SUGAR BEET YIELD AND QUALITY DEPENDENCE ON FERTILIZING WITH NPK NUTRIENTS

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Abstract: *The experiment was conducted in the year 1965, on soil type chernozem, in Rimski Šančevi, AP Vojvodina, Republic of Serbia. It was organised as a four-field crop rotation. During the trial, 20 variants of fertilizing were studied (19 + control), with increasing quantities of NPK nutrients (50, 100 and 150 kg ha^{-1}). Total quantity of phosphorus and potassium, and ½ of nitrogen were applied in autumn. The remaining quantities of nitrogen were applied before sowing. Usual agronomy practices for sugar beet were applied. Due to the use of nitrogen root yield was increased by 6,33 t ha^{-1}, due to the use of phosphorus the increase in root yield was 4, 83 t ha^{-1}, and due to potassium the increase was 3,64 t ha^{-1}. The increase in nitrogen resulted in decrease of sugar content by 1,29 %, in phosphorus by 0,64 % and in potassium by 1,20 %. When fertilized with excessive NPK nutrients, the sugar yield was lower by 1.140 kg ha^{-1}. Only rational fertilizing can have a positive effect on achieving optimal results.*

Key words: *sugar beet, NPK fertilizing, yield*

INTRODUCTION

Sugar beet taproot production, yield and quality depend on numerous factors. Among several important factors, mineral nutrients have a dominant role. Until recently, it was considered that only excessive fertilizing with nitrogen can have a negative effect on sugar beet yield and quality. However, many authors point out that a surplus in phosphorus and potassium can also have a negative effect. MARINKOVIĆ et al. was one of the first to point out these problems in papers published in year 1998.

In order to achieve high and stable yields, utmost attention should be given to agronomy practices. The yield height is determined by the production factor that is in deficit, but nutrients that are in surplus can also significantly decrease the yield. Due to this specificity in production and its high demands, sugar beet is often referred to as “queen of the fields”. This crop has the ability to transform high amounts of sun kinetic energy to organic matter energy. This is why sugar beet is highly dependent on production factors!

MATERIAL AND WORK METHOD

The experiment was conducted on a long-term stationary trial in Rimski Šančevi, in Institute of Field and Vegetable Crops. It was conducted on soil type černozem, subtype on loess, variety carbonate, form medium deep.

The trial was set up in year 1965 as a four-field crop rotation, with following crops rotating: sugar beet, corn, sunflower, wheat. Field size is 2 ha. During the trial, 19 variants of fertilizing with NPK nutrients were studied and a control variant without fertilizing. The examined quantities of nutrients are: 50, 100 and 150 kg ha^{-1}. Basic plot size was 176 m^2.

The examined variants are the following:

1) Ø

2) N 100
3) $P_2 O_5$ 100
4) $K_2 O$ 100
5) N 100 P_2O_5 100
6) N 100 K_2O 100
7) P_2O_5 100 K_2O 100
8) N 50 P_2O_5 50 K_2O 50
9) N 50 P_2O_5 100 K_2O 50
10) N 50 P_2O_5 100 K_2O 100
11) N 100 P_2O_5 50 K_2O 50
12) N 100 P_2O_5 100 K_2O 50
13) N 100 P_2O_5 100 K_2O 100
14) N 100 P_2O_5 150 K_2O 50
15) N 100 P_2O_5 150 K_2O 150
16) N 150 P_2O_5 50 K_2O 50
17) N 150 P_2O_5 100 K_2O 50
18) N 150 P_2O_5 100 K_2O 100
19) N 150 P_2O_5 150 K_2O 100
20) N 150 P_2O_5 150 $K_2 O$ 150

The planned quantities of phosphorus, potassium and ½ of nitrogen were applied in autumn, before basic soil tillage. The remaining quantities of nitrogen are applied before sowing. During the experiment, sowing was conducted in second and third decade of March. During the vegetation period, standard nourishing methods were applied. Hybrid variety NS Hy8R was examined in trial. The harvest was in October. Root yield was measured, and sugar content was determined in laboratory, as well as harmful K, Na and α-amino N. Sugar use efficiency and sugar yield were calculated.

Results were processed using the ANOVA.

RESULTS AND DISCUSSION

Table 1 shows root yield, sugar content, sugar use and sugar yield on triple NPK variants. Double and single variants of fertilizing will not be analysed in this paper. When fertilizing with 50 kg N ha^{-1}, the increased quantities of P and K nutrients (by 50 kg ha^{-1} each) did not have major impact on yield growth. Slight growth of 2,1 t ha^{-1} was recorded with the increase of phosphorus from 50 to 100 kg ha^{-1}. When 100 kg N ha^{-1} was used, a noticeable growth was recorded only when quantity of nitrogen increased from 50 to 100 kg ha^{-1} (an increase of 3,36 t ha^{-1}). Next increase of phosphorus to 150 kg ha^{-1} increased the yield by 6,35 and 2,99 t ha^{-1} compared to 50 i 100 kg P ha^{-1}. First difference (between 50 and 150 kg P_2O_5 ha^{-1}) is significant. Next difference of 2,99 t ha^{-1} is not significant. When fertilizing with 150 kg N ha^{-1}, the increased quantity of phosphorus had no significant on yield increase (0,87 t ha^{-1}).

