Oat tillering under nitrogen levels in eucalyptus alley cropping system in southern Brazil

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Introduction

During oat earlier growth and development, different competition scenarios in response to nitrogen result in different balances of supply and demand for photosynthate when initiating the grain filling period (Browne *et al.*, 2006). The oat tillering is determinant to the number of panicle production. Increases in oat yield are resultant from nitrogen by increasing panicle numbers and grain numbers per panicle and from seed rate only by increasing panicle numbers (Browne *et al.*, 2006).
The interactions between species in integrated systems include aspects of water and nutrient cycle, microclimate and biodiversity (Quinkenstein *et al.*, 2009). The net result of synergistic and antagonistic interactions among the components results on the system productivity (Jose *et al.*, 2004).
The objective of this study is determine how the oat tillering are influenced by nitrogen levels, and positions between adjacent tracks of eucalyptus alley cropping agroforestry system (ACS) and no tillage system (NTS), in southern Brazil.

Materials and methods

The experiment was conducted at the Experimental Station Model Farm of the Agronomic Institute of Paraná (25°06'19" S 50°02'38" O, 1020 m above mean sea level) located in Ponta Grossa, Paraná, southern Brazil. The tree specie of the ACS is *Eucalyptus dunnii* Maiden, which was implemented in 2007. The no-tillage system was located next to the arborized system (less than 200 m). The tree tracks were positioned in a guideline level. The spacing between two tree tracks along the guideline level direction is 20 m, the distance between two rows in a track is 4 m, and between two trees in a row is 3 m. The average tree height and diameter on April 2010 were 11.9 m and 13.9 cm, respectively. Intercropped annual crops are planted 1 m from the tree stems, totaling annual crop track with 18 m long. The eucalyptus trees were thinned out and the remaining trees had their branches pruned to half of trees height. Using a no tillage implement, the oat (*Avena sativa* L. cv. IPR 126) was sown at the rate of 40 kg seeds ha^{-1} and fertilized at 300 kg ha^{-1} of 04-30-10 (N-P-K), on June 16th 2011. Ten days after sowing the emergence occurred and was used as reference. The experiment was carried out in a split-block, in a randomized complete block design arrangement, with four replicates, that included two levels of nitrogen (12.0 and 80.0 kg N ha^{-1}) as main plots and six positions as split-blocks. At the tillering stage, 28 days after emergence (DAE), additional nitrogen in urea form (46 % N) was uniformly hand-applied (68.0 kg N ha^{-1}) or non-applied (0.0 kg N ha^{-1}). The split-blocks were 14 rows 5 m long with 18 cm between rows. Therefore, the distances, denoted as positions, represent the oats growing at A: 7.2 m,

B: 3.6 m, C: 0.0 m, D: 3.6 m, E: 7.2 m away from the central position between the tree tracks, and the position F represents the NTS.
Oat tillering was assessed by harvesting 1 m of row in seven sampling dates during the oat cycle, starting 21 days after emergence, and continuing with intervals of 21 days until the sixth sample and finished with interval of 28 days for the latter. The plants were uprooted to enable identification of the tillers. The tillers number per plant was accessed by the product of tillers number and plants number per 1 m of row collected.
The statistical analyses were performed using the framework split block design, in the General Linear Models procedure of Statistica 8.0 for Windows (StatSoft, Inc., Tulsa, OK, USA). For verification the residuals normality distribution, was used the Shapiro-Wilk test. Means of nitrogen factor were compared using the Duncan method ($\alpha = 0.05$). For compare means of NTS (control treatment) with positions inside ACS, the Dunnett two sided method were utilized ($\alpha = 0.05$).

