Tiller size/density compensation in temperate climate grasses grown in monoculture or intercropping systems under rotational grazing

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Introduction

From the standpoint of tiller population dynamics, it is well known that the size and numbers of tillers in forage grasses are inversely related, where a greater tiller population density (TPD) is associated with smaller tillers and vice versa (Sbrissia *et al*. 2003; Hernandez-Garay *et al*. 1999; Matthew *et al*. 1995). This relationship has traditionally been made with the self-thinning power law described by Yoda *et al*. (1963), which considers the leaf area index (LAI) of the pasture constant when the slope of the relationship between numbers and size of tillers, on a logarithmic scale, is approximately -3/2 (Matthew *et al*. 1995). Notably few studies have assessed this relationship in intercropping systems. Moreover, although studies that evaluated intercrops showed relationships that were nearly -3/2 for the individually analysed species (Yu *et al*. 2008; Nie *et al*. 1997; White and Harper 1970), Nie *et al*. (1997) suggested that all plants that occur in the grass field should be used to properly estimate self-thinning in mixed species pastures. Thus, the aim of the present study was to test the main hypothesis that the tiller size/density compensation mechanisms operate in the same way in mixed pastures of oat and Italian ryegrass under rotational grazing and that the plant communities adapt their population to maintain a relatively constant LAI.

Methods

The experiment was conducted at the Centre of Agriculture and Veterinary Sciences at the Santa Catarina State University (CAV/UDESC), Lages, SC, Brazil (27º47' S, 50º18' W). The period of data collection was from June 26 to November 1. The treatments that were used included pastures of black oat (*Avena strigosa* cv. IAPAR-61) and annual ryegrass (*Lolium multiflorum* L. cv. Common) in monoculture and intercropping pastures of both species distributed in a randomized block design with four replicates (12 experimental units (paddocks) with 98 m^2 each). The pre-grazing sward heights were 23, 17 and 20 cm for the oat, ryegrass and intercropping, respectively. The initial sward height was reduced by 40% using three Holstein heifers. Pre and post-grazing sward heights were monitored with a *sward stick* (Barthram, 1985) at 50 points per experimental unit. To determine the pre-grazing aerial biomass, indirect non-destructive measurements were performed based on the relationship between the compressed sward height (measured with a rising plate meter (Farmworks®, F200, New Zealand)) and the amount of dry matter (DM) present in the plate area (0.1 m^2). Tiller population density was measured by using three 10 cm diameter PVC rings per experimental unit before grazing. For the intercropping pastures, the oat and ryegrass tillers were counted separately. The mass per tiller was obtained from the ratio between the pre-grazing aerial biomass and TPD. Because sample error occurred in both axes, the analyses between the TPD and the mass per tiller were performed with the Past® statistical software, version 2.16 using the RMA (reduced major axis) method for estimating the slope (La Barbera 1989).

Results

The slope of the relationship between TPD and mass per tiller of oat and ryegrass when cultivated as monocultures was close to -3/2, according to the *self thinning rule* (Yoda *et al*. 1963) (Fig. 1a and 1b). Because the increase in size and, consequently in mass per tiller, with advanced stages of development of pastures, the self-thinning mechanisms decreased the plant population and was able to maintain a relatively constant LAI (Matthew *et al*. 1995). However, no relationship was found when the two species were analyzed separately in the intercropping (Fig. 1c). The difference in production seasonality and climatic requirements may have favored one species or another, so that tiller size/density compensation mechanisms did not work separately for each species. Nevertheless, when the relationship between the TPD and the mass per tiller were considered for all tillers present in the area (regardless of species), this functional relationship became more robust and had slopes that were similar to those found in monoculture pastures (Fig. 1c). This result indicated that the maintenance of LAI throughout the period of pasture growth depended on the interactions between the tillers of the different species that were present in the area. This response clearly shows that the size/density compensation processes operate at the plant community level, at least when the pastures are formed exclusively by two winter grasses.

The tiller size/density compensation that was observed in the monoculture treatments and in the total plant populations in the intercrop treatment showed that the plant community tended to maintain a LAI that enabled high

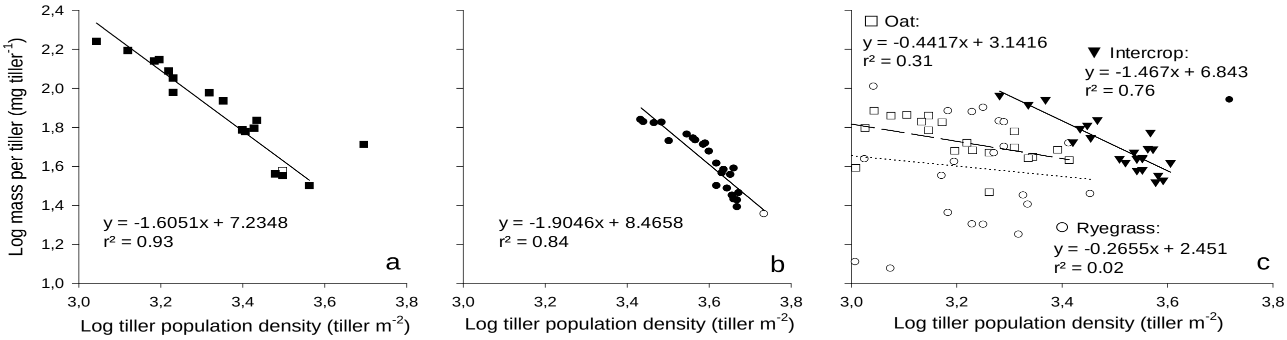

Figure 1. Diagram between the log of the tiller population density (tiller/m^2) and the log of the mass per tiller (mg/tiller) for the oat (a), ryegrass (b) and intercropping oat + ryegrass (c) pastures throughout the experimental period

forage production. These findings revealed an important advantage of intercropping grasses over using monocultures, since in prolonged periods of pasture use, the intercropping of two or more grass species with different requirements and adaptation can be used to increase yield and stabilise forage production.

Conclusion

In the black oat and annual ryegrass intercropping system, the tiller size/density compensation processes occurred in the total plant community of the similar way that observed in the monoculture systems, which suggested that the grass plants worked together to maximise the LAI through seasonal population adjustments of each species that comprises the canopy.

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