Effect of strip seeding of *Trifolium repens* on a sward under continuous cattle grazing

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Effekte von Streifeneinsaaten von *Trifolium repens* in Grünlandbeständen unter forführender Dauerbeweidung

1 Introduction

To introduce desired plant species into grasslands, strip seeding is a possible method. Strip seeding is a non-arable technique of grassland improvement that minimizes the costs of sward renovation and protects soil from eroding (KOHOUTEK et al., 2002). To increase the yield and quality of herbage, productive grasses with a high content of carbohydrates and clovers are introduced into the sward in this way. White clover (*Trifolium repens*) is an important plant for the pasture sward, since it contributes to a high quality forage and also fixes atmospheric N for its own growth and for the growth of the grasses and forbs. In temperate grasslands, nitrogen fixation was estimated at 40–150 $kg.ha^{-1}$ per year (i.e. FRAME, 1992; ÚLEHLOVÁ, 1993; ČUNDERLÍK, 2001; ELGERESMA and SCHLEPERS, 2001).

T. repens is a shade-intolerant species and is rapidly suppressed in tall vegetation (GRIME et al., 1988). On the other hand, *T. repens* is highly expansive in intensively grazed productive pastures. During one growing season, creeping

Zusammenfassung

Der Einfluss von Streifeneinsaat von Weißklee auf die Grasnarbe einer Standweide mit Färsen wurde im Isergebirge über einen Zeitraum von fünf Jahren (1993–1997) untersucht. Zwei Varianten wurden geprüft: Nachsaat (R) und Kontrolle (C) ohne Nachsaat. Die Höhe der Grasnarbe schwankte zwischen 5–7,3 cm; diese Narbenhöhe wurde durch die Anpassung der Größe der Weidenfläche bzw. der Besatzdichte mit Färsen eingehalten. Obwohl zu Beginn des Versuches Weißklee in der Kontrollvariante nur zu geringen Anteilen vorkam, wurden ab dem dritten Versuchsjahr in beiden Varianten vergleichbare Kleeanteile festgestellt. In der Kontrollvariante, die nicht nachgesät worden war, nahm der Kleeanteil mit der Zeit zu. Das Ergebnis zeigt, dass die Streifeneinsaat von T. repens gegenüber einer Kontrolle ohne Einsaat nur einen geringen Effekt hat, wenn Weißklee in der Vegetation vorhanden ist bzw. Samen aus benachbarten Weiden oder der Samenbank des Bodens eindringen bzw. auflaufen können.

Schlagworte: Grünland, Weißklee, Grünlanderneuerung, Pflanzenbiomasse

Summary

The effect of strip seeding of white clover on a sward under continuous stocking of heifers was studied in the Jizerské hory Mountains over five years (1993–1997). There were two treatments applied in our study: reseeded pasture (R) and control (C) without reseeding. The sward was maintained at a height of 5–7.5 cm, varying the grazing area and reducing the number of heifers under both treatments in late summer. Although a low share of white clover was recorded under treatment C at the start of the experiment, a similar cover and biomass production was revealed under both treatments during the third, fourth and fifth experimental season. The white clover cover and biomass production under the control, which received no renovation, increased with time. The result demonstrates the low importance of *T. repens* strip seeding into pastures where at least some plants or seeds are present in a sward, or in adjacent pastures, or in the soil seed bank.

Key words: Grassland, white clover, pasture renovation, plant biomass.

