Energy implications of the mycosphaerella sp. in eucalyptus globulus stands.

C. Tejedor*, S. Pérez**, C. J. Renedo**, A. Ortiz**, M. Mañana**, D. Silió**.

*Bosques 2000 S.L. Grupo Sniace. Ganzo 39300 Torrelavega
Phone: +34 942 835421
**Department of Electric and Energy Engineering
ESTI Industriales y Telecomunicación, University of Cantabria
Av Los Castros s/n, 39005 Santander (Spain)
Phone: +34 942 201382, fax: +34 942 201385, e-mail: renedoc@unican.es

Abstract. In the last decade, the emergence of leaf disease caused by the fungus Mycosphaerella sp. is jeopardizing the development of some species of the genus Eucalyptus at its juvenile life stage.

The development of forest species for energy purposes, namely to generate biomass in shorter periods, must take into account this circumstance at the time of measuring the energy density generated by these species.

This paper defines a method which relates the measure of the severity of the disease with the energy lost per Ha.

First, it has been characterized from the energy point of view, thus, it has quantified the calorific value of the biomass of Eucalyptus globulus decomposing it in their respective fractions at certain moisture. Then, depending on the degree of severity of the disease, it has been estimated the amount of dry biomass per tree at the age of 27 months and crossing it with the calorific values it has been determined the energy loss per unit of area according to the overall damage index.

Finally, a brief economic analysis considering the consequences of this disease in a stand of Eucalyptus globulus for energy production, has been performed.

Key words

Bioenergy, Eucalyptus, Calorific value, Overall damage index

1. Introduction

The energy of the biomass plays an important role as one of the power sources of the future. This is due to two characteristics: (1) neutrality in the emissions of CO2, and (2) relative abundance and uniformity to a world-wide level. It could provide from the 14 to the 50 percent of the total energy consumed in the world [1].

On the other hand, it is necessary to consider the environmental benefit of the use of the biomass like primary source of energy, mainly by his effectiveness in the reduction of the greenhouse effect [2].

Vegetal species of fast growth are one of the suitable ways to take advantage of the potencial power of the biomass. This allows us to avoid the operation of native forest of high ecological value. These species are commonly called energy crops and they must meet mainly two premises: (1) to adapt to the territory in that they are cultivated, and (2) to have a good energy efficiency.

The bioclimatic and geographic characteristics of Cantabria form an optimal scenario for the development of forest species. The Cantabrian forests suppose more than 2/3 of its territory, where almost 60% of them are in use. This supposes a great forest surface that is still susceptible of growing in an important way.

Table 1. Forest surface in Cantabria [3].

Use	Hectares (Ha)
Forest with trees	209,611
Forest without trees	145,201
Total forest	359,458
Total Cantabria	532,139
Eucalyptus	29,513

In 2000, the first damage of the disease called Mycosphaerella sp. appeared in youth plantations of Eucalyptus Globulus in the North of Spain. It causes very important losses of leaves in the trees, causing great loss of biomass.

Figure 1 shows a stand of Eucalyptus globulus, in its youth period, which has not been affected by the attack of the fungus Mycosphaerella sp.

Figure 1.- Stand of Eucalyptus globulus not affected by the fungus.

This plague causes a great loss of biomass in the forest, as it can be observed in Figure 2.

Figure 2.- Stand of Eucalyptus globulus affected by the Mycosphaerella sp.

Due to the short rotation period of the energy crops of Eucalyptus, this loss of growth is even more important because affects the youth development of this species.

The objective of this work is to determine how the energy density varies in a plantation of Eucalyptus Globulus depending on the severity of the disease.

In this way, it has defined an index of total damage depending on the severity of the disease, which identifies losses in biomass. These losses are divided into types: leaves, branches and bark.

Combining these losses with the calorific value of the components that form the biomass generated by this species, a relationship between the damage and loss of energy per Ha can be established.

2. Materials

The materials used can be divided into two groups, those related to energy aspects and those related to forest aspects. In the first group, there are a precision calorimeter, model IKA C 5000, a precision balance used to weigh samples and a moisture meter. As materials for forest studies, it can be highlighted the hipsometer laser Vertex III for measuring heights and diameters.

3. Methods

The experimental design of all tests consists of complete blocks of a tree with 25 repetitions. Trials of the same series contain the same genetic material for two different seasons. We have assessed the physical parameters of all trees that are described in Table 2.

Table 2. Measurement period of various physical parameters in the tests of 2000, 2002, 2004 and 2005.

	Series 2000	
	Location	
	Mazcuerras	Cabuérniga
Altitude (m)	210	580
Severity	18	26
Height	21	19
Volume	38 and 50	38
	Series 2002	
	Location	
	Herrerías	Guriezo
Altitude (m)	220	580
Severity	12 and 25	12
Height	16	27
Volume	27	
	Series 2004	Series 2005
	Location	
	Penagos	Liérganes
Altitude (m)	320	320
Severity	17	7 and 13
Height		
Volume		

The total volume, with bark, was calculated with the method described by [4] for the eucalyptus in northern Spain. The method is based on the total height and the diameter of the tree.

