Ciência Rural, Santa Maria, v.44, n.1, p.71-78, jan, 2014
ISSN 0103-8478

Oat tillering and tiller traits under different nitrogen levels in an eucalyptus agroforestry system in Subtropical Brazil

Perfilhamento e características dos perfilhos da aveia submetida a níveis de nitrogênio em sistema agroflorestal com eucalipto no subtrópico brasileiro

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ABSTRACT

*In oat production, tillering persistence is the determinant of one important yield component, namely the number of panicles. This process is highly influenced by the inter- and intraspecific interactions of the agroecosystem, which in turn depend on agronomic practices. The hypothesis of this research is that nitrogen does not increase oat tolerance to negative interference from trees, so oat tillering persistence in grain production remains un-modified by nitrogen at distances relative to the eucalyptus tracks, within the alley cropping agroforestry system (ACS). Thus, nitrogen should not be used to increase oat yield potential in these systems. The objective of this study was to determine how the tillering persistence for grain production and oat (**Avena sativa** L. cv. 'IPR 126') tiller traits were influenced by nitrogen levels (12 and 80kg N ha^{-1}) at five equidistant positions between two adjacent eucalyptus (**Eucalyptus dunnii** Maiden) double line tracks [20m (4mx3m)] in ACS and traditional no-till agriculture in subtropical Brazil. The experiment was conducted in a split-block randomized block design with four replicates. The goal was to evaluate the oat phytomass, tiller-to-main shoot phytomass ratio, tillers per main shoot, grain yield and tiller-to-main shoot grain yield ratio. The oat tillering persistence for grain production is dependent on different nitrogen levels at distances relative to adjacent eucalyptus tracks and therefore, different nitrogen levels should be used in those areas, to improve oat yield potential inside ACS in subtropical Brazil.*

Key words: ***Avena sativa*** *L.,* ***Eucalyptus dunnii*** *Maiden, alley cropping system.*

RESUMO

*Na produção de aveia, a persistência do perfilhamento é determinante para um importante componente de rendimento, o número de panículas. Esse processo é bastante influenciado pelas interações interespecíficas e intraespecíficas no agroecossistema, que, por sua vez, depende das práticas agronômicas. A hipótese deste trabalho é que o nitrogênio não aumenta a tolerância da aveia à interferência negativa das árvores, logo, a persistência do perfilhamento para produção de grãos não é modificada pelo nitrogênio em distâncias relativas às faixas de eucaliptos, em sistema agroflorestal em aleias (SAF). Assim, o nitrogênio não deve ser utilizado para aumentar o potencial de rendimento da aveia nestes sistemas. O objetivo deste trabalho foi determinar como a persistência do perfilhamento para produção de grãos e as características dos perfilhos da aveia (**Avena sativa** L. cv. 'IPR 126') são influenciados por níveis de nitrogênio (12 e 80kg N ha^{-1}), em cinco posições equidistantes entre duas faixas adjacentes de linhas duplas [20m (4mx3m)] de eucalipto (**Eucalyptus dunnii** Maiden) e agricultura tradicional de plantio direto, no subtrópico brasileiro. O experimento foi realizado em faixas, no delineamento de blocos ao acaso, com quatro repetições. Foram avaliados a fitomassa da aveia, a razão de fitomassa entre o colmo principal e os perfilhos, o número de perfilhos por colmo principal, o rendimento de grãos e a relação do rendimento de grãos entre o colmo principal e os perfilhos. A persistência do perfilhamento para produção de grãos de aveia é dependente de diferentes níveis de nitrogênio em distâncias relativas a faixas adjacentes de eucaliptos, portanto, diferentes níveis de nitrogênio devem ser utilizados nessas distâncias, para aumentar o potencial de rendimento da aveia nos SAF no subtrópico brasileiro.*

Palavras chave: ***Avena sativa*** L., ***Eucalyptus dunnii*** *Maiden, sistemas de aleias.*

INTRODUCTION

Gramineous species produce tillers, which originate from the axillary buds of the parent shoot at the base of the parent phytomer internode, which is immediately above the node and sheath insertion

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**Received 10.16.12 Approved 08.10.13 Returned by the author 11.07.13
CR-2012-0988.R2**

of the preceding phytomer (EVERS et al., 2006). Oat plants with lower values of main stem to tiller mass ratio can have a higher productivity potential because tiller development is similar to main stem development (ALMEIDA & MUNDSTOCK, 2001). The developmental synchronism of tillers in relation to the main stems is important for oat tiller survival and is dependent on the agronomic practices (e.g., population density). The tillering persistence determines the panicle number.