shoots of *T. repens* may reach over 1 m in diameter (SANDERSON in THÓRHALLSDOTTIR, 1990a). THÓRHALLSDOTTIR (1990b) investigated the fine (1 cm) scale dynamics of a pasture sward. *T. repens* never occupied the same space in the subsequent year more often than could be accounted for by chance. In addition, there was no relationship in its local abundance between successive years. *T. repens* therefore appears to move very rapidly through the sward and its pattern is highly dynamic. THÓRHALLSDOTTIR (1990a) recorded a white clover biomass of only 20 % in plots in which it had been sown. *T. repens* regenerates almost exclusively through rooted stolons in closed communities to form large diffuse clonal patches, but colonizes new sites mainly through seed that germinates mainly in spring (GRIME et al., 1988). Seeds are long-lived and may form persistent soil seed banks (see BEKKER et al., 1997). In BEKKER's (1997) study, its seeds were recorded in soil seed banks in a wide range of meadow communities over Western Europe. Seeds survive ingestion by livestock and can be spread through excrements. In regularly fertilized fields, seeds of *T. repens* are frequently documented in seed banks instead of its low plant densities (HEJCMAN, 1997; ALBRECHT and PILGRAM, 1997). Seed transmission by cattle manure is the main reason for its high densities there (ALBRECHT and FORSTER, 1996; ALBRECHT and PILGRAM, 1997). *T. repens* tolerates frequent defoliation, mainly on account of its low creeping growth and the high number of meristems present in the year of defoliation. To support regeneration after defoliation, low growth enables the majority of the biomass to escape from being grazed (see BRISKE, 1996 for the concept of grazing resistance).

T. repens grows in frequently defoliated or trampled swards, where the competitive ability of high grasses is restricted (MORAVEC, 1995). This demonstrates the high influence of applied management as grazing or trampling on *T. repens* occurrence. In our study, we investigated the effect of strip seeding of *T. repens* on its abundance and biomass production in seminatural grassland.

2 Material and methods

2.1 Study site

The experiment was carried out in an experimental pasture near the town of Liberec in the Jizera Mountains (51° 20' N, 15° 02' E), Czech Republic, at an altitude of 420 m above sea level. The exposition is NE and the declination 9°. The mean annual temperature was 7.2 °C and the average annual precipitation 803 mm (Liberec Meteorological Station). Climate diagrams (WALTER and LIETH, 1967) for the study years are shown in Figure 1. The geological substratum is biotic granite underneath medium deep, brown soil (cambisol) with pH/KCl 4.8, C_{ox} 3 %, available P content 43 mg.kg^{-1}, available K content 70 mg.kg^{-1}, and available Mg content 68 mg.kg^{-1}. According to phytosociological nomenclature (MORAVEC, 1995), the vegetation of the experimental grassland was classified as *Arrhenatherion.* The dominant species prior to the start of the experiment were *Agrostis capillaris, Elytrigia repens, Alopecurus pratensis* in control plots, and *Agrostis capillaris, Lolium perenne, Trifolium repens* and *Taraxacum* spp. in reseeded treatments. No fertilizers have been applied since 1992. The annual productivity of the grassland varied from 5 to 7 t.ha^{-1} of dry matter biomass.

2.2 Experimental design

There were two treatments: reseeded pasture (R) and control (C) without reseeding. C plots were used for hay or haylage making and occasionally grazed in September before the start of the study. R plots were strip sown with white clover (*Trifolium repens* L. cv. Pastevec, 6 kg.ha^{-1}) in spring 1990 and rotationally grazed. Reseeding was performed with rotational strip seeding drill (3 cm depth, 5 cm width, 12.5 cm distance of strips). During the study period (1993–1997), continuous stocking was applied under both treatments. The sward was maintained at a height of 5–7.5 cm (Table 1) by varying the grazing area and reducing the number of heifers under both treatments in late summer.

Table 1: Mean height of grazed sward (cm) under reseeded (R) and control (C) treatments for years 1993–97. (s.e.m. – standard error of a mean)

Tabelle 1: Mittlere Höhe der Grasnarbe (cm) in der nachgesäten Variante (R) und der Kontrolle (C) für die Jahre 1993–97 (s.e.m.– Standardfehler des Mittels)

Treatment	1993	1994	1995	1996	1997
R	6.90	6.63	6.03	5.83	6.69
s.e.m.	0.06	0.07	0.06	0.05	0.05
C	6.34	6.57	5.88	6.52	6.00
s.e.m.	0.05	0.06	0.05	0.06	0.05

2.3 Biomass sampling

At the beginning of May, five random quadrats (0.5 m × 0.1 m) were cut to ground level with electric shears in two

