction for spatial variance in environmental variables. The analyses reported here were focused on 1) comparing the performance of bird's foot trefoil with that of red clover, and 2) evaluating the added value of including ribwort plantain and/or chicory in mixtures with the grass-legume mixtures.

Table 2. A) Species and cultivars; B) Sown species proportions in treatments included here. Rates given are the proportions relative to the species-specific recommended sowing rates of pure stands.

A)

Code	Species	Cultivar
G1	Timothy (*Phleum pratense*)	Grindstad
G2	Perennial ryegrass (*Lolium perenne*)	Birger
L1	Red clover (*Trifolium pratense*)	Gandalf
L2	Bird's foot trefoil (*Lotus conrniculatus*)	Leo
H1	Chicory (*Chicorium intybus*)	Puna II
H2	Ribwort plantain (*Plantago lanceolata*)	Ceres Tonic

B)

G1	G2	L1	L2	H1	H2	No. of replicate plots
0.5	0	0.5	0	0	0	1
0.5	0	0	0.5	0	0	3
0	0.5	0.5	0	0	0	1
0	0.5	0	0.5	0	0	3
0	0	0.5	0	0.5	0	1
0	0	0.5	0	0	0.5	1
0	0	0	0.5	0.5	0	1
0	0	0	0.5	0	0.5	1
0.33	0	0.33	0	0.33	0	1
0.33	0	0.33	0	0	0.33	1
0.33	0	0	0.33	0.33	0	1
0.33	0	0	0.33	0	0.33	1
0	0.33	0.33	0	0.33	0	1
0	0.33	0.33	0	0	0.33	1
0	0.33	0	0.33	0.33	0	1
0	0.33	0	0.33	0	0.33	1
0.25	0.25	0.25	0.25	0	0	3
0.17	0.17	0.17	0.17	0.17	0.17	3

Results and discussion

The experiment in Romania

The analysis of variance regarding fresh matter accumulation showed a very significant influence of species composition, alfalfa component and their interaction (Table 3).

Table 3. Analysis of variance for fresh matter accumulation

Source of variation		Fresh matter accumulation		
	DF	Sum of squares	Mean square	F value
Species composition	7	362146	51735	982***
Error A	14	737	53	
Alfalfa component	14	78169	5584	998***
Interaction	98	235528	2403	430***
Error B	196	1253	6	

*** significant for P < 0.01%

The growth of plants, as measured by fresh matter (FM) accumulation was lower in pure alfalfa than in mixtures, except the mixture of alfalfa and timothy. The mixtures with three species had higher total FM yields (Fig. 1).

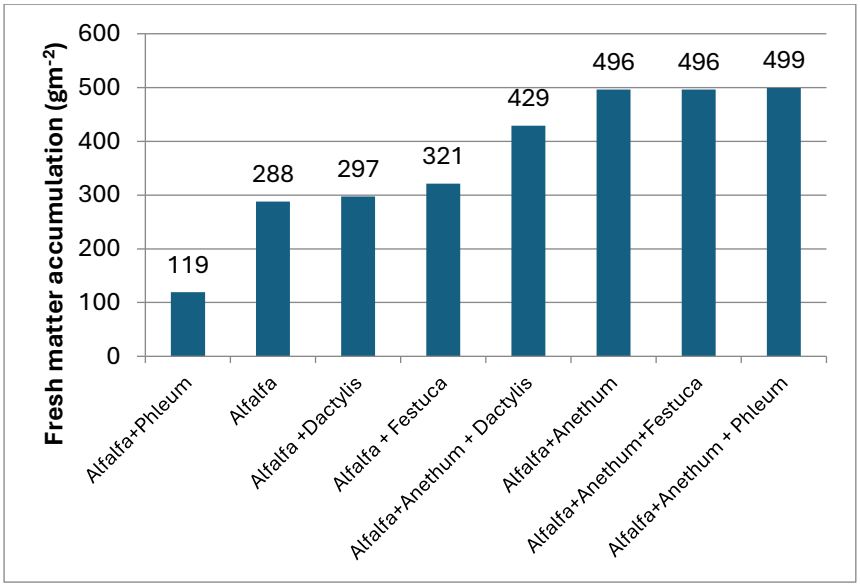

Fig. 1. The biomass accumulation (average fresh matter) in the different species compositions.

