PERSISTENCE AND ESTABLISHMENT OF RED CLOVER UNDER EXTENSIVE FORAGE PRODUCTION SYSTEMS IN NORWAY

Ievina STURITE[1], Tor LUNNAN[2]
Norwegian Institute of Agricultural and Environmental Research, [1]Bioforsk Tjøtta, [2]Bioforsk Løken.
Tjøtta, NO-8860, Norway and Volbu, NO-2940 Heggenes, Norway
Email: ievina.sturite@bioforsk.no; tor.lunnan@bioforsk.no

Abstract. *Longevity and establishment of red clover in grassland was examined in field studies in Nordland County and in experiments at Tjøtta and Løken in Norway. Red clover plants in old swards showed very high age and a branched root system. Only a few seedlings were found suggesting that self-seeding was insignificant. Experiments with leaving the grassland after the first cut for seed production of clover failed due to poor seed produc tion. Surface seeding of red clover in pure grass plots gave good results, especially with early spring seeding.*

Key words: *clover age, longevity, self-seeding, surface seeding, sward.*

INTRODUCTION

The amount of clover in the field is decisive for the N_2 fixation, the protein content and general quality of the forage produced. One of the major problems in maintaining a desired content of clover in grassland is the seasonal and annual variation in performance. Red clover (*Trifolium pratense* L.) is normally a short-lived perennial with no vegetative propagation. The number of plants in the field normally declines rapidly. Lunnan (2004) found a decline from 60-90 plants m^{-2} in the autumn the year after sowing to 30-50 plants m^{-2} in the fourth production year with a corresponding decline in clover proportion of the stand and N_2 fixation.
In mainly grass producing areas most farmers prefer to have long-lasting grassland, while the costs and labour demand with a frequent renewal are high. In Japan, Sakanoue (2002) reported that a red clover stand has persisted for 20 years since its establishment under regular cutting at an altitude of 1200 m. The ability of legumes to regenerate from the soil seed bank has been also observed in Australia and the USA (Carr et al., 2005). These observations suggest that red clover might be maintained by self-seeding over time. However, most of the red clover seeds do not germinate immediately after falling to the ground. A large proportion of hard seeds germinate in the following spring leading to sufficient amount of clover in the subsequent year (Sakanoue, 2002).
Reseeding of clover in grass-dominated turf has been done with variable success in Norwegian experiments (Rivedal et al., 2001; Volden et al., 2005). One other option is to try self-seeding where red clover plants are allowed to set seed and thus renewing clover plants in the sward. This has not been tried in Norwegian experiments. After seed shattering the crop must be removed, and the sward should be kept short with grazing the following spring with no N fertilisation to reduce competition for clover seedlings.
In Nordland County there is a farm with a fairly good clover stand in more than 15 years old grassland. In the presented study we examined grassland botanical content and attempted to recognise age of red clover plants. Our hypotheses was 1) that extensive grassland management promotes self-seeding of red clover 2) self-seeding maintaining a desired content of red clover over time. In addition, we tested two harvesting regimes of the first cut for seed maturation and seed quality at two locations in Norway.

MATERIALS AND METHODS

Farm study

This study was carried out at the Handnesøya in Nordland County (66.27°N). The farm has been managed organically for 20 years. Plenty of grassland area allows extensive management, one cut during the growing season. The growing conditions are typical for coastal climate. Closeness to Polar Circle results in 24 hours light during summer and compensates low air temperatures during growing season. Winters are unstable with shallow snow cover and several freezing and thawing events. We chose to map 3- and 20-years old swards in early spring 2011. We assessed clover age and its content in sward. Age of red clover was evaluated randomly by digging up red clover plants and by assessing their root system. The roots of more than 30 red clover plants

were dug up in each of sward and part of them was carefully washed under tap water. Botanical composition of the sward and the content of red clover was determined by the dry-weight range method (t'Manntetje and Haydock 1963).

