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INTRODUCING FAST GROWING TREE SPECIES FOR AGRO-FORESTRY PRACTICES ON AGRICULTURAL LAND IN MACEDONIA

TODOROV V., STAVREVSKA – PANAJOTOVA A., PETROVSKI S., KAMPEN P.
SNV Netherlands development organisation, Office in Skopje, Macedonia
Correspondig author e-mail address: voislav.todorov@cnvp-eu.org

ABSTRACT: Biomass produced from wood is increasingly used for energy. Currently in Macedonia mainly firewood (wood logs/traditional system) is used for heating. Modern production of wood chips and/or pellets is in limited use. This market is increasing rapidly in the region and EU. Fast growing species offer a good possibility for production of biomass for energy in the region. In Macedonia many agricultural lands are not or marginally used. Some of these lands are not very suitable for agricultural farming, but can be used for fast growing species and biomass production. In 2010 the fast growing species *Salix alba* var. *express* was introduced at total of 10 different sites as tree belts in Macedonia. Besides the production of biomass tree belts also fulfil other functions as wind protection, reducing water inundation in wet areas, improvement of micro climate conditions, erosion control of river banks, soil conservation, as well biodiversity or landscaping, serve as flowering plants for honey production. Planting was done in March before the growing season started, with 10.000 stumps/ha and soil preparation with ploughing up to 25-30 cm deep. Species showed a very good growth in the first season with height of 1,5 to over 2 meter, with estimated growth of 3.8 m^3 of biomass. In the second year growth resulted in heights up to 4 m and estimated over 70 m3/ha. Farmers showed good interest indicating that fast growing species can be integrated trough agro-forestry practices in their farming systems.
Keywords: biomass, fast growing species, agro-forestry, energy.

1 BACKGROUND

Today forestry and forests are gaining increased attention in the world. Importance of environmental issues and importance of forest ecosystems in mitigating climate changes is one of the top priorities today in the world. Forest resources also have significant impact on the quality and improvement of live in rural communities. Forests contributes up to 70% of earth carbon (C) fixation and are a major sink for CO_2 on a global scale.

Afforestation, defined as the establishment of forests on lands that have not been recently forested, can have multiple environmental and social benefits, such as: wildlife habitat protection, recreational potential, visual and aesthetics benefit, improvement of soil, water and air quality. Tree planting and establishment of fast growing plantations can contribute to mitigation of climate change today stocking CO_2 in the wood.

Fast growing plantations are usually established for production of wood biomass and used for production of energy.

Bio-energy can to some extent replace fossil fuels and has the advantage of being almost CO_2 neutral (the emitted carbon is absorbed in the biomass when sustainable managed). That is the reason why fast growing plantations for production of woody biomass/ bio-energy have received high attention currently.

In Europe several fast growing species are introduced and used for production of woody biomass.

Macedonia is one of the countries that have good potential for development of fast growing plantations due to its geographic position and availability of land resources.

This paper presents the farmer based experimental establishment of fast growing plantations with *Salix* species in Macedonia with purpose to test and show the results of introduction of Hungarian variety *Salix alba* var. *express* and its economic and environmental viability for biomass production.

Taking in consideration the commitment of R. Macedonia to use 20% renewable energy till 2020 and the strategy for Rural Development, establishment of fast growing plantations on agricultural land offers a reasonable potential.

With this pilot project, the Agro-forestry concept was practiced as well in Macedonia. Agro-forestry is an integrated approach of using the interactive benefits from combining trees and shrubs with crops and/or livestock. It combines agricultural and forestry practices to create more diverse, productive, profitable, healthy and sustainable land-use systems. Research over the past 20 years in the world has confirmed that agro-forestry can be more biologically productive, more profitable, and be more sustainable than certain forestry or agricultural monocultures.

2 METHODOLOGY

For the purpose of this project a farmer based research is applied to be able to obtain direct field experience from farmers giving practical results that can provide guidance to the practical application of fast growing species in agro-forestry systems in Macedonia. Empirical data from the farmer based field practices are used to present and justify the findings in this paper.

The plantation of *Salix alba* var. *express* species aims to investigate and obtain data about the rate of success and growing rate of *Salix alba* var. *express* in Macedonia under real farmer field conditions.

The species is autochthon in Macedonia, but however for this improved variety, imported from Hungary, there was no data previously in Macedonia about conditions and sites where it can be successfully cultivated. The results gained from the planting sites and monitoring done in the previous 2 years are data that will be used in this paper, in order to present the real situation and development of the species in selected fields in Macedonia.

