Root growth of ryegrass-white clover swards depends on sward age

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1 Introduction

How the root system, the quantity as well as quality, differs among sward ages seldom received attention. It was assumed that the root system of older sward is likely to be more efficient, whereas better rooting characteristics of resown sward was expected either to perform a better yield in dry years or to have greater uptake / growth hence reducing nitrate leaching; but direct observation among sward ages is scant. Earlier study found that the sward age has close relation in soil N availability in leys, which gives rise to difficulty in distinguishing sward age effect from the effect of N where ferilizer is added. The specialty in ryegrass-clover swards is that N addition will decrease the proportion of clover, who inherently had no response in terms of SRL, root production and root C/N ratio, which are all lower compared with that of perennial ryegrass [3], hence the effect of sward age and N would be confounded by the alternation in sward composition. After renovation of grassland, applying organic N manure not only improved sward establishment and root standing biomass but also increase soil total C and total N compared with mineral fertilizer. On the other hand, grasslands treated with slurry are also associated with increased respiration as well as fastened SOM mineralization involving the C/N and SRL [5], indicating the contribution of improved root standing biomass to long-term C sequestration is limited due to alternation in the root quality.
Interaction of sward age and fertilizer (if exists) may alter the sward composition which drives the C and N cycle in grasslands in an indirect way and the quantity and quality (*e.g.* chemical and morphological traits) of roots in a direct way, hence being a driving factor altering decomposition in the litter-soil continuum. In present work, we tested how root growth pattern (quanitative and qualitative parameters) responses to different sward ages and slurry level in concern with sward composition.

2 Material and methods

Two years' field experiment was performed in managed perennial ryegrass (*Lolium perenne* L.) – white clover (*Trifolium repens* L.) swards (4 defoliation per year) nearby Kiel to investigate effect of sward age (1-, 2-, 5-years' old sward and permanent grassland control, referred as Y1, Y2, Y5 and PG then) and cattle slurry (0 or 240 kg N $ha^{-1}y^{-1}$, referred as N0 and N1 then) on root growth. Total root production was estimated by accumulative root biomass in 4 sequential ingrowth core sets [1] in all swards with special concern of specific root length (SRL, m g^{-1}) and root *in-season* turnover which was calculated as difference between BNPP and retained root biomass in a long-term ingrowth-core in Y1 and Y5 to evaluating fine root lifespan. Belowground biomass (BGB) as well as sward composition (classified into grass, clover and herbs) were observed at each defoliation day. Results was first examined in respect to sward age, slurry and sampling dates in three-way ANOVA; while no interaction of sampling date with other factors the annual weighted means of parameters were compared in two-way ANOVA. Experimental year was considered as random effect

in models. To estimate the effect of sward composition, ANCOVA was performed with the aboveground white clover proportion (CP) as covariable.

Tab. 1: Belowground biomass (BGB) and annual root production (BNPP) among the four ages of sward treated without (N0) or with (N1) slurry.

		Y1	Y2	Y5	PG
BGB (g m^{-2})		427 ± 28 B	518 ± 27 B	599 ± 21 A	621 ± 24 A
BNPP (g m^{-2})	N0	575 ± 52 bA	403 ± 27 bB	312 ± 31 bB	368 ± 21 aB
	N1	630 ± 60 aA	571 ± 87 aA	416 ± 38 aC	433 ± 50 aB

Different capital letters showed significant difference between rows at α level of 0.05. Mean±1 SE, n=12.
Different lower-case letters showed significant difference among columns at α level of 0.05.

Tab. 2: Comparison of three-way ANOVA and ANCOVA with the aboveground white clover proportion (CP) as covariable in assessing the fixed effect of sward age (Y), slurry (N) and sampling date (D) on root production (g m^{-2}) at each defoliation.

