THE AGRO CLIMATICAL YIELDS ANALYSIS OF BASKET WILLOW (SALIX VILIMALIS) PHYTOMASS PRODUCTION

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Abstract

This contribution deals with the creation of agrometeorological models of phytomass production, which can be used for benchmark foreboding of phytomass harvests by the occurrence of temperatures and rainfall. It showed that the harvest of phytomass, which were established by agrometeorological model showed an average probability of 86%. In the approximately 40% of years was probability of appearance amount of harvest phytomass provided with an accuracy of 96%. Finally, we can conclude that the simple mathematical - statistical model provides a solid ability for prediction of salix phytomass.

Key words: *salix, phytomass, agrometeorological model*

1. INTRODUCTION

Autotrophic plants are characterized by a unique capability - create in the process of photosynthesis bioproduction, i.e. phytomass harvest, Fazekašová (2014). However, the amount of harvest is a resultant interaction of genetic potential of plants and external environmental factors, especially agro climatic factors. In highly productive variety of the plant species is an energy and water balance of ecosystem, which is the plant part of a limiting factor in the creation of organic matter, Bárek (2008). Any divergency from optimal energy and water conditions of plants at any stage of its growth has a negative effect on its further growth and development and thus affects the overall yield.

In the presented work is analyzed the relationship between phytomass production of salix (Salix vilimalis) and energy and water balance by mathematical - statistically methods. Water and energy balance is expressed by the average air temperature and total atmospheric rainfall for the months of major growing season (MGS) limited by entering and leaving the average daily air temperature $T \geq 5.0$ ºC. For the determination of this relationship is also used the methodology for modeling plant crops developed by Šalitovom (1975). In our conditions eg. Kurpelová (1982), Zachar (1982), Špánik, Šiška, Repa (1992) and others devoted similar issue.

2. DATA AND METHODS

Data about the crops were obtained from polyfactors field experiments with salix which were made by Otepka and Habán (2006). Experiment was stablished in the years 1996-2003 on an experimental basis of SPU – Malanta by Department of sustainable agriculture and herbology. Experimental base lies at an altitude of 173 m, latitude 48 º 19` and longitude 18 º 07`.

Analysis included 3 varieties of salix (Salix vilimalis ULV, RAPP, ORM) at 2 options according to clip sowing (Figure 1,2).

In the 8 years experimental period was created 48 strong set of biological data, i.e. phytomass harvests in $kg.m^{-2}$ for the analysis.

Agrometeorological characteristics: air temperature (T °C) and atmospheric rainfall (R in mm) were measured on the agro climatic station KBH, FZKI, SPU in Nitra, which is situated in the area of experimental bases. Agro climatic analysis is applicable to the growing production of phytomass, i.e. calendar vegetation period, bounded from April to September.



Figure 1. 2. Three varieties of salix during four years cycle growth

2.1 Effect of temperature and rainfall on yield was analyzed:

1. For the winter half-year of the growing season (10. - 3.) according to non-linear correlations. Selection of appropriate test functions of the reporting relationship (parabola quadratic and cubic, and polynomial function exponential) was the coefficient of determination (R^2). Demonstrativeness margin for N = n - 2 = 48 - 2 = 46 for $\alpha = 0.05$ when $R^2 = 0.28644$.

For more comprehensive analysis of the impact of temperature and precipitation for the production of phytomass were according to the highest values of R^2 set 4 + 8 temperature and precipitation characteristics.

2. Interactive relationship between crop phytomass and agro climatic characteristics of the growing season with the highest R^2 values was mathematical - statistically analyzed by the linear regression.

3. RESULTS AND DISCUSSION

3.1 The temperature and the production process

Temperature as a basic condition of life affects the nutrient intakes, transpiration, photosynthesis, breathing, and other environmental operations of plants that are directly or indirectly involved in the production of crops.

