Influence of the Fertilization Pattern on Production and Quality of Sugar Beet Roots Meant for Bio-Ethanol Extraction

Ricuţa-Vasilica Dobrinoiu, Luminiţa Vişan, Silvana Dănăilă-Guidea, Andrei-Gabriel Ivan, Marius Căruţaşu

Abstract - Sugar beet growing as raw material for bioethanol production represents an extremely important opportunity for farmers, under the circumstances of some productive varieties use on areas adequately irrigated and fertilized. In comparison with the maize, used as raw material in bio-ethanol production, the sugar beet offers a series of important advantages, such as: the acquirement of a bigger ethanol quantity on the cultivated area (6.300 l bioethanol from sugar beet, in comparison with almost 3.400 l bioethanol obtained from maize grown per hectar), the crop adequacy in colder climate areas, unfavourable to maize, and an irrigation norm with 40 smaller. In this respect, on the one hand, the present work aims at bringing viable and pheasible arguments in favour of sugar beet crops fertilization, in order to obtain an economic effective production, especially during the years with low precipitations and, on the other hand, for a superior valorization of sugar beet production by bioethanol production.

Keywords: bioethanol, foliar fertilization, organic fertilization, sugar beet.

I. INTRODUCTION

The extension of biofuels use and production within transports industry isn't due only to aspects related to oil, but only to the necessity of diminishing greenhouse effect gases.Within this context, we have to mention EU strategy for economic development *Europe 2020*, which is based on three major objectives, which must be reached 2020, such as: the diminishement of greenhouse effect gases with 20% in comparison with 1990 (even 30% uder the circumstances of an international agreement), the diminishment with 20% of the energy consumption and the acquirement of 20% out of the energy necessary amount, obtained from renewable sources (in comparison with 8,5% nowadays). [3].

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In order to achieve the latest mentioned objective, the European Comission for esaw, that in every country, at least 10% out of the fuel used in transports should come from renewable energy sources (biofuels, hydrogen etc.). [4]. Sugar beet growing for bioethanol extraction presents the following advantages: the improvement of crop rotation on about 850.000 ha, by using a 4 years rational crops alternation; new jobs possibility, not only in agricultural farms which grow sugar beet, but also in the ethanol distilleries which will be founded; animal husbandry farms development, by the use as feed or as a source of bioethanol of the lees resulted from the ethanol distilleries, besides the vegetal remains resulted after the tops cutting; the increase of farmers income by means of sugar beet crops valorization for bioethanol production. [4]. Balanced application of foliar fertilizer *Bonus K-Energy* in critical stages of growth will greatly favour the level and quality of agricultural productions. For these reasons we introduced in the sugar beet plants technology of cultivation this new method of fertilization by using a new formula, specially designated to improve yields and increase the production efficiency for biofuel crops. [1]. *Bonus K-Energy* (10-5-38 +3MgO) fertilizer contains a unique balance of macro and micronutrients, ment to increase the plant production of sugars and fats. This fertilizer also contains special adjuvants for a better adherence on the leaf surface to improve the absorption and to prolong the action. [2]

II. MATERIAL AND RESEARCH METHOD

A. Research objectives

The conducted trials aimed at studying the influence of different fertilization patterns for sugar beet in order to obtain high roots productions, with high quality technology, the obtained biomass being used for bioethanol production. The research main goal has been the one of establishimg the studied factors over sugar beet production and technological quality, grown for bioethanol, following to calculate the ethanol quantities which may be obtained on a hectar of sugar beet, taking into account that 6,8 kg biological sugar (proper to ferment) which is found in the roots mass can be turned in 4,54 litters ethanol according to (Mother's Alcohol Fuel Seminar © The Mother Earth News, 1980). RANKOVIĆ (2009) shows in the work, entitled *''Bioethanol production from intermediate products of sugar beet processing with different types of Saccharomyces cerevisiae"*, that the effectiveness of the sugar,obtained out of the juice extracted from the beet within the bioethanol extraction process, reaches at least 98 - 99%. [5]. Within the trial, we aimed at determining the fertilization variant with

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foliar fertilizers or manure which allows getting the most important sugar beet biomass quantity, with best technological quality, respectively roots productions of over 70 to/ha and sugar content of over 17 %. The dimensioning of experimental plots as well as their positioning was closely connected to the studied factors.

