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SUGAR BEET YIELD PARAMETERS ON CARBONATE CHERNOZEM SOIL TYPE

SUMMARY

In the three year trials tested yield and quality of five sugar beet genotypes. According to results, highest average weight of root ($\overline{X}$ =1.13 kg), as well as highest value of root mass (X_{max}=1.35 kg) was recorded by variety Otis. Variation in yield by varieties was statistically significant. Highest yielding varieties were Chiara and Otis. Highest yielding variety Chiara had 97% higher yield than variety Severina, 36.76 t ha^{-1}. Highest digestion individual and in average, have had varieties Severina and Irina while the lowest was variety Otis. Highest digestion stability had variety Irina (Cv=2.52%). Quality, namely technological root value largely depends of genotype. Coarseness of the root was in inverse proportion to the content of sugar.

Key words: sugar beet (*Beta vulgaris*), variety, yield, technological root value

INTRODUCTION

Sugar beet (*Beta vulgaris ssp. esculenta var.saccharifera* L.) is relatively young plant although to the garden herb known for more than 3000 years. The commercial production was introduced in Germany in XVIII century. First processing plants were made in Russia and Germany (Schlezing province) at same time. Sugar beet is transferred to America in 1838. In Serbia sugar beet starts to cultivate at the end of the XIX and beginning of XX century. In 1898 first sugar refinery was built in Belgrade. Sugar beet is cultivated for its thick root which contains sugar – sucrose in amount of 15-18%. 70% of total biomass of plant belongs to thick root while 30% are above-ground organs – heads (shorted trunk) and leaves (*Glamočlija*, 1986).

Root consists in average of 75-80% water and 20-25% of dry matter. The largest part of dry matter belongs to soluble sugars 16-19%. On second place is cellulose with 4-5% and after them are mineral salts 1.5%, nitrogen matters 1,5% and oils 0,2% (Bojovic 2014). Sugar is not evenly distributed in root mass. Its biggest percentage is in central part around fourth and fifth cambial ring. Average content of sugar – digestion in sugar beet root is 15-18%, even so there

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are some varieties with 25% sucrose. Coarseness of root is inverse proportion with sugar content. Beside main product – sucrose, on different technological procedures from crop residue we get after processing a lot of different products. Heads and leaves which remain in the field, have high nutritional value because they content 13% dry matter of which 6.8% BEM 2.4% total proteins, 2.4% mineral salts, 0.9% cellulose and 0.5% oil (Glamočlija, 1990). Chemical composition of root varies depending on shares of applied nutrients, and also on genotype (Kuzevski at al., 2008). Beet pulp and beet molasses, as side products of sugar beet processing are very prized as a food for domestic animals or as a raw material for further industrial processing. Dry pulp contains 8.5% total proteins, 0.4% oil, 58% BEM, 17% cellulose, 4.8% mineral salts, and 12% water (*Lüdecke*, 1953). As animal food dry pulp is used in fresh state, then for silage making or as a dried or briquetted. Molasses of residual syrup is suitable for domestic animal feed. It is easily digested and higher nutritional value then wheat bran. Chemical composition of molasses depends of technological value of the root and perfection of technological procedure of sugar beet processing. Molasses contains 48-52% total sugar, 10-12% total proteins, 8-10% mineral salts, 17-20% water, vitamins B_1, B_2 and B_3, microelements, zinc, iodine, cobalt and iron (Filipović, 2009).

Sugar beet is one of most important plants for industrial processing and its products as a raw material for other industries. Agro-ecological and soil conditions as well as applied cultural practices have equal impact on root yield and quality of root (*Cambell and Kern,* 1982 and 1983; *Glamočlija and Rekanović,* 1990, *Glamočlija*, 1990). Quality, namely technological value of the root depends on sort, but also on interaction of sort, mineral nutrition, thickness of crops and time of root extraction *Čačić* et al, 1997; *Jaćimović et al,.* (2006); *Kovačev et al.,* (2006); *Pejić et al*. (2010); *Bojović* (2014); *Dobrovnaya et al.* (2009); *Filipović et al.* (2007, 2009). *Rosso and Candolo* (2001) conclude that meteorological conditions at vegetation period have very important impact on genetic potential of variety fertility.

Aim of this research was to examine parameters of fertility of tested varieties of sugar beet in dry land farming conditions.

