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Effect of Fertilization, Cultivar and Weeds on the Productive Behavior of Tall Fescue (*Lolium arundinaceum* (Schreb.) Darbysh)

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ABSTRACT

The agricultural intensification in Argentina's Pampean region has pushed livestock farming towards marginal areas such as the Salado Depression. In this context, tall fescue pastures emerge as a sustainable forage alternative. However, their production can be limited by factors such as soil fertility and weed competition. This study evaluates the impact of fertilization and weed presence on the yield of five tall fescue cultivars during their first year of establishment in the Salado Depression. The experiment was conducted in a pasture of a farm located in the district of Punta Indio, in the province of Buenos Aires, Argentina. A completely randomized block design was implemented with ten treatments and three replications, where the factors were five cultivars with and without fertilization at sowing (60 kg ha^{-1} of diammonium phosphate). Biomass cuts were taken in September and December, and tiller density and weight were counted. The results showed that fertilization at sowing significantly increased biomass production, mainly due to an increase in tiller density. On the other hand, competition with other annual grasses reduced biomass production, especially in unfertilized treatments. Although the evaluated cultivars responded similarly to the treatments, differences in tiller density were observed over time, highlighting the importance of selecting cultivars adapted to local conditions. Fertilization at the time of sowing is confirmed as a key practice to improve the yield of tall fescue pastures in the Salado Depression. However, an integrated management that combines the selection of suitable cultivars and weed control is essential to achieve maximum productive potential, pasture permanence, and ensure the sustainability of these grazing systems.

Keywords: continental fescues, spontaneous species, tiller density, perenniality.

INTRODUCTION

The intensification of agriculture in Argentina, particularly in the Pampean region, has led to a territorial reorganization of livestock activity. The increasing demand for agricultural land has significantly reduced the area dedicated to pastures, displacing livestock production to less suitable regions for agriculture, such as the Salado Depression (Paruelo et al., 2005, 2006; Maresca, 2018). In this new scenario, perennial pastures play a strategic role by offering a more sustainable productive alternative, allowing for greater efficiency in the use of natural resources and reducing pressure on ecosystems.

Tall fescue (Lolium arundinaceum (Schreb.) Darbysh.) is a perennial grass of great relevance in Argentine livestock production, especially in the humid and subhumid temperate regions. In the Salado Depression, its adaptation to diverse environments has positioned it as a key species in rearing systems, where its forage quality meets the nutritional demands of growing animals (Scheneiter et al., 2016; Rimieri, 2021). The two main genetic groups of tall fescue, temperate-humid (known as continental) and Mediterranean, exhibit differentiated seasonal growth patterns. The former stand out for their greater production in spring and summer, while the latter show more pronounced autumn and winter vigor (Mazzanti & Arosteguy, 1985).

The loss of productivity in pastures can be attributed to various factors, including nutrient deficiency, weed competition, and adverse environmental conditions (Agnusdei et al., 2010; Tozer et al., 2011; Masibon et al., 2015). These factors influence the structure of grasses, affecting both tiller size and density. While tiller size relates to the competitive capacity of plants and their productive potential (Gatti et al., 2012; 2013), tiller density is a key indicator of pasture persistence, determining its capacity to occupy space and resist disturbances (Hume, 1991; Reeve et al., 2000). The relationship between tiller size and density, influenced by genetic and

environmental factors, defines the carbon partitioning pattern and plays a crucial role in the dynamics of plant communities (Lemaire & Maillard, 1999).

Nitrogen (N) is an essential nutrient for the growth of temperate pastures and is considered the main limiting factor for biomass production after water (Lemaire & Gastal, 1997). Nitrogen deficiency in tall fescue significantly reduces leaf growth rate, tillering, and leaf area index, limiting solar radiation capture and resource use efficiency (Lemaire & Denoix, 1987). Nitrogen fertilization increases N availability, promoting vegetative growth and increasing both tiller size and density, although the response to fertilization depends on cutting frequency and environmental conditions (Wilman & Wright, 1983). In the Salado Depression, nitrogen and phosphorus deficiencies limit forage production, making fertilization a key practice to improve pasture productivity (Marino & Agnusdei, 2007; Méndez et al., 2016).

Efficient pasture design requires understanding the complex interactions between cultivated species and weeds. These highly competitive weeds can significantly reduce pasture productivity if not adequately controlled (Radosevich et al., 1997). Understanding the mechanisms underlying species competition is crucial for developing effective management strategies. Morphogenetic and structural traits of grasses, such as leaf appearance rate, tiller size, and density, are key indicators of their competitive ability and can predict their performance in mixtures with other species (Lemaire & Chapman, 1996; Lemaire & Agnusdei, 2000; Lemaire & Maillard, 1999). Understanding these mechanisms enables the design of pastures with stable and productive floristic compositions, minimizing control needs and maximizing pasture potential.

