The Effect of shading on yield of sunflower production in agroforestry system with Eucalyptus.

A. C. V. de Oliveira[1]; A. de Moraes[1]; M. F. S. Ribeiro[2]; V. P. da Silva[3]; C. R. Lang[2]; R. R. Nogueira[2]; E. B. de Oliveira[3]; J. L. Moletta[2]

[1]UFPR- Universidade Federal do Paraná, [2]IAPAR-Instituto Agronômico do Paraná, [3]EMBRAPA FLORESTAS- Empresa Brasileira de Pesquisa Agropecuária.

Keywords: *Helianthus annuus L.; integrated systems ; leaf area index ; productivity ; shading; white rot.*

Introduction

The sunflower (*Helianthus annuus L.*) is grown in many regions of the world due to its great phenotypic plasticity. Today is the fourth oil production then the palm, soybean and canola. In Brazil the sunflower production has increased due to the rise in the demand, in the price paid to the producer and the diversity of products from the plant combined with the wide adaptability to different environmental conditions and ease to produce it (Leite *et al*, 2005). Dugan *et al*, 1997 and Silva, 2012 confirmed in their studies, the potential of sunflower for animal feed in partial substitution for compound feed for corn and soybeans, due to the high protein content of the grain and excellent quality of oil.

Regarding the agroforestry systems, these consist of associations of forest trees with annual crops simultaneously, resulting in less dependence on inputs, greater food security and allowing the achievement of a greater number of products in the same area (Dubois, 1996). However, according to the above author, the forestry component may adversely affect the yield of agricultural crops in the agroforestry systems. Furthermore, the reduction in photosynthetically active radiation during the grain filling causes a decrease in oil production in sunflower (Aguirrezábal *et al*, 2003)

Considering the relevant interest in the sunflower cultivation associated to consumer demand for products from sustainable production systems, this study aimed to evaluate the effect of shading, caused by eucalyptus, in sunflower yield in the agroforestry system.

Materials and methods

The study was conducted at the Fazenda Modelo experimental station of the IAPAR in Ponta Grossa, Paraná (25 ° 07'22" S, 50 ° 03'01" W, and altitude 953m) in 2011-2012.

We used two areas: one with 300 m^2 for the crop system (CS) and another with 1200 m^2 characterizing the agroforestry system (AFS). The experimental design was a randomized block with four replications and 3 genotypes (Aguará 04, Catissol and NTO 2.0). The plots were arranged in five tracks 4, 8, 12, 16 and 20m away from the rows of eucalyptus. Each genotype was sown in a plot of 5 rows of 5 m length, spaced 0.7 m between rows and 0.3 m between plants. Only the three central lines of each plot were considered useful for evaluations. The crop management was performed following the recommendation of research (Leite *et al*.,2005).

In full flowering (stage R5.5) measurements were made of the width of the leaf blade largest of all leaves of 6 plants in each plot and then the leaf area was estimated using the model by Maldaner *et al*.,2009. The leaf area index (LAI) was then calculated as the ratio of the leaf area of plants in each plot and that occupied by plants.

The evaluation of the incidence of white rot of sunflower (*Sclerotinia sclerotiorum L.*), consisted in the counting of the capitules with the disease in the three central rows of each plot at harvest.

The data were statistically analyzed by Statistica software, version 5.5, applying the F test for variance and Duncan test for medium.

Results and discussion

There was no significant difference among cultivars in the incidence of white rot and LAI (*P> 0.05*) (Table 1).

However, the increased incidence of the disease, about 70.5% of the useful area of plants in the plot, was observed in agroforestry system (AFS). The incidence of white rot was 13.75% on crop system (CS), in other words, approximately 5 times lower than the incidence in the AFS. The shading caused by the trees on the sunflower generated in lower average temperatures by 1 ° C and average relative humidity higher by 25% compared to the crop system.

According to Leite *et al.*, 2005, the optimal conditions for development of the mycelium of the fungus *Sclerotinia sclerotiorum (Lib.)* are relative humidity above 70% and temperature between 18 ° C and 25 ° C.

The mean LAI differed significantly between tracks and between CS and AFS to the genotypes Catissol and NTO 2.0, being higher in the crop system. In the case of the Aguara 04, the largest LAI was obtained in plants grown in line 3 (central). This takes about the same amount of photosynthetically active radiation that plants in the crop system.

The LAI in sunflower generally is associated with intense accumulation of biomass and grain yield, however, conditions of low levels of radiation and air temperature during grain filling result in fewer total biomass, despite the high LAI (Bange *et. al.*, 1996).

According to Merrien and Milan, 1992, a LAI between 2.5 and 3.0, obtained during flowering, is enough to ensure good yield, nevertheless, it is essential to keep the photosynthetic activity of this leaf surface after flowering, since grain filling being characterized by a period of strong competition among assimilated achene abortion may occur in plants showing incipient leaf surface, mainly as a result of premature senescence.

