RESEARCH ON THE INFLUENCE OF THE FERTILIZATION SYSTEM, THE NUTRITION SPACE AND THE SEEDING - HARVESTING PERIODS OVER THE QUALITY OF SUGAR BEET BIOMASS USED TO OBTAIN BIOFUELS

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ABSTRACT

Under crisis conditions which put pressure on humanity at present, it is imperative to find new sources of energy and food. Promoting production and consumption of bioethanol is one of the major objectives of EU. The purpose of the experiments made within this study is to establish the fertilization system of the nutrition space and of the sugar beet seeding - harvesting period which allows obtaining a quantity of biomass as high as possible, with a high quality, in order to use it in the production of biofuels. Investigations were carried out between 2007 and 2009 at the National Research and Development Institute for Potato and Sugarbeet – Brasov. The results have revealed the versions of fertilization with manure as being the ones which have given the most sugar content (more Than 18%), but the largest roots production have been recorded using the version of fertilization with chemical fertilizers (over 81 tonnes / ha). The plant density version of 100,000 plants / ha has been noted in the case of the Evelina and Chiara hybrids with productions exceeding 14 tonnes of biological sugar / ha. The sugar beet seeded at a density of 100,000 plants / ha in the first period and harvested in the last decade of October, fertilized with 40 tonnes of manure, recorded the highest production / ha, the highest sugar content and implicitly the most quantity of bioethanol.

***Key words**: sugar beet, biofuels, bioethanol.*

INTRODUCTION

Even though the father of compression-ignition engines (Rudolf Diesel) envisioned since the beginning the possibility of their functioning on vegetable fuel, says Burnete in 2001, he presented on this line at the Mondial Exhibition from Paris in 1900, an compression-ignition engine which functions on ground-nut oil; however, the use of fuels coming from vegetable oils in internal combustion engines has become a priority only during recent years, and this as a consequence of reducing the fuel supplies from petroleum origin and especially because of the need of reducing environmental pollution.

In 2006, on the occasion of the BIOCOMB 2006 Conference, was launched in Cluj the idea of establishing the Biofuels Platform from Romania (BIOCARO) and in February 2007 its *Secretariat* was established.

Starting with Directive 2003/30EC of The Council and of The European Parliament of May 8th 2003, which stipulates the obligation of ensuring a minimum percentage of biofuels and up to Directive 2009 /28/EC of The European Parliament and of The Council of April 23 2009, on promoting energy from renewable sources, of amendment and subsequently repeal Directives 2001 /77/EC and 2003 /30/EC, The European Union has agreed to gradually replace the 10 percent of fuels used in transportation with biofuels by 2020, says Fred Zeller into the report ”Le developpement de la production of bioethanol en Europe: Quel avenir pour la production de betteraves” presented at the 41th CIBE Congress (Cracovia, 2006).

The solar energy stored in the biomass of sugarbeet may constitute a renewable and environmentally friendly energy source which can show its value by using sugar beet for the production of bioethanol (Gherman, 2008).

Sugar beet has proved to be a good raw material for the production of European bioethanol because it has a higher production than grain. The report GAIN 36081 (2006) specifies: EU produces 2 million tonnes of sugar beet more than wheat. Moreover, the sugar beet production is higher: a sugar beet hectare can produce 30 hectolitres of ethanol/ha, on average, more than wheat can. This is the first statement in the series of reports on the production of bioethanol in EU.

In the present there are still no ethanol distilleries on sugar beet and research on this issue was made within the research project "New modern, unconventional technologies for the improvement of biomass - obtaining biofuel, BIOBENZ", which intended to obtain environmental biofuels on the basis of the bioethanol found in sugar beet (Gherman, 2008).

Sugar beet is recommended for cultivation in order to use it in the biofuels industry due to large yields per hectare and due to its high sugar content; however, the technology used in the production of sugar from sugar beet intends to obtain average size and relatively equal roots, to harvest at technological maturity and to properly fertilize in order to maintain the harmful nitrogen content to a low level, avoiding the sugar content to block in the molasses. A part of harmful nitrogen blocks 25 parts of sucrose in the molasses. (Clotan et al., 2005).