Site selection process was done in consultation with farmers, explaining the agro-forestry concept and opportunities of fast growing plantations for biomass production. For the selection, internal network of National Association of Private Forest Owners in Macedonia was used. Farmers were selected by their

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willingness to participate in the project; farmers not necessary being members of the forest owners association. Selection of specific plots was done in consultation with participating farmers, according to their needs and vision on utilizing part of their agricultural land. Sites were selected to represent different site conditions, in first place difference in access to underground water. Farmers indicated small plots of their agricultural land that was not in use or marginal land covered with shrubs and trees with purpose to protect the fields form erosion and wind. No specification were given on size and siutation, as the research aims to follow real farmer interest and options for agro-forestry within their farrming systems.

A varieties of sites were selected: land plot placed by the river bank where farmer wanted to protect the land from erosion; piece of land in the corner of a land plot with no possibility for cultivation; land plots where high level of water under the ground was limiting cultivation; piece of land where trees were planted as a tree/hedge-row fence with the neighbor. Sites were selected taking also in consideration different soil and climate conditions needed for the project results.

3 BIOMASS PRODUCTION IN MACEDONIA

Biomass production and use of wood for energy production in Macedonia is mainly concentrated on utilization of forests and use of firewood in individual households. Part of the wood is coming from the trees that are growing on agriculture land. Annually in Macedonia from state and private forest are harvested around 700.000-800.000 m^3 of wood for heating. Also some amount of not registered wood is harvested, approximately 25 – 30 % as stated in REC working paper [2]. Different concepts of production and utilization of wood biomass have been developed in the World and Europe. Among these different concepts is as well the previously mentioned agro-forestry concept, widely used in developed countries.

In Hungary, based on the production rates experienced with *Salix alba* var. *express*, a biomass production of 23 ton/ha in the first year was achieved. This would lead to at least 65 ton/ha on a three year cycle. It is important to note that Hungarian experiences with fast growing plantations are based on climate and site conditions specific for Hungary.

Although practiced in reality, but not as a deliberate management system, it is a challenge to have acceptance for the agro-forestry concept as it is new in Macedonia and to plant the fast growing species on agriculture land. In 2010 *Salix alba* var. *express* was introduced on some farmer based pilot schemes at limited scale, to investigate the results of growth and analyze their potential and agro-forestry practice potential. A total of 9 different experimental sites were planted in Macedonia with different soil and climate conditions.

4 BIOMASS CULTIVATION DATA

4.1 Sites

The selected experimental plots are placed in the villages of Amzibegovo, Mustafino and Meckuevci, located close to Sveti Nikole (East Macedonia) and in Taor near to Skopje (North Macedonia).

Experimental sites in the village of Amzibegovo have been spread on four locations:

- Site 1 is on moist sandy clay soil, located along the river, flooded in the period of high waters.
- Site 2 is on stony clay soil, 10 m higher than the level of the river alongside. On this plot there is a good irrigation system that can be used to irrigate the plantation.
- Site 3 is on moist clay soil located along the river, with high level of underground water.
- Site 4 is on moist clay soil located along the river, owned by 1 farmer. It has high level of underground water. This parcel has big risk for spreading of reed, and it was recommended to the owner to take control over reed spreading in vegetation period.

In the village of Mustafino all three sites have been grouped as one location due to very similar growing conditions. The sites are on moist clay soils along the river bank with medium level of underground water.

Village of Meckuevci has only one planting site, planted with *Salix*, on stony clay soil few meters above the water level of the stream. This plot was with low level of underground water, dry during the year except in rain season.

In the village of Taor there are three different sites, planted with *Salix* on moist clay soil, with high level of underground water.

4.2 Planting

Planting (striking) of cuttings/stumps is done by hand or using specially made planting tools for creating planting hole. It can however also be done by machine in large scale plantings. The stumps need to be pushed vertical and tightly completely under the soil (1-2 cm) to protect them from evaporation.

Planting was done with density of 10.000 stumps/ha. Tree stumps/cuttings were 20-30 cm of length and diameter of 1.5-2.5 cm.

Fugure 1: Cuttings/ Stumps

On some sites soil preparation was done mechanical by ploughing the soil up to 25-30 cm deep. On the plot in Meckuevci planting was done directly by making holes with planting tool and than sticking the cuttings in to the holes.

Cuttings were made at the end of the winter, February, immediately prior to planting. Planting was done in March, before the growing season starts. Since this variety is not yet available in Macedonia stumps were imported from Hungary, product of *Sylvanus Csoport Kft*. The costs come to around 0.2 euro/stump. With an average of 10.000 pc/ha costs are 2.000 euro/ha for supplying planting material.