The study of tall fescue and its response to fertilization is important to improve the sustainability of livestock farming in the Salado Depression region. Fertilization is expected to increase biomass production and improve tiller weight and density. The results of this work are expected to optimize pasture management practices and promote efficient use of forage resources in the breeding and rearing systems of the region.

The objective of this study was to evaluate the impact of fertilization at sowing time and the presence of spontaneous species on biomass production, tiller weight, and density in five continental tall fescue cultivars during their establishment year on a farm in the Salado Depression. The study aimed to determine whether there are differences in cultivar responses to treatments and to assess the effect of weeds on productive pasture parameters.

MATERIALS AND METHODS

The experiment was conducted in a pasture at the La Espadaña farm (Catholic University of Argentina), located in Verónica, Punta Indio district (35°27'46"S, 57°22'42"W). This site is within the Salado Depression, a subregion of the Depressed Pampas characterized by saline and alkaline soils with limited drainage, restricting agricultural use. The predominant soil series in the study site are Vieytes and Verónica, typical of the region, with silty-clay textures and low levels of available phosphorus (Lavado, 1992). The experimental soil, classified as Hapludert, has an A horizon at 5-12 cm depth with 5 ppm of Bray phosphorus, 3.8% organic matter, and a pH of 6. It also features a Bt horizon at shallow depth, which limits root development and water infiltration.

A completely randomized block design experiment was conducted to evaluate the effect of fertilization on biomass production of five continental tall fescue cultivars. Ten treatments with three replications (n=30) were implemented, where the factors were cultivars (C1, C2, C3, C4, and C5) and fertilization (with (F+) and without fertilization (F-)). Thirty plots measuring 2.5 x 5 m were established, sown on March 10, 2019, at a density of 12 kg ha^{-1}. Fertilization was applied at sowing with 60 kg ha^{-1} of diammonium phosphate (10.8 kg of N ha^{-1} and 12 kg of P ha^{-1}), a quantity commonly used by local producers. Two biomass cuts were performed in each plot, at ground level from a 0.25 m^2 area: one on September 19 and another on December 11, 2019.

Analysis of Collected Material

The harvested plant material was separated in the laboratory into tall fescue biomass and biomass of spontaneous species (weeds): annual winter grasses, broadleaves, and legumes. Samples were dried in an oven at 60°C until constant weight, and dry matter was determined for each (kg DM ha^{-1}). Tiller density (number of till).

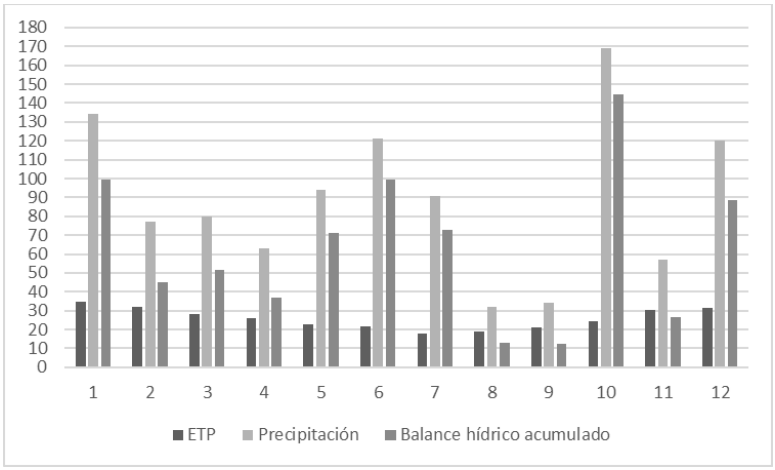

Figure 1: *Accumulated water balance (Precipitation- evapotranspiration Penman) for the year 2019 in the Punta Indio district. Prepared based on data from https://meteostat.net/.*

Fertilization at sowing time had a highly significant effect ($p<0.0001$) on the increase in tall fescue biomass (BF). The fertilized plots showed 48% more total biomass over the evaluated period compared to the unfertilized plots (128.67 $g.m^{-2}$ vs. 66.71 $g.m^{-2}$). BF was significantly higher (p: 0.0409) in the September cut (September: 110.67 $g.m^{-2}$ vs. December: 84.71 $g.m^{-2}$) (Figure 2). No significant differences were found between the evaluated cultivars or interactions between the factors.

