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Italian ryegrass establishment by self-seeding in integrated crop–livestock systems: Effects of grazing management and crop rotation strategies

Armindo Barth Neto[a,b,*], Jean Victor Savian[b], Radael Marinho Tres Schons[b], Olivier Jean François Bonnet[b], Marcos Weber do Canto[c], Aníbal de Moraes[a], Gilles Lemaire[d], Paulo César de Faccio Carvalho[b]

[a] Federal University of Paraná, Rua dos Funcionários, 1540, Juvevê, Caixa Postal 19061, CEP 81531-990, Curitiba, PR, Brazil
[b] GPEP - Grazing Ecology Research Group, Faculty of Agronomia, Federal University of Rio Grande do Sul, Avenida Bento Gonçalves, 7712, Agronomia, Caixa Postal 776, CEP 91501-970, Porto Alegre, RS, Brazil
[c] State University of Maringá, Avenida Colombo, 5790, Jardim Universitário, CEP 87020-900, Maringá, PR, Brazil
[d] National Institute for Agriculture Research, Unité d'Ecophysiologie des Plantes Fourragères, 86600, Lusignan, France

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ABSTRACT

We evaluated the re-establishment of an Italian ryegrass pasture by self-seeding on a no-till integrated crop–livestock systems (ICLS) in the southern region of Brazil. This work is part of a long-term experimental protocol initiated in 2003. We tested the effects of various management practices, such as summer crop systems (soybean vs. maize–soybean rotation), stocking methods (continuous vs. rotational) and grazing intensities (low vs. moderate), on Italian ryegrass pasture establishment. In addition, we tested resilience of the system by testing pasture's ability to re-establish following a year without seed head production. The experiment consisted in the rotation, on the same area, of Italian ryegrass pasture grazed by sheep during the winter and up to the end of the grass production cycle, and soybean or soybean–maize grain crops rotation cultivated during the summer. The pasture established itself by self-seeding since 2005. Data were collected in 2011 and 2012 stocking season. The soybean summer crop, continuous stocking and low grazing intensity, all positively affected the production of reproductive tillers in 2011. Grazing intensity in 2011 strongly influenced early vegetative tiller densities (before crop harvest) in 2012. However, none of the grazing intensity or the stocking method treatments affected herbage mass at the end of pasture establishment in 2011 or 2012. On the other hand, the soybean summer crop positively affected pasture establishment, both in term of tiller densities and herbage mass at the end of pasture establishment. The removal of all seed heads in 2011 (preventing seed production) resulted in the total failure of pasture establishment in 2012. Overall, Italian ryegrass establishment by self-seeding relies on the annual replacement of the soil seed bank. This experiment demonstrated that under various stocking methods, moderate grazing intensity and maize or soybean summer crop, Italian ryegrass pasture establishment by self-seeding remains successful even when the stocking periods extended up to the end of the grass production cycle. Self-seeding with moderate grazing intensity ensures successful pasture establishment, reduces labour and costs and allows to increase the stocking period and so animal live weight gain over the grazing season.

1. Introduction

Recent research in various regions of the world has indicated that ICLS can enhance sustained crop and livestock production by efficiently using agricultural system resources (Russelle et al., 2007; Liu et al., 2012). In the subtropical South American regions of Brazil, Argentina, Uruguay and Paraguay, soybean (*Glycine max* L. Merril) and maize (*Zea mays* L.) summer crops are widely grown in rotation

* Corresponding author at: Federal University of Paraná, Rua dos Funcionários, 1540, Juvevê, Caixa Postal 19061, CEP 81531-990, Curitiba, PR, Brazil.
Tel.: +55 51 3308 7402; fax: +55 41 3350 5601.
E-mail address: arm_barth@hotmail.com (A. Barth Neto).

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with Italian ryegrass (*Lolium multiflorum* Lam.) winter pastures as integrated no-till systems (Carvalho et al., 2010). Italian ryegrass is traditionally established from one year to the other by self-seeding. This practise reduce pasture production costs and, more important, can substantially extend the grazing period by allowing earlier entry of the animals in the system (Evers and Nelson, 2000). However, in case of mismanagement, pasture establishment can be delayed or fail due to low seedling number and/or vigour (Evers and Nelson, 1994).

The successful establishment of Italian ryegrass by self-seeding depends on the production, year after year, of a sufficient amount of seeds and the emergence of numerous seedlings from the resulting soil seed bank (Bartholomew and Williams, 2009). In no-till systems, Maia et al. (2007) reported that Italian ryegrass seed banks had a low persistence rate, and its viability in the soil is variable. According to Bartholomew and Williams (2009), densities between 885 and 5650 seed heads m^{-2} are required each year to achieve a minimum reseeding rate of 500 established seedlings m^{-2}. Evers and Nelson (2000) reported that self-seeding Italian ryegrass in no-till systems did not have lower forage productivity capacity than conventional systems with mechanical seeding. However, many authors reported that stocking period must be terminated earlier in the spring to ensure the reproductive tillers development, and therefore the re-establishment success (Young et al., 1996; Evers and Nelson, 2000; Bartholomew and Williams, 2009). Nowadays, this technique represents the standard management practice for winter pastures based on Italian ryegrass in subtropical South America. However, by reducing the stocking period this practice is costly in terms of animal production and questions the real benefice of self-seeding for these systems.

