Journal of Agricultural Sciences
Vol. 53, No2, 2008

UDC: 633.63 : 631.816
Original scientific paper

INFLUENCE OF FERTILIZATION AND NITRATE-NITROGEN POSITION IN SOIL PROFILE ON THE SUGAR BEET ROOT YIELD AND QUALITY

G. Jaćimović[1], B. Marinković[1], J. Crnobarac[1], Darinka Bogdanović[1], L. Kovačev[2] and D. Danojević[2]

Abstract: Researches, which have lasted for two years, were carried out on long-term trial field at Rimski Šančevi, Novi Sad, Serbia. In this trial, the eight fertilization variants of N, P_2O_5 and K_2O increased amounts were studied. Sugar beet root and tops yields were determined, as well as the elements of technological sugar beet root quality. Based on these results, percentage of sugar utilization and refined sugar yield was defined. In the spring, before applying of N fertilizer, amount of nitrate nitrogen in the soil and its influence on yield and quality was determined.

The highest root yield in 2002 was produced at the variant $N_{100}P_{150}K_{150}$, and in 2003 at the variant $N_{150}P_{150}K_{150}$. However, in both years, referring to the variant $N_{100}P_{100}K_{100}$, the differences were not statistically significant. Increasing of nitrogen amounts had negative effects on refined sugar yield. Amounts of NO_3-N in the soil in spring, before sugar beet sowing, in 2002 had significant influence on root yield and refined sugar yield. In the year 2003, which was highly dry, high correlation ratio were gained between amounts of NO_3 -N in the soil and root quality parameters, but it wasn't significant between nitrogen amounts and root and refined sugar yield.

Key words: sugar beet, fertilization, root yield, sugar yield, technological quality

Introduction

Sugar beet has huge production of organic matter for which it must have adequate mineral nutrition amounts. Sugar beet fertilization is very specific because

[1] Goran Jaćimović, M.Sc., assistant, jgoran@polj.ns.ac.yu, Branko Marinković, full prof., Jovan Crnobarac, full prof., Darinka Bogdanović, full prof., Faculty of Agriculture, D. Obradovića Square 8, 21000 Novi Sad.

[2] Lazar Kovačev, PhD, scientific adviser, Dario Danojević, B.Sc., Institute of Field and Vegetable Crops, M. Gorkog 30., 21000 Novi Sad.

beside the high root yield, the technological quality of root must be good as well. Between all elements of mineral nutrition, the highest influence on yield and qualitative beet properties has nitrogen. Negative effects, especially on sugar yield which can have nitrogen surplus, can be avoided by following and determining its amounts and dynamics in soil. At the same time herewith the economical and ecological fertilization aspects will be respected.

The main cause of these investigations was to explore the influence of NPK mineral nutrition at root yield and underground biomass as well as the influence on technological root properties.

Also, based on the amounts of soil nitrate-nitrogen before sowing and its distribution in soil profiles we will try to determine its correlation dependency with root yield and quality.

Material and Methods

Researches have lasted for two years and they were conducted at stationary field trial at Institute of Field and Vegetable Crops -Novi Sad. The trial was designed by *split-plot* plan, in four repetitions. The main plots were 150 m^2, with eight fertilization variants by different amounts of N, P_2O_5 and K_2O: Ø (control), N_2P_2, N_2K_2, $N_1P_2K_2$, $N_2P_2K_2$, $N_2P_3K_3$, $N_3P_2K_2$, $N_3P_3K_3$ (where $_1$ =50, $_2$ =100, $_3$ =150 kg active matter of each nutrition element per hectare).

After extraction of a root, root samples were taken from all fertilization variants to the end that determine technological root quality properties and next parameters were determined: sugar percentage, content of harmful nitrogen, K and Na, and based on these properties sugar utilization and refined sugar yield were valuated. Determination of technological root quality was done by standard methods in automatic beet laboratory „WENEMA", in Institute for Field and Vegetable Crops at Rimski Šančevi, Novi Sad.

In the spring, before nitrogen fertilizers' application, the content and distribution of soil mineral nitrogen was monitored. The soil samples were taken in layers from 30 cm, till the depth of 120 cm. The samples were analyzed on NO_3-N content by standard methods.