Figure 2: Planting site village Amzibegovo

Planting schemes used were on average of 10.000 pcs/ha in the pilot, this can vary also depending on harvest method. If mechanical harvesting is done via harvester or trailed chipper, spacing in plantations and rotation periods should fit for the machinery. In the small scale pilots, where willow is planted closer, manual harvesting is foreseen. The following planting schemes were used:

Table I: Planting scheme

	Single row technology		
Spacing in row/between rows (in m)	1 x 2	1 x 1	0.7 x 1
Amount of cuttings (pc)	10.000	10.000	10.000
Rotation (yrs)	2-3 years	2-3 years	2-3 years

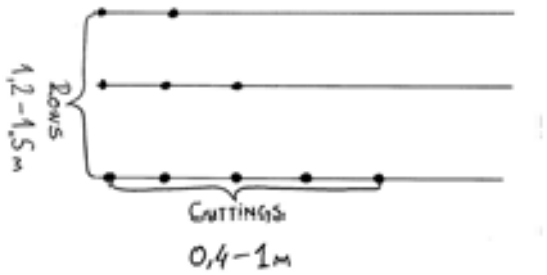

Figure 3: Planting scheme

4.3 Tending

After planting manual weed control is recommended 1-2 times to avoid overgrowing by weeds. Chemical weed control is recommended by producer of the *Salix*, but was not practiced in the experimental plots in order to follow natural growth of the species and be close to actual farmer conditions (low input farming). In case of a dry spring irrigation might be needed, but was not applied in the experimental plots from the same reason. However a favorable spring was experienced in the first year of growth. In the Second year mechanical cleaning of invasive grasses is needed in the plantations.

Harvesting of wood is usually practiced in rotations of 2-3 years. The lifespan of energy willow is usually 25-30 years.

After harvest the remaining stumps is recommended to be sprayed with *Vegesol eReS*, 4-5 l/ha as a basic treatment to increase protection of the stumps from fungal and bacterial infection and increase the life cycle and yield of the plantation. Pest control under normal field conditions is not needed. Nutrients supply is sufficient from the remaining's (mulching) after the harvest. In experimental plots in Macedonia only mechanical weeding was applied on one parcel in Taor by the farmer. It was left on purpose to be decided by the farmer to allow real field situation to follow the growth in natural conditions and with minimal interventions by farmers.

5 BIOMASS PRODUCTION DATA

This was an experimental pilot in Macedonia and the real field data are only available from monitoring done in years 2010-2011. Results of growth and monitoring from the years of 2010 and 2011 will be presented in this paper.

Monitoring on the experimental plots was conducted several times in the two year period. On monitored sites few parameters were measured: success rate, top height, reached number of sprouts per cutting and stump diameter.

First monitoring was conducted one month after planting in March 2010. On the first monitoring almost all sites showed a survival rate of over 90% of the plants. Planting was successful and disaster rate was mainly caused by biotic factors, in first place climate and also on some spots weed invasion.

All sites showed good growth, reaching a height of around 10 cm with 3-5 sprouts with diameter of 0.2 – 0.3 cm in the first month.

The second monitoring done in June 2010, before the dry season started, showed also good results in the survival rate ranging from 60-100%. Only site in Meckuevci had a survival rate of 15% due to very hard site conditions, strong and dry winds and draught. Height reached in this stage was ranging from 40 – 200 cm, with 2-5 sprouts and diameter ranging from 0.5-1.5 cm.

In the first year last monitoring was done at the end of the growing season in October. Success rate ranged from 70 – 100 %. Meckuevci planting site had rate of success 0%, due to biotic and abiotic factors like animal grazing, draught and to high insolation.

In 2011 two monitoring missions were conducted, one in the beginning of June and other one at beginning of October.

Results obtained in these two monitoring missions showed results that were significantly different from the previous season.

Most of the experimental plots were totally destroyed by human factor. Only success was evident in site 1 in Amzibegovo and site in village of Taor. Success rate on site 1 was 70% with top height of 450 cm with sprouts diameter of 5-6 cm and number of sprouts was ranging from 2-4. On the site in Taor success rate was ranging from 70-95% top height was up to 400 cm, with sprouts diameter ranging from 5-7 cm.

After these two monitoring seasons it was evident that the best sites were those having a high water table with moist clay soils. The care of the farmers and protection of the experimental plots was as well crucial for the obtained results. With very limited tending and no additional costs for irrigation, fungal, bacterial or pest

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control and nutrients supply, these few sites showed very good results on the field.