The fertile tiller number of cereals is dependent on the environmental conditions at tiller primordium initiation and the subsequent stages until flowering (ALMEIDA & MUNDSTOCK, 2001). Oat yield increases result from nitrogen, which increases the panicle and grain numbers per panicle and from the seed rate only by increasing the panicle number (BROWNE et al., 2006). During early growth and development, different competition scenarios resulted in different supply and demand balances for photosynthate in response to nitrogen when initiating the grain filling period (BROWNE et al., 2006).

The hypothesis of this research is that nitrogen does not increase oat tolerance to negative interference from trees, so oat tillering persistence during grain production is not modified by nitrogen at distances relative to eucalyptus tracks in the alley cropping agroforestry system (ACS). Thus, nitrogen should not be used to increase oat yield potential in these systems.

The objective of this study was to determine how tillering persistence for grain production and oat (***Avena sativa*** L. cv. 'IPR 126') tiller traits are influenced by nitrogen levels (12 and 80kg N ha^{-1}) in positions relative to adjacent eucalyptus (***Eucalyptus dunnii*** Maiden) tracks in ACS and traditional no-till agriculture (AGR) in subtropical Brazil.

MATERIAL AND METHODS

This study was conducted at the Experimental Station Model Farm of the Agronomic Institute of Paraná (25°06'19" S 50°02'38" W, 1.020m above mean sea level) located in Ponta Grossa, Paraná, Brazil. According to the Köppen classification system, the climate is temperate, with no definite dry season and the average total annual rainfall, temperature, evapotranspiration and relative humidity are between 1600 to 1800mm, 17 to 18°C, 900 to 1000mm and 70 to 75%, respectively (http://www.iapar.br/modules/conteudo/conteudo.php?conteudo=677).

According to SANTOS et al. (2006), the soil classification of the study area is a typical dystrophic red-yellow Latosol, with a moderate, mild medium texture and a wavy soft relief phase (4-8% slope). Soil samples were collected at 0-0,20m depth at a position level as described below and were collected into a composite sample for the whole experimental area. Soil analysis revealed the following characteristics (means ± standard deviation, n=6): pH ($CaCl_2$) 4,9±0,20, pH (SMP) 6,2±0,15, Al^{+3} 0,13±0,13$cmol_c$ dm^{-3}, H^++Al^{+3} 4,43±0,55$cmol_c$ dm^{-3}, Ca^{+2} 3,07±0,79$cmol_c$ dm^{-3}, Mg^{+2} 2,47±0,37$cmol_c$ dm^{-3}, K^+ 0,12±0,03$cmol_c$ dm^{-3}, P 6,65±2,17mg dm^{-3}, C 26,4±1,3g dm^{-3} and clay 447±16g kg^{-1}.

The ACS tree is ***Eucalyptus dunnii*** Maiden, which were planted in 2007 in double line tracks. AGR was used as a control to compare the predominant form of agriculture in the region and was located next to the arborized system (less than 200m). Both systems were previously covered with native grassland and had similar cultural histories.

The tree tracks were positioned at a guideline level, in which the tracks located in the center of the slope were made in level and the other adjacent tracks were placed in parallel up and down the slope. The spacing between two adjacent tree tracks (intercropped track) along the guideline level direction was 20m, the distance between two adjacent rows in a track was 4m and the distance between two trees in a row was 3 m.