The purpose of research was to determine the studied factors influence on the yield and technological quality of the sugar beet cultivated for bioethanol, followed by calculating the amounts of ethanol that can be achieved on a sugar beet cultivated hectare, taking into account that 6.8 kg of biological sugar (fermentable) from the mass of roots can be converted into 4.54 liters of ethanol. (Mother's Alcohol Fuel Seminar © The Mother Earth News, 1980).

MATERIAL AND METHODS

The dimensioning and positioning of the experimental parcels was closely linked to the studied factors. Thus 3 experiments were organized in which their influence on the technological quantity and quality of the roots production was monitored.

The biological material used is represented by five sugar beet hybrids: Chiara, Evelina, Rustica, Canaria and Diamant. The seed is treated against harmful diseases, calibrated and treated with alternative layers of insecticides fungicides.

Main qualitative indices of these hybrids are:

- high productivity
- high content of sugar
- low-K-Na-N in the root
- a low quatity of fodder mixed with molasses
- high germination
- over 98% monogerm
- rapid emergence (good seed vigour)
- high percentage of field emergence

The provided indices manifest particularly more or less noticeably to the five hybrids used and recommend them because they lend themselves totheir growing for biofuels production.

Factors and graduations

Experiment I: The influence of the fertilizer doses and hybrids on the yield and technological quality ofsugar beet roots

The objective of the experiment was the establishment of the fertilization type which satisfies best the plants needs during growing season. The factors taken into study were hybrids and fertilization versions.

<u>Fertilization versions</u> use organic fertilizer and chemical fertilizer. Two manure doses and two complex fertilizers doses 15-15-15 were used.

The experiment depended on 2 factors and was organized in 3 iterations.

A factor:sugar beet hybrids with 2 graduations :

a1 - Chiara
a2 - Evelina

B factor: fertilization versions (agrofond) with 5 graduations:

b1 - unfertilized
b2 - 30 tonnes manure/ha
b3 - 40 tonnes manure/ha
b4 - N-90; P-90; K-90
b5 - N-135; P-135; K-135

Experiment II - The study of the influence of varieties and space of nutrition on the yield and technological quality of sugar beet.

The aim of this experience was to establish the density and variety which lend themselves best to the conditions of the experimentation space.

The experiment was organized after the model of the subdivided parcels. On a mineral agrofond created through the basic autumn fertilization with complex fertilizers 15-15-15;

N90-P90-K90; 5 sugar beet hybrids with different properties were studied. Two densities were entailed for each hybrid, respectively 100,000 plants and 65,000 plants per hectare. Depending on the presented characteristics it had to be established which of the 5 hybrids responded best to environmental conditions in the area of experimentation and which of the two densities provided the nutrition space better appreciated by plants.

To achieve the nutrition spaces of 22 X 45 cm (100,000 plants per hectare), respectively 34 X 45 cm (65,000) manual intervention was needed.

The experiment depended on 2 factors and was organized in 3 iterations.

A factor: Density with 2 graduations:

- a1-100.000 plants/ha
- a2-65.000 plants/ha

B factor: Sugarbeet hybrids with 5 graduations:

- b1 -Canaria
- b2 - Diamant
- b3 - Rustic
- b4 - Chiara
- b5 - Evelina

Experiment III. The study of the influence of the seedling - harvesting periods on yield and technological quality of sugar beet.

The aim of the experience was to determine the seeding periods in which we have the best emergence in terms of uniformity, percentage and plants' strenght, essential characteristics for starting the vegetation culture. Also, the harvest period has particular importance because of the effects they may have on the yield value and technological quality of the roots.

3 periods of seeding and 3 epochs of harvesting were studied, thus that the sugar beet seeded on a specific date to be harvested in 3 different periods. The emergence and the first period of vegetation, as well as the last part of the vegetation period, when sugar aggregation and sugar beet roots ripening take place, were considered particularly.

The experiment was organized after the model of the subdivized parcels on the same agrofond.