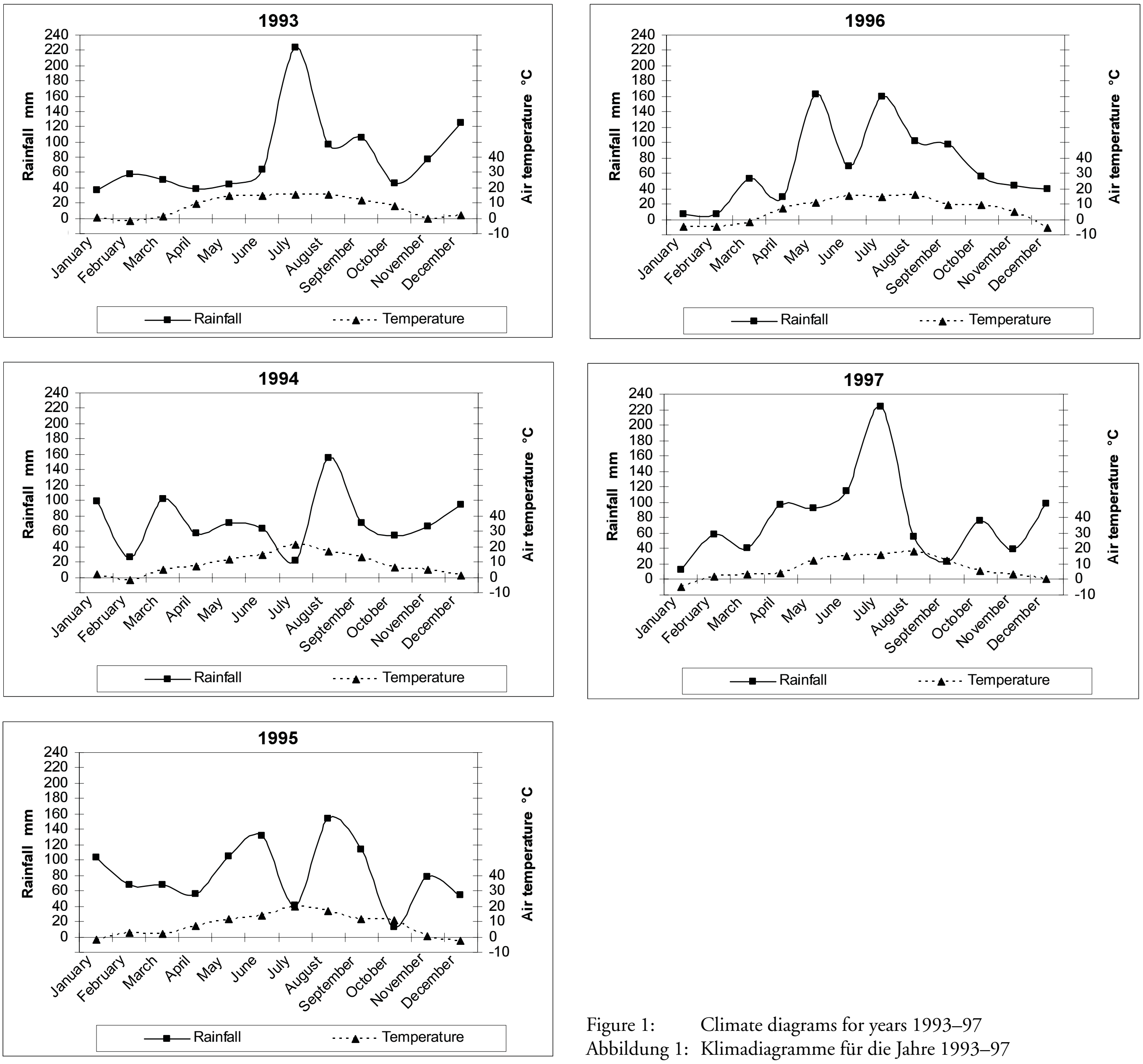

Figure 1: Climate diagrams for years 1993–97
Abbildung 1: Klimadiagramme für die Jahre 1993–97

randomized blocks under each treatment. The biomass samples were separated into grasses, white clover, dandelion (*Taraxacum* spp.), other forbs and dead material. All components were dried and weighed.