The average tree height and diameter on December 2011 were 17,41m and 21,22cm, respectively. The eucalyptus trees were thinned out and the remaining trees had their branches pruned to half the tree height. Intercropped annual crops were planted 1m from the tree stems because of a physical limitation related to agricultural implement measurements, making oat tracks that were 18m long.

Six days prior to sowing the oats, glyphosate (0,9kg ae ha^{-1}) was applied to eliminate the remaining weeds from corn (***Zea mays*** L.), which was the preceding crop. The oats (***Avena sativa*** L. cv. 'IPR 126') were sown under a no-till system at 40kg seeds ha^{-1} and fertilized at 300kg ha^{-1} of 04-30-10 (N-P_2O_5-K_2O) on June 16, 2011. Seedling emergence occurred ten days after sowing and this date was used as a reference. During the oat cycle, metsulfuron-methyl (2,4g ai ha^{-1}) was applied to control weeds before the tillering stage and pyraclostrobin + epoxiconazole (183g ai ha^{-1}) was applied to control diseases at the booting stage.

The experiment was carried out in a split-block, which each treatment set was placed in a randomized complete block design arrangement, with four replicates that included two levels of nitrogen (12,0 and 80,0kg N ha^{-1}). The blocks were set as main plots and six positions (five positions between two eucalyptus tracks and one outside the system) were used as split-blocks. At the tillering stage, which started 28 days after emergence (DAE), additional nitrogen in urea form (46% N) was uniformly hand-applied (68,0kg N ha^{-1}) or not-applied (0,0kg N ha^{-1}). There were 14 rows of split-blocks that were 5m long with 18cm between the rows. A 0,4m border was left on each split-block side.

The five positions between the eucalyptus tracks and one outside the intercropping system were denoted A, B, C, D and E for ACS and F for AGR. The positions within the integrated system with trees (A_E) were the distances between the tree tracks. The letter A represented the smallest elevation of the slope and the letter E was the highest elevation of the slope. This designation is always valid because the system was implemented with a guideline level. Therefore, the distances, which are denoted here as positions, represent the oats growing at A: 2,8m, B: 6,4m, C: 10,0m, D: 13,6m and E: 17,2m away from the track positioned at the lowest elevation of the slope between two adjacent eucalyptus double line tracks.

For the tillering analysis, the split-blocks area (12,6m^{-2}) was subdivided into seven crescent portions (0,3m for the first with increment of 0,1m for subsequent, until 0,9m for the last) for sampling over the oat cycle. Collets were made in the central position of each portion (described below). Oat tillering was assessed by harvesting 1m^{-1} on seven sampling dates during the oat cycle. The oat development stages at the sample time were as follows: leafy at 21DAE, tillering at 42DAE, tillering peak at 63DAE, elongation start at 84DAE, booting/flowering at 105DAE, grain filling at 126DAE and maturation at 152DAE.

The plants were uprooted to enable tiller identification and the roots were then cut to determine their dry matter. One m^{-1} was collected from a central position of the portion designated for each sample (as described above), by placing a 1,8m long by 10cm wide rectangular cast iron (positioned perpendicular to the tracks of trees), which made 10 crop rows with 10cm length. All plants from 1m^{-1} were collected, counted and separated into main shoot and tillers and each plant was broken down into leaves, shoots (stems) and senescent material in the vegetative stages and panicles in the reproductive stages, dried at 65°C and weighed after reaching a constant weight. The oat phytomass per plant was evaluated during the entire oat cycle. The tiller-to-main shoot phytomass ratio (mg mg^{-1}) (phytomass ratio) was determined by taking oat phytomass per plant disregarding the senescent material.

The oat phytomass per plant and its tillers were determined from the product of oat phytomass and its tillers per square meter by the total number of plants collected per square meter.

The grains were threshed in a motorcycle tire chamber and separated from other materials (rachis, branches and glumes) with a pressurized air blower. The grains were re-dried at 65°C and weighed after reaching a constant weight. The grain yield per plant was determined by adding the tillers and main shoot grains with husks yield. The tillers-to-main shoot grain yield ratio (mg mg^{-1}) (grain yield ratio) was obtained by dividing the tillers grain yield by the grain yield of the main shoot. The grain weight was measured on a dry basis without moisture.

