

Grasses versus legumes for biorefining of protein - effects of fertilizer and defoliation regimes

Objective: quantify effect of plant species, fertilization, cut frequency and height on biomass production and regrowth of perennial systems.

Method: Rainfed loamy sandy soil in Foulum (Denmark); 2019 establishment year, 2020-2021 production years; nitrogen (N) fertilizer split at each cut; cut biomass sample- dry matter and N content. Annual values in mixed-effects linear model.

Table 1. List of main treatments and their levels in the field experiment.

Plant species (P)	Nitrogen fert. (N)
G1 Perennial ryegrass (<i>Lolium perenne</i>)	N1 300 kg N ha ⁻¹ N2 500 kg N ha ⁻¹ N0 0 kg N ha ⁻¹
G2 Tall fescue (<i>Festulolium arundinacea</i>)	
L1 Alfalfa (<i>Medicago sativa</i>)	
L2 Grass-legume mix	N0 0 kg N ha ⁻¹
L3 Red clover (<i>Trifolium pratense</i>)	
Cut frequency (F)	Cut height (H)
F1 2 weeks	H1 7-9 cm
F2 4 weeks	H2 12-14 cm
F3 6 weeks	

$$Y(\text{biomass, nitrogen})_{ijkm} = \mu_{\text{mean}} + P_i + F_j + H_k + N_m + (P_i \times F_j \times H_k \times N_m) + \text{Block}_{n=4} + \text{error}_{ijkm}$$



Fig. 1. Grass-legume mix vs. tall fescue (left) and tall fescue cut at 6 and 2 weeks - regrowth (right), July 2020.

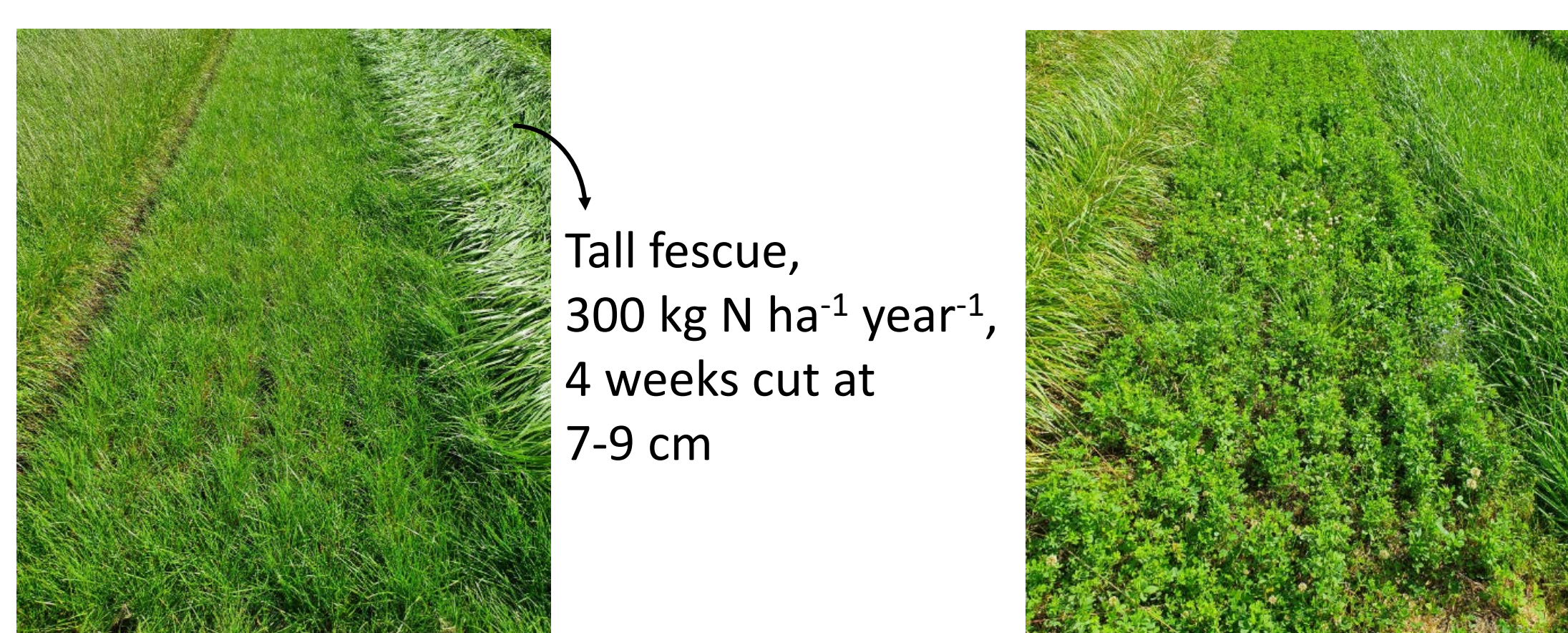


Fig. 2a. Ryegrass, 500 kg N ha⁻¹ year⁻¹, 2-weeks cut at 7-9 cm.



Fig. 2b. Lucerne, 0 kg N ha⁻¹ year⁻¹, 2-weeks cut at 7-9 cm.

Results:

Table 2. Significance of treatment factors in first production year 2020. On mean 2020-2021 basis, significant factors turned P, F and H, as well as P:F, P:H and F:H.