Mathematical - statistically analysis for the creation of above-average yields observed in the analyzed months of the growing and pre-term growing intervals of optimal air temperatures listed in table 1. The tightness of the relationship of temperature to the harvest in parts of vegetation and analyzed pre-vegetation period is expressed as a coefficient of determination (R^2).

The analysis shows most optimal average air temperature during the 4th – 9th ranging from 17.5 to 18.5 ºC ($R^2 = 0.060$). Particularly important seems the temperature in the third quarter of year i.e. during the 7th – 9th month ranging from 18.0 to 20.00 ºC ($R^2 = 0.41$). Analysis shows the generally

high conversion of thermal energy to the energy of chemical bonds in the production process of willow. This relationship confirms direct dependence height of the harvest from air temperature.

Time	**Interval of optimal characteristics**			
period	**T (ºC)**	**R^2**	**R (mm)**	**R^2**
10. - 3.	3.5 – 5.5	0.17	200 – 250	0.33
4. - 9.	17.5 – 18.5	0.6	185 – 360	0.35
4. - 6.	14.5 – 17.0	0.15	50 – 190	0.33
7. - 9.	18.0 – 20.0	0.41	130 – 190	0.12
4	10.0 – 13.0	0.11	20 – 65	0.44
5	17.0 – 19.0	0.21	25 – 85	0.34
6	19.5 – 21.0	0.03	5 – 75	0.05
7	20.5 – 22.5	0.2	50 – 85	0.17
8	21.0 – 23.0	0.32	50 – 85	0.0001
9	15.0 – 18.0	0.29	5 – 85	0.01

Table 1. Interval of optimal average air temperature (T ºC) and total atmospheric precipitation (R in mm) for the creation of phytomass (Y_{Fa} in $kg.m^{-2}$) according to the non-linear correlations.

3.2 Rainfall and production process

Water forms in plant cells dispersive environment for colloidal plasma, in which biochemical processes of metabolism are in progress and they formed new organic matter, e.i. the new harvest. In order to these processes are carried out optimally, plant cells must be sufficiently saturated with water - hydrated. Each water deficit leads to decline in intensity of biochemical production processes and thus yields.

From mathematical - statistically analysis listed in table 1 shows close direct relationship ($R^2 = 0.33$) between rainfall and phytomass harvest in the winter half-year (10. – 3) in which period the stock kept moisture in the soil profile needed for the spring beginning of vegetation period, but also a progressive water supply plants in other parts of vegetation, the highest of yields phytomass has proved the most accumulated atmospheric precipitation in the range 200 - 250 mm. In the summer half-year (4. - 9.) were recorded the best conditions for production process in the range 180 - 360 mm. However, the analysis also showed that in the summer half-year of the production process has been limited primarily temperature and not by moisture. This results from a low coefficient of determination, and outstanding and mainly indirect depending on rainfall harvest.

Year	$R_{10.-3.}$ (mm)	$T_{4.-9.}$ (ºC)	$T_{8.}$ (ºC)	Y_{Fa} (kg.m^{-2})	Y_{Fm} (kg.m^{-2})	Δ U (kg.m^{-2})	Probability of appearance (%)
1996	166	16.0	19.4	2.43	3.03	0.60	80
1997	138	16.2	20.8	3.02	2.99	-0.03	99
1998	178	17.3	20.9	3.19	4.16	0.97	77
1999	184	17.3	19.0	4.24	4.05	-0.19	96
2000	235	17.6	22.1	5.92	4.91	-1.02	83
2001	255	17.7	23.1	5.33	5.21	-0.12	98
2002	134	17.5	20.8	5.17	3.87	-1.30	75
2003	194	18.4	22.7	4.12	5.20	1.08	79
Average	185	17.2	21.1	4.18	4.18		86

Table 2. Parameters of agro climatic analysis of salix phytomass production under the linear regression (Nitra, 1996 - 2003)

3.3 Multiple correlation analysis

For multi-correlation analysis of the production process of salix, according to the index of determination (R^2)

were assigned several combinations of agro climatic characteristics.