Water balance of sugar beet, Rimski Šančevi	Average values for RŠ (1963-2003)	Year	
		2002	2003
ETP (lm^{-2})	576	621	648
Precipitations (lm^{-2})	361	274	236
ETR (lm^{-2})	391	310	272
Deficit (lm^{-2})	185	311	376
Surplus (lm^{-2})	23	0	0

Weather conditions in investigated years: Sugar beet yield and quality and seeded areas in our county are very variable from year to year. Besides the applied practical measures and economical reasons, the huge influences on the like fluctuations have the mutable weather conditions. By comparing the water balance elements (Bioclimatic method, Vučić*; 1971*) in observed years with average values from Rimski Šančevi site, we can mark the very high values of potentially evapotranspiration (ETP) and higher precipitation deficit in a both years, in relation to a long-term period average.

The year 2002 was very dry. Percentage of real evapotranspiration (ETR) in relation to potentially (ETP) was only 50 %, and totally water deficit in relation to plants requirements was 311 lm^{-2}. Year 2003 was climatic more unfavorable. Totally, during the vegetation period there was less precipitations for 125 lm^{-2} and at the same time the temperature was higher for 2.1 ^{0}C regarding to the multi-annual average. Plant water requirement (= ETP) in 2003 was 648 lm^{-2}, and real ET was only 272 lm^{-2}, while precipitation deficit was 376 lm^{-2}. The highest water deficit during vegetative period was in June and August.

Results and Discussion

All fertilization variants have positive effects on root yield (tab. 1) with the exception of variant $N_{100}K_{100}$ during the year 2000. Average yield increasing for all variants was 39% in relation to control in 2002, and 60% in 2003, respectively.

Tab. 1. – Influence of different amounts of mineral fertilizers on root, tops and sugar yield

Amount of fertilizer (kg ha^{-1})		Root yield (t ha^{-1})		Sugar beet tops yield (t ha^{-1})		% of sugar utilization (%)		Rafined sugar yield (t ha^{-1})	
		2002	2003	2002	2003	2002	2003	2002	2003
Ø		58.16	40.05	27.85	17.77	14.4	12.5	5.98	4.14
$N_{100}P_{100}$		68.36	65.06	37.22	35.42	13.7	10.5	7.19	4.88
$N_{100}K_{100}$		53.33	48.83	31.42	29.99	12.8	11.5	5.70	4.20
$N_{50}P_{100}K_{100}$		82.27	63.03	32.99	25.39	15.0	12.1	9.33	5.73
$N_{100}P_{100}K_{100}$		94.16	70.00	44.09	32.70	14.0	11.1	8.63	5.84
$N_{100}P_{150}K_{150}$		98.86	53.93	59.27	34.10	14.3	11.1	8.91	5.31
$N_{150}P_{100}K_{100}$		79.46	68.15	45.55	38.83	13.1	10.8	8.70	5.11
$N_{150}P_{150}K_{150}$		89.87	80.58	51.01	45.20	12.9	10.5	8.29	5.68
Average		78.06	61.20	41.17	32.42	13.8	11.3	7.84	5.11
LSD	0.05	10.52	11.71	5.44	3.28	0.81	1.3	1.54	1.74
	0.01	14.31	15.93	7.41	4.47	1.11	1.8	2.10	2.36

The highest amounts of mineral fertilization didn't produce significant increasing of fresh root yield. So in the 2002 year the highest yield was accomplished with applying of 100 $kgha^{-1}$ N, 150 $kgha^{-1}$ P_2O_5 and 150 $kgha^{-1}$ K_2O. However, the root yield at this fertilization variant in relation to variant with by 100 $kgha^{-1}$N, P_2O_5 and K_2O, was higher, but that difference was not statistically significant. The highest NPK fertilizer amounts (by 150 $kgha^{-1}$) in relation to medium (100 $kgha^{-1}$NPK) even now produced lower root yield for 4.6 %. During the 2003 year the highest yield was accomplished at variant $N_{150}P_{150}K_{150}$ and root yield differences were significant in relation to the all fertilization variants except $N_{100}P_{100}K_{100}$. According to our results Sarić and Jocić *(1977)* refers that the yield increasing with the fertilizer amounts bigger than 100kg ha^{-1} N, P_2O_5 and K_2O is minimal.