Statistical analyses were performed by using the framework split block design in the General Linear Models procedure in Statistica 8.0 for Windows (StatSoft, Inc., Tulsa, OK, USA) with the following factors: the nitrogen levels (supply or non-supply of additional nitrogen upon tillering) and positions (five positions between two eucalyptus tracks and AGR). Other analyses were performed as described, but they only used five positions between two eucalyptus tracks, to test nitrogen and position effects inside the integrated system. The block and its interactions were treated as random effects. To verify the dataset distribution of, the Shapiro-Wilk test was applied at α=0,01 significance. Only the tiller-to-main shoot phytomass ratio, at both 84 and 126DAE, did not reach normality; the square-root transformation was used to improve that result. Differences between the means with consideration of the nitrogen effect were determined using the Duncan method at α=0,05 significance. To compare the AGR means (control treatment) with positions inside the ACS, it was applied the Dunnett two sided method at α=0,05 significance. To find significant position effect inside the ACS, a simple regression analysis for linear, quadratic and cubic polynomial degrees were determined. The mathematical models were chosen according to the equations with the best fit, confirmed by the higher determination coefficients and the significance of the regression F test until 5% probability, or the lowest value of significance when it was above 5%.

RESULTS AND DISCUSSION

Until 21DAE, the above-ground phytomass did not differ among systems, and inside the alley cropping system, there was a subtle linear increment from the lowest to the highest elevation of the slope between two adjacent tree tracks. However, inside the alley cropping system from 42DAE until 152DAE, a quadratic phytomass response was observed, with trees promoting negative interference on both sides of the oat track (Figure 1a).

Tillering had already started at 42DAE and additional nitrogen application began to promote a greater phytomass accumulation, both

