Analele Universităţii din Oradea, Fascicula Protecţia Mediului Vol. XXIII, 2014

ASPECTS REGARDING THE ACACIA CULTURE IN AGRO-FORESTRY SYSTEM FOR THE PRODUCTION OF WOOD BIOMASS

Budău Ruben*, Timofte Adrian Ioan, Kopacz Nandor*****

*University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea; Romania, e-mail: rubenbudau2014@gmail.com
** University of Oradea, Faculty of Environmental Protection, 26 Gen. Magheru St., 410048 Oradea; Romania, e-mail: adi_timofte@yahoo.com
*** Intr. Ind. Kopacz Nandor, str. Vanatorilor nr.4,Harghita, Romania,
e-mail: kopacznandor@yahoo.com

Abstract
The pronounced development of society in the last century at a global level favored high pressures on the environment especially by high consumption of natural resources, energy such as gas, liquid and solid fuels, and now the current challenge for humanity is to produce on a short, medium and long term alternative fuels to generate power at cost as low as possible. In addition to modern techniques of obtaining energy through complex wind, solar or hydrological systems, wood biomass produced in a short production cycle is of particular importance for achieving energy. This paper presents experimental data are based on the way of production and quantitative values of acacia wood biomass grown in an agro-forestry system.

Key words: acacia, wood biomass, agro-forestry system, alternative energy, energy crop, acacia biomass.

INTRODUCTION

In general, acacia has been greatly used for the forestation of degraded lands, on eroded slopes, raw soils, being a good ground fixer. Its ecological plasticity determined its cultivation, sometimes even in improper conditions, because acacia has yet certain limits of ecological plasticity, that are well defined and known both in literature and in numerous experiments made during the approximately 150 years of culture in our country (Budău R., 2014).

The results obtained in Lugoj, within three years, due to which the acacia (Robinia pseudacacia L.) was grown in agro-forestry system, are really promising and correspond to similar studies in the literature. (Erik Temeşvar et.all) states that former agricultural lands that have been abandoned due to optimization and intensification of agriculture, can be used now for other purposes, by planting some forest species to produce alternative energy. A crucial element is the right choice of plant species to coincide with the pedo-climatic factors of the area where the energy crops are installed. (McKendry, 2001) states that the main criteria for selection for biomass are the growth rate, ease of management, harvesting and some of its properties such as, moisture, ash, alkali content, and (Rede, 2011) says that in Hungary, acacia is the most suitable species for wood biomass production through the establishment of energy crops in agro-forestry system.

According to (www.resource-ce.eu, 2010) other major advantage is that acacia species has the ability to fix nitrogen from the atmosphere and thus to improve long-term soil fertility, recommending short cycle crops production.

MATERIAL AND METHODS

The research was conducted on the private lands of the business operators interested in wood biomass for its use in the production of thermal energy from the neighborhood of Lugoj, Timis county, during 2012-2014.

For the establishment of plantations, the land has been well prepared with works throughout the concerned area by scarification to an average depth of 0.6 meters, soil plowing to a depth of 0.4 meters, soil shredding with a disc harrow, and respectively mechanized planting of acacia seedlings (Figure 1). The material used for plantation was purchased from Bărzani Farm, and it was a first quality material according to the Romanian standards it.

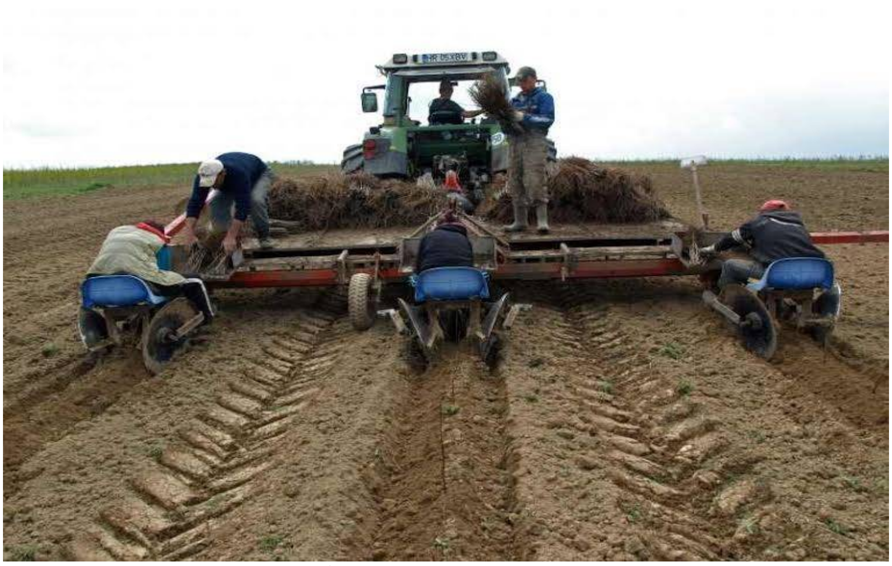

Fig.1 Establishment of culture through mechanized planting
(planting scheme 2x0.5 meters)

According to Table 1, three planting schemes were used with a minimum effective of 6250 plants/ha, average effective of 10,000 plants/ha and respectively maximum effective of 16,000 plants/ha.