	ANOVA				ANCOVA		
	numDF	F value	P - value		numDF	F value	P - value
Y	1	41.2	0.0014	Y	1	27.0	0.0035
N	1	9.95	0.0103	N	1	0.461	0.513
D	3	33.0	< 0.0001	D	3	30.0	< 0.0001
Y × N	1	0.457	0.514	Y × N	1	0.491	0.499
Y × D	3	2.53	0.0659	Y × D	3	2.11	0.109
N × D	3	0.125	0.9443	N × D	3	0.158	0.924
Y × N × D	3	0.888	0.452	Y × N × D	3	0.811	0.493
				CP	1	31.8	< 0.0001

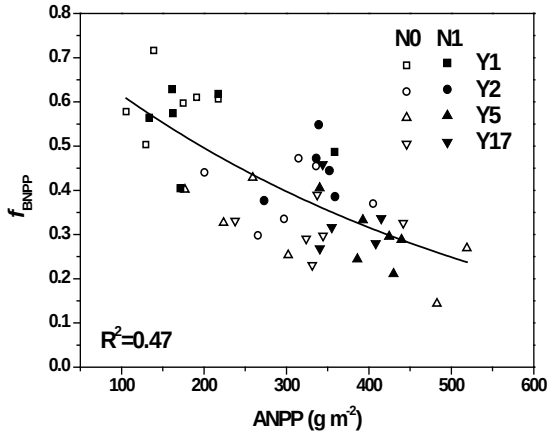

Fig. 1: Herbage production (ANPP) and fraction of root production in total production (f_{BNPP}) at silage cut.

3 Results and discussion

Root mortality and morphological regulation indicated by SRL and N concentration differed with sward age

When comparing the SRL of new roots between Y5 with Y1 at each defoliation date, it was comparable and is not affected by either slurry or clover proportion (CP). Effect of slurry and CP was significant on root C/N and N concentration, sward components other than clover (mostly perennial

ryegrass) in Y5 had a significant higher root N concentration during the last defoliation interval as well as a significant lower SRL of retained root, indicating that in Y5N1 there's a larger proportion of finest lateral roots of the ryegrass roots had undergone turnover due to the improved N concentration. The SRL in vegetative regrowths was significantly higher than that at the silage cut. Among the three vegetative regrowths, ryegrass component of Y5 had a higher SRL during late summer when suffereing drought, therefore it is indicated that the older ryegrass could more efficiently regulate its SRL when facing with low resource availability.

BGB accumulation in relation with sward age

Interestingly, the in-season root turnover rate in Y1 and Y5, had no relation with either slurry or sward composition. Therefore, the unchanged in-season root turnover in the ryegrass component in Y5N1 compared with Y5N0 has two indications: (1) it was a trade-off between the amount of turned over C and N: more N was lost in Y5N1 compared with Y5N0 especially in late growing season when suffering mortality; and (2) decomposition of root necromass could thus be promoted regarding to that the higher N loss mainly commenced in late growing season when microbial activity was more competitative. When such indications about root growth pattern from Y5 was extrapolated to PG, the root C/N ratio, N concentration, root fraction (f_{BNPP}) and sward composition were all considered. Y5 and PG showed consistent pattern on all the above parameters: lower C/N ratio throughout growing season, and higher root N concentration as well as lower f_{BNPP} of the ryegrass component during late growing season were found in Y5 and PG.

On the sward level, slurry improved BNPP in all swards but was attributed to an effect on reducing the CP who had a smaller root system. BGB was not excessively accumulated as sward ages, which should be explained by the faster decay of root necromass stimulated by ryegrass. The allocation pattern (Fig.1) also suggested that older swards are prone to have a relatively smaller root system and this effect is over the effect of N. Albeit the sward age's effect is only beyong effect of N by the silage cut, however, since the root production till silage cut already counted 40% total BNPP and not affected by N, its impact on the annual buget is substantial. The allocation pattern varying with sward ages, may be caused by both the higher N availability in older sward as well as the more sensitive root system. The slow-down root-C accumulation was also verified by the fact that the SOM restoration to a large extent commenced in Y1 and Y2; differences of SOC between Y5 and PG was negligible in a parallel experiment [4]. Therefore, we suggest that although the CP was suggested to have a faster root turnover than ryegrass as well as a low C/N ratio [2] which apperered adverse for root-C retaining in soil, however, white clover also gives smaller priming effect and such effect accentuated more as sward aging due to that the mortality of ryegrass becomes more sensitive in older sward.

4 Conclusion

Our results highlighted the stimulated root mortality and degradation of old root litter/particulate organic matter (i.e. an enlarged labile C pool) brought by slurry gradually became beyond its initial effect in increasing C influx to soil as sward ages. To main the clover proportion may especially favour root-C residence in long-term low-input system besides its advantage in fixation of N.

5 Literature

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