There was a variability for fresh matter accumulation also of the alfalfa component. The highest average yields were obtained in cultivars F 2315-14, F 2010-08 and Teodora (Table 4). The lower fresh matter accumulation by the alfalfa-timothy mixture may is explained by the sensitivity to drought of timothy. The results showed a very significant influence of different species compositions on the degree of weed presence in the experimental plots (Table 5). In the mixtures with dill there was no attack by *Hypera variabilis* (alfalfa leaf weevil) (Table 6, Fig. 2).

Table 4. The fresh matter accumulation for the studied alfalfa components in the different species compositions.

Variants	SYN 1-20	SYN 1-6-20	SYN 6-20	F 2404-15	F 2312-14	F 2315-14	F 2616-12	F 2014-08	F 2010-08	F 1918-07	Anastasia	Pompilia	Teodora	Catinca	Dorinela
Alfalfa + Phleum	124	56	70	188	327	189	124	118	121	76	42	53	148	64	89
Alfalfa	249	287	288	288	308	379	171	250	275	332	384	221	362	338	187
Alfalfa + Dactylis	364	270	221	299	116	196	148	344	458	356	500	308	332	293	255
Alfalfa + Anethum	278	456	275	247	360	254	299	277	372	243	368	298	353	352	390
Alfalfa + Festuca	634	278	607	329	302	518	202	196	395	668	490	381	618	400	416
Alfalfa + Anethum + Dactylis	537	624	466	653	537	841	459	282	693	370	362	373	374	352	518
Alfalfa + Anethum + Festuca	547	686	484	479	642	618	286	516	513	469	276	238	823	480	434
Alfalfa + Anethum + Pleum	409	410	360	391	391	482	269	283	438	361	348	281	423	330	350

Table 5. Analysis of variance for degree of weed presence

Source of variation		Number of weeds		
	DF	Sum of squares	Mean square	F value and significance
Total	23	246739	-	
Replicates	2	156	-	
Species composition	7	245884	35126	705***
Error B	14	698	50	

*** significant for P < 0.01%

Table 6. Effect of species composition on attack by Hypera variabilis

Species composition	*Hypera variabilis*
Alfalfa	+++
Alfalfa + Festuca	++
Alfalfa+Phleum	+++
Alfalfa +Dactylis	++
Alfalfa+Anethum	0
Alfalfa+Anethum+Festuca	0
Alfalfa+Anethum+ Phleum	0
Alfalfa+Anethum + Dactylis	0

+: increase, 0: little or no attack

-

Fig. 2. Attack by Hypera variabilis

The experiment in Norway

In the establishment year (2022), there were no significant effect on DM yield when replacing red clover with bird's foot trefoil, cv. Leo, in the mixtures (Fig. 3). After the first winter however, mixtures with bird's foot trefoil had lower yields than those with red clover (significant for grass-legume and grass-legume-herb mixtures; Fig. 3). Replacing red clover with bird's foot trefoil tended to increase the NDF and ME content and reduce the ADF and protein content in 2022. In 2023 NDF content was also higher, and protein content lower, in mixtures with bird's foot trefoil rather than red clover (Fig. 3). This appeared to be due to a combination of a higher content of NDF and lower content of protein in the bird's foot trefoil biomass, a higher proportion of weeds in mixtures with bird's foot trefoil, and lower survival rate of bird's foot trefoil in the winter between 2022 and 2023 (data not shown).

The choice of herb species had no significant effect on DM yield or forage quality variables in any of the years (data not shown). Also, adding bird's foot trefoil, chicory or ribwort plantain to a grass-red clover mixture did not significantly affect DM yield or forage quality variables in any of the years (data not shown). Other cultivars should also be tested before making conclusions on the species as such.