Table 1

Planting scheme and number of plants / ha

Planting scheme		
2 x 0.3	2 x 0.5	2 x 0.8
Number of plants /ha		
16000	10000	6250

During the growing season after planting, the interval between seedlings rows was maintained throughout the period of vegetation under the form of black fallow and for the removal of weeds which were also a competitor for the optimal development of acacia seedlings, the total culture herbiciding was made.

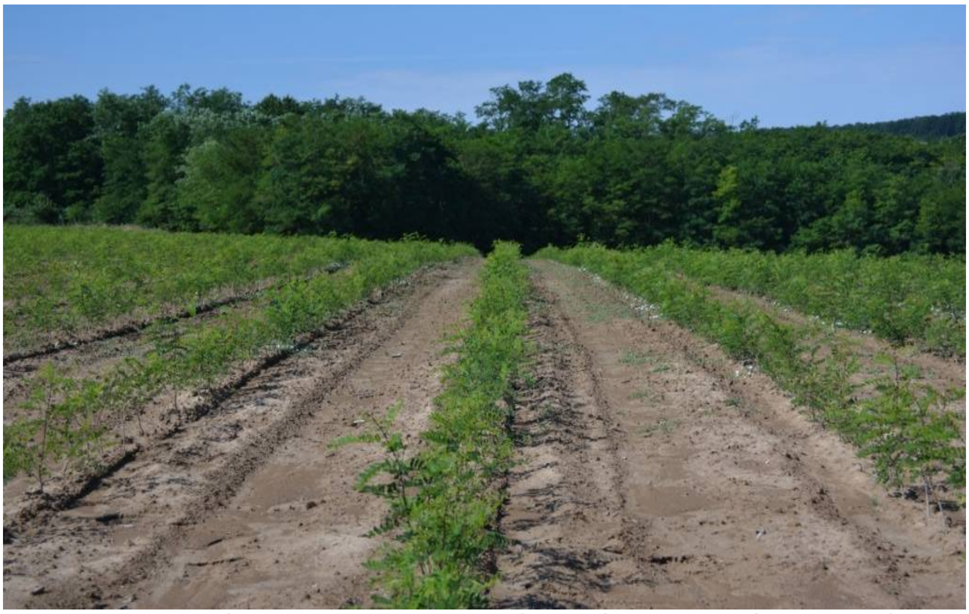

Fig.2 Overview of acacia energy plantation after the first 30 days of vegetation from planting

Data collection consisted in random manual harvesting of 30 pieces for each used sample, respectively for each scheme used in the study and the period in which measurements were made was at the end of the active vegetative growth, 15 to 20 October, then, the sample mass was determined by direct weighing in kg, the collected data being pooled for the three planting schemes as it is shown in Table 2.

Table 2

Determination of average increases in kg versus planting scheme

Planting scheme		
2 x 0.3	***2 x 0.5***	***2 x 0.8***
1) 0.85 2) 0.85 3) 1.15 4) 1.35 5) 1.17 6) 1.48 7) 1.08 8) 1.77 9) 2.48 10) 1.52	1) 4.24 2) 2.3 3) 2.47 4) 2.2 5) 2.2 6) 1.3 7) 1.3 8) 1.81 9) 2.5 10) 2.6	1) 3.7 2) 2.4 3) 2.3 4) 2.3 5) 1.25 6) 2.8 7) 1.8 8) 1.3 9) 7.7 10) 2.2
$\bar{x}$ = 1.37kg/plant	$\bar{x}$ = 2.382 kg/plant	$\bar{x}$ = 2.775 kg/plant
1.37x16000=21920kg/ha **21.92 t/ha**	2.962x10000=23820kg/ha **23.82 t/ha**	2.775x6250=17343.75kg/ha **17.34 t/ha**

Out of the centralization and making the averages between/among the values obtained in t/kg, it can be concluded that the planting scheme 2 x 1, for which an average value of 23.82 t/ha was achieved, is the recommended scheme for acacia wood biomass production in energy plantations. Following the research, average chips amount (20% moisture) was obtained per ha, ranging in the first year between 8 and 9 tons/year/ha, 14 and 15 t/year/ha in the second year, 20 and 22 t /year/ha in the third year, 19 and 20 t /year/ha, resulting a total average of approx. 400 tons/ha/20 years.