2.4 Cover estimate

In spring 1993, a randomized complete block experiment with three replications was established. The cover of *T. repens* was visually estimated at permanent 1 m^2 of the 10 m × 10 m plot. We used a continuous grid of 9 subplots (0.33 m × 0.33 m each) to make a precise cover estimation. The cover of the 1 m^2 plot was calculated as the mean of 9 estimations.

To obtain baseline data for each plot, initial sampling was conducted in 1993 before the introduction of continuous grazing to both treatments. The plots were sampled at the beginning of May before the start of grazing.

2.5 Data analysis

Repeated measurement ANOVA was used to evaluate the data sets. If the data form a repeated measurement with a baseline, the interaction term of treatments and year corresponds to the temporal development of plots under different treatments. Significant interaction indicates non-parallel successive development of at least one treatment. If only the year is the significant factor, all plots are subjected to the same temporal trend without the influence of experimental treatments. To remove the variability caused by blocks, blocks coded with a single independent variable were used as a random factor.

3 Results

3.1 Cover estimate

In 1993, the coverage of *T. repens* in the R and C treatments was 10 % and 2.4 %, respectively. The non-significant interaction of year and treatments indicates a parallel development of the R and C plots. Although the coverage and biomass production of *T. repens* was low in the C plots in 1993, 17.9 % coverage was recorded in the next vegetation season, one year after the introduction of continuous grazing. In the R treatment, 10.7 % coverage was recorded in 1994. There was a higher coverage of *T. repens* in the C plots than in the R plots in 1995, 1996, and 1997, respectively (see Figure 2), but the effect of treatment was not significant (Table 2). We revealed a temporal trend, which was independent of the tested treatments. Coverage of *T. repens* increased under both treatments, with the exception of 1995. In 1995, a decrease was revealed as a reaction to severe drought during the previous vegetation season (Figure 1). At the end of the experiment in 1997, the coverage of *T. repens* was 30.8 % and 33.2 % in the R and C treatments, respectively.

Table 2: Repeated ANOVA measurement result of *T. repens* coverage data. F-ratio – the F-ratio statistics; P-value – corresponding probability value. The asterisk (*) indicates interaction between variables

Tabelle 2: ANOVA-Ergebnisse (wiederholte Messungen) der Bodenbedeckung von T. repens. F-Wert – aus der F-Statistik. P-Wert = korrespondierende Wahrscheinlichkeit. Der Stern (*) zeigt die Interaktion zwischen Variablen

Effect	Degrees of freedom	F-ratio	P-value
Year	4	5.08	0.024
Treatment	1	1.57	0.337
Treatment*Year	4	0.51	0.729

3.2 Biomass sampling

Biomass production of *T. repens* reflected the coverage estimation during the whole experiment with one exception in 1994. In 1993, dry matter biomass production was 0.60 and 26.47 g.m^{-2} under the R and C treatments, respectively (Figure 3). Gradual increase of clover production under the C treatment was recorded during the entire study period. On the other hand, a decrease of production was found until 1995 and an increase was revealed under the R treatment for the rest of the experiment. Biomass production was slightly higher under the control without reseeding at the end of the experiment in 1997. A significant effect of year and an interaction of year and treatment was revealed, indicating a successive shift of both treatments and a different development of the treatments during the experiment.

The effect of treatment and interaction of treatment and year was not significant for other sward components. One exception was the dead biomass. During the experimental

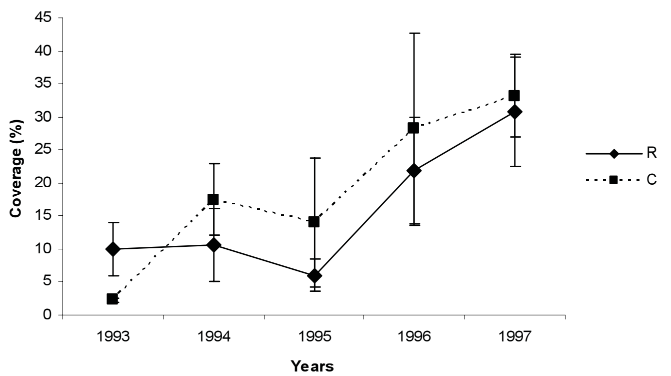

Figure 2: Changes in coverage (%) of *T. repens* under reseeded (R) and control (C) treatments for years 1993–97. Standard errors are indicated by the vertical lines

