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CARDOON, RENEWABLE SOURCE OF ENERGY

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Abstract

Cardoon (Cynara cardunculus) is a herbaceous perennial plant in the vegetable, artichoke, wild or garden, which belongs to the Compositae family (Asteraceae Compositae-and more precisely Cynara species) and is grown specifically for the production of biomass (solid bio fuel as a pellet, or solid and liquid bio fuel, bio diesel). In this paper I have tried to highlight the profitability and economic efficiency of growing of this plant. Production capacity exceeding 2 tonnes dry matter/1000mp. The yield depends on climatic conditions, adequate soil moisture, soil nutrients, and range from 1 to 3 t/1000mp, dry. Cardoon seed contains on average 24% oil (category: 19-32%), with the same qualities as the sunflower. Quantity of seed production to 480 kgs/1000mp, while ordinary productivities range 70 to 330 kg/1000mp, always depending on the total biomass production. Growing cardoon can replace traditional crops, partly by ensuring a good profit for the farmer (double the wheat and rapeseed) and bio fuel production with high energy content. Solid bio fuels (pellets, briquettes, artichokes, etc.) can reach the end-user, at prices up to 30-40% lower than the price of oil. Because cardoon is a perennial plant which grows once every 10-12 years, and preparing the ground and sowing it will be carried out at intervals so large (this plant is harvested annually),it is remarkable cost reduction efficiency of growing this plant.In addition to the obvious environmental advantages by producing green energy, growing artichokes garden preserves the soil covered for the most part of the year, thereby minimizing the risk of soil erosion and limit the pollution of soil and groundwater with agrochemical products, especially in areas with intensive agriculture, because it does not require additional fertilization and/or with the use of chemical fertilizers or pesticides.

Key words**:** *bio diesel, bio fuel, cardoon, pellet, plant energy*

INTRODUCTION

Currently, biomass is an important alternative energy source being entirely useful (M. Berca, 2006). It is available for use worldwide. Affordable cost and neutral character of the emissions of greenhouse gases make a promising biomass energy resource.
Given the biopedoclimatic particularities, in Romania there are favourable conditions for the cultivation of energy plants as raw material sources. 95% of biomass that is achieved is used directly for heat production. Almost 1/3 of the utilized agricultural area is uncultivated. Favoured fertile soil rich in humus and favourable climate conditions, energy plants have a high potential for cultivation. There is a great potential for investment in plantations with short term productivity by rotation.
Cardoon - Cynara cardunculus - vegetable is a herbaceous plant, perennial, belonging to compositae family (Asteraceae, Compositae and accurate species Cynara), which is grown specifically for biomass production. It is also called wild artichoke or garden, in our country it is grown on small areas and chard leaves and leaf stalks that are eatable.
Cardoon cultivation in Romania as energy plant represents a new entry on the economic and environment market, and this is a remarkable progress in the development of agriculture, by the diversification of crops and achieving performance in these areas.

MATERIALS AND METHODS

The main objective in this paper is to study morphological, biological and biochemical features of Cardoon in order to use it as power plant, as well as the environmental requirements to the major crop factors: light, temperature, water and soil. I tried to

emphasize the profitability and economic efficiency of the energy plant cultivation.

Cardoon development begins with the first rains of autumn, and continues (taking advantage of the rain) until the beginning of summer. Thus, the air section of the plant dries and it can be harvested dry to the end of summer. With the first rains of autumn it can be observed again a rapid development of cardoon, that covers entirely the ground in a few days.

The transition from winter to spring (temperature increases and sun appears), marks the next stage of plant development, the emergence of strains. This takes place about the middle of May, it extends in a fast way (up to 4 inches per day) and it can reach a height of up to 2.5 meters. At the same time, with extension of strain, the stem sessile leaves sessile create, deep-section interchangeable alternatively.

Stem growth in height ends with the first appearance of main inflorescence (calatidiu). Next, branches are appearing, their height varies from 0.5 to 1.2 meters. At the top of each branch is an inflorescence. Some small leaves, thick, thorny and divided form along the branches. The latter is characterized by high levels of nitrogen in their tissues (3.0-3.6 g N m^{-2}), contributing to increase plant photosynthesis and increase photosynthetic surface. Total number of flowers is a function of the variety of plant, soil and climatic factors, and of course the variety.

On an average, 10-15 buds are formed in a plant. They are gathered in a large inflorescence, spherical green one. Simultaneously with the formation of the final number of buds, flowering starts itself, characterized by the emergence of purple stamens, situated at the top of each inflorescence. The end of flowering, calatidii reached final size, following maturation, their colour change from green to golden yellow, top to bottom.