In 2002 year increasing of the nitrogen amounts from 50 to 100 $kgha^{-1}$, at the same level of P and K ($P_{100}K_{100}$), increased root yield for 14.5 % (increasing in relation to control was 62 %) which is statistically significant. The further increasing for 50 $kgha^{-1}$ N decreased yield for 15.6 %, which is also statistically very significant. With the lowest nitrogen amounts (N_{50}) in 2003, the root yield increased for 57 % in relation to control, which was high significant. By increasing nitrogen dose to 100 $kgha^{-1}$ (variant $N_{100}P_{100}K_{100}$) in relation to the previous variant the yield was increased for 6.97 tha^{-1}(11 %), however the difference wasn't statistically significant. Additionally 50 $kgha^{-1}$ of nitrogen (at variant $N_{150}P_{100}K_{100}$) decreased root yield for 1.85 tha^{-1} (2.6 %), that also wasn't statistically significant. The results of these investigations are in accordance with the results referred by Lawinski and Grzebisz *(2000),* Nenadić et al. *(2003)*, Marinković et al. *(2004)*.

The highest sugar beet tops' yields were accomplished at variants with the average or high nitrogen amounts and with the higher doses of P and K, accordingly at variants $N_{100}P_{150}K_{150}$ in 2002, and $N_{150}P_{150}K_{150}$ in 2003, respectively.

Against positive nitrogen effects on root and tops yield, its influence at technological root properties was negative (tab. 2). With increasing of nitrogen amounts, -amino-nitrogen and the other no-sugar matter amounts increased, which has negative effects on sugar utilization during root processing. A large number of authors quote results that indicated that by increasing of nitrogen amounts decreased the sugar content and get worse root quality traits for beet processing *(*Reiniefeld, Baumgarten (1975), Marinković et al. (2004).

Tab. 2. – Influence of different amounts of mineral fertilizers on root technological quality

Amount of fertilizer (kg ha^{-1})	Sugar content (%)		Content of –amino N (mmol 100 g $^{-1}$)		Content of Potassium (mmol 100 g $^{-1}$)		Content of Natrium (mmol 100 g $^{-1}$)	
	2002	2003	2002	2003	2002	2003	2002	2003
Ø	15.9	14.2	2.6	2.9	3.1	3.2	0.6	0.9
$N_{100}P_{100}$	15.1	12.3	3.6	3.7	2.4	3.1	0.7	0.9
$N_{100}K_{100}$	14.7	13.6	4.8	5.2	3.5	3.6	0.7	0.9
$N_{50}P_{100}K_{100}$	16.6	14.0	2.7	2.7	3.2	3.5	0.6	1.3
$N_{100}P_{100}K_{100}$	15.9	12.9	4.2	4.0	3.5	3.3	0.6	0.9
$N_{100}P_{150}K_{150}$	16.2	13.0	3.8	4.0	3.8	3.6	0.6	1.0
$N_{150}P_{100}K_{100}$	14.9	12.6	5.7	4.6	3.0	3.4	0.6	0.8
$N_{150}P_{150}K_{150}$	15.0	12.5	5.9	4.8	3.5	3.5	0.8	1.1
Average	15.5	13.2	4.2	4.0	3.2	3.4	0.7	1.0
LSD 0.05	0.9	1.2	0.8	0.8	0.5	0.5	0.2	0.5
LSD 0.01	1.2	1.6	1.0	1.1	0.7	0.6	0.3	0.7

The highest sugar content (16.6 %) in 2002 year was accomplished by fertilizing variant with the smallest nitrogen amount ($N_{50}P_{100}K_{100}$), and at control variant in 2003. The smallest sugar content was gained at variants $N_{100}K_{100}$ and $N_{100}P_{100}$, while follows variants with the highest nitrogen amounts. Šoltysova *(2003)* also quoted that the highest nitrogen amounts significantly decreased digestion (0,33 % averaged), and the refined sugar yield (for 0,38 %) in relation to unfertilized variant.

Intensively nitrogen fertilizing significantly influenced on increment of harmful nitrogen content in root: the highest content in 2002 have variants with the highest nitrogen amounts. In 2003 year the highest content of harmful nitrogen was obtained at variant $N_{100}K_{100}$, but higher content had fertilizing variants by the highest nitrogen doses. As we expect, the smallest amount of harmful nitrogen has control variant and variant with the smallest N amount (50 kgNha^{1}).

