

FERTILIZATION OF SUGAR BEET IN FUNCTION OF ROOT YIELD AND QUALITY

Marinković J. Branko¹, Crnobarac Ž. Jovan¹, Jaćimović P. Goran¹, Marinković B. Jelena²

Latković Dragana¹, Marinković B. Duško³, Vasilchenko Aleksandr Mihailovich⁴

¹ University of Novi Sad, Faculty of Agriculture, Dositej Obradovic Sq. 8, 21000 Novi Sad, Serbia

² Institute of Field and Vegetable Crops, Maxim Gorky Sq. 30, 21000 Novi Sad, Serbia

³ Victoria Group, Hajduk Veljko Sq. 11, 21000 Novi Sad, Serbia

⁴ Kemerovo State Agricultural Institute, Markovceva Sq. 5, 650056 Kemerovo, Russia

Abstract

The results of these studies were obtained on a stationary trial which has begun in the year 1982, on a soil type carbonat chernozem. Chernozem has good physical, chemical and biological characteristics, which enable a high production potential. The influence of organic and mineral fertilizers, with increasing amounts of nitrogen, on yield and technological quality of sugar beet taproot was tested in the experiment.

The experiment was conducted as a split plot design. Within factor A, the following were examined organic and mineral fertilizers.

Factor B were the amounts of nitrogen in following order: from 0 to 200 kg N ha⁻¹

On average, the highest root yield was made on treatment with plowed harvest residue (59,12 t ha⁻¹). The lowest root and sugar yield was on harvest residue and liquid manure treatment (54,79 t ha⁻¹). The absolute highest root yield (64,15 t ha⁻¹) was made on treatment with manure and 50 kg N ha⁻¹. The highest sugar yield (7,42 t ha⁻¹) was on harvest residue treatment in combination with 100 kg N ha⁻¹. With the increase of nitrogen, the sugar content was decreasing, the highest (14,64%) being the one on treatment with manure without nitrogen.

Key words: *sugar beet, organic fertilizers, nitrogen, yield*

1. INTRODUCTION

Optimal and timely applied agronomy practices, especially fertilization, lead to total success in field crops production. Agronomy practice must be in alignment with potentials of every field, variety and year production potential.

The sugar beet production has more specificities compared to production of other field crops. Fertilizing simultaneously enables increased yield and technological quality. This is the reason why this measure is extremely important, and should be treated with utmost attention.

2. MATERIAL AND WORK METHOD

The study of influence of fertilizing on sugar beet yield and quality was performed on a stationary trial on Rimski Šančevi. The trial began in the year 1982 on a soil type carbonate chernozem, which has good physical, chemical and biological characteristics. The experiment was conducted in four-field crop rotation like split plot design. Within factor A, the following were examined:

1. mineral P and K fertilizers
2. manure + mineral fertilizers P and K
3. harvest residue + mineral fertilizers P and K
4. harvest residue + liquid manure + mineral fertilizers P and K

The quantity of nitrogen mineral fertilizers was examined within factor B, in following order:

- 1) no nitrogen
- 2) 50 kg N ha⁻¹
- 3) 100 kg N ha⁻¹
- 4) 150 kg N ha⁻¹
- 5) 200 kg N ha⁻¹

The crop preceding sugar beet was wheat, and soil tillage was conducted according to establishing and renewing of arable land principle. This paper shows the average four year results. The sowing of sugar beet was performed in optimal date (during the middle of March). Other agronomy practices were performed in timely manner. At the end of vegetation period (October) the following were measured: root yield, the above-ground mass yield, content of sugar, content of harmful K, Na, α -amino N, while sugar use efficiency and sugar yield t ha⁻¹ were calculated. All data was statistically processed.

3. RESULTS AND DISCUSSION

Table 1 shows the root yield (t ha⁻¹). There were no significant differences between the examined organic and mineral fertilizers, on average. The highest average yield was on variants with harvest residue, but the difference is not statistically significant. The absolute highest root yield (64,15 t ha⁻¹) was made on variant with manure and 50 kg N ha⁻¹. Statistically, this yield is significantly higher compared to all variants without nitrogen. The yield is also significantly higher compared to variants with 200 kg N ha⁻¹, excluding the variant with harvest residue.