Results and discussion

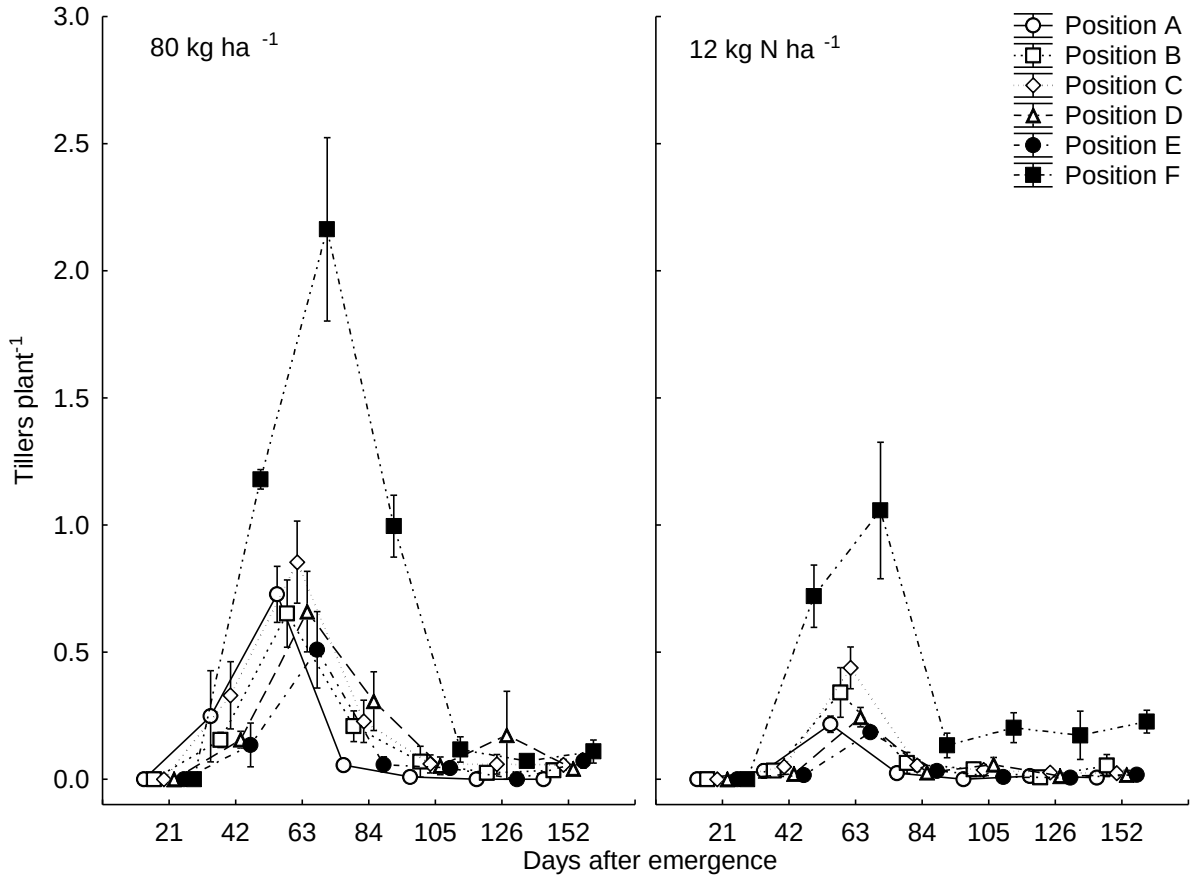

Figure 1. Oat tillering under nitrogen levels (12.0 kg N ha^{-1} and 80.0 kg N ha^{-1}) in alley cropping agroforestry system (at A: 7.2 m, B: 3.6 m, C: 0.0 m, D: 3.6 m, E: 7.2 m away from the central position between two adjacent eucalyptus double line tracks [20 m (4 m x 3 m)]) and no tillage system (F), in southern Brazil. Vertical bars denote standard errors.

At 21 DAE the oats tillers had not yet issued. On the systems comparison, the interaction of nitrogen and positions was significant both at 42 DAE ($P = 0.04$) and 84 DAE ($P < 0.0001$). At 42 DAE, the NTS had higher tillers number compared to all positions inside ACS, with both nitrogen levels (12 and 80 kg N ha^{-1}). At 84 DAE only the NTS with 80 kg N ha^{-1} was

superior to ACS in terms of tiller number, and when was applied 12 kg N ha^{-1}, the NTS did not differ to all positions inside ACS (Figure 1). In the earlier oat development, the light quality modulates the stem elongation and the tillering, therefore the interrelationship between the light availability and the tillers development degree is determinant to the intraspecific competition and the community structure (Almeida and Mundstock, 2001). In a 75% of shade, wheat tiller emergence occur at a higher physiological age than in plants under full sunlight, maximal delay was proximal of one phyllochron (Evers *et al.*, 2006). Wheat grown in a eucalyptus ACS, with trees planted in a fan design and root pruned to a depth of 50 cm in northern India, had lower tillers number and greater duration of tillering (days after sowing to 50% tillering) in comparison to a wheat cultivated as a sole crop (Kohli and Saini, 2003).
The oat tiller traits phytomass, vegetative phytomass, total weight of grains, harvest index and tiller grain yield by main shoot, under tiller-depressing long day conditions did not respond to 120 kg N ha^{-1} or 80 kg N ha^{-1} application rate, except in that the numbers of tillers and head-bearing tillers per main shoot (Peltonen-Sainio *et al.*, 2009). In the systems comparison, the nitrogen effect on the oat tillering, was significant from 42 DAE until 84 DAE (42 DAE $P = 0.047$; 63 DAE $P = 0.021$; 84 DAE $P = 0.014$), and positions promote significant effect until 152 DAE (42 DAE $P < 0.0001$; 63 DAE $P < 0.0001$; 84 DAE $P < 0.0001$; 105 DAE $P = 0.0018$; 152 DAE $P < 0.0001$), in exception of 126 DAE ($P = 0.2603$) where the effects were no significant. The nitrogen increased the tiller number until 84 DAE. The position effect denoted with the NTS compared to the ACS, has higher tiller number per plant, in exception of 105 DAE, when the position D inside ACS did not differ of NTS.

Conclusions

In southern Brazil, the nitrogen levels did not alleviate the eucalyptus tiller-suppression for oat cereal production, in alley cropping system.

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