In both years the highest percentage of sugar utilization was accomplished at the variant fertilized with the smallest nitrogen dose ($N_{50}P_{100}K_{100}$) and at control variant. Increasing of nitrogen dose from 50 to 100, in other words using of 150 kgha^{-1}, causes significant decrease of sugar utilization.

Refined sugar yield in 2002 year was the highest at variant $N_{50}P_{100}K_{100}$. Variants with the smallest refined sugar yield were control variant and $N_{100}K_{100}$. Increasing of nitrogen amount had negative effect on refined sugar yield. The smallest N dose gave the sugar yield for 700 kgha^{-1} higher than the medium and 630kg ha^{-1} higher yield than the highest N dose. The highest sugar yield in 2003 year was accomplished at the variants with the medium amounts of all three nutrition ($N_{100}P_{100}K_{100}$).

In the spring, before nitrogen application, the amount of soil nitrate-nitrogen was monitored at all variants, as well as its influence on root yield and quality was determined by correlative analysis. The amount of NO_3-N in the soil before sugar beet sowing in 2002 significantly influenced on root and refined sugar yield (tab. 3).

Tab. 3. – Correlation coefficients between nitrat-nitrogen in soil and yield and some indices of technological quality of sugar beet

NO_3-N in soil layers		Koeficijent korelacije r - Correlation ratio					
		Root yield	Yield of aerial part	Digestion	-amino N	Sugar utilization	Rafined sugar yield
2002	0-120 cm	0.77*	0.67	0.10	0.35	0.02	0.72*
	0-30 cm	0.62	0.58	-0.06	0.28	-0.05	0.57
	30-60 cm	0.83**	0.78*	0.05	0.44	-0.09	0.65
	60-90 cm	0.72*	0.63	0.23	0.20	0.15	0.72*
	90-120 cm	0.55	0.36	0.18	0.25	0.13	0.68
2003	0-120 cm	0.21	0.60	-0.55	0.72*	-0.61	0.05
	0-30 cm	0.22	0.52	-0.27	0.52	-0.33	0.11
	30-60 cm	0.15	0.46	-0.40	0.51	-0.44	0.17
	60-90 cm	0.12	0.50	-0.47	0.66	-0.53	0.03
	90-120 cm	0.36	0.73*	-0.71*	0.83**	-0.75*	-0.12

The biggest influence at root yield had the amount of NO_3-N in the soil layer from 30-60 cm, (high significant correlation; r=0.83**), then in the layer 60-90 cm (r=0.72*). Hanačkova *(2003)* obtained the high correlation between the amount of mineral nitrogen in soil layer 0-60 cm and root yield. At sugar beet tops yield significant correlation obtained with the amount of NO_3-N in layer 30-60 cm, while at refined sugar yield the biggest influence had NO_3-N from soil layer 60-90 cm (r=0.72*). These results are in accordance with the results of Marinković et al. *(1994)*. According to them, root yield is depending from NO_3-N which is situated in the layer 30-60 cm, while the correlation with the NO_3-N amount in the layer 0-30 cm was negative.

During the spring 2003, the amount of NO_3-N in soil layer from 90-120 cm had significant positive effect at beet tops yield (r=0.73*) and at -amino nitrogen content (r=0.83**). Effect at sugar content (r=-0.71*) and percentage of sugar utilization (r=-0.75*) were negative. The total amount of NO_3-N (in the layer 0-120 cm) significantly influenced at increasing of -amino nitrogen. That plant alimentation isn't dependent only by sum of available N aspects, but and of their distribution in soil profile, quote Malešević et al *(1990)*.

Conclusion

The highest amounts of mineral fertilizers didn't produce at the same time the highest increase of root yield. The high dosage of all three mineral nutrients didn't statistically sustainable. Intensively nitrogen fertilizing significantly influenced on increment of harmful nitrogen content in root as well as on decreasing sugar content.

In both years the highest percentage of sugar utilization was accomplished at the variant fertilized with the smallest nitrogen dose ($N_{50}P_{100}K_{100}$) and at control variant. Increasing of nitrogen amount had negative effect on refined sugar yield.