Table 1 Root yield (t ha⁻¹)

Variants (A)	N kg ha ⁻¹ (B)					Average
	Ø	50	100	150	200	
MF	53,23	58,76	60,93	59,82	59,58	58,46
M	54,64	64,15	61,32	56,47	55,77	58,47
HR	53,87	57,68	62,41	61,18	60,48	59,12
HR+LM	47,31	56,27	59,24	55,69	55,44	54,79
Average	52,26	59,22	60,98	58,29	57,82	

LSD		A	B	B Δ A	A Δ B
	0,05	5,16	4,04	8,08	8,25
	0,01	7,83	5,43	10,87	11,52

MF: Mineral fertilizers

M: Manure

HR: Harvest residue

HR+LM: Harvest residue + Liquid manure

Numerous scientific papers have been written about the role of manure. Majority of them agrees that during manure fertilization an optimal NPK fertilization must exist, because the surplus can have a negative influence on sugar beet taproot yield (Marinković et al. 1993; 2001; 2006).

With the increase of nitrogen quantities up to 100 kg N ha⁻¹, the yield increases on all variants, except the variant with manure (increase up to 50 kg N ha⁻¹). Those differences are significant compared to variant without nitrogen. The exception is variant with only mineral fertilizers. The yield of variant with manure and 50 kg N ha⁻¹ was higher by 3,22; 1,74 and by 4,91 t ha⁻¹ compared to the highest yield (100 kg N ha⁻¹) of other types of fertilizers. In these variants additional 50 kg N ha⁻¹ of mineral fertilisers were used, but lower yield was achieved. The stated data clearly show the role of manure. Harvest residue had an impact on maximal yield growth by 1,48 t ha⁻¹ (on variant with 100 kg N ha⁻¹).

Optimal quantity of nitrogen varied in different agro-ecological conditions and years. Krivusudska et al. (2003) states that the optimal quantity of nitrogen was 80 kg N ha⁻¹, Marinković et al. (1998; 2012) state that optimal quantity was 100 kg N ha⁻¹, the same as Jaćimović et al. (2005). Nowak et al. (2002) states that the optimal quantity of nitrogen was 180 kg N ha⁻¹, similar as Sarić and Jocić (1993).

Table 2 shows the content of sugar (%). It decreases with the increase of nitrogen. The exception is the variant with harvest residue without nitrogen. The highest decrease is on variant with 200 kg N ha⁻¹ compared to variant with 150 kg N ha⁻¹. Highest sugar percentage, with 100 kg N ha⁻¹ of fertilizers, was accomplished on variant with harvest residues (14,11%). The difference, compared to other fertilizing variants, was 0,13; 1.30 and 0,66%, and therefore not statistically significant. However, it could be economically significant.

Table 2 Sugar content (%)

Variants	N kg ha ⁻¹					Average
	Ø	50	100	150	200	
MF	14,31	14,19	13,98	13,75	11,77	13.59
M	14,64	13,98	12,81	12,63	12,29	13,27
HR	13,10	14,24	14,11	13,40	11,95	13,36
HR+LM	14,56	14,24	13,45	12,89	11,70	13,37
Average	14,15	14,16	13,57	13,17	11,93	

LSD		A	B	B Δ A	A Δ B
	0,05	0,64	0,45	0,91	0,95
	0,01	0,98	0,61	1,22	1,33

MF: Mineral fertilizers

M: Manure

HR: Harvest residue

HR+LM: Harvest residue + Liquid manure

Sugar use efficiency like sugar content, decrease with the increase of nitrogen quantity (Table3). That is not surprising because the content of harmful matters (K, Na and α-amino N) increases with the increase of nitrogen. The highest sugar use efficiency, when applying 100 kg N ha⁻¹, was on variant with harvest residue (11,87%). The highest difference between two quantities of nitrogen was between 150 and 200 kg N ha⁻¹ (on average 3,85%).

All of the researchers agree that with the increase of nitrogen, the sugar content is decreasing, as well as the use efficiency. These results were achieved by Milošević and Stefanović (1984), Nenadić et al. (1990 i 2003), Marinković et al. (2004), Jaćimović et al. (2008). The fact that phosphorus and potassium can, when in surplus, have a negative influence on sugar beet yield and quality, is emphasised by Marinković et al. (2003, 2006, 2011).

Table 3 Sugar use efficiency (%)

Variants	N kg ha ⁻¹					Average
	Ø	50	100	150	200	
MF	12,50	12,29	11,85	11,42	6,77	10,97
M	12,44	11,62	10,25	10,05	7,24	10,32
HR	10,87	12,22	11,87	10,98	6,97	10,58
HR+LM	12,49	12,01	10,96	10,46	6,77	10,54
Average	12,08	12,03	11,23	10,79	6,94	

LSD		A	B	B Δ A	A Δ B
	0,05	0,60	0,48	0,96	0,98
	0,01	0,91	0,65	1,30	1,38

MF: Mineral fertilizers

M: Manure

HR: Harvest residue

HR+LM: Harvest residue + Liquid manure

Table 4 Sugar yield (t ha⁻¹)