Field studies

Red clover cv Bjursele (2x), Betty (4x) and Lea (2x) were sown in mixture with timothy (*Phleum pratense* L.) and meadow fescue (*Festuca pratensis* L.; 6 kg ha^{-1} red clover + 7 kg ha^{-1} timothy + 3 kg ha^{-1} meadow fescue) at two sites in Norway – Løken (530 m a.s.l., 61.12° N) and Tjøtta (10 m a.s.l., 65.49°N). The first cut was carried out at two different points of time: early heading of timothy and ten days later. In order to allow seed ripening about one third of the plot containing cv Bjursele was not harvested under the second cut. The forage yield was recorded under the both cuts. At Løken, forage quality was analysed. In late autumn, non-harvested red clover plants were cut and placed on the surface of pure grass plots (1 m^2 each). The establishment of red clover after different cutting regimes was recorded year after and compared with following surface seeding treatments: either 0, 2 and 10 kg ha^{-1} surface seeding in late autumn or early spring in pure grass plots. In addition, red clover seeds of cv Bjursele after different cutting regimes were collected in late autumn and tested for germination. Seeds were placed on wet filter in plates of Petri for one week at 18 °C. Thereafter number of germinated seeds was counted and germination capacity determined. All treatments described above had three replicates. Statistical analysis of ANOVA was performed to find out the effect of treatment.

RESULTS

Farm study

Assessment of botanical composition showed that timothy and meadow fescue dominated both in 3 and in 20 years old swards (Fig.1). The content of red clover in the old sward was moderate, on average 4%. In the three years old sward red clover content was significantly higher than in the old sward and was on average 27%.

Red clover plants from the young sward had a taproot, major part of roots were white and little branched (Fig.2). In contrast, the plants from the old sward had brown, dark brown and a branched root system (Fig.3 and 4). Those plants had no taproot and observations suggested that plants relied on lateral roots. Thus, red clover plants in old swards showed very high age. A proportion of young red clover plants was low (Fig.5). Very few seedlings of red clover were found in the 20 years old sward suggesting that self-seeding was insignificant.

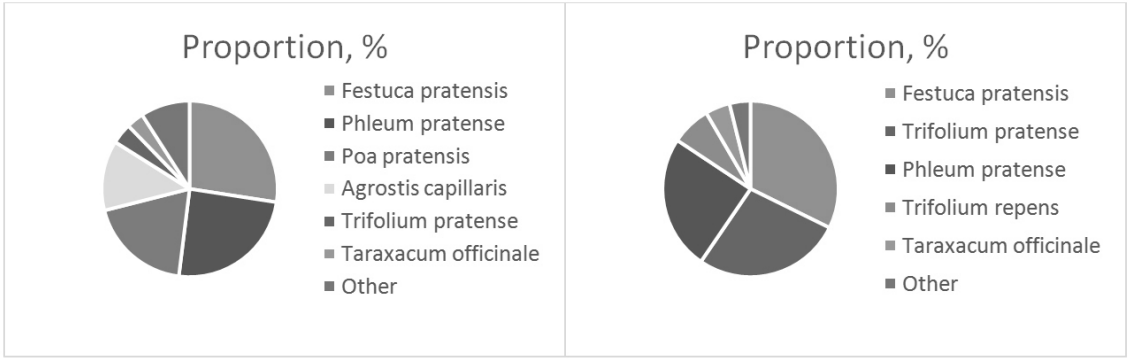

Figure 1. **Botanical composition in a 20 yr old grassland (left) and three year old grassland (right) at Handnesøya, Nordland County.**

Establishment of red clover

The content of red clover in the herbage varied between 30-70% at both experimental sites and years. Forage yields and quality of different cutting times at the first harvest are shown in Table 1. There were no difference in yield between red clover varieties, locations and years. However, cv Bjursele gave somewhat lower herbage yield than Betty and Lea in the second production year at Tjøtta. On average for both locations, uncut red clover after the first harvest resulted in 3.25 tons DM per ha loss of forage yield.

Figure 2. **A taproot of 3 years old red clover plant**

Figure 3. **A branched root system of more than 10 years old red clover plant**

Figure 4. **Red clover plants from 20 years old sward**

Figure 5. **Red clover seedling found in 20 years old sward**

Table 1

Yield, tons DM per ha, energy value, fodder units per kg DM and protein content (% of DM) in clover-rich grassland at two harvest times for the first cut. Average of three red clover cultivars and two fields

	Yield, t DM ha^{-1}		Energy value, FU kg^{-1} DM		Crude protein, % of DM	
Cut no	1	2	1	2	1	2
Early 1st cut	4.35	3.65	0.91	0.83	14.6	16.7
Medium 1st cut	6.00	2.85	0.81	0.87	14.5	17.3

About 90% of red clover plants flowered at both sites and experimental years. However, cold and rainy second part of summer limited seed development and maturing, particularly at the first experimental year at Løken when there were no mature seeds at all (Table 2). Red clover seeds collected at Tjøtta showed better germination capacity at the first production year than at the second production year.