The severity (percentage of leaf affected) of the disease called Mycosphaerella has been evaluated using the method described in [5]. This severity assessment has been added to the defoliation assessment in the case of the stand of Herrerías (25 months old), because of the extensive damage that it suffers. In this case, for the calculation of the loss of leaf area or overall damage index, the severity of the disease in leaf area on the tree has been added to the defoliation, according to Ec. 1.

$$\text{Overall Damage Index} = D + \frac{S*(100-D)}{100} \quad \text{(Ec. 1)}$$

where:

D is the % of defoliation
S is the % of severity

Once the severity percentage and the damage index has been determined, these variables are related to the volume at the age of 27 months.

Taking into account the method proposed by [6], using diameters and heights, the percentage of each fraction of the tree can be determined, and then the energy loss per hectare is compared to the energy density of the stand not attacked by Mycosphaerella.

4. Results

Table 3 shows the gross calorific value of the different components that compose the biomass of a tree of E globulus [7] to maximum humidity, throughout the year. In this calorific value, the large concentration of volatile elements and aromatic substances has a decisive influence. These exist in the different parts of the tree, but especially in the leaves, with calorific values over 40,000 kJ / kg [8]. This feature gives to the genus Eucalyptus better behaviour from the energy point of view, than other tree species that could be used as energy crops (Poplar, willow,…).

Table 3. Annual gross calorific value (kJ/kg) of the four different parts of the Eucalyptus globulus (Age: 2-3 years, Moisture: 55 - 35 %).

E. globulus	LEAVES	13,583
	WOOD	8,048
	BARK	6,432
	BRANCHES	7,618

Combining heat analysis, with the loss of biomass due to Mycosphaerella sp. for different severity degrees of this, the paper will offer the loss of energy per area unit in Eucalyptus stands.

The loss of biomass compared with the overall damage index, for trees 27 months old, is presented in Figure 3.

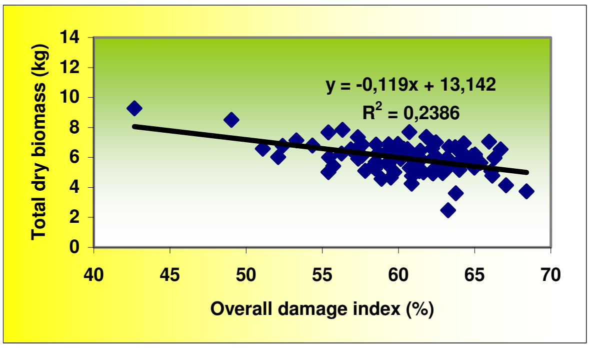

Figure 3.- Total weight of biomass versus overall damage index.

The variation, in kilograms of biomass produced, between a stand with a overall damage of 0% and other with a overall damage of 65% could be around 8 kg per tree. Considering that the stand has a density of 2,500 trees per Ha, the total loss of biomass could be approximately 20 tonnes per Ha.

This dry biomass can decompose in the fractions it consist of, leaves, branches, wood and bark.

In Figure 4, the loss of leaves depending on the overall damage index at 27 months of age, is shown. As a result of this loss leaves with increasing severity of the disease, the quality of the fuel decreases, since is this part of the tree the one that has the highest calorific value.

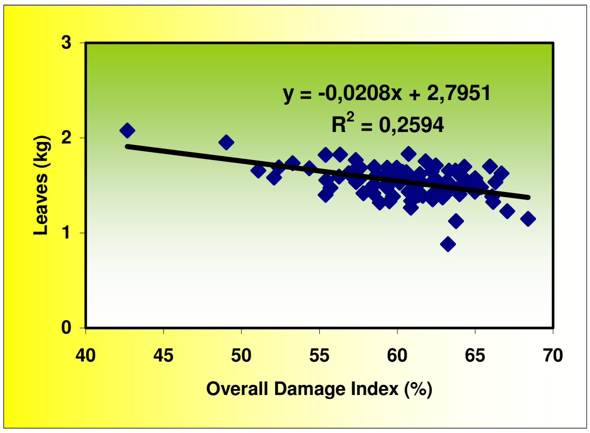

Figure 4.- Weight of leaves versus overall damage index.

Similarly, Figures 5 and 6 show the loss in weight of the wood with bark and the branches for trees 27 months old. It is noted that for rates of damage higher than 65%, the weight of wood with bark can be three times lower than with rates of damage near zero.