Abbildung 2: Veränderung in der Bodenbedeckung (%) von *T. repens* in der nachgesäten Variante (R) und der Kontrolle (C) für die Jahre 1993–97. Vertikale Linien geben den Standardfehler an

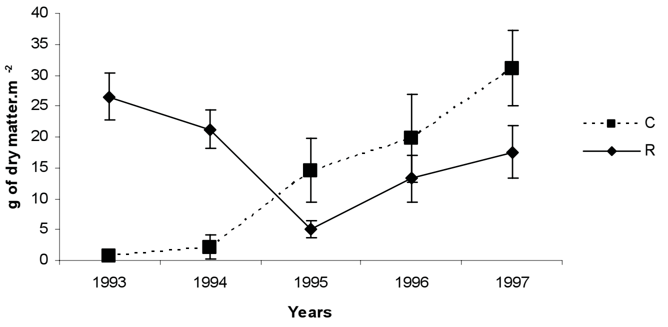

Figure 3: Changes in biomass of *T. repens* under reseeded (R) and control (C) treatments for years 1993–97. Standard errors are indicated by the vertical lines

Abbildung 3: Veränderung der Biomasse von T. repens in der nachgesäten Variante (R) und der Kontrolle (C) für die Jahre 1993–97. Vertikale Linien geben den Standardfehler an