B. Studied biological material

The biological material is represented by sugar beet hybrids from sugar beet coming from two societies, seed suppliers which function in our country (KWS and Danisco „Maribo Seed"), *CHIARA, EVELINA* hybrids which come from KWS society.

C. Research method in the field

The trial had as objective the establishment of a fertilization pattern which best satisfy the plants needs during the vegetation period. The trial was biofactarial, organized in 3 repetitions, the studied factors being the following:

A FACTOR – sugar beet hybrids tested within the trial with two grades:

a_1 – *CHIARA hybrid;*

a_2 – *EVELINA hybrid.*

B FACTOR – fertilization pattern tested within the trial, with 5 grades:

b_1 – unfertilized;

b_2 – fertilized with 30 t/ha manure;

b_3 – fertilized with 40 t/ha manure;

b_4 – fertilized with 40 kg/ha Bonus – KEnergy (10-5-38+3MgO+ME);

b_5 – fertilized with 60 kg/ha Bonus – KEnergy (10-5-38+3MgO+ME).

The dimensioning of experimental plots as well as their positioning was connected to the studied factors. [6]

III. RESULTS AND DISCUSSION

Beet production is influenced by more factors. A very important role is played by the crop vegetation start and its good functioning during the whole vegetation period.The presence of water in soil but also of other nutritive elements necessary to plants during vegetation generates superior quality high productions. The observations during the vegetation, starting with the roots sprouting until roots maturation, focussed on plants capacity to develop under different circumstances met with every experimental trial.

A. Number of leaves plant, 60 days distance from sprouting

The values proper to the average of leaves number on the two trial years, at 60 days distance from sprouting are rendered in table 1.

Table 1

Number of leaves/plant, 60 days distance from sprouting, the interaction hibrid x agrarian nature

Hybrids test	Fertilizers tested	Leaves/plant	Relative values (%)	Diff.	Semnific.
a_1 *CHIARA*	Unfertilized (Mt.1)	13.4	100.00	0.00	Mt.
	30 t manure/ha	13.8	102.98	0.4	-
	40 t manure/ha	14.1	105.22	0.7	*
	40 kg/ha Bonus - KEnergy	14.3	106.71	0.9	**
	60 kg/ha Bonus - KEnergy	16.3	121.64	2.9	***
a_2 *EVELINA*	Unfertilized (Mt. 2)	13.1	100.00	0.00	Mt.
	30 t manure/ha	13.7	104.58	0.6	*
	40 t manure/ha	14.3	109.16	1.2	**
	40 kg/ha Bonus - KEnergy	14.6	111.45	1.5	**
	60 kg/ha Bonus - KEnergy	16.8	128.24	3.7	***

DL 5% = 0.6; DL 1% = 0.9; DL 0.1% = 1.6

We can assert that the fertilization variant highly influences the moment when the root starts to grow in diameter because this happens after 16 leaves forming. Analysing the data in table 1, we may easily notice that *EVELINA* hybrid has a better answer to fertilization than *CHIARA* hybrid, presenting for each experimental variant (at least for the unfertilized control) a bigger number of leaves, at 60 days distance from sprouting.

B. Plants number at harvest

The average of roots number for the two trial years concerning the interaction (A x B) is rendered in table 2. The roots number at harvest is an important factor, by means of the fact that sugar beet has a high self-adjustment capacity, thus, it benefits of space, respectively light and soil volume, thus the root grows a lot , this process lowering its technological qualities.

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Table 2

Roots number at harvest, hibrid x agrarian nature interaction

Hybrids test	Fertilizers tested	Number roots	Values relative(%)	Diff.	Semnific.
a_1 *CHIARA*	Unfertilized (Mt.1)	221.5	100.00	0.00	Mt.
	30 t manure/ha	221.7	100.09	0.2	-
	40 t manure/ha	227.7	102.79	6.2	-
	40 kg/ha Bonus - KEnergy	212.8	96.07	-8.7	-
	60 kg/ha Bonus - KEnergy	223.2	100.76	1.7	-
a_2 *EVELINA*	Unfertilized (Mt.2)	218.8	100.00	0.00	Mt.
	30 t manure/ha	218.5	99.86	0.3	-
	40 t manure/ha	214.0	97.80	-4.8	-
	40 kg/ha Bonus - KEnergy	220.8	100.91	2.0	-
	60 kg/ha Bonus - KEnergy	213.7	97.66	-5.1	-

DL 5% = 22.6; DL 1% = 46.2; 0.1% DL = 131.3

The differences among hybrids concerning the roots number obtained when harvesting for the same fertilization variant are insignificant, in comparison with the control variants proper to every tested hybrid.

