RENOVATION INTENSITIES FOR OVERSOWING TEMPERATE LEGUMES ON BASALTIC GRASSLANDS

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ABSTRACT
Three sward pretreatments (control = 12% bare soil, low and high renovation intensities = 30% BS and 50% BS, respectively) were used on a basaltic natural grassland to oversow a legume mixture, to evaluate effects on establishment. The seeding mixture was white clover (*Trifolium repens* L.), birdsfoot trefoil (*Lotus corniculatus* L.), red clover (*Trifolium pratense* L.) and *Lotus tenuis* Waldst & Kit. The renovation intensities had no significant effects on legume establishment until 120 days after sowing onwards when the density of established plants in the control treatment was higher than in the other renovation treatments. The population dynamics of red clover and *Lotus tenuis* did not differ between experimental treatments. Renovation had favourable effects on summer plant survival by reducing competition from summer grasses. In autumn plant density was greater in the intense renovation treatment.

KEYWORDS
Establishment, natural grasslands, oversowing, persistence, renovation intensities, temperate legumes

INTRODUCTION
Natural grasslands comprise 85% of the total area of Uruguay. Animal production systems based on natural grasslands are extensive and, due to a combination of uncontrolled grazing management, low winter forage production and low forage quality over the year, their productive outputs are still low (Millot *et al.*, 1987). Oversowing natural grasslands with adapted legumes and phosphorous fertilization is a profitable alternative to develop those extensive animal production systems. However, unsuccessful legume establishment is frequent as a result of bad pre-sowing management and climatic uncertainty. Appropriate grazing management and tillage treatment previous to oversowing are technologies that should be adjusted for different pastures and soils. Paddock characteristics such as pasture condition, ground cover, biomass availability and their interaction with defoliation frequency and intensity should be considered to have a successful establishment and productive persistence of the introduced legumes.

MATERIALS AND METHODS
The experiment was conducted on a natural grassland in Northern Uruguay under rotational grazing with cattle. It was a component of a National Research Project involving the Faculty of Agronomy and INIA (National Institute for Agricultural Research) funded by World Bank.. Grazing frequency was 60 days (resting period) and 3 days of occupation. The soil type was a deep brown basaltic earth, had high natural fertility and medium to heavy texture (5.6 % organic matter; pH=6). The effects of three removal intensities of the sward on the establishment of oversown temperate legumes were evaluated over an experimental period of 300 days. The sward removal treatments applied before sowing (June 1994) were: Control without removal (R_0 = 12% of bare soil); Light renovation performed with a Hoe Removal (R_1 =30 % bare soil.) and Intensive renovation with Harrow Disks Removal (R_2 = 50% bare soil). The oversown legume mixture and the respective sowing rate were: white clover (WC=*Trifolium repens*), 2 kg.ha^{-1} ; red clover (RC= T. pratense), 6 kg.ha^{-1} ; birdsfoot trefoil (BT = *Lotus corniculatus*), 6 kg.ha^{-1} ; and L. tenuis (LT), 4 kg.ha^{-1}. Phosphorus fertilization was applied according to the recommended dose of 60 kg.ha-1 P_2O_5. The experimental design was a randomized block with ten replications. Each experimental plot was 50 m^{-2} in size. The number of plants.m^{-2} was counted at 40, 120 and 300 days after sowing, on nine fixed quadrats (0,25m x 0,1m) per plot. The establishment percent was calculated on the viable seed m^{-2} basis. Percentual summer plant survival was estimated as the number of plants detected in autumn (300 days after sowing) on the basis of the spring population established 120 days after sowing. An ANOVA model was used for all the studied variables and the Tukey Test (5%) was employed for mean comparisons.

RESULTS AND DISCUSSION
The effects of sward renovation on the oversown legume establishment varied according to the the considered species and season (Table 1). Early germination (40 days after sowing) was slightly higher in the renovation treatments. The germination values recorded at that time were the highest for most species over the experiment, with the exception of white clover, which increased its population up to the last sampling date. In spring, 120 days after sowing, a negative effect of removal treatments was observed on legume establishment, as the rate of plant death in that treatments was greater than on the control treatment. The more intensive treatment increased bare soil cover, which was the less favorable site for legume establishment. However WC plant population increased during this period because of a high proportion of hard seeds. Red clover and LT populations did not respond (P-0.05) to removal treatments over the experimental period. The establishment of WC and BT in the control treatment during spring was high, but plant survival after summer (300 days after sowing) was favoured by the more intense sward removal treatment. Water and temperature stress during summer, as well as competition from C_4 grasses caused important reductions in the oversown legume populations. Summer survival of each oversown legume differed according to the renovation treatment (Figure 1). Plant populations 300 days after sowing were an indirect result of survival and reseeding strategies. Autumn plant density of WC and BT in the intense renovation treatment was significantly higher (P-0.05) than in the control treatment. The other species showed the same trend.

Oversown legume species had a different establishment pattern over the year. Birdsfoot trefoil had the highest population in all renovation treatments since spring, suggesting its adaptation to this enviroment. This legume species mantained the initial plant populations up to 80 days after sowing. Red clover was rapidly established in all experimental treatments, reaching its greatest population 40 days after sowing. However, RC showed low persistence in all renovation treatments and maintained a reduced plant density 300 days after sowing. White clover establishment was slowest. It germinated over a longer period of time than the other legume species and it reached the highest plant density 300 days after sowing. In these heterogeneous environments, hard seed is an important attribute to improve survival and adaptation. Regardless of its low initial establishment, *Lotus tenuis* was not affected by renovation treatments and proved to survive environmental stress.

The effects of renovation were significant (P-0.05) on the oversown legume populations at the second autumn (300 days after sowing). This could be attributed to the control of summer competition from

resident C_4 grasses by the renovation treatments used in this experiment. This information is relevant to improve the establishment and the persistence of oversown legumes.

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Table 1
Effects of renovation intensities on oversown legume density at three sampling dates.

Plants m^{-2} SPECIES	Plants m^{-2} **Germination (40 d.a.s)**			Plants m^{-2} **Establishment (120 d.a.s)**			**Autumn (300 d.a.s)**		
	R_0	R_1	R_2	R_0	R_1	R_2	R_0	R_1	R_2
White clover	10 a	14 a	26 a	34 a	15 b	29 ab	20 b	30 ab	41 a
Red clover	156 a	189 a	181 a	84 a	64 a	71 a	24 a	25 a	35 a
Birdsfoot trefoil	177 a	233 a	287 a	177 a	126 b	140 b	56 b	81 ab	113 a
Lotus tenuis				27 a	23 a	40 a	14 a	13 a	16 a
TOTAL LEGUMES	343	436	494	322	228	280	114	149	205
Significance (P(0.05)	a	a	a	a	b	ab	b	ab	a

d.a.s, days after sowing.
Within the same row treatments without a common letter are significantly different at the 5 % level of probability.

Figure 1
Effects of renovation intensities on legumes summer survival