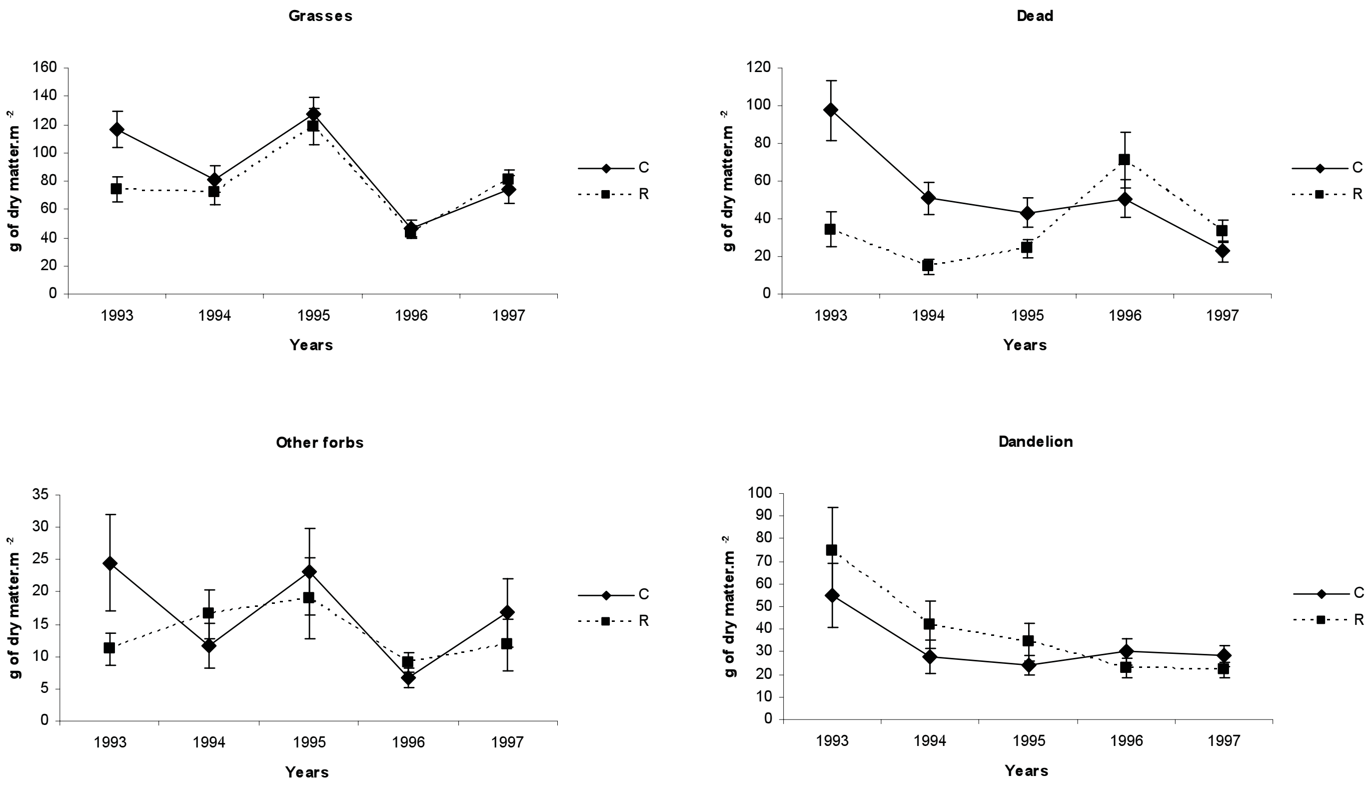

Figure 4: Changes in biomass of grasses, dead material, other forbs and dandelion under reseeded (R) and control (C) treatments for years 1993–97. Standard errors are indicated by the vertical lines

Abbildung 4: Veränderung in der Biomasse von Gräsern, toter Pflanzenmasse, sonstigen Kräutern und Löwenzahn in der nachgesäten Variante (R) und der Kontrolle (C) für die Jahre 1993–97. Vertikale Linien geben den Standardfehler an

period, the curves of the measured parameters were similar to the year to year variation (Figure 4).

4 Discussion

In the C treatment, the coverage (less then 3 %) and biomass production of *T. repens* were low as a response to the management before the start of the study. Before the start of the study, the C plots were mowed once a year in late June or at the start of July. Late mowing resulted in an elimination of light-sensitive species and in an increased share of high grasses (*Elytrigia repens* and *Alopecurus pratensis*) able to cope effectively with light in the higher sward. *Trifolium repens* is rapidly suppressed in tall vegetation on account of its shade intolerance (GRIME et al., 1988), as was documented in several experiments (e.g. BAKKER, 1989; MARRIOT et al., 2003; PAVLŮ et al., 2005).

In 1995, there was a decrease of *T. repens* in the R treatment as a consequence of the summer drought recorded in 1994 (see Figure 1). This finding corresponds to FRAME's results (1992) and indicates its high sensitivity to shortage of moisture. The response of *T. repens* to moisture shortage must be evaluated with regard to the whole plant community and to management practices. In the period between 1993 and 1997, there was an upward trend of *T. repens* coverage recorded under both treatments. This result demonstrates the ability of *T. repens* to cope with intensive grazing, which led to a reduction of tall plant species (CORRELL et al., 2003; PAVLŮ et al., 2006). At the end of the experiment, the coverage and biomass production of *T. repens* was higher under the C treatment than under the R treatment. This indicates the primary effect of defoliation management on clover content in the sward and a secondary effect of its reseeding. Our result is in accordance with findings by MUTO and MARTIN (2000) that a shift to a high white clover content is primarily due to defoliation management. They also reported that the most noteworthy effect was an increase in the proportion of white clover in the check plots which received no renovation treatment.

The high content of dead biomass in the C treatment reflected one- or two-cut management applied before the start of this experiment. At the end of the experiment the content of dead biomass was similar. High year to year variability was found caused by seasonal effects.

5 Conclusions

T. repens is able to quickly colonize naturally suitable environments. Our results demonstrate the low importance of *T. repens* strip seeding into pastures where at least some plants or seeds are present in a sward, in adjacent pastures, or in the soil seed bank. *T. repens* is able to quickly colonize in a natural way the intensively grazed sward of fertile soils.

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