A factor : The seed period with 3 graduations:

a1 01-05 April

a2 10-15 April
a3 20-25 April

B factor : The harvest period with 3 graduations:
b1 20-25 September
b2 05-10 September
b3 20-25October

RESULTS

For the prominence of the factors' influence on yields measurements have been made during the harvest. Analysis of data in the tables below reveals that the roots yield is strongly influenced by the fertilization system, so all those 4 versions used in the experience gave, up against the model version, very significant positive differences, statistically insured.

In case of sugar content (table 2), the noticeable versions through high content of sugar (over 18) are those fertilized with manure.

Table 1

The roots production in tonnes (2007-2009)

Experiment I

Varieties	Fertiliser	Roots production	%	Difference	Meaning
	Unfertilized	40,9	100,0	0,0	**Mt**
	30t manure / h	65,9	161,1	25,0	***
CHIARA	40t manure/ha	73,1	178,7	32,2	***
	600kg/haNPK	68,5	167,5	27,6	***
	900kg/haNPK	77,9	190,5	37,0	***
	Unfertilized	39,5	100,0	0,0	**Mt**
	30t manure / ha	64,5	163,3	25,0	***
EVELINA	40t manure / ha	71,9	182,0	32,4	***
	600kg/haNPK	68,3	172,9	28,8	***
	900kg/haNPK	81,2	205,6	41,7	***
				DL 5%	6,3
				DL 1%	8,7
				DL 0,1%	12,0

Table 2

The sugar content in rates (2007-2009)

Experiment I

Varieties	Fertiliser	Digestion	%	Difference	Meaning
	Unfertilized	16,8	100,0	0,0	**Mt**
	30t manure / ha	18,6	110,7	1,8	***
CHIARA	40t manure / ha	18,6	110,7	1,8	***
	600kg/haNPK	16,2	96,4	-0,6	
	900kg/haNPK	15,7	93,5	-1,1	oo
	Unfertilized	16,8	100,0	0,0	**Mt**
	30t manure / ha	18,8	111,9	2,0	***
EVELINA	40t manure / ha	18,5	110,1	1,7	***
	600kg/haNPK	16,3	97,0	-0,5	
	900kg/haNPK	15,7	93,5	-1,1	oo
				DL 5%	0,8
				DL 1%	1,1
				DL 0,1%	1,5

The production of biological sugar (table 3) is in direct correlation with the roots production and sugar content. Although fertilization versions with chemical fertilizers have recorded small values of sugar content, because of large roots yields, the amount of ethanol obtained per area unit is slightly less than of those fertilized with manure. But the differentiation is made at the economic calculation (table 4) where it can be seen that in order to produce the necessary sugar beet for a litre of ethanol in a fertilization system with manure is spent wih about 0.3 lei less than through a fertilization system with chemical fertilizers.

Table 3

The biological sugar production in tonnes (2007-2009)

Experiment I

Varieties	Fertiliser	Sugar production	%	Difference	Meaning
	Unfertilized	6,9	100,0	0,0	**Mt**
	30 t manure / ha	12,3	178,3	5,4	***
CHIARA	40 t manure / ha	13,6	197,1	6,7	***
	600 kg/haNPK	11,1	160,9	4,2	***
	900 kg/haNPK	12,2	176,8	5,3	***
	Unfertilized	6,7	100,0	0,0	**Mt**
	30 t manure / ha	12,2	182,1	5,5	***
EVELINA	40 t manure / ha	13,3	198,5	6,6	***
	600 kg/haNPK	11,2	167,2	4,5	***
	900 kg/haNPK	12,8	191,0	6,1	***
				DL 5%	1,4
				DL 1%	2,0
				DL 0,1%	2,7

Table 4

The ethanol production estimated for experiment I and the costs associated with a litre of ethanoll