Soil nitrate-nitrogen amounts and distribution have important influence at root yield and root quality traits, in the spring before sowing.

REFERENCES

1. Hanačkova, E. (2003): Zmeny anorganickeho dusika v pode a ich vplyv na urodu a kvalitu repy cukrovej. V celoslovenska vedecka reparska konferencia, Nitra, Zbornik vedeckej konferencie z medzinarodnou učastou, 176-179.
2. Lawinski, H., Grzebisz, W. (2000): Estimation of the effect of cultivation method and nitrogen rate on yield and quality of sugarbeet. Folia Universitatis Agriculturae Stetinensis, Agricultura, No. 84, 251-256.
3. Malešević, M., Bogdanović, Darinka; Spasojević, B. (1990): Primena azota u proizvodnji pšenice na bazi utvrđivanja sadržaja nitrata u zemljištu (N-min metoda). Savremena poljoprivreda, Vol. 38, br. 5-6, 579-585.
4. Marinković, B., Crnobarac, J., Balešević Svetlana (1994): Proizvodnja šećerne repe sa osvrtom na preduseve i mineralnu ishranu. Zbornik radova, Institut za ratarstvo i povrtarstvo, Novi Sad, sv. 22, 507-519.
5. 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, 373-378.
6. 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, 1-9.
7. Reiniefeld, E., Baumgarten, G. (1975): Verarbeitungseigenschaften der Zuckerube in Abhagigkeit vom Sticksoffangebot. Zucker, 2, Hanover, 61-65.
8. Sarić, M., Jocić, B. (1977): Proučavanje efekta mineralne ishrane šećerne repe. Savremena poljoprivreda, 11-12, 19-29.
9. Šoltysova, B. (2003): Učinok hnojenia na zmeny kvantitativnych a kvalitativnych parametrov repy cukrovej. V celoslovenska vedecka reparska konferencia, Nitra, Zbornik vedeckej konferencie z medzinarodnou učastou, 162-166.
10. Vučić, N. (1971): Bioklimatski koeficijenti i zalivni režim biljaka – teorija i praktična primena. Vodoprivreda, 6-8.

Received: March 21, 2008
Acceted: July 10, 2008

UTICAJ ĐUBRENJA I DISTRIBUCIJE NITRATNOG AZOTA U PROFILU ZEMLJIŠTA NA PRINOS I KVALITET KORENA ŠEĆERNE REPE

G. Jaćimović[1], B. Marinković[1], J. Crnobarac[1], Darinka Bogdanović[1], L. Kovačev[2] i D. Danojević[2]

Rezime

Dvogodišnja istraživanja uticaja rastućih količina NPK hraniva na prinos i kvalitet korena šećerne repe izvedena su na stacionarnom poljskom ogledu na Rimskim Šančevima. U proleće, pre primene N đubriva, praćena je količina nitratnog azota po slojevima zemljišta, te njegov uticaj na navedena svojstva. U obe godine, razlika u prinosu korena postignutog pri najvećim količinama NPK hraniva nije bila statistički značajna u odnosu na varijantu $N_{100}P_{100}K_{100}$. Povećanje količine azota delovalo je negativno na prinos rafinisanog šećera. Količina NO_3-N u zemljištu u proleće pre setve u 2002. godini imala je značajan pozitivan uticaj na prinos korena i rafinisanog šećera. U izrazito sušnoj 2003. godini visoki koeficijenti korelacije dobijeni su između količine NO_3-N u zemljištu i parametara kvaliteta korena, ali nisu bili značajni između količine azota i prinosa korena i rafinisanog šećera.

Primljeno: 21 mart 2008
Odobreno: 10 jul 2008

[1] mr Goran Jaćimović, asistent, dr Branko Marinković, red. prof., dr Jovan Crnobarac, red. prof., dr Darinka Bogdanović, red. prof., Poljoprivredni fakultet Novi Sad, Trg D. Obradovića 8, 21000 Novi Sad.

[2] Dr Lazar Kovačev, naučni savetnik, dipl. ing. Dario Danojević, Institut za ratarstvo i povrtarstvo, M. Gorkog 30., 21000 Novi Sad.