Once completed also this stage, white papus appear and the crop is ready for harvest (late August - mid September).After about a week of harvesting, crop begins to grow again (new branches leaves) and growth rate / Issue leaf (petiole, deep-section), which grow from the root (2nd year), is typically 5-10 times higher than those from seeds (first year). Chard seed is dark green-brown.

Land cover rate is clearly faster than the first year and depends on soil moisture and air temperature (10-25 days). Usually from the root 1-4 plants burgeon again at the same time, that develop parallel and contribute to rapid soil cover.

Later, after rosette formation, each root will feed one, at most two plants depending on soil available nutrient components. Also, with the inevitable small losses during harvest, it is observed germination of new seeds, but these seedlings will eventually disappear because of the other plants.

In the first year of vegetation, the amount of biomass is usually 1/3 to 2/3 lower than that found in the second year. Cardoon is deep and woody roots and can reach a depth of 5 m, while the width of the root system can reach 2 m (Danalatos N. et al., 2008).

RESULTS AND DISCUSSIONS

The optimum temperature for development Cardona (temperature below which plant / seed will not grow) is about 8 - 6˚C. Seed germination temperature of 15-20 ˚ C lasts only 1-2 weeks, and it is recommended to sow in the second decade of august until mid-September (autumn sowing) and March-April (sowing spring).

The optimum temperature for plant photosynthesis is 19 to 23 ˚ C, while daily temperatures of around 22 ˚ C can be observed maximum plant growth in volume (April-May). Night temperature also plays an important role in the growth and development of Cardoon so high night-time temperatures (> 25˚C) increase carbohydrate intake (weight loss).

Cardoon is very strong also at cold (snow, ice) provided that it enters a higher phenological stage. Total development stage rosette, the plant can withstand even at temperatures as low as -20 ˚ C. In general, at temperatures < -5 ˚ C it is observed bending leaves, which starts at the local stem rot which contains

large amounts of water. During periods of prolonged frost or heavy snow, there is a break stems and total destruction of biomass. With increasing temperature, the culture is to insert new leaves from the main root of the plant, arranged in rosette. Depending on the time of the event and highlight the phenomenon, the final output is reduced (10-30% if there is winter, up to 50% if it happens in March) Cardoon collection varies, based on the end use of culture as bio diesel or solid fuel.

The best time to harvest is when the 5% of calatidii fully opened, papus becoming visible. Harvesting late (more than 50% calatidii open) causes a decrease in seed production (due to shaking).

If seed for bio diesel, culture must be harvested in August, mid-September (9.12% seed moisture) using a common threshing machines by adding a suitable type of knife in front.

In the case of complete collection of dry biomass, the most suitable solution is to use a powered machine that collects all biomass and simultaneously creates large rectangular bales, weighing 400-500 kg/bale. This method is also the most economical and quality. At the same time, new types can be used for large presses that cut and link/collect biomass. Alternatively, the crop can be harvested with the use of equipment which is the usual way as quality, but less growth (biomass harvested weighs very little, approx. 100-150 kg / m³, compared with 200-350 kg/m³ at large bales, increasing transport costs). (Danalatos N. et al., 2008).

Cardoon is demanding to light and is considered big day plant. The photosynthesis rate maximizes (50kg CO2 ha^{-1} h^{-1}) to the total intensity of solar radiation above 600 W/m².

Minimum interval of precipitation (from sowing or germination until the end of flowering, usually in May-June) should be at least 400mm, to avoid becoming a limiting factor in the availability of moisture.

Cardoon prefers slightly acidic soils to the alkaline, clay (pH 6.5 to 8.2), and heavy soils, acid completely are not recommended.

Since culture is perennial, land preparation and planting will occur once every 7 to 12 years. However, particular attention will be paid to care, since during preparation and sowing mistakes are irreversible and can decrease productivity and life of the culture.

In general, Cardoon sowing depth should not exceed 3 to 5 times of the largest seed dimension. Soil moisture on a normal seeding depth should be 2-3 cm, while on a soil surface moisture lost is sown deeper, to 4-6 cm.

Usually, the amount of biomass is due to the density per hectare. In the case of cardoon, which is a complex plant with many uses / industrial uses (both seed production and biomass), best density is 4-6 plants / m². Distances between rows are adapted to mechanical equipment available to 70-75 cm. In many cases, MMB weight varies from 20 to 50 grams, depending on size. Sowing seeds will be selected so that MMB weight is> 35 grams.

Special attention must be given to the residual activity of certain herbicides from previous crops. Usually, problems may occur after growing oilseed rape, maize and sorghum, as well as active substances (eg atrazine, and so on). A good precedent is considered wheat.

Culture is affected by herbs, but only during the first stage, that is from sowing until full coverage of land (first year only).