Varieties	*Fertiliser*	Biological sugar production kg	Expenses / beet ha lei	Ethanol production l / ha	Expenses/ litre of ethanol lei
	Unfertilized	6.900	3.983	4.610	0,9
	30t manure / ha	12.300	4.720	8.218	0,6
CHIARA	*40t manure / ha*	13.600	4.966	9.087	0,5
	600kg/haNPK	11.100	5.621	7.417	0,8
	900kg/haNPK	12.200	6.266	8.152	0,8
	Unfertilized	6.700	3.983	4.477	0,9
	30t manure / ha	12.200	4.720	8.152	0,6
EVELINA	*40t manure / ha*	13.300	5.015	8.887	0,6
	600kg/haNPK	11.200	5.621	7.483	0,8
	900kg/haNPK	12.800	6.415	8.552	0,8

Tables 5, 6 and 7 show the roots production, the sugar content and biological sugar production in case of experiment II. The biological factor has its say in case of roots production, the differences, although not very big, may be relevant for choosing a hybrid for the biomass production allocated for biofuels. The Eveline hybrid is distinguished,which produces in case of a density of 100,000 plants with 3.1 tonns more than the average, while the Canaria hybrid produced with 4.4 tonnes less than the average.

Table 5

Root production in tonnes (2007-2009)

Experiment II

Varieties	Densities	Roots production	%	Difference	Meaning
Average / densities		78,9	100,0	0,0	**Mt**
Canaria	**100000**	74,5	94,4	-4,4	**o**
Diamant	**100000**	78,4	99,3	-0,5	
Rustica	**100000**	78,4	99,3	-0,5	
Chiara	**100000**	81,4	103,1	2,5	
Evelina	**100000**	82,0	103,9	3,1	
Average / densities		74,9	100,0	0,0	**Mt**
Canaria	**65000**	72,3	96,5	-2,6	
Diamant	**65000**	72,2	96,3	-2,7	
Rustica	**65000**	76,4	101,9	1,5	
Chiara	**65000**	75,3	100,5	0,4	
Evelina	**65000**	78,5	104,8	3,6	*

DL 5%	3,5
DL 1%	6,8
DL 0,1%	10,1

Table 6

Sugar content in rates (2007-2009)

Experiment II

Varieties	Densities	Digestion	%	Difference	Meaning
Average / densities		17,4	100,0	0,0	**Mt**
Canaria	**100000**	17,4	100,1	0,0	
Diamant	**100000**	17,5	100,7	0,1	
Rustica	**100000**	17,3	99,5	-0,1	
Chiara	**100000**	17,7	101,8	0,3	
Evelina	**100000**	17,0	97,8	-0,4	
Average / densities		17,1	100,0	0,0	**Mt**
Canaria	**65000**	17,1	100,1	0,0	
Diamant	**65000**	17,2	100,7	0,1	
Rustica	**65000**	16,8	98,4	-0,3	
Chiara	**65000**	17,0	99,5	-0,1	
Evelina	**65000**	17,3	101,3	0,2	
				DL 5%	0,4
				DL 1%	0,8
				DL 0,1%	1,3

Table 7

Biological sugar production in tonnes (2007-2009)

Experiment II

Varieties	Densities	Average	%	Difference	Meaning
Average / densities		13,7	100,0	0,0	**Mt**
Canaria	**100000**	12,9	94,0	-0,8	**o**
Diamant	**100000**	13,7	99,9	0,0	
Rustica	**100000**	13,6	99,1	-0,1	
Chiara	**100000**	14,4	105,0	0,7	
Evelina	**100000**	14,0	102,0	0,3	
Average / densities		12,5	100,0	0,0	**Mt**
Canaria	**65000**	12,2	97,9	-0,3	
Diamant	**65000**	11,9	95,5	-0,6	
Rustica	**65000**	12,5	100,3	0,0	
Chiara	**65000**	12,4	99,5	-0,1	
Evelina	**65000**	13,3	106,7	0,8	*
				DL 5%	0,8
				DL 1%	1,2
				DL 0,1%	1,8

Sugar beet disposes of a particular self-adjustment system; in case of a small crop or small densities this harnesses best the nutrition space and light develops a lot. But in this case, the plant will fight very hard with the herbage, not managing to cover the ground and stop the weeds from growing through shading and suffocation. Also, it is not very favourable for industrial crops because the additional expenses made for weed control and losses from the harvest increase the device value and implicitly economic efficiency decreases.