C. Roots production

The roots production is an important factor for determining the bio-ethanol quantity which may be obtained from a hectare cultivated with beet.

Table 3

Roots production (t/ha), hybrid x agrarian nature interaction

Hybrids test	Fertilizers tested	The production of roots (t/ha)	Relative values (%)	Diff. (t/ha)	Semnific.
a_1 *CHIARA*	Unfertilized (Mt.1)	40.9	100.00	0.00	Mt.
	30 t manure/ha	65.9	161.12	25.0	**
	40 t manure/ha	73.1	178.72	32.2	***
	40 kg/ha Bonus - KEnergy	68.5	167.48	27.6	***
	60 kg/ha Bonus - KEnergy	77.9	190.46	37.0	***
a_2 *EVELINA*	Unfertilized (Mt.2)	39.5	100.00	0.00	Mt.
	30 t manure/ha	64.5	163.29	25.0	**
	40 t manure/ha	71.9	182.02	32.4	***
	40 kg/ha Bonus - KEnergy	68.3	172.91	28.8	***
	60 kg/ha Bonus - KEnergy	81.2	205.56	41.7	***

DL 5% = 7.4; DL 1% = 12.4; DL 0.1% = 26.6

For each of the 4 fertilization patterns, the roots production is highly influenced, in a positive way, by fertilization.The sugar beet presents a good answer to the good fertilized fields, thus the differences between them and the control unfertilized variant go over 25 tonns/ha, no matter the hybrid tested within the trial. The interaction between factors is rendered in table 3, it emphasizes the fact that *EVELINA* hybrid had a better response to maximum dosis of fertilizers, applied as agrarian nature, the maximum production being obtained for the fertilization with 60 kg/ha Bonus – KEnergy variant, where there were obtained 81,2 tonns roots/ha while, *CHIARA* hybrid achieved after the same fertilization pattern a roots production of 77,9 tonns roots/ha. The recorded differences, in comparison with the unfertilized control variants, proper to each hybrid were comprised between 25 and 41,7 tons roots/ha, with high significant ensurance (***), except the variants which were fertilized with 30 t/ha manure for both tested hybrids, variants where the differences between then and the unfertilized control variant had a distinctly significant statistical ensurance(**).

D. Sugar content

After the harvest, there were taken samples from the field, in order to effect the lab analysis. The samples were represented by 25 sugar beet roots for every trial variant, roots which were subject to determinations related to the main quality indicators. The sugar content (digestion) is determined from a beet roots mass, cleaned by impurities and correctly top cut. The data presented in table 4 mirrors the difference among the studied hybrids for a certain fertilization pattern. Analysing these data, one can notice, that making a comparison with the unfertilized variants, the differences were comprised between 1,7 and 2 percentual points for the experimental variants fertilized with 30 and 40 t/ha manure for both tested hybrids, differences ensured statistically as being distinctly significative (**) while for the variants fertilized with 40 or 60 kg/ha Bonus – KEnergy, the differences between them and the unfertilized

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control variant were comprised between 0,5 and 1,1 percentual points, with statistical insignificant ensurance (-) when administering 40 kg/ha Bonus – KEnergy and significantly negative (o) for the variants which received 60 kg/ha Bonus – KEnergy.

Table 4

Sugar content (%), hybrid x agrarian nature interaction

Hybrids test	Fertilizers tested	Sugar content (%)	Relative values (%)	Diff. (%)	Semnific.
a_1 *CHIARA*	Unfertilized (Mt.1)	16.8	100.00	0.00	Mt.
	30 t manure/ha	18.6	110.71	1.8	**
	40 t manure/ha	18.6	110.71	1.8	**
	40 kg/ha Bonus - KEnergy	16.2	96.42	0.6	-
	60 kg/ha Bonus - KEnergy	15.7	93.45	-1.1	an
a_2 *EVELINA*	Unfertilized (Mt.2)	16.8	100.00	0.00	Mt.
	30 t manure/ha	18.8	111.90	2.0	**
	40 t manure/ha	18.5	110.11	1.7	**
	40 kg/ha Bonus - KEnergy	16.3	97.02	-0.5	-
	60 kg/ha Bonus - KEnergy	15.7	93.45	-1.1	an

DL 5% = 0.8; DL 1% = 1.2; DL 0.1% = 2.3

E. Biological sugar production

Biological sugar production represents a determining factor in ethanol quantity calculus which may be obtained from one hectare of sugar beet. For every fertilization pattern practised within the experiment, there were recorded productions of over 11 tonns biological sugar/ha.