For this phase of evaluation, we analyzed the 3 most important characteristics:

- rainfall for the winter semester ($R_{10.-3.}$ in mm),

- average air temperature in the growing season ($T_{4.-9.}$ in ºC),

- average air temperature in August (T_{8} ºC).

According to the multiple correlation analysis was compiled following functional equation modeling phytomass production of the calculation (in kg.m^{-1} U_m)

$Y_m = - 11.217 + 0.0085\ Z_{10.-3.} + 0.7084\ _{T4.-9.} + 0.07597\ T_8$

$R = 0.71395$

The above equation expresses the proportion of the impact of temperature and precipitation characteristics in the creation of willow phytomass. Thus the functional equation can be regarded as a simple mathematical - statistical agrometeorological model creation phytomass tree.

Comparison of actual yields (Y_{Fa}) and the model set yields (Y_{Fm}) are listed in table 2 and figure 3. It appeared that the crop phytomass which was established by model, occurred with an average probability of 86%. In the approximately 40% of years was probability of appearance amount of harvest phytomass provided with an accuracy of 96%. This model can be used for a solid estimate of crop production or tree phytomass under the rainfall in the winter semester.

Generally, therefore we can conclude that the simple mathematical - statistical model provides a solid possibility of crop options under the most agrometeorological characteristics, i.e. the average air temperature and atmospheric precipitation and vegetation pre-period of salix.

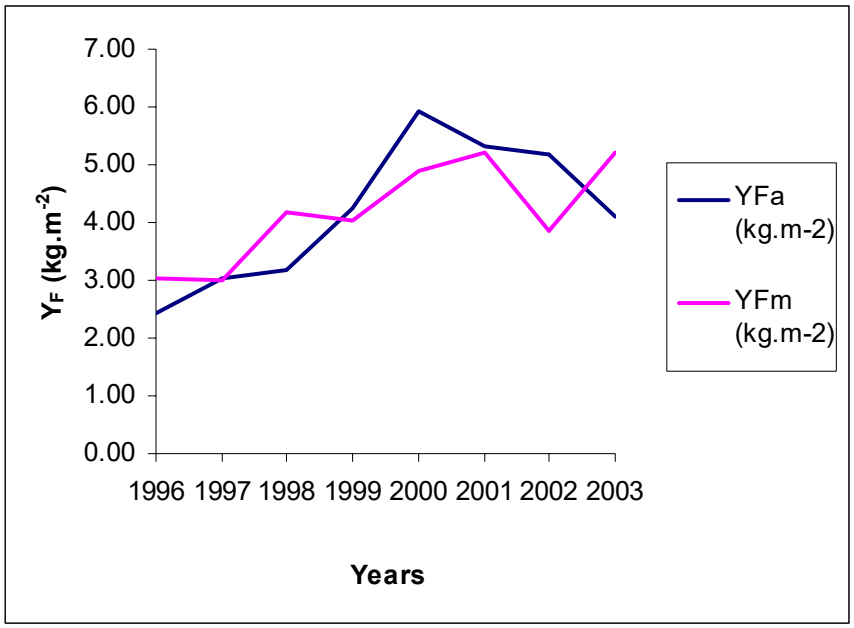


Figure 3. Curently Y_{Fa} and modelled Y_{Fm} salix phytomass harvest in kg.m^{-2} (T $_{4.-9.}$, T $_{8.}$, Z $_{10.-3.}$, Nitra, 1996 – 2003)

4. CONCLUSIONS

Relationship between phytomass production of salix and energetical (temperature T in ºC) and water characteristic (from rainfall in mm) was analyzed according to the programs of the non-linear correlation and linear regression. The analysis was designed simple agrometeorological model phytomass production of salix, which can be used for benchmark foreboding of phytomass harvests by the occurrence of temperatures and rainfall in the pre-growing and crop-growing period of analyzed plant.

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