Because Cardoon has a very deep and extensive rooting (up to 5m), it offers an advantage in the ability to absorb nutrients from deeper soil layers. Thus, the culture of cardoon has minimal fertilizer needs for the first 2-3 years after installation. There was a significant influence in increasing the production of fertilizers during the first 4-5 years of cultivation. In addition, the culture of cardoon produces a large amount of plant mass (up to 1000kg leaves/ha) during the first phenological stages, which leaves the ground. Leaves fall under physiological conditions is achieved when the nitrogen content of plant tissues is minimized (0.7 to 1.1%). That is, culture can only feed up to 8 kg nitrogen / sqm. On a clay soil texture and organic matter content approx. 3-7 units of nitrogen per year

are mineralized. Thus, the final absorption plant can reach up to 10-15 units of nitrogen. Nutrient uptake by plants depends also on the harvest, and the distribution of dry matter in shoots, leaves, seeds and so on, since different parts of the plant have varied nutrient content (eg seeds contain 3,2% nitrogen, while only 0.65% offspring). In this way, if harvesting takes place in August, when the crop is dry (humidity <15%), the number of nutrients will be removed (remobilisation of nutrients) unlike an early spring harvest green fodder (humidity> 60%).

In soils with high groundwater, water use additional roots, developing biomass (>3t/ha) needs optimum rainfall is 400mm/period of cultivation. 100-150 ml spring water irrigation enhances biomass production (and seed) by 40-50%.

So the Cardoon can be used as solid fuel (pellets or briquettes) for heating or electricity generation.

Production capacity exceeds 3.2 tonnes /1000square meters dry substance. The efficiency depends on climatic conditions, proper humidity soil nutrient availability in the soil, and varies from 1 to 3 t/1000mp, dry. Usually, the final output can be associated with the durum wheat (wheat production cardboard production of seed x = 4). Energy efficiency depends on the distribution of biomass during harvest and of the dry substance and their heating capacity (Table 1).

Table1. Energy efficiency of biomass Cardoon

Class cardoon plant	Distribution to substance dry	Value Energy (MJ / kg)	
		maximum	minimum
Root+ branches	45%	17,67	16,47
Calatidii without seed	36%	17,26	16,01
Seed	19%	23,43	21,88
Total/ plant	100%	18,61	17,33

Dry matter distribution changes with time, with climatic conditions (especially temperature) and growing care (eg irrigation). On fertile soils, sufficiently watered, the proportion of seeds / biomass increases, increasing also the total energy of the plant, while on the field it may reach 12%. When calculating the total energy value is not taken into account and leaves, as is <2.1% of output and usually destroy (friction) during the harvesting procedure. Biomass can be used to produce electricity entirely through processing into pellets and then used as fuel in furnaces, boilers or industrial waste (Arion V. et al., 2008).

Cardoon seed oil contains on average 24% (category: 19-32%), with the same quality as that of the sunflower. Raw can not be used as engine oil. Seed production quantity reaches 480 kg/1000mp, while normal efficiency is 70 to 330 kg/1000mp always based on total biomass production.

Production of bio-oil from seeds of cardoon is estimated at 0.878 t / ha on average, ranging up depending on way of creating the crops and on the plant age, between 0.713 and 1.190 t / ha.

In terms of biochemical values, Cardoon contains large amounts of sugars, acids, nitrogen and phosphorus.

CONCLUSIONS

From the data presented above, we can deduce that this power plant located in Southern Romania finds favourable climatic and agro pedology conditions for its cultivation and it can be a source of plant material used for obtaining liquid or solid.

Cardoon cultivation may partially replace traditional crops, ensuring a good profit for the farmer (double compared to the current prices at wheat and rape, for example, 70 € / t dry biomass at the entrance to the factory) and bio fuel production with high energy. Solid bio fuels (cardoon pellets, briquettes, etc.) can reach the end user, at prices 30-40% lower than oil prices.

Reduce costs regarding the efficiency of cultivating this plant is obvious, because Cardoon is a perennial plant that grows every 10-12 years, and its soil preparation and sowing is done every so high (although this plant is harvested annually).

Besides producing green energy, growing cardoon keeps soil layer covered most of the year, eliminating the risk of soil erosion.

Cardoon cultivation limits the soil and ground water pollution with agrochemicals, especially

in areas of intensive farming because it requires no additional fertilization with chemical fertilizers or pesticides. Even in additional irrigation, cardoon uses minimal amounts of water.

Due to the minimization of soil works and cultivation practices, rest and enrich the soil with organic matter, cardoon leaves for the crops that will be sown later, well-structured soil, creating a rich humus and increased chemical characteristics.

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