Maximum sugar productions were obtained by the two tested hybrids for the variants fertilized with 40 tones manure (13,6 tonns sugar/ha, for *CHIARA* hybrid and 13,3 tonns sugar/ha, for *EVELINA hybrid*) and 60 kg/ha Bonus – KEnergy (12,2 tonns sugar/ha for *CHIARA* hybrid and 12,8 tonns tone sugar /ha for *EVELINA hybrid*).

Table 5

Biological sugar production (t/ha), hybrid x agrarian nature interaction

Hybrids test	Fertilizers tested	Biological sugar production (t/ha)	Relative values (%)	Diff. (t/ha)	Semnific.
a_1 *CHIARA*	Unfertilized (Mt.1)	6.9	100.00	0.00	Mt.
	30 t manure/ha	12.3	178.26	5.4	***
	40 t manure/ha	13.6	197.10	6.7	***
	40 kg/ha Bonus - KEnergy	11.1	160.86	4.2	***
	60 kg/ha Bonus - KEnergy	12.2	176.81	5.3	***
a_2 *EVELINA*	Unfertilized (Mt.2)	6.7	100.00	0.00	Mt.
	30 t manure/ha	12.2	182.08	5.5	***
	40 t manure/ha	13.3	198.50	6.6	***
	40 kg/ha Bonus - KEnergy	11.2	167.16	4.5	***
	60 kg/ha Bonus - KEnergy	12.8	191.04	6.1	***

DL 5% = 1.4; DL 1% = 2.1; DL 0.1% = 3.7

In table 5, it is presented the interaction between the two experimental factors. One may notice that for the fertilization with foliar fertilizers, the insignificant digestion is compensated by higher digestions. Thus, one reaches to the close productions to sugar/ha in different fertilization variants productions. The differences registered in comparison with the unfertilized control variants, proper to each studied hybrid were comprised between 4,2 and 6,7 tone zahăr/ha, statistically assured as being very significant(***).

F. Economic effectiveness calculus

The sugar production, including the ethanol quantity which may be obtained from one ha with sugar beet depends on the crop good functioning, respectively on the technological quality and the obtained production. In table 6, there are presented ethanol productions, taking into account the sugar turning coefficient in alcohol, respectively 0,667 litters ethanol for each kg of sugar, according to (*Mother's Alcohol Fuel Seminar © The Mother Earth News, 1980*) and the necessary expenses to get one litter of ethanol, taking into account the estimate costs for one hectare cultivated with beet, using the studied fertilization variants and hybrids. The estimate was calculated according to the data supplied by The Association of the Bod Sugar Beet Growers (ACSZ-Bod).

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Table 6

Economic effectiveness of sugar beet crop meant to obtain bioethanol

Hybrids test	Fertilizers tested	Sugar production (t/ha)	Total expenditure (€/ha)	The production of ethanol	Expenses/liter ethanol (€/liter)
CHIARA	Unfertilized	6,900	911,44	4,610	3,75
	30 t manure/ha	12,300	1080,09	8218	2,49
	40 t manure/ha	13,600	1136,38	9087	2,40
	40 kg/ha Bonus - KEnergy	11,100	1064,07	7417	2,70
	60 kg/ha Bonus - KEnergy	12,200	1100,68	8.152	2,57
EVELINA	Unfertilized	6,700	911,44	4,477	3,88
	30 t manure/ha	12,200	1080,09	8.152	2,53
	40 t manure/ha	13,300	1147,59	8887	2,44
	40 kg/ha Bonus - KEnergy	11,200	1064,07	7483	2,70
	60 kg/ha Bonus - KEnergy	12,800	1100,68	8552	2,44

Analysing the data from table 6, we notice that *CHIARA* hybrid fertilized with 40 tonns/ha manure registers the highest quantity of ethanol and the least cost price. One may observe that the cost price for one ethanol litter, for the variants fertilized with manure is the lowest for both hybrids, these variants proving to be the most advantageous in terms of economic effectiveness.

IV. CONCLUSIONS

1. Yearly climate variations from the three critical vegetation stages of the sugar beet are significantly mirrored in the biomass and quality mass.