After the three years of study it can be concluded that the optimal planting scheme for acacia energy crop is 2 x 0.5 meters, with a total of 10,000 pieces / ha (Figure 1). This scheme has also been adopted taking into account the best way of mechanized harvesting at a reduced price of wood biomass.

Fig.3 Overview of acacia energy plantation after the first 130 days of vegetation from planting (planting scheme 2x0.5).

Similarly, in a comparative lot in which the plantation is not cut for two-year, on an area of ten hectares, and that was planted in 2012, we have a lower density due to the setting percent of approx. 65-70%, which was influenced by several reasons: inappropriate planting machine, poorer seeding material.

The measurements were determined by harvesting 30 subsequent plants in the same row. The average on this plot was 3,503kg / plant, and the production was at the time of the measurements of about 24.5 t / ha of wood biomass.

In terms of harvesting wood biomass, it is harvested mechanically by a cutting device (in the stage of patenting) foreseen with a runnout conveyor /palletization system of the wood biomass (Figure 4, 5, 6). The lots of acacia that were not harvested and had at the second and third year of production cycle, the diameter, when packed, presented significant increases of 4-7 centimeters. The harvesting and chopping process of wood biomass requires appropriate devices to resist to the efforts needed for these two processes; the greater the wood material in the stem diameter, the much more effort to harvest in optimal conditions.

The costs of the harvesters are hundreds of thousands of dollars, which in a first phase of investment has a huge cost and the annual harvest by a relatively simple and affordable device, greatly reduce the production costs of wood biomass.

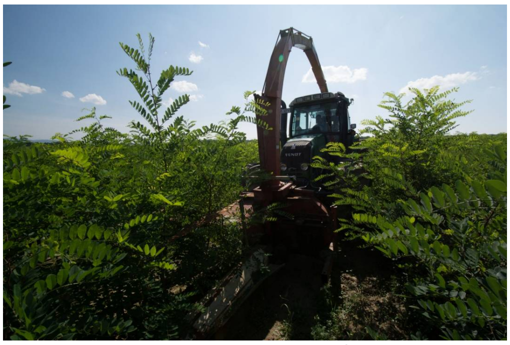
Fig.4 Mechanized harvesting of acacia wood biomass – front view


Fig.5 Mechanized harvesting of acacia wood biomass - side view

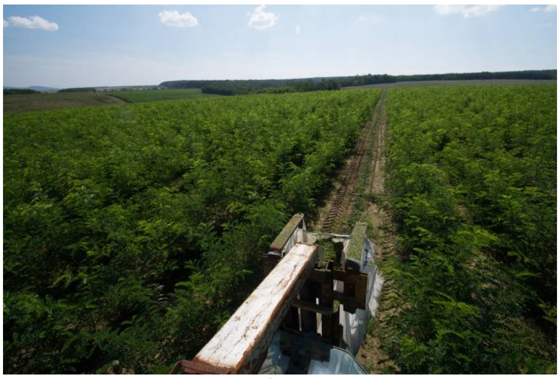
Fig.6 Mechanized harvesting of acacia wood biomass - rear view

RESULTS AND DISSCUSIONS

From the results of these measurements, the three-years experience of growing acacia under energy plantation system and planting schemes, the density of plants / ha, and from the study of literature, several aspects of the most efficient method of establishing and exploiting a acacia plantation begin to take shape for the production of wood biomass in agro-forestry system, so that:

I. Being a light demanding variety, the growth of timber is directly proportional to the existing growing space (light), being the highest in the first year after cutting, decreasing every year without cutting because of the self-shading effect. Moreover, the root system increases in volume each year of vegetation, is stimulated by each cutting, and an eventually average scarification near the harvested acacia row could have a positive effect on the growth of shoots of the new generation, producing a soil oxygenation and facilitating the work of symbiotic bacteria by extracting the nitrogen from the atmosphere, allowing a natural free fertilization, etc;

II. In the first year after cutting, the shoots, being thinner, allow an easier and less expensive harvesting with light equipment that does not create problems in case of excessive soil moisture, the harvesting becoming faster and without the risks of losing the optimal cutting timing.

III. Due to the small diameters of shoots, after the leaves fall, the relative humidity will decrease rapidly.

IV. It is interesting that acacia bark has a higher calorific value than the acacia wood itself, having the highest calorific combustion value among the varieties used in the energy plantations (Fehér, 2013).