Biomass yield			Nitrogen content		
Factor	F value	Pr(>F)	Factor	F value	Pr(>F)
P	153.8	<2.2 10 ⁻¹⁶ ***	P	170.9	<2.2 10 ⁻¹⁶ ***
F	65.2	<2.2 10 ⁻¹⁶ ***	F	82.6	<2.2 10 ⁻¹⁶ ***
N	22.2	6.5 10 ⁻⁶ ***	N	131.6	<2.2 10 ⁻¹⁶ ***
H	42.0	1.9 10 ⁻⁹ ***	H	23.0	4.5 10 ⁻⁶ ***
F:H	6.6	0.0018 **	F:H	3.5	0.0322 *
P:F:H	2.6	0.0099 **	P:F:H	2.1	0.0431 *
F:N	2.4	0.0929 .	F:N	3.3	0.0393 *
P:N	3.7	0.0555 .	P:F:N	3.7	0.0379 *

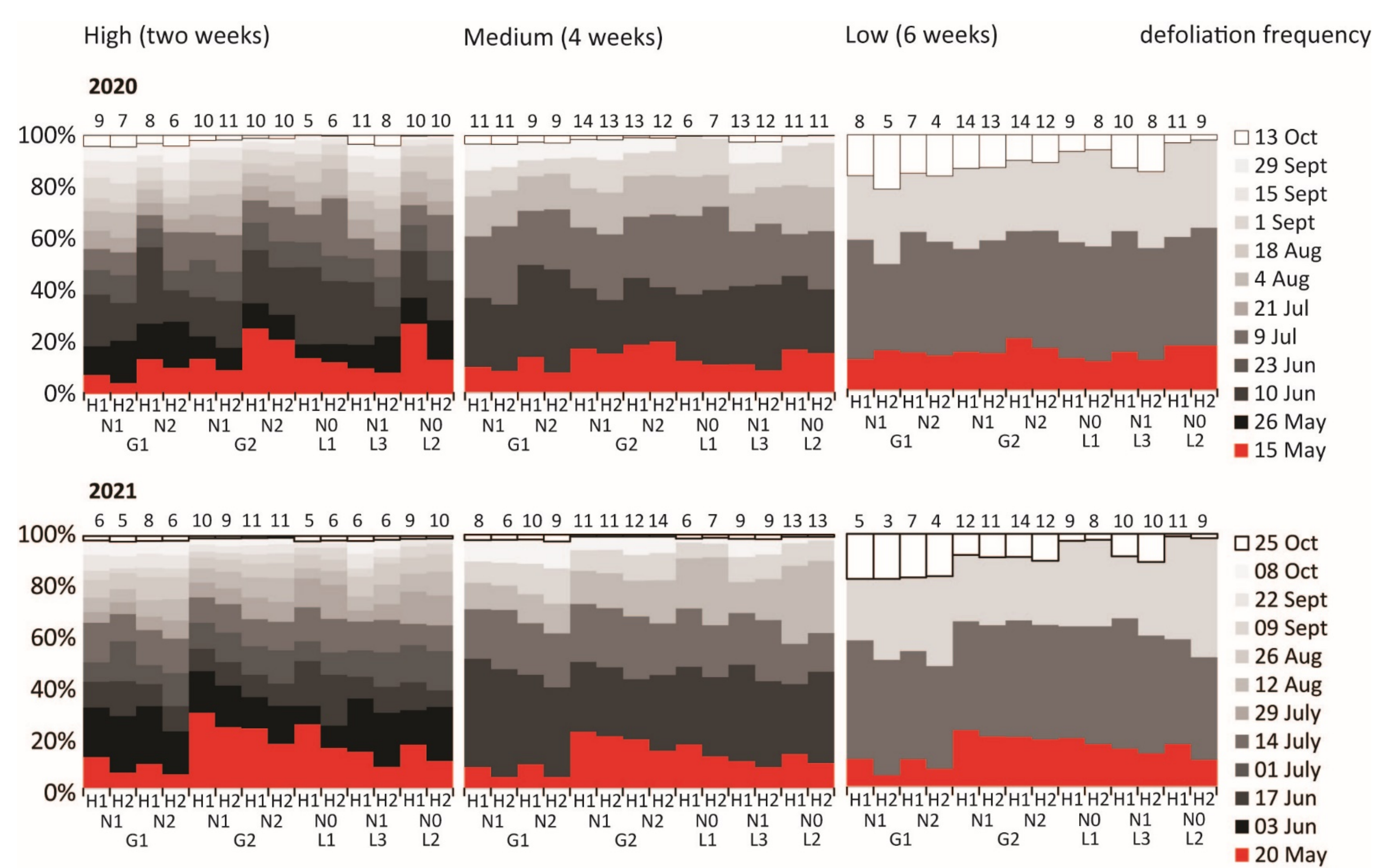


Fig. 3: Contribution of defoliation in annual biomass. Treatment codes on the x-axis are shown in Table 1.

Conclusion: Tall fescue and grass-legume mix cut 4 or 6 weeks - most productive for biomass; red clover cut 2 to 4 weeks yielded largest N; 2021 data confirm this response. Spring cut - substantial for some treatments - regrowth stimulation.