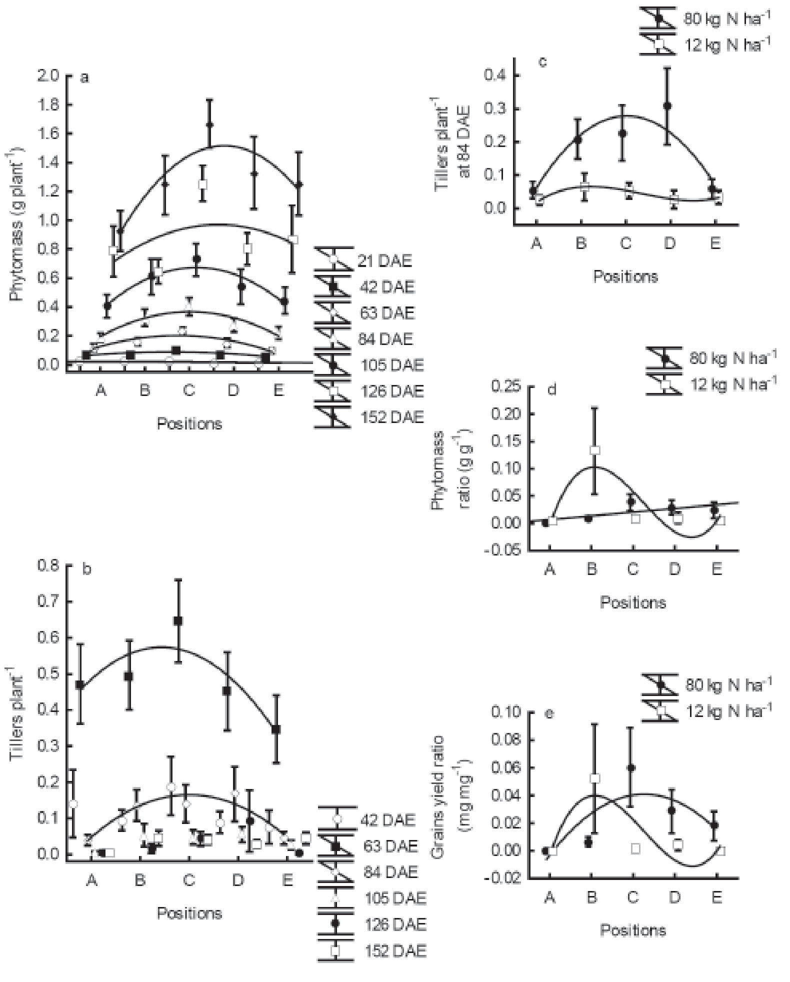

Figure 1 - Oat (***Avena sativa*** L. cv. 'IPR 126') traits under nitrogen levels (12,0kg N ha^{-1} and 80,0kg N ha^{-1}) in days after emergence (DAE), above-ground biological yield (21DAE: Y=0,023-5,00 10^{-4}x, R^2=60,0, P=0,06; 42DAE: Y=0,039+0,010x-5,46 $10^{-4}x^2$, R^2=58,1, P=0,0056; 63DAE: Y=0,023+0,037x-0,0019x^2, R^2=80,6, P=5,55 10^{-5}; 84DAE: Y=0,037+0,065x-0,0033x^2, R^2=85,3, P=1,19 10^{-5}; 105DAE: Y=0,172+0,099x-0,0049x^2, R^2=87,3, P=0,003; 126DAE: Y=0,514+0,081x-0,0036x^2, R^2=19,4, P=0,07; 152DAE: Y=0,448+0,191x-0,0085x^2, R^2=80,8, P=0,007), tillers-to-main shoot phytomass ratio at 152DAE (80kg N ha^{-1}: Y=0,0011+0,0019, R^2=49,1, P=0,42 and 12kg N ha^{-1}: Y=-0,235+0,124x-0,014 x^2+4,38 $10^{-4}x^3$, R^2=70,4, P=0,01) tillers per main shoot (63DAE: Y=0,318+0,058x-0,0033x^2, R^2=74,7, P=0,02; 84DAE: Y=-0,074+0,047x-0,0023x^2, R^2=89,3, P=0,003; 84DAE: 80kg N ha^{-1}: Y=-0,161+0,085x-0,0041x^2, R^2=82,4, P=0,0005 and 12kg N ha^{-1}: Y=-0,072+0,047x-0,0049x^2+1,49 $10^{-4}x^3$, R^2=99,8, P=0,54) tillers-to-main shoot grain yield ratio (80kg N ha^{-1}: Y=-0,042+0,015x-6,63 $10^{-4}x^2$, R^2=60,55, P=0,076 and 12kg N ha^{-1}: Y=-0,095+0,049x-0,0055x^2+1,72 $10^{-4}x^3$, R^2=68,4, P=0,09) in alley cropping agroforestry system, at A: 2,8m, B: 6,4m, C: 10,0m, D: 13,6m and E: 17,2m away from track positioned at the lowest elevation of the slope, between two adjacent eucalyptus (***Eucalyptus dunnii*** Maiden) double line tracks [20m (4mx3m)], in subtropical Brazil. Vertical bars denote standard errors.

in the system comparison (P=0,01) and inside ACS (P=0,02), which also did not differ from the central position between the tree tracks for AGR (P=0,001). The trees reduced the radiation intensity and altered the light wave lengths arriving at the soil surface (TAIZ & ZEIGER, 2010). Oats detected precociously alterations in the light quality and they modulated their growth and tillering, thought the lower formation of tillers and accumulation of tiller mass (ALMEIDA & MUNDSTOCK, 2001). A low intensity of supplemented far red light increased the differences between the oat main stem and tiller masses, demonstrating the prioritization of resource allocation to the main stem in the detriment of the tillers (ALMEIDA & MUNDSTOCK, 2001). In wheat, supplemented red light did not promote tillering in comparison to no supplemented light; however, supplementing red light to far red light, back-reversed the tiller inhibition promoted by far red light, demonstrating the phytochrome mediation of the detrimental far red light effect (UGARTE et al., 2010). At this time (i.e., 42DAE), the nitrogen effect increased the phytomass ratio only in the systems comparison (P=0,081), AGR had a higher phytomass ratio than ACS (*P*<0,0001) and in both nitrogen levels, AGR had more tillers per main shoot than ACS (P=0,04) (Figure 2c).