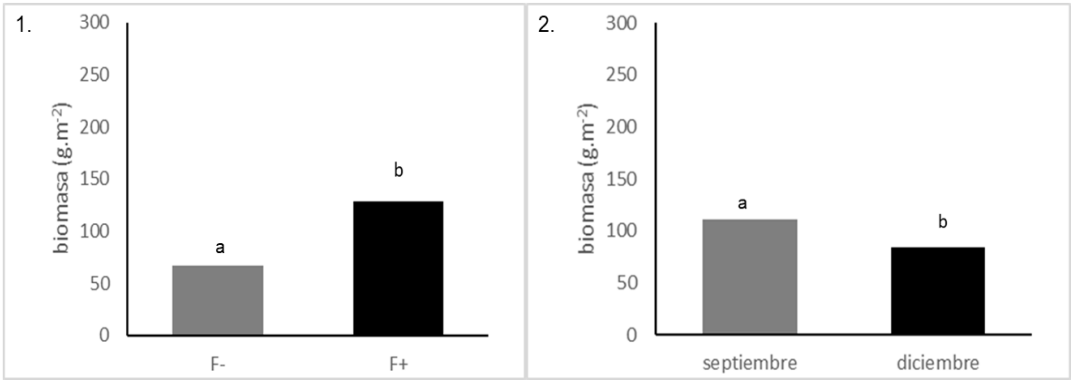

Figure 2: *Biomass production of tall fescue ($g.m^{-2}$): 1. with and without fertilization (F+ and F-) and 2. at different cutting dates (September and December). Different letters indicate significant differences between treatments ($p<0.05$).*

Yield Components

Fertilization at the time of sowing significantly increased the number of tillers in tall fescue plants (p: 0.005), resulting in greater biomass production. This effect was evident in both months when cuts were performed, reaching its peak in September ($p<0.0001$). Although no significant differences were found between cultivars, there was an interaction between cultivar and cutting month (p: 0.0125). In September, the highest number of tillers was recorded in C1, intermediate values in C2, C5, and C3, and those recorded in December: C2, C3, and C5, while the lowest number of tillers was counted in C1 and C4 in December (Figure 3).

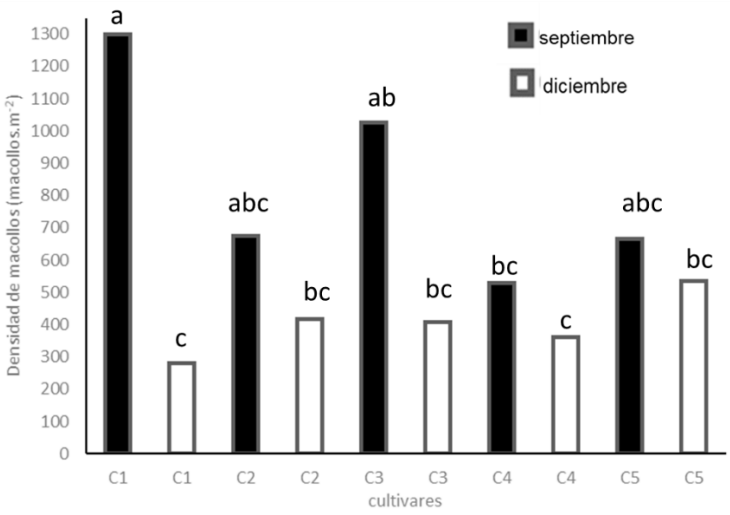

Figure 3: *Tillering density (number of tillers m-2) of five cultivars of tall fescue (C1, C2, C3, C4, and C5) on different sampling dates (September and December). Different letters between bars indicate significant differences (p<0.05).*

The weight of the tillers was greater in December than in September, although no significant differences were recorded when fertilized or between cultivars (Figure 4).

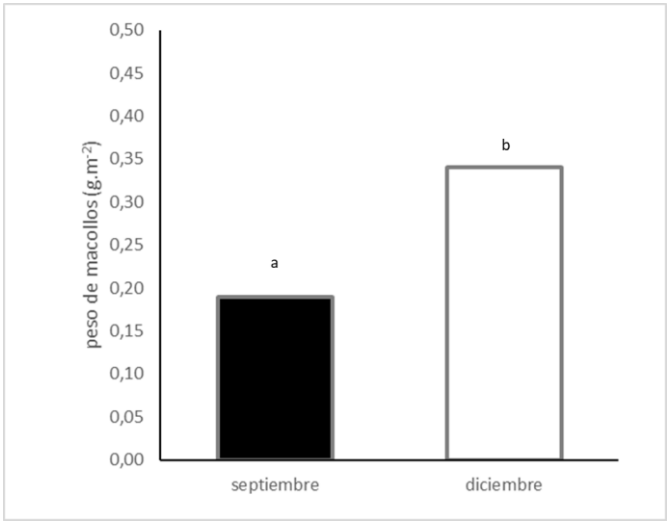

Figure 4: *Tiller weight (g.m⁻²) of five tall fescue cultivars at different sampling dates (September and December). Different letters between bars indicate significant differences (p<0.05).*

Weed Effects

Analysis of the main components confirmed that fertilization was the factor that most influenced the increase in tall fescue biomass by promoting an increase in tiller density. The presence of legumes and broadleaves, although not significantly affecting total biomass, showed different behaviors. On the one hand, the presence of spontaneous legumes was positively related to tiller density and negatively related to tiller weight. Conversely, the presence of broadleaves had a positive relationship with tiller weight and a negative relationship with tiller density, indicating compensatory mechanisms. Annual winter grasses, in turn, had a negative effect on tall fescue biomass production, especially in unfertilized treatments.