A sugar beet crop seeded late and harvested early fails to reach maturity and records significant losses in production.

Late seeding influences the production by slowing down the start in vegetation and reducing the number of days with optimum necessary conditions for the development of plants. Likewise, sugar beet plants which start late in the vegetation are most sensitive because of encountered adverse conditions.

In tables 9 and 10 can be seen how the second and third seeding periods influence negatively the production of roots and digestion, its inclination decreasing from the first period towards the last one. Yet, the factor of the harvest period influences positively the sugar quantity in second and third periods, the inclination decreasing.

The biological sugar content per area unit exceeds the threshold of 10 tonnes for the sugar beet seeded in the first period even if this is harvested very early. The amount of ethanol is almost double in the case of the sugar beet seeded in the first period and harvested in the last, in relation to the one seeded in the last period and harvested in the first.

DISCUSSION

The issue of using agricultural land in order to obtain biofuels in the detriment of food raised much controversy; that is why it is very important to get as much ethanol as possible on area unit. According to 'Bioethanol in Deutschland, Landwirschaftsverfag Munster', from a wheat hectare with a 7.3 tonnes production, a quantity of 2760 ethanol litres can be obtained; from a potato hectare with a 43 tonnes of tubers production with an average content of starch, approximately 3550 liters of ethanol can be obtained; and from a sugar beet culture with a 61.7 tonnes production and a sugar content of 16 percent,one may get 6620 liters of ethanol; if the sugar content increases, the amount of ethanol per area unit increases too - it may reach 9600 liters per hectare (table 8).

Table 8

Estimated ethanol production for experiment II and the costs associated with a litre of ethanol

Varieties	Densities	Biological sugar production kg	Expenses / beet ha lei	Ethanol production l / ha	Expenses/ ethanol litre lei
Canaria	**100000**	12900,0	5152,0	8619,3	0,6
	65000	12200,0	5570,0	8151,6	0,7
Diamant	**100000**	12800,0	5134,0	8552,5	0,6
	65000	13700,0	6230,0	9153,8	0,7
Rustica	**100000**	11900,0	5201,8	7951,1	0,7
	65000	13050,0	5862,0	8719,5	0,7
Chiara	**100000**	13600,0	5741,0	9087,0	0,6
	65000	12500,0	5683,0	8352,0	0,7
Evelina	**100000**	13400,0	5012,0	8953,4	0,6
	65000	14400,0	6326,0	9621,5	0,7

Table 9

Roots production in tonnes (2007-2009)

Experiment III

Seeding period	Harvesting period	Roots production	%	Difference	Meaning
Seeding periods average		61,1	100,0	0,0	**Mt**
Seeding period I	*Harvesting period I*	67,0	109,7	5,9	*
Seeding period II	*Harvesting period I*	64,9	106,2	3,8	
Seeding period III	*Harvesting period I*	51,4	84,1	-9,7	oo
Seeding periods average		66,2	100,0	0,0	**Mt**
Seeding period I	*Harvesting period II*	72,3	109,2	6,1	*
Seeding period II	*Harvesting period II*	69,6	105,1	3,4	
Seeding period III	*Harvesting period II*	56,7	85,6	-9,5	oo
Seeding periods average		68,1	100,0	0,0	**Mt**
Seeding period I	*Harvesting period III*	74,1	108,8	6,0	*
Seeding period II	*Harvesting period III*	71,4	104,8	3,3	
Seeding period III	*Harvesting period III*	58,9	86,4	-9,2	oo

DL 5%	5,8
DL 1%	7,8
DL 0,1%	11,0

According to Bod Sugar Factory, in case of sugar beet processed for obtaining white sugar, the registered losses in the technological process (technological losses) add up between 3 and 4% of the sugar content. Of these, approximately 50% is found in technological mud, draff and unknown losses and 50% represents sugar blocked in the molasses due to detrimental nitrogen. If the sugar beet enters directly in the technological process of producing bioethanol, the whole quantity of sugar found in the beet's body (the sugar content) - tables 2, 6 and 10 - can be transformed into biomethanol through distillation.