During earlier tillering, in addition to less phytomass accumulation in oats next to the trees, it became evident that the eucalyptus was delaying tillers. Under 75% shade, wheat (***Triticum aestivum*** L. cv. 'Minaret') tiller emergence occurred at a higher physiological age than in plants under full sunlight and the maximum delay was close to one phyllochron (EVERS et al., 2006). Wheat grown in a eucalyptus ACS with trees planted in a fan design and with their roots pruned to a depth of 50cm in northern India had a lower number of tillers per row length and longer

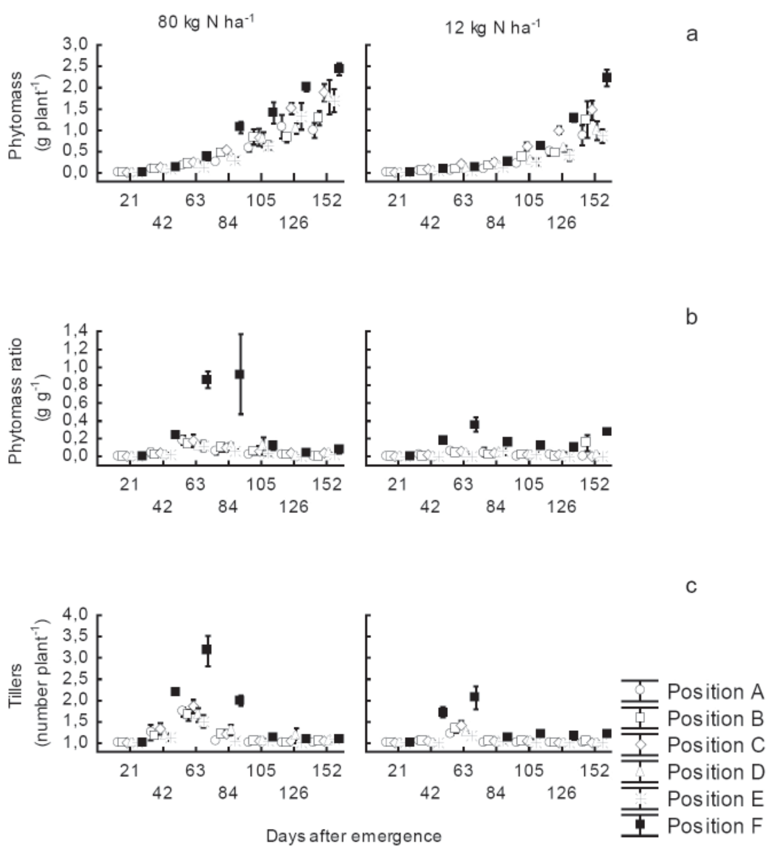

Figure 2 - Oat (***Avena sativa*** L. cv. 'IPR 126') phytomass, tillers-to-main shoot phytomass ratio and tiller number under nitrogen levels (80,0kg N ha^{-1} and 12,0kg N ha^{-1}) in alley cropping agroforestry system, at A: 2,8m, B: 6,4m, C: 10,0m, D: 13,6m and E: 17,2m away from track positioned at the lowest elevation of the slope (4-8%), between two adjacent eucalyptus (***Eucalyptus dunnii*** Maiden) double line tracks [20m (4mx3m)] and traditional no-till agriculture (F) in subtropical Brazil. Vertical bars denote standard errors.

tillering duration (days after sowing to 50% tillering) than wheat cultivated as a sole crop (KOHLI & SAINI, 2003).