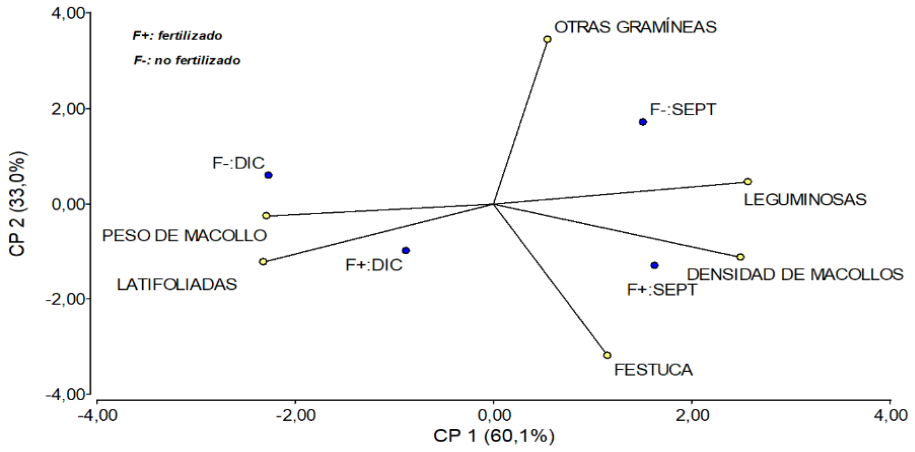

Figure 5: *Principal component analysis, including fertilization (F+/F-), tall fescue biomass, and weeds (divided into broadleaves, legumes, and other grasses) in September (SEPT) and December (DEC).*

DISCUSSION

Fertilization was confirmed as an effective strategy to increase tall fescue biomass production on a livestock farm in the Salado Depression. In this study, fertilization significantly increased tiller density across all cultivars and times. This increase in density translated into greater BF accumulation. Previous studies have demonstrated the limitations in tall fescue and wheatgrass pasture production due to deficiencies in P and N supply (Agnusdei et al., 2010), indicating that fertilization is a tool that improves the performance of temperate pastures, especially for C3 grasses like tall fescue (Cornaglia et al., 2007; Bazzigalupi & Bertini, 2014).

The production of foliar biomass showed seasonal variability, being higher in September and lower in December. These results could be related to the root system characteristics of this species. Although it has considerable root development, it is concentrated in the top few centimeters of soil, especially during the first year of cultivation (Errecart et al., 2020). Consequently, during periods of higher water demand, such as in December, the root biomass may be insufficient to meet the plant's needs, resulting in lower foliar biomass production. While the studied cultivars showed similar responses to fertilization, differences were found in the total number of tillers produced depending on the month of counting, suggesting a differential response of each cultivar over time.

The analysis of the main components revealed a complex interaction between tall fescue biomass and different types of weeds. While spontaneous legumes and broadleaves showed compensatory effects, annual grasses exerted direct competition, reducing tall fescue biomass production, especially under low nutrient input conditions. This finding aligns with reports by Scheneiter et al. (2010), who observed size/density compensation mechanisms in tillers once nutritional limitations were overcome. The presence of weeds, especially annual grasses, poses a significant challenge to tall fescue production. The high persistence of these annual grass seeds in the soil seed bank, combined with their synchronized emergence with tall fescue, complicates their control. Understanding the competitive relationships between the crop and weeds allows better assessment of weed control needs and taking advantage of the competition exerted by the crop over weeds as part of integrated management (Gherza et al., 2000; Green et al., 2006).

CONCLUSIONS

Fertilization at sowing time significantly increased the biomass of a tall fescue pasture in the Salado Depression, promoting its productivity and persistence by stimulating tiller production. Annual winter grasses competed with tall fescue plants, negatively affecting their production, especially in the absence of fertilization. Although the evaluated cultivars responded similarly to the treatments, they showed variations in tiller density over time. These results highlight the importance of combining initial fertilization with the selection of adapted cultivars and integrated weed control to optimize production and persistence of tall fescue pastures in the Salado Depression.

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