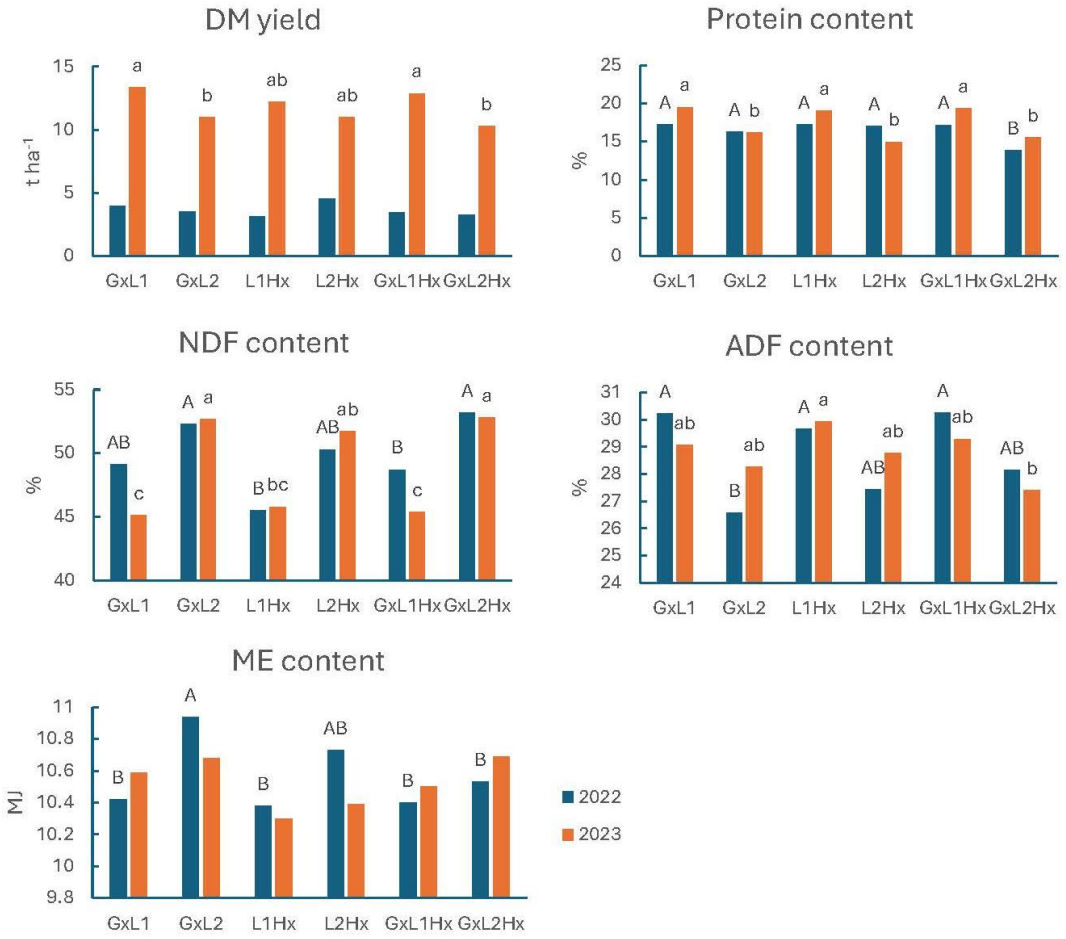

Fig. 3. Yield and forage quality of grass-legume and grass-legume-herb sown mixtures where red clover has been replaced by bird's foot trefoil, cv. Leo. DM, dry matter; NDF, neutral detergent fiber; ADF, acid detergent fiber; ME, metabolizable energy; L1, red clover; L2 bird's foot trefoil; Gx, timothy or perennial ryegrass; Hx, chicory or ribwort plantain. Values not accompanied by the same letter were significantly different within year (P<0.05).

Conclusions

The Alfalfa–Anethum-Festuca, Alfalfa–Anethum-Dactilys and Alfalfa–Anethum-Phleum mixtures generally performed better than the Alfalfa–Phleum mixture, and they represent valuable alternatives for forage production in Romania. In these mixtures, no attack by *Hypera variabilis* was reported, which is all the more recommended for the organic farming system.

Bird's foot trefoil, cv. Leo, did not perform as well in as red clover in forage mixtures in Norway, in terms of DM yield and protein concentration, but increased the concentration of NDF and metabolizable energy. Addition of bird's foot trefoil, chicory or ribwort plantain to grass-red clover mixtures did not have a significant effect on DM yield or forage quality.