Peak tillering was observed at 63DAE. The oat phytomass of AGR did not differ only for position C inside the ACS, where 80kg N ha^{-1} was applied, but the 12kg N ha^{-1} AGR was similar, in terms of phytomass, to ACS (P=0,058) (Figure 2a). However, AGR had a higher phytomass ratio in terms of both nitrogen levels (P=0,001) (Figure 2b) and more tillers per plant than in ACS (*P*<0,0001). Inside the ACS at 63 DAE, the tiller number diminished as the oats got closer to the eucalyptus (P=0,007). At peak tillering, it was more evident with the tiller delay actually came from eucalyptus tiller suppression, which was possibly caused by both light intensity reduction and quality alteration, not accounting for other factors (competition for water and nutrients) that may have limited oat growth before. Below-ground competition for water reduced cotton plant size and nitrogen use efficiency in ***Pinus taeda*** ACS (ZAMORA et al., 2009). Shade reduced tillering and "a fixed red: far red and photosynthetic active radiation (PAR) intercepted inside the canopy" determined the ceasing of wheat tillering (EVERS et al., 2006). Therefore, it is natural to expect that plants stop tillering in the environments most shaded by trees, even before intraspecific community interaction is considered (Figure 1b).

At 84DAE with 80kg N ha^{-1}, the phytomass of AGR became higher than all of the positions inside ACS and the systems remained indifferent with 12kg N ha^{-1} (*P*<0,0001) (Figure 2a). AGR had more tillers per plant than ACS only where additional nitrogen was applied (*P*<0,0001) (Figure 2c) and AGR remained at a higher phytomass ratio than ACS (P=0,0002). Inside ACS, which had a higher nitrogen level, the tillers per main shoot increased from approximately 0,05 to 0,3, when the oats were more distant from trees; with a lower nitrogen level, there was a subtle increase in tiller numbers from 0,03 to 0,06, from positions D to B, followed by a decrease to a tiller number of 0,02 until position A (P=0,054) (Figure 1c).

From 105DAE to 152DAE, oats growing in the AGR had a higher phytomass than that of ACS, which did not differ at position C inside the ACS, both at 105DAE and 152DAE (105DAE P=0,0002; 126DAE *P*<0,0001; 152DAE *P*<0,0001). The phytomass ratio of AGR did not differ at position C inside ACS at 126DAE (P=0,003) and only the lower nitrogen level had a higher phytomass ratio than ACS at 152DAE (P=0,002) (Figure 2b). Inside ACS at 152DAE where the lower nitrogen level was applied, the phytomass ratio had a greater expression only at position B (P=0,066) (Figure 1d). In terms of tiller number, AGR was superior to ACS at 105 (P=0,0018) and 152DAE (*P*<0,0001), with no difference only at position D inside ACS at 105DAE.

In this study, the higher nitrogen level favored greater oat tillering, although the tillering was more persistent at lower nitrogen level applications at the end of the cycle. This result may be explained by high intraspecific competition where higher nitrogen levels were applied, as promoted by the higher number of tillers at 63DAE during the tillering peak, which was succeeded by a greater phytomass accumulation and phytomass ratio at 84DAE, added to the lodging occurrence in AGR and at positions B and C inside ACS. Greater tillering occurred in traditional systems (i.e., AGR) as the plant density reduced (e.g., EVERS et al., 2006), and inside ACS as the tillering was favored by microclimate conditions (e.g., KOHLI & SAINI, 2003).

At the end of the oat cycle (i.e., 152DAE) the grain yield was higher where there was higher applied nitrogen, both in the systems comparison (P=0,03) and inside the ACS (P=0,03). The grain yield did not differ between systems. However, the grain yield ratio of AGR was higher than that inside the ACS (P=0,0004) (Table 1). Oats under tiller-depressing long day conditions, the tiller trait phytomass, vegetative phytomass, total grain weight, harvest index and its tillers-to-main shoot ratios did not respond to the 120kg N ha^{-1} or 80kg N ha^{-1} application rates, except in the numbers of tillers and head-bearing tillers per main shoot (PELTONEN-SAINIO et al., 2009).