Numerous papers concerning the effects of fertilizing with phosphorus and potassium on sugar beet root yield have been published. SARIĆ ET AL. (1999); ŽERAVICA (1971 I 1972); JOCIĆ (1986) and most authors emphasize the positive effect of increased quantities of phosphorus, and especially potassium on yield. However, MARINKOVIĆ et al. (1998) points out that a surplus in phosphorus and potassium can have a negative effect on yield. This is also confirmed in later studies of MARINKOVIĆ et al. (1998)

Table 1

Root yield and sugar beet quality, hybrid HyR8

Fertilizing variant		*Root yield (t/ha)*	*Sugar content (%)*	*Sugar use efficiency (%)*	*Consumable sugar (t/ha)*
Ø		37,08	17,06	15,40	5,65
$N_{50}P_{50}K_{50}$		48,09	16,84	15,10	7,21
$N_{50}P_{100}K_{50}$		50,19	16,96	15,24	7,64
$N_{50}P_{100}K_{100}$		50,86	17,27	15,47	7,80
$N_{100}P_{50}K_{50}$		51,28	16,51	14,67	7,44
$N_{100}P_{100}K_{50}$		54,64	16,66	14,83	8,00
$N_{100}P_{100}K_{100}$		55,18	16,62	14,75	8,07
$N_{100}P_{150}K_{50}$		57,63	16,65	14,84	8,51
$N_{100}P_{150}P_{150}$		57,56	16,42	14,50	8,33
$N_{150}P_{50}K_{50}$		55,93	16,05	14,23	7,86
$N_{150}P_{100}K_{50}$		56,24	16,07	14,17	7,86
$N_{150}P_{100}K_{100}$		56,80	15,56	13,66	7,70
$N_{150}P_{150}K_{100}$		55,48	15,70	13,97	7,63
$N_{150}P_{150}K_{150}$		55,74	15,28	13,33	7,37
LSD	**1%**	**4,95**	**0,54**	**0,66**	**0,72**
	5%	**3,72**	**0,46**	**0,50**	**0,54**

These results show that the yield in all variants with fertilizing was higher than that in control variant. All authors mentioned in this paper made the same observation!

Despite the increase in yield, fertilizing had a negative effect on sugar content. The only exception was variant N 50 P_2O_5 100 K_2O 100, in which the sugar content was increased by 0,21% compared to control variant. Positive effect of increased quantities of P and K nutrients on sugar content was recorded only on variant with 50 kg N ha^{-1}. When fertilized with 100 kg N ha^{-1}, the increased quantity of phosphorus had a slight effect on increase of sugar content (0,15 and 0,14 %). When fertilized with 150 kg N ha^{-1}, the increased quantities of phosphorus and potassium resulted in lower sugar content (from 0,35 to 0,77 %).

On all variants after N 100 P_2O_5 150 K_2O 50 the sugar content was significantly lower. On variant with 150 kg N ha^{-1}, the content of nitrogen was significantly lower compared to other variants of fertilizing.

Sugar use efficiency depends on fertilizing the same or similarly as sugar content does, especially when fertilizing with 50 kg N ha^{-1}. When fertilized with 100 kg N ha^{-1} the increase of phosphorus resulted in better sugar use (by 0,16 and 0,17 %). When fertilized with 150 kg N ha^{-1} the increase of phosphorus and potassium resulted in the decrease of sugar use (by 0,06 and 0,90%).

The sugar yield was highest on variants with 100 kg N ha^{-1}, and the absolute highest (8,51 t ha^{-1}) was on variant N 100 P_2O_5 150 K_2O 50. On this variant, the yield was significantly higher compared to all other variants. Compared to this variant, on variant with 150 kg ha^{-1} NPK nutrients, the yield was lower by 1.140 kg ha^{-1}, despite using 50 kg N ha^{-1} and 100 kg K_2O ha^{-1} more.

Table 2 shows the same examined parameters for different quantities (50, 100 and 150 kg ha^{-1}) of individual N, P, K nutrients on average independent to other two nutrients.