Surface seeding in established pure grass stand gave better results than placement of cut red clover donor plants (Table 3). The surface seeding in early spring showed better result of red clover establishment than the surface seeding in late autumn.

Table 2

Germination rate (%) of red clover seeds collected late autumn after early and medium harvest time in the first cut at Tjøtta and Løken

	Early 1st cut	Medium 1st cut
Tjøtta 2012	43	12
Tjøtta 2013	9	13
Løken 2012	0	0
Løken 2013	25	17

Table 3

Number of established red clover plants per m^2 in pure grass stands at Løken and Tjøtta

	Red clover plants, n m^{-2}		
	Løken, autumn 2013	Løken, summer 2014	Tjøtta, autumn 2013
Grass control	0	1	0
Donor after early 1st cut	2	4	0
Donor after medium 1st cut	1	0	0
Autumn seed, 2 kg ha^{-1}	14	5	3
Autumn seed, 10 kg ha^{-1}	67	41	24
Spring seed, 2 kg ha^{-1}	90	67	17
Spring seed, 10 kg ha^{-1}	309	213	49
SE mean	6.6	13.0	6.7
P value	<0.001	<0.001	0.001

DISCUSSION

Usually, there are very few red clover plants in old swards. Common harvesting systems in Norway do not promote seed development and self-seeding in older grasslands. Thus, red clover content and density decrease with time. Moreover, thick layer of dead plant material in old sward may limit establishment of seedlings. Mapping of red clover at Handnesøya suggests that renewal of red clover by self-seeding was low in swards up to 20 years age. Sometimes red clover seeds do not germinate immediately after falling to the ground. A large proportion of hard seeds might germinate after some period leading to sufficient amount of clover in the subsequent years (Sakanoue, 2002). In our study, the majority of red clover plants were old with branched root system. This finding suggests that extensive harvesting system with one cut during the growing season and long regrowth period after may preserve red clover plants rather well. However, we were not able to find out exact age of the plants but the root system suggested that red clover plants were old.

Experiments with red clover for self-seeding showed that the growing period and weather conditions after the first cut were unsatisfactory for seed ripening at both Løken and Tjøtta. In such weather conditions, seed development probably would be more successful without cutting. The yield loss without cutting usually will have higher economical value for the farmer than buying seeds for reseeding. This self-seeding method therefore only might be interesting for farmers with a surplus of grassland area compared to the forage need. In practical farming, seed could be produced in stripes while the rest of the area is harvested in normal time for forage. The seed crop then can be spread over the total area after cutting.

Field experiments showed that surface seeding in spring gave the best results. Thus, winter damages might be repaired by spring reseeding in young swards. Our experiments also showed that red clover seeds germinate well without any soil tillage. However, in old swards some restrictions may occur. The seed contact with soil surface may be limited and decomposing plant material may affect seed germination (Haugland and Brandsæter 1999). Under such conditions, some soil tillage must be applied. In practise, the clover plants are small in the seeding year and have small impact on forage yield and quality. The effect of clover increases in the next production year.

CONCLUSIONS

This study shows that in northern climate, growing season is too short for qualitative red clover seed production after the first cut. Thus, self-seeding of red clover would be rare in extensive managed grasslands. Assessment of red clover plants in old swards showed that clover might have a very long lifespan if only one cut applied during the growing season. Old red clover plants lived on branched lateral root system as the taproot had died away. Spring surface sowing of red clover might work well in young grass swards.

REFERENCES

1. Carr P M, Poland W W and Tisor L J 2005. Natural reseeding by forage legumes following wheat in Western North Dakota. Agron.J. 97: 1270-1277.
2. Haugland E og Brandsæter L O 1999. Veksthemmende forbindelser i vinterskadd eng. Planteforsk Grønn Forsking 6: 16-18.
3. Lunnan T 2004. Avling, kvalitet og varigheit i økologisk kløvereng. Grønn kunnskap 8 (2): 136-143.
4. t'Mannetje L og Haydock K P 1963. The dry-weight-rank method for the botanical analysis of pasture. Grass and Forage Sci. 18: 268-275.
5. Rivedal S, Øpstad S L and Skjelvåg A O 2001. Innsåing av raudkløver og gras i eng. Grøn Forsking 2: 325-332.
6. Sakanoue 2002. Seedling appearance, survival and flowering of *Trifolium pratense* in cutting meadow. JARQ 36: 235-241.
7. Volden B, Vastveit K and Haugland E 2005. Våtsåing av kløver og flerårig raigras i etablert grasmark. Grøn kunnskap 9(2)