Inside the ACS, the grain yield ratio was increased by the higher nitrogen level only at position C and it was increased by the lower nitrogen level only at position B (P=0,085). Where 12kg N ha^{-1} was applied (where lodging did not interfere with growth), most likely on position B, was the location where oats used light most efficiently inside ACS to promote tillering persistence for grain production (Figure 1e). At 84DAE, after peak tillering had occurred, a greater number of tillers already stood in this position, which could provide a significant contribution to the grain yield (Figure 1c). In a fan design, the nearest eucalyptus tree rows were 5,15m from the center towards the east and west, and the wheat had maximum tillering, which may have resulted from the more efficient utilization of available light by the crop (KOHLI & SAINI, 2003).

In the intermediate position B between eucalyptus tracks, the higher nitrogen level did not increase both the phytomass and grain yield ratios,

Table 1 - Oat (***Avena sativa*** L. cv. 'IPR 126') grain yield per plant and tiller-to-main shoot grain yield ratio, under nitrogen levels (12.0kg N ha^{-1} and 80.0kg N ha^{-1}) in alley cropping agroforestry system (A_E) and traditional no-till agriculture (F) in subtropical Brazil.

Positions	A[a]	B	C	D	E	F	Mean A-F[c]		Mean A-E	
	Grain yield (mg $plant^{-1}$)									
80 kg N ha^{-1}	187.0	191.1	221.3	302.7	235.6	304.7	240.4	A	227.5	A
12 kg N ha^{-1}	152.6	223.4	260.3	189.4	170.7	231.5	204.7	B	199.3	B
Mean	169.8	207.3	240.8	246.1	203.1	268.1	222.5		213.4	
	Tiller-to-main shoot grain yield ratio (µg mg^{-1})									
80 kg N ha^{-1}	0.00	6.64	60.59	28.62	18.05	105.13	36.51		22.78	
12 kg N ha^{-1}	0.08	52.14	1.82	4.03	0.32	162.75	36.86		11.68	
Mean	0.04	29.39	31.2	16.33	9.19	133.94	36.68		17.23	
	**[b]	**	**	**	**	Control				

[a] positions: A: 2.8m, B: 6.4m, C: 10.0m, D: 13.6m and E: 17.2m away from track positioned at the lowest elevation of the slope, between two adjacent eucalyptus (***Eucalyptus dunnii*** Maiden) double line tracks [20m (4mx3m)]. Values followed (within column) by the same capital case letters, are not significantly different using the Duncan´s test (α=0.05). [b] ** (within line) indicates the significance at 0.01 of the comparison with a control by the Dunnett two sided test. [c] Means including traditional no-till agriculture (A_F) or within alley cropping system (A_E).

suggesting that the nitrogen level for these places should be inferior of 80kg N ha^{-1}. The higher nitrogen level increased both phytomass and grain yield ratios at positions C, D and E inside the ACS, indicating that the nitrogen level should be maintained or even increased (Figure 1d,e). In contrast to the AGR, in the ACS an accurate fertilizer recommendation for nitrogen must consider the tree interference on intercropped species.

The contribution of tillers to the total yield was small, both in AGR and ACS. However, the eucalyptus tiller-suppression was strong near the trees, suggesting that in addition to nitrogen, other agronomic practices must be used, such as a higher seeding rate (e.g., PELTONEN-SAINIO et al., 1995; ALMEIDA et al., 2003) combined or not with other plant arrangements, to the community took on uniculm growth habit. GILL et al. (2009) observed a declining trend in the tiller number of wheat varieties, which increase in age from 4 to 6 years old in a poplar plantation.

CONCLUSION

The nitrogen levels did not alleviate the eucalyptus tiller-suppression of oat and the tiller contribution to grain production is small both in ACS and AGR. Oat tillering persistence, in terms of both phytomass and grain yield ratios, is dependent on different nitrogen levels at distances relative to adjacent eucalyptus tracks, and different nitrogen levels should therefore be used at those distances to improve the oat yield potential inside ACS in subtropical Brazil. This is an evidence that an adjustment in the nitrogen levels of the integrated systems should be taken into account, with attention to the interspecific interaction between annuals and perennial crops.

ACKNOWLEDGMENTS

This research results from the technical cooperation agreement SAIC / AJU No. 21500.10/0008-2 signed by Instituto Agronômico do Paraná and Embrapa Florestas

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