Table 10

Sugar content in rates (2007-2009)

Experiment III

Seeding periods	Harvesting periods	Average	%	Difference	Meaning
Seeding periods average		15,1	100,0	0,0	**Mt**
Seeding period I	*Harvesting period I*	15,8	104,6	0,7	
Seeding period II	*Harvesting period I*	15,3	101,3	0,2	
Seeding period III	*Harvesting period I)*	14,2	94,0	-0,9	o
Seeding periods average		16,1	100,0	0,0	**Mt**
Seeding period I	*Harvesting period II)*	17,1	106,0	1,0	*
Seeding period II	*Harvesting period II*	16,4	101,7	0,3	
Seeding period III	*Harvesting period II*	14,9	92,4	-1,2	oo
Seeding periods average		17,1	100,0	0,0	**Mt**
Seeding period I	*Harvesting period III*	18,2	106,2	1,1	**
Seeding period II	*Harvesting period III*	17,0	99,2	-0,1	
Seeding period III	*Harvesting period III*	16,2	94,6	-0,9	o
				DL 5%	0,8
				DL 1%	1,1
				DL 0,1%	1,5

I. Popovici et al. (1972) have studied fertilizers influence on some sugar beet varieties at different densities; they were compared on a moderate fertilized agrofond (600 kg chemical fertilizers NPK 15-15-15 trading product) and on an agrofond affluent in fertilizers (1200 kg chemical fertilizers NPK 15-15-15 trading product). The obtained production in the case of the version fertilized with 1200 kg NPK 15-15-15 trading product had a low technological quality with low sugar content, this version not being an economical one. In case of the versions with NPK 15-15-15 of 900, respectively 600 kg trading product used in the experiments within the National Institute of Research and Development for Potato and Sugar Beet, it has been registered a production of about 10 tonnes of roots up against the version with 600 kg NPK (table 1), but the recorded sugar content was 0.5% less (table 2).

Table 11

Biological sugar production in tonnes 2007-2009

Exp III

Seeding periods	Harvesting periods)	Average	%	Difference	Meaning
Seeding periods average		9,3	100,0	0,0	**Mt**
Seeding period I	*Harvesting period I*	10,6	114,4	1,3	***
Seeding period II	*Harvesting period I*	9,9	106,8	0,6	***
Seeding period III	*Harvesting period I*	7,3	78,8	-2,0	ooo
Seeding periods average		10,7	100,0	0,0	**Mt**
Seeding period I	*Harvesting period II*	12,4	115,5	1,7	***
Seeding period II	*Harvesting period II*	11,4	106,2	0,7	***
Seeding period III	*Harvesting period II*	8,4	78,3	-2,3	ooo
Seeding periods average		11,7	100,0	0,0	**Mt**
Seeding period I	*Harvesting period III*	13,5	115,4	1,8	***
Seeding period II	*Harvesting period III*	12,1	103,4	0,4	*
Seeding period III	*Harvesting period III*	9,5	81,2	-2,2	ooo
				DL 5%	0,3
				DL 1%	0,5
				DL 0,1%	0,6

Table 12

Estimated ethanol production for experiment III and the si costs associated with a litre of ethanol

Seeding periods	Harvesting periods	Biological sugar production kg	Expenses/ sugarbeet lei/ha	Ethanol production l/ha	Expenses ethanol lei/litre
Seeding period I	*Harvesting period I*	**10.600**	**5.157**	7.083	0,7
	Harvesting period I	**12.400**	**5.199**	8.285	0,6
	Harvesting period I	**13.500**	**5.241**	9.020	0,6
Seeding period II	*Harvesting period I*	**9.900**	**5.157**	6.615	0,8
	Harvesting period I	**11.400**	**5.199**	7.617	0,7
	Harvesting period I	**12.100**	**5.199**	8.085	0,6
Seeding period III	*Harvesting period I*	**7.300**	**5.074**	4.878	1,0
	Harvesting period I	**8.400**	**5.074**	5.613	0,9
	Harvesting period I	**9.500**	**5.115**	6.348	0,8

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