Despite the importance of Italian ryegrass as a winter pastures in ICLS, information regarding its establishment and stability under self-seeding are particularly scarce. This is especially true with the widely used soybean and maize annual crops. Several studies reported that early-established Italian ryegrass' seedlings maintained good growth capacity beneath crop canopy (Favreto and Medeiros, 2004; Barth Neto et al., 2012). However, how different grazing management or grazing intensity practices affects the re-establishment of Italian ryegrass pastures by self-seedling is virtually unknown. Grazing intensity, and not only stocking period duration, can strongly affect the demography of the reproductive tillers and consequently the success of pasture establishment in the next stocking season.

In subtropical areas where Italian ryegrass is used for winter pastures in ICLS, the effects of crop rotation, stocking methods or grazing intensities on the subsequent ability of Italian ryegrass to re-establish self-seeding are unknown. The objectives of this study are as follows: (1) to evaluate the effects of management practices, crop rotation, stocking method and herbage allowance on the re-establishment of Italian ryegrass pastures by self-seeding and (2) to investigate how resilient these systems are by determining if the pastures are able to establish themselves following a year without seed production.

2. Materials and methods

This work is part of an long-term experimental protocol of ICLS initiated in 2003 at the experimental farm of the Federal University of Rio Grande do Sul (UFRGS), in the south of Brazil (30°05′ S; 51°39′ W). The ICLS protocol consists in the rotation, on the same area, of an Italian ryegrass pasture grazed by sheep during the winter and a soybean or a soybean–maize grain crops rotation cultivated during the summer. Italian ryegrass pasture establishes itself each year by self-seeding since 2005, which is the common practice in the region for ICLS. The present work investigates the properties of Italian ryegrass establishment during the stocking season of 2011 and 2012.

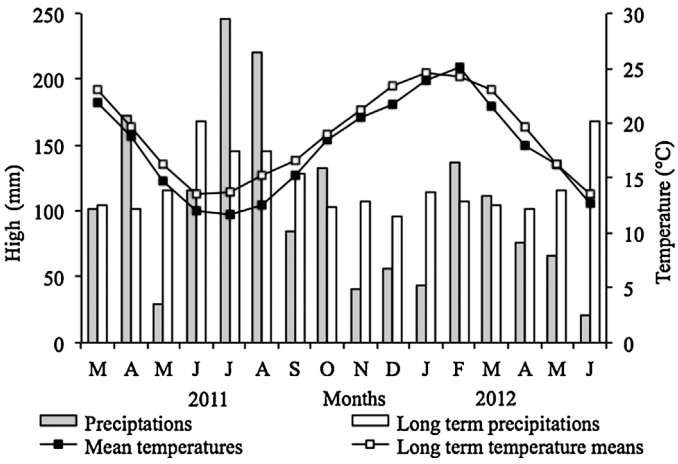

Fig. 1. Monthly precipitations and means temperature observed at the experimental site in 2011 and 2012 vs. long-term climatic means between 1970 and 2000.

2.1. Experimental site

The southern region of Brazil where was conducted the experiment is classified as subtropical humid (Cfa classification, Köppen and Geinger, 1928). It is characterized by a marked seasonality of temperature and a homogeneous repartition of precipitations along the year (Fig. 1, data from the meteorological station located 800 m from the experimental site). However, the study period suffered from an excess of precipitations during the winter 2011 and a deficit of precipitations during the summer 2011–2012. The soil at the experimental site was classified as a Typic Paleudult (USDA, 1999) with 15.2% clay. The chemical soil characteristics for the horizon 0–20 cm are listed as follows: pH = 4.87; SMP index = 5.82; P = 51.78 mg dm^{-3}; K = 106.01 mg dm^{-3}; OM = 1.99%; Al = 0.59 $cmol_c$ dm^{-3}; Ca = 1.95 $cmol_c$ dm^{-3}; Mg = 0.95 $cmol_c$ dm^{-3}; cation exchange capacity = 8.61 $cmol_c$ dm^{-3} and base saturation = 37.04%.

2.2. Experimental design

The experimental site covers a total area of 4.8 ha subdivided into 16 paddocks of similar size. The long-term experimental protocol consists in four replicates of a 2 × 2 balanced factorial design with two stocking methods (continuous and rotational) and two herbage allowances (moderate and high) resulting in 16 paddocks arranged in a randomized complete block design. During the summer, each paddock was divided into two summer crop systems (soybean summer crop and maize–soybean summer crop rotation), in a no-till system, which results in 32 experimental units.

Intake rate of lambs or lactating ewes grazing perennial ryegrass is considered as unrestricted when daily forage allowance reach at least 3 times their potential dry matter intake (Gibb and Treacher, 1976). As a result, herbage allowances treatments were defined as 2.5 times (moderate grazing intensity) and 5 times (low grazing intensity) the potential daily dry matter intake of lambs or lactating ewes according to the NRC (1985). Resulting herbage allowances were 10 kg (moderate grazing intensity) and 20 kg (low grazing intensity) herbage dry matter per 100 kg ha^{-1} animals live weight.

Here, we present dada on Italian ryegrass reproductive tiller density, vegetative tiller density and herbage mass collected in 2011 and 2012. Fig. 2 illustrates the timeline of land use for the paddocks during the study period. In order to test the persistence