2. *EVELINA* hybrid answers better than *CHIARA* hybrid to fertilization, showing for each experimental variant (at least for the unfertilized control variant) a higher number of leaves up to 60 days from sprouting.

3. The differences between hybrids, regarding the roots number obtained with the harvest for the same fertilization variant, are insignificant, in comparison with the control variant proper to each tested hybrid.

4. *EVELINA* hybrid answers better to maximum administered fertilizers dosis, the maximum production being obtained in the fertilization case with 60 kg/ha Bonus – KEnergy, variant, where there were achieved 81,2 tonns roots/ha while, *CHIARA* hybrid obtained a roots production of de 77,9 tonns roots/ha, as a consequence of the same fertilization pattern.

5. The differences between them and the control variants concerning the sugar content were comprised between 1,7 and 2 percentual points, for the experimental variants fertilized with 30 and 40 t/ha manure for both tested hybrids, differences assured statistically as distinctly significative (**).

6. The variants fertilized with 40 or 60 kg/ha Bonus – KEnergy recorded, concerning the sugar content, differences between the rest of variants and the unfertilized control variant comprised between 0,5 and 1,1 percentual points, with unsignificant statistical ensurance (-) when administering 40 kg/ha Bonus – KEnergy and significantly negative (o), with the variants that benefited 60 kg/ha Bonus – KEnergy.

7. The maximum sugar productions were obtained the two tested hybrids for the variants fertilized with 40 tonns manure (13,6 tonns sugar /ha, for *CHIARA* hybrid and 13,3 tonns sugar/ha, for *EVELINA* hybrid) and kg/ha Bonus – KEnergy (12,2 tonns sugar/ha, for *CHIARA* hybrid and 12,8 tonns sugar/ha, *EVELINA* hybrid).

8. *CHIARA* hybrid fertilized with 40 tonns manure/ha registers the highest ethanol quanity and the least cost.

9. The maximum economic effectiveness was achieved by the *CHIARA* hybrid fertilized with 40 tonns manure/ha, this one ensuring the lowest cost for the beet necessary to obtain one ethanol litter (0,55 lei/l).

10. Sugar beet fertilization with a dosis of kg/ha Bonus – KEnergy commercial product/ha gave birth to the increasing of the growth period and of nutritive substances assimilation, to the disadvantage of sugar accumulation, determining roots technological quality devaluation, by lowering the cellular purity juice, respectively reduced digestion acquirement (below 16 %).

REFERENCES

[1] Ricuta – Vasilica Dobrinoiu, Ştefana Jurcoane, Ana Roşu, Silvana Dănăilă-Guidea, Maria Moraru, Marin Dumbravă, 2011 - The impact of new technological approaches upon establishing production components and yield randament in Carthamus tinctorium L culture, Romanian Biotechnological Letters, Vol. 16, No.2 2011, p. 6125-6134;

[2] Ricuţa-Vasilica Dobrinoiu, Luminiţa Vişan, Silvana Dănăilă-Guidea, Marin Dumbravă - Impact of some technological links on the production and quality parameters in castor-oil plants (Ricinus communis L.), International Journal of Agriculture Innovations and Research - Volume 2, Issue 6 , ISSN (Online) 2319-1473, p. 1084-1089, 2014.

[3] Simona - Clara Bârsan, Ancuţa - Maria Puşcaş, E. Luca, A. Setel, 2008, - Bioetanolul şi cultura sfeclei de zahăr, Agricultura–Revistă de ştiinţă şi practică agricolă, nr. 3-4 (67-68)/2008, p. 11-15;

[4] Gh. Manea, 2003 - Elemente pentru o politică naţională de promovare a biocombustibililor, Promovarea în România a surselor regenerabile de energie, Editura Chiminform data, Bucureşti;

[5] Jovana Rancovic, Jelena Dodic, Sinisa Dodic, S. Popov, 2009 - Bioethanol production from intermediate products of sugar beet processing with different types of Saccharomyces cerevisiae, Chemical Industry & Chemical Engineering Quarterly, 15 (1), 13-16;

[6] N. Saulescu, 1959 - Câmpul de experienţă. Ed. Agro-Silvică de Stat, Bucureşti, p. 223-228.

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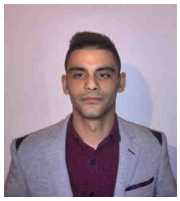

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