Variants	N kg ha ⁻¹					Average
	Ø	50	100	150	200	
MF	6,70	7,20	7,30	6,97	5,28	6,69
M	6,83	7,45	6,26	5,67	4,04	6,30
HR	5,91	7,12	7,42	6,84	5,72	6,05
HR+LM	5,89	6,85	6,47	5,87	3,77	5,77
Average	6,33	7,16	6,86	6,34	4,70	

LSD		A	B	B Δ A	A Δ B
	0,05	0,74	0,56	1,13	1,16
	0,015	1,12	0,76	1,52	1,62

MF: Mineral fertilizers

M: Manure

HR: Harvest residue

HR+LM: Harvest residue + Liquid manure

Table 4 shows sugar yield (t ha^{-1}), which represents the basic goal and purpose of sugar beet production. Highest sugar yield was achieved on variant with 100 kg N ha^{-1} with mineral fertilizers ($7,30 \text{ t ha}^{-1}$) and harvest residue ($7,42 \text{ t ha}^{-1}$). On variants with manure and harvest residue + liquid manure the highest yield was when using 50 kg N ha^{-1} .

The absolute highest root yield ($7,45 \text{ t ha}^{-1}$) was made on variant with manure and 50 kg N ha^{-1} and was higher by 250, 33, or 600 kg ha^{-1} compared to other variants. Unfortunately, the sugar beet grown area fertilized with manure is only 9,5%. Compared to variant with only mineral fertilizers (dominant in our region), the sugar yield increase was 250 or 150 kg ha^{-1} , depending on the nitrogen quantity (50 or 100 kg N ha^{-1}).

Decrease of sugar yield on variant with 150 kg N ha^{-1} compared to variant 100 kg N ha^{-1} was 330; 590; 580 and 600 kg ha^{-1} , and additional 50 kg N ha^{-1} was spent.

Irrational fertilizing had a negative impact on sugar yield, which many authors emphasise, such as: Jaćimović et al. (2005, 2008), Radivojević (1981), Marinković et al. (2001; 2004), Pospíšal (2004), Campbell (2002).

Only with rational fertilizing, based on the field and year potentials, and crop demands, the desired results can be achieved.

4. CONCLUSIONS

The absolute highest root yield ($64,15 \text{ t ha}^{-1}$) was made on variant with manure and 50 kg N ha^{-1} .

At other types of organic fertilizers, the highest yield was achieved on variant with 100 kg N ha^{-1} . Compared to variant with manure the yield was lower by 3,22; 1,74; and $4,91 \text{ t ha}^{-1}$ despite applying 50 kg N ha^{-1} more.

Highest content and highest sugar use efficiency was on variant without nitrogen.

Most significant decrease of sugar content (1,24%) was when 200 kg N ha^{-1} were applied, compared to 150 kg N ha^{-1} .

The biggest difference in sugar use efficiency (3.85%) between two quantities on nitrogen was from 150 to 200 kg N ha^{-1} .

On variant with 200 kg N ha^{-1} sugar use efficiency was between 6,77 and 7,24 %.

Highest sugar yield ($7,45 \text{ t ha}^{-1}$) was accomplished on variant with manure and 50 kg N ha^{-1} , and slightly lower ($7,42 \text{ t ha}^{-1}$) on variant harvest residue and 100 kg N ha^{-1} .

Optimal yields can only be achieved with optimal fertilizing, which must be adapted to plants demands, field and year yield potential as well as mineral nitrogen distribution in soil. Winter precipitations have a great impact on mentioned limitations.

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LITERATURE

Campbell, L. G. (2002): Sugar beet quality improvement. *Journal of Crop Production*, Vol. 5, No. 1/2, pg. 395-413.

Jaćimović, G. (2005): Dinamika formiranja prinosa i kvalitet šećerne repe pri različitim nivoima đubrenja. *Magistarska teza, Univerzitet u Novom sadu, Poljoprivredni fakultet Novi Sad*.