V. The more the number of shoots per plant, the highest the percentage of bark and implicitly of heating power.

CONCLUSIONS

The results of three years of experience indicate that the annual cutting in energy acacia plantation is the most effective and inexpensive method of biomass exploitation, therefore it is recommended the annual harvest of wood biomass from the energy plantations of acacia, the most efficient method being the plantations with a total of 10,000 plants / ha, using the scheme 2x0.5 plants.

The costs of this method depend on several aspects according to parameters of the field that was chosen to establish the energy crop:

a) the amount of mechanical work necessary to prepare the soil for planting;

b) geometry of the chosen plot (slope, soil texture, existing vegetation, degree of prior usability, etc.;

c) the position of the plot with respect to the nearest infrastructure for the deployment of logistics for plantation setting up works;

Depending on these studied issues, the total costs of an energy acacia plantation vary from 1500 €/ha to 1800 €/ha without VAT, including all the mechanical works, herbicide, labor force until the first cutting. Cutting, chopping, packaging and transport to the storage place adds an extra cost of approx. € 200 /year/ha.

The average amounts of chips (20% moisture) obtained per ha range between 8 and 9 tons /year/ha in the first year, 14 and 15 t /year/ha in the second year, 20 to 22 t /year/ha in the third and a simulation calculation indicates an average production of approx. 19 - 20 t /year/ha in the twentieth year after planting, resulting a total of approx. 400 tons / ha/20 years.

In terms of average cost /ha, we conclude the following:

- € 1,650 (cost to establish the plantation);
- € 4,000/20 years (harvesting and maintenance costs);
- € 5,650/20 years (total expenses for the production of acacia wood biomass);

If the production costs are compared to the amount of acacia wood biomass that can be obtained through a short cycle of production (annual), but over at least two decades installation period of the acacia culture in agro-forestry system, a total production cost of € 14,125 / t results.

The comparison of the current price of natural gas and acacia biomass production cost: 1 m^3 methane gas = 2kg acacia chips as calorific power; 500 m^3 methane gas = 1 t acacia chips; 500 m^3 methane gas = 500 lei at the current price of natural gas for state subsidized consumers!; 1 t chips= 14,125 EUR = 63.8 lei direct expenditures on energy plantation.

We may conclude that the current price of natural gas is significantly higher (800%) than the price of acacia biomass production which clearly demonstrates the economic efficiency of acacia energy plantations in agro-forestry system.

In the current context, we suggest further research in this area and the adoption of some legislative measures for the potential capitalization of producing wood biomass for the species that have a significantly higher growth on a short-term as well as the subsidized support of the investment in this area.

According to (www.europe-aliens.org) acacia is recorded as one the top 100 species, the most invasive in Europe, but all the same specific source and planting species that modern systems and control, is a renewable energy source.

REFERENCES

1. Budău R., 2014, Experimental results on variability of several productive and quality characters in two natural black acacia varieties: Robinia pseudoacacia l., var, rectissima and R. pseudoacacia var. oltenica.
2. Dario M., Maik V., Dirk F., 2012, Biomass production and water use of Black Locust (Robinia pseudoacacia L.) for short-rotation plantation.
3. Erik T., E. Zöld. Black Acacia (Robinia Pseudoacacia) as Possible Energy Sources, Hungary.
4. Fehér S., Komán S., Antalfi E., Szeles P., 2013, Energetikai ültetvények égési jellemzőinek vizsgálata. NYME SKK, Faanyagtudományi Intézet, Sopron, Hungary.
5. Peter M., 2001, Energy production from biomass (part 1): overview of biomass.
6. Károly R., Imre C., Zsolt K., 2011 Black acacia (Robinia pseudoacacia L.) Short-Rotation Crops under Marginal Site Conditions .Acta Silv. Lign. Hung., Vol. 7 (2011) 125–132. Hungarian Forest Research Institute, Sárvár, Hungary.
7. Timofte, A.I. şi Dorog S.L., 2011, Biostatistică forestieră, Ed. Universității din Oradea.
8. *** Recomandări privind cultura salcâmului., Bucureşti, 1969.
9. *** www.europe-aliens. org/*Robinia pseudoacacia*, Delivering Alien Invasive Species, Inventories for Europe, 2006.
10. *** http://rubenbudau.wordpress.com/cultura-salcamului.
11. ***www.resource-ce.eu, 2010, Biomass on recultivated stockpiles. CENTRAL EUROPE Project 1CE084P4.
12. ***http://silvicultorul.wordpress.com/2011/02/01/puterea-calorica-a-lemnului-kcal/.