Figure 4: Beginning and end of season 2010-2011

Based on the trials taken from the experimental plots and measurements and calculations the average weight and tones of biomass produced on hectare were estimated.

In October 2011 at both sites the potential of growth showed very good results. At one site two trial pieces of energy willow were harvested. The total weight of piece of cut *Salix* was 4 kg. After natural drying in January 2012 the weight of the same wood decreased to 2,6 kg due to drying process. The moisture was measured in the ranges of 5,5% to 64%, depending on the size of the wood piece.

Analyzing the results from the measurements, after two years of growth, potential was estimated on 52 t/ha in the moment of harvesting. Having in mind measurements, the potential of growth transferred in semi dry wood (2-6 months of aerial drying) is estimated on 33,8 t/ha.

The weight of *Salix*, semi dried is 460 kg/m^3. Transfering 33,8 t/ha is equal to potential of 73,48 m^3 wood/ha in a two year period [5]. That is very high growth potential that hardly any species in Macedonia can reach close to.

Knowing that heat potential of *Salix* is approximatly 50% of hard wood, the real potential from the perspective of heating with wood that ussualy is used on the market is arround 36 m^3 of wood.

6 CONCLUSIONS AND RECOMMENDATIONS

Planting fast growing species on agriculture land has multiple effects for the farmers and their land. In practices around the world there are variety of combinations of forestry and agriculture. In some areas forest are combined with pastures providing fodder (acorn) for the cattle and wood for the farmer. There are areas where forests are combined with agriculture crops improving microclimate conditions and at the same time providing heating wood.

Some of the species planted have the possibility to influence the water regime, such as *Salix* sp. In the areas where the level of water is high one of the proposed solutions may be planting of fast growing species.

Based on the experiences and results gained from the experimental planting of *Salix alba* var. *express*, there is opportunity for the land owners to improve the income for their households. Planting fast growing species provides opportunity to land owners to supply themselves with biomass for their households. According to official statistic data, around 90% of wood for heating is spent in the households in Macedonia for house heating. (State Statistical Office, Energy report 6.1.11.92, 2011). Regarding growth potential, energy willow showed very good potential on good sites.

The ussual annual increment of native forest species in Macedonia is in ranges of 1 to 5 m^3/ha annualy. The average annual increment of *Salix* is 36 m^3/ha on the best sites and with proper treatment and protection. The results from the growth potential highly recommends planting of energy willow on the sites that are suitable and where is a real farmer interest.

Absorption of CO_2 of fast growing willow plantations is also an asset; it also enriches soil with mineral and microelements, nutrients of natural origin. According to some experiences in Europe 1 ha of energy willow plantation absorbs more than 200 tons of CO_2 from air during 3 years [2].

Planting fast growing species offer a variety of options for agro-forestry providing products and services according to the needs and possibilities of farmers. It may be implemented on the corners of the land that is not maintained or as a windbreak belts contributing to very different aspects such as wind protection and reduced evaporation, erosion control on the river banks, improvement of biodiversity and aesthetic/landscape improvement. Fast growing plantations as well contribute to creation of natural microclimate in the places of people residence or functioning as green belt or corridor for wild life and fauna.

The pilots showed that such multiple opportunities exist and farmers were interested to participate. However it is crucial for success that the farmers have genuine interest and provided the needed protection and silvicultural treatment.

In the case of this experiment and conditions for Macedonia it is evident that *Salix alba* var. *express* growing can be successfully done only if soil preparation is done on time, proper treatment against weed and pest control is applied before planting, and proper protection provided for grazing or human induced damages. Beside the management factors the first and the ultimate site condition for successful growth is access of water and humidity of soils. This *Salix* variety needs a humid soil condition to be able to reach such high growth rates.

The use of fast growing species in farmer based agro-forestry practices are related to the measures of EU Rural Development policy: agro-forestry, afforestation on agriculture land and diversification of economy.

The result from the experimental sites can be used to present, increase awareness and promote support for activities related to plant fast growing species on small scale farming and to include as eligible measure for the National Rural Development program.

Through the activities on the field, and planting of willow, farmers gained knowledge and experience on possibilities to implement agro-forestry measures and positive effects that these measures can have on development of their farms and providing opportunities for diversified income generation.

Figure 5: Village Amzibegovo, site monitoring October 2010

Figure 6: Village Amzibegovo, monitoring June 2011

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Ss. Cyril and Methodius University in Skopje
Faculty of Forestry in Skopje

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