- Jaćimović, G., Marinković, B., Crnobarac, J., Bogdanović, D., Kovačev, L., Danojević, D. (2008): Influence of fertilization and nitrate-nitrogen position in soil profile on the sugar beet root yield and quality. *Journal of Agricultural Sciences*, Vol. 53, No 2, 83-90.
- Krivosudska, E., Karabinova, M. (2003): Hustota porastu a uroda repy cukrovej v zavislosti od stupnovanyh davok hnojenja. V celoslovenska vedecka reparska konferencia, Nitra, Zbornik vedeckej konferencie z medzinarodnou ucastou, str. 89-93.
- Marinković B., Crnobarac J., Jaćimović G. (2004): Đubrenje šećerne repe azotom, fosforom i kalijumom u funkciji prinosa i kvaliteta. »Zbornik radova«, Naučni institut za ratarstvo i povrtarstvo, Novi Sad, Sveska 40, str. 373-378.
- Marinković B., Crnobarac J., Jaćimović G., Starčević LJ., Janković Snežana (2003): Influence of Sugar Beet fertilization on the yield and root quality in agroecological conditions of Vojvodina, results from trials and production. Zilele Academice Timișene, Editia a VIII-A, Timișoara, 22-23 mai 2003. Lucrări științifice Facultatea de Agricultură (Timisoara's Academic Days, VIIITH edition, Timisoara, 22-23 May 2003. Scientific papers, Faculty of Agriculture). 31-37.
- Marinković, B., Crnobarac, J., Jaćimović, G., Latković, D., Marinković, D., Radivojević, S. (2012): Effect of nitrogen fertilizer on root yield and technological quality of sugar beet. 6th Central European Congress on Food (CEFood 2012), May 23-26. 2012., Novi Sad, Serbia. Abstract Book, 325. (Publisher: University of Novi Sad, Institute of Food Technology), UDC: 338.439.4 (048.3), ISBN 978-86-7994-028-5 M₃₄ (0,5)
- Marinković, B., Crnobarac, J., Jaćimović, G., Latković, D. (2011): Primena NPK hraniva u funkciji očuvanja plodnosti zemljišta i prinosa šećerne repe. I Međunarodni naučno-stručni skup „Zemljište, korišćenje i zaštita“, Andrevlje, 21-23. septembar 2011., Međunarodna Menadžerska Akademija Novi Sad. Tematski zbornik radova, 85-89
- Marinković, B., Crnobarac, J., Jaćimović, G., Polaček, M., Mircov, D. V., Florin, I. (2006): Sugar beet yield and quality in dependency of nutrition element source. The 2nd edition of the Scientific Conference »Durable Agriculture–Agriculture of the Future«. Annales of the University of Craiova, Romania, Vol. XXXVI/A 2006, pg. 344-347.
- Marinković, B., Crnobarac, J., Mihailović, T. D., Rajić, M., Lalić Branislava (2001): Optimalizacija tehnologije proizvodnje šećerne repe. Zbornik radova, Naučni institut za ratarstvo i povrtarstvo, Novi Sad, sveska 35, str. 291-306.
- Marinković, B., Crnobarac, J., Rajić, M. (1998): Sugar beet fertilization with NPK in function of root and sugar yield. Proceedings of 5th Congress European Society for Agronomy, Nitra, The Slovak Republic. Vol. I, str. 299-300.
- Marinković, B., Starčević, Lj., Crnobarac, J., Balešević, S., Latković, D. (1993): Uticaj zaoravanja žetvenih ostataka na premeštanje mineralnog azota u dublje slojeve zemljišta. EKO-93, Novi Sad. Zaštita životne sredine u poljoprivredi, No 6, 266-267.
- Milošević, R., Stefanović, D. (1984): Uticaj azota na prinos i kvalitet šećerne repe. Savremena poljoprivreda, Vol. 32, br. 7-8, str. 305-316.
- Nenadić, N., Nedić, M., Živanović, Lj., Kolarić, Lj., Gujaničić, T. (2003): Effect of genotype on Sugar Beet Yield and Quality. *Journal of Agricultural Sciences*, Vol. 48. No. 1, Pages 1-9.
- Nenadić, N., Zarić, D., Slović, S., Vidojević, S. (1990): Prinos i kvalitet sorata šećerne repe u zavisnosti od đubrenja azotom i gustine useva. Zbornik radova poljoprivrednog fakulteta, Beograd, god. 35, sv. 594, str. 9-24.
- Nowak, W., Sowinski, J., Pytlarz-Kozicka, M. (2002): Zmiany ilości azotu mineralnego w glebie podczas wegetacji buraka cukrowego oraz plony korzeni i cukru w zalezności od nawożenia organicznego i azotowego. *Biuletyn Instytutu Hodowli i Aklimatyzacji Roślin*, No. 222, pg. 295-302.

- Pospišil, M. (2004): Temeljne mjere uzgoja šećerne repe. Glasnik zaštite bilja, god. 27, br. 5, Zagreb, str. 108-113.
- Radivojević, S. (1981): Uticaj azota na dinamiku akumulacije šećera u repi. Magistarski rad, Poljoprivredni fakultet, Novi Sad.
- Sarić, M., Jocić, B. (1993): Biološki potencijal gajenih biljaka u agrofitocenozi u zavisnosti od mineralne ishrane. Zbornik radova, Naučni institut za ratarstvo i povrtarstvo, Novi Sad, Sveska 21, str. 7-21.