Table 2

Sugar beet yield and quality at average quantities of individual nutrients, hybrid HyR8

Fertilizing variant		*Root yield (t/ha)*	*Sugar content (%)*	*Sugar use efficiency (%)*	*Consumable sugar (t/ha)*
N_{50}		49,71	17,02	15,27	7,55
N_{100}		55,26	16,57	14,72	8,07
N_{150}		56,04	15,73	13,87	7,68
P_{50}		51,77	16,28	14,45	7,65
P_{100}		53,99	16,44	14,58	7,89
P_{150}		56,60	15,80	13,93	7,78
K_{50}		53,01	16,48	14,66	7,89
K_{100}		54,58	15,96	14,13	7,80
K_{150}		56,65	15,28	13,33	7,37
LSD	**1%**	**4,95**	**0,54**	**0,66**	**0,72**
	5%	**3,72**	**0,46**	**0,50**	**0,54**

With the increase of nitrogen, the root yield increased up to 150 kg N ha^{-1}. However, the difference is significant only between 50 and 100 kg N ha^{-1} (5,55 t ha^{-1}). Following increase in nitrogen did not have a significant influence on increasing the root yield (0,88 t ha^{-1}).

In literature, one can find different results about optimal quantities of nitrogen. KRIVUSUDSKA et.al. (2003) states that optimal quantity of nitrogen was 80 kg N ha^{-1}. MARINKOVIĆ et al. (1998; 2012) states that optimal quantity was 100 kg N ha^{-1}, and so does JAĆIMOVIĆ ET AL. (2005). NOWAK et.al. (2002) states that optimal quantity of nitrogen was 180 kg N ha^{-1}, similar to results obtained by SARIĆ AND JOCIĆ (1993).

With further increase of nitrogen, the sugar content and efficiency is decreasing, the differences between the examined quantities of nitrogen were significant.

All authors agree that with further increase of nitrogen the sugar content is decreasing, as well as sugar use efficiency. MILOŠEVIĆ AND STEFANOVIĆ (1984), NENADIĆ ET AL. (1990 I 2003), MARINKOVIĆ ET AL. (2004), JAĆIMOVIĆ ET AL. (2008) came to these results. The fact that phosphorus and potassium, when in surplus, can have negative effects on sugar beet yield and quality is highlighted by MARINKOVIĆ et al. (2003; 2006; 2011).

Sugar yield increases up to 100 kg N ha^{-1}, specifically by 520 kg ha^{-1}, and further increase in nitrogen (150 kg N ha^{-1}) resulted in a decrease of sugar yield by 390 kg ha^{-1}.

Fertilizing with phosphorus and potassium, had an effect on the increase of root yield, on average. With phosphorus the increase was 2,22 and 2,61 t ha^{-1}, and with potassium 1,57 and 2,07 t ha^{-1}. This means that phosphorus had greater impact on increasing root yield.

Sugar content and use efficiency increased (0,16 and 0,13%) with the increase of phosphorus up to 100 kg ha^{-1}. It is the same with sugar content (an increase up to 240 kg ha^{-1}). Higher quantity of phosphorus (150 kg ha^{-1}) had a negative effect on sugar content (-0,32 %), use efficiency (-0,65 %) and sugar yield (-110 kg ha^{-1}).

When the quantities of potassium increased, the sugar content decreased by 0,52 and 0,68 %, use efficiency was lower by 0,53 and 0,80 %, sugar yield was lower by 90 and 520 kg ha^{-1}.

Irrational fertilizing has negative effects on sugar yield, which is emphasized by following authors: JAĆIMOVIĆ ET AL. (2005, 2008), RADIVOJEVIĆ (1981), MARINKOVIĆ ET AL. (2001, 2004, 2011), POSPIŠIL (2004), CAMPBELL (2002).

Results in these studies match the results of MARINKOVIĆ et al. (2001, 2006, 2007, 2011), who has warned about harmful effect of surplus phosphorus and potassium for years.

Only optimal mineral nutrition leads to the desired goals, which are good taproot yield and quality.

We must nourish our crops in order to preserve our soil.

CONCLUSION

Based on above mentioned results, the following is concluded:

- Phosphorus had greater positive effects (4,83 t ha^{-1}) on root yield than potassium (3,64 t ha^{-1}).
- The increase of root yield when nitrogen was applied was 6,33 t ha^{-1} on average.
- Optimal quantity of phosphorus (100 kg ha^{-1}) and potassium (50 kg ha^{-1}) changes with different quantities of nitrogen.
- The sugar content decreased with the increase of NPK nutrients.
- The use nitrogen resulted in decrease of sugar content by 1,29 %, phosphorus by 0,64 % and potassium by 1,20 %.
- With the increase of nitrogen sugar use efficiency decreased by 1,40 %, phosphorus by 0,65 % and potassium by 1,33%.
- Sugar yield was highest (8,51 t ha^{-1}) on variant N 100 P_2O_5 150 K_2O 50 kg ha^{-1}.
- High quantities of NPK nutrients (by 150 kg ha^{-1}) resulted in the decrease of sugar yield by 1.140 kg ha^{-1}.
- Irrational nitrogen fertilizing leads to a decrease of sugar yield by 390 kg ha^{-1}, phosphorus by 110 kg ha^{-1} and potassium by 520 kg ha^{-1}.

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