Table 1. Mean LAI and incidence of white rot of sunflower genotypes arranged in tracks between rows of Eucalyptus in the agroforestry system (AFS) and in the crop system (CS).

	Aguara 04		**Catissol**		**NTO 2.0**	
CS (Tracks)	LAI	Incidence	LAI	Incidence	LAI	Incidence
1	5.35b	23.39a	5.37bc	28.81a	5.88abc	27.90ab
2	6.54ab	32.93a	5.66abc	21.86ab	6.36ab	31.34a
3	7.32a	33.07a	6.39ab	21.84ab	6.28abc	30.49a
4	6.36ab	25.99a	5.62abc	29.44a	5.25bc	28.64a
5	5.70b	23.39a	4.86c	15.53bc	4.96c	16.94b
AFS	5.34b	6.26b	6.79a	8.20c	7.12a	2.33c
Mean	6.1	24.17	5.78	20.95	5.97	22.94
CV(%)	12.79	40.58	12.09	38.63	13.21	49.52

Means followed by different letter in the same column differ ($P<0.05$) by Duncan test.

There was a significant effect of productivity between the CS and AFS ($P <0.05$) whereas the yield obtained in the crop system was higher than that in the agroforestry system and it was the lowest in the bands near the rows of eucalyptus (tracks 1 and 5), (Table 2).

Cantagallo and Hall, 2002 examined the effect of radiation stress in the sunflower production and they concluded that light stress during the floret differentiation interval can irreversibly reduce the number and grain yield in sunflower.

Table 2. Average total yield of sunflower genotypes arranged in the five tracks between the rows of eucalyptus in the Agroforestry System (AFS) and in the Crop System (CS).

Total Yield (Kg ha^{-1})			
CS (Tracks)	Aguara 04	Catissol	NTO 2.0
1	1810.75b	1414.75cd	1631.75d
2	2270b	2508.75b	2571.75bc
3	2320.75b	1998.75bc	2893.25b
4	2138b	1908.25bc	2152.75cd
5	984.5c	1018.5d	620.25e
AFS	4686.5a	4489a	5098.50a
Mean	2368.42	2223	2494.71
CV (%)	52.27	54.98	60.31

Means followed by different letter in the same column differ (*P<0.05*) by Duncan test.

Analyzing the table 1 and the table 2, we can infer that the shading caused a reduction in photosynthetically active radiation and air temperature generating ideal conditions for the incidence of white rot of sunflower and reduced the overall LAI which was reflected in the fall in productivity about 60% in the agroforestry system.

Conclusions

The shading caused by eucalyptus created ideal conditions for the increased incidence of white rot in sunflower and induced the negative effect on the mean LAI.
The decrease in these parameters reflected in a decline of approximately 60% of the productivity of sunflower from the agroforestry system.
The production of sunflower can be feasible in the first years of implementation of the agroforestry system, however further researches on the subject are necessary.

Acknowledgements

This work was supported by the Instituto Agronômico do Paraná, Universidade Federal do Paraná, and was sponsored by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Financiadora de Estudos e Projetos (FINEP).

References

Aguirrezábal, L.A.N., Lavaud, Y., Dosio, G.A.A., Izquierdo, N.G., Andrade, F.H. and González, L.N. (2003) Intercepted Solar Radiation during Seed Filling Determines Sunflower Weight per Seed and Oil Concentration. *Crop Science* 43, 152-161.

Bange, M., Hammer, G., Rickert, K. (1996) *Physiological determinants of potential yield of sunflower*. In: International Sunflower Conference, Lyaoning Academy of Agricultural Sciences, Beijing, pp. 570-575.

Cantagallo J.E. and Hall A.J (2002) Seed number in sunflower as affected by light stress during the floret differentiation interval. *Field Crops Research*, 74, 173-181.

Coloni, R.D. (2008) Farelo de girassol na alimentação de aves e suínos. Pubvet, Londrina, 2, 49, 462.

Dubois, J. C. L., Viana, V. M., Anderson A. B. (1996) *Manual agroflorestal para a Amazônia*. Rebraf, Rio de Janeiro, 228p.

Leite, R.M.V.B. C., Brighenti, A.M. and Castro, C. (2005) *Girassol no Brasil*. Embrapa Soja, Londrina, BR, 641pp.

Maldaner, I. C., Heldwein, A.B., Loose, L.H., Lucas, D.D.P, Guse, F.I., Bortoluzzi, M.P. (2009) Modelos de determinação não-destrutiva da área foliar em girassol. *Ciência Rural,* Santa Maria, 39, p.1356-1361.

Merrien, A., Milan, M.J. (1992) *Physiologie du Tournesol*. Cetiom, Paris, 66p.

Dugan M., Aldai N., Aalhus J., Rolland D., Kramer J. (2011) Review: Trans-forming beef to provide healthier fatty acid profiles. *Canadian Journal of Animal Science*, 91, 545-556.

Silva, C. A. and Agostini, P. S. (2007) Utilização da torta de girassol em suínos. Pubvet, Londrina,1, 11.