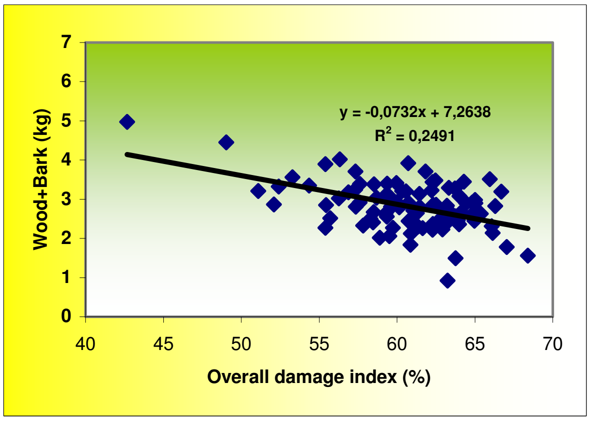

Figure 5.- Weight of wood and bark versus overall damage index.

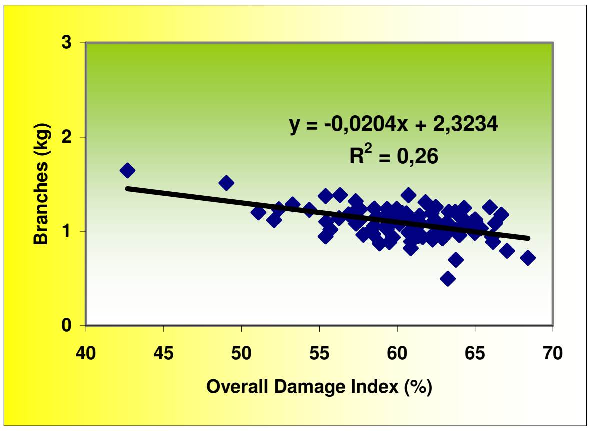

Figure 6.- Weight of branches versus overall damage index.

Figure 7 shows these losses translated to energy units, MJ per Ha, for a 27 months old stand.

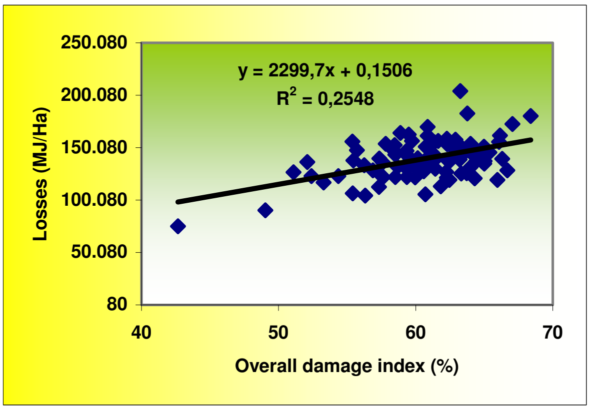

Figure 7.- Energy losses per surface unit versus overall damage index.

It is remarkable that when the overall damage index is higher than 60%, the losses reach values around 150,000MJ/Ha.

Considering that the electrical energy generated from this kind of biomasa is regulated by specific legislation [8] and, if the electrical performance of the power station is 20%, these losses will reach approximately 1200 €/Ha for trees 27 months old.

These results will determine the options and strategies to be followed in the future for the genus Eucalyptus as energy crop in northern Spain.

5. Conclusions.

The adoption of a forest species to obtain energy involves not only its knowledge from energy point of view, but also from the forestry perspective.

In northern Spain, the damage caused by the foliage disease called Mycosphaerellla sp threaten the viability of using forest species such as Eucalyptus globulus for energy production systems in short rotations.

In the future, species that are adapted to this new scenario of forest production should be considered. The key would be to maximize the calorific variables and the biomass production

References

[1] Faaij, A., Energy from biomass ans wastes. Dissertation Utrech University, Departament of science, Technology and Society, Utrech University, Utrech, 1997.

[2] Williams, R.H., and Larson E.D., Biomass and bioenergy. Vol.10,pp 149-166

[3] 3er Inventario Forestal Nacional. Dirección General de Montes y Conservación de la Naturaleza del Gobierno de Cantabria.

[4] Pita, P.A. Tablas de cubicación de diámetros normales y alturas totales. I.F.I.E Ministerio de Agricultura, Madrid, España (1967).

[5] Carnegie A.J., Keane P.J., Ades P.K., Smith I.W. (1994) Canadian. Journal of. Forest. Research (1994). 24: 1751-1757.

[6] Reed, D. And Tomé, M. Total aboveground biomass and net drymatter accumulation by plant component in young in response to irrigation. Forest Ecology and Management.(1998) 103:21:32

[7] Pérez S., Renedo C., Ortiz A., Mañana M. Study of seven different species of Eucalyptus as energy crops. IX World renovable energy congress. Florencia. Italia, 2006.

[8] E. Martín, F Lara. Inflamabilidad y Energía de las Especies del Sotobosque, Ed Instituto Nacional de Investigaciones Agrarias, Ministerio de Agricultura, Pesca y Alimentación, 1989.

[9] REAL DECRETO 661/2007, de 25 de mayo, por el que se regula la actividad de producción de energía eléctrica en régimen especial.