MATERIAL AND METHODS

Studding influence of genotype on productive property of sugar beet was preformed 2007, 2008 and 2009 in agro-ecological conditions of South Banat on experimental fields of PSS institute “Tamis”. Objects of study were five genotypes of sugar beet: Otis, Chiara, Lititia, Irina and Severina. Sort Otis, produced by Strube – Dickman is designed for medium terms of extraction. Lititia and Severina produced by KWS are recommended for medium terms of extraction. Sort Chiara produced by KWS, is tolerant on dry conditions and recommended for medium and late terms of extraction and Irina produced by Institute of Field and Vegetable Crops, Novi Sad; NS seed has good balanced yield of root and sugar contents and it is recommended for late term extraction.

The experiment was set in a randomized block – system in four replications. Preceding crop every year was wheat. Soil treatment was performed twice (August and October). Seedbed preparation and sowing were at the end of March. Care and protection of crops were standard. Samples of roots taken from experimental fields were processed in laboratory of sugar refinery in Kovacica.

Samples are taken for determination of root yield and aboveground biomass from experimental parcels, recalculated per hectare. The data were analyzed by STATISTICA 10 for Windows statistical method.

Soil conditions. Soil where the experiments were performed is of carbonate chernozem type formed on loess terrace. In texture is loam. According to chemical analyses of soil, we got a conclusion that trials in every of this three year have been conducted on land that is uniform production traits and high natural fertility. pH reaction of soil is weakly alkaline. Soil is humus and very calcareous. Percentage share of humus in top layer of soil is 3.5% while increasing depth shows decreasing of humus content. This is typical carbonate soil reaching $CaCO_3$ which content increase by increasing of depth. Total nitrogen, in average, was over 0.2% in content, corresponding medium amounts in soil. It is also medium provided in easily accessible phosphorus and potassium, table 1.

Table 1. Agrochemical properties of soil (2007-2009)

year	depth cm	pH in KCl	$CaCO_3$ %	Humus %	Total N %	P_2O_5	K_2O
						mg/100g	
2007	0-30	7.44	11.60	3.57	0.203	27.30	17.70
	30-60	7.50	15.16	3.26	0.194	17.10	12.10
2008	0-30	7.46	11.50	3.51	0.205	27.30	17.90
	30-60	7.50	15.11	3.26	0.195	17.20	12.40
2009	0-30	7.46	11.90	3.56	0.203	27.70	17.70
	30-60	7.50	15.14	3.26	0.192	17.50	12.50

Meteorological conditions. Beside soil conditions, meteorological conditions have also large impact on plant growing (Popović, 2010, Malešević et al., 2010, Kolarić et al., 2014). Meteorological conditions during this research were at long-term average and significantly higher than plant conditionally–optimal needs, table 2.

Table 2. Average air temperature of sugar beet vegetation period, ^{o}C

Year	2007	2008	2009	(1999-2009)	Optimal value
I period (4., 5. month)	17.10	16.60	17.80	16.30	10.70
II period (6.,7.,8. month)	24.70	23,40	22.60	23.10	18.80
III period (9., 10. month)	17.50	18,40	18.90	18.20	16.50
Vegetation period	18.20	18.00	18.10	17.60	15.30

Total and monthly precipitation varied a lot by year. Smallest precipitation was in 2008 and highest in 2009 (table 3).

Table 3 Average precipitation of sugar beet vegetation period, mm

	2007	2008	2009	(1999-2009)	Optimal sum
I period (4. 5. month)	80	82	62	109	90
II period (6.7.8.month)	128	143	296	209	225
III period (9.10. month)	176	106	83	115	65
Vegetation period	384	331	440	426	380
Winter period	356	240	437	244	240

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RESULTS AND DISCUSSION

Root mass. According to research obtained results, highest average root mass ($\bar{X}$ = 1.13 kg), as well as highest individual value of root mass (X_{max} = 1.35 kg) were achieved by Otis. Severina had lowest average value of this indicator ($\bar{X}$ =0.54 kg), table 4, figure 1.

Table 4 Descriptive statistic for root mass (kg) of studied sorts

Variety	$\bar{X}$	X_{min}	X_{max}	$S_{\bar{x}}$	S	Cv (%)
Otis	1.13	0.76	1.35	0.06	0.19	16.56
Chiara	0.93	0.71	1.07	0.04	0.11	11.86
Laetitia	0.70	0.48	0.98	0.06	0.19	26.65
Irina	0.60	0.41	0.75	0.04	0.11	19.11
Severina	0.54	0.46	0.62	0.02	0.05	9.36

Varying data within varieties was quite high, which is shown by interval of variation coefficient (Cv) and it was in interval of 9.36% < Cv < 26.65%. Higher dispersion of root mass value had Laetitia, and it is showing that this variety is most sensitive when root mass is in matter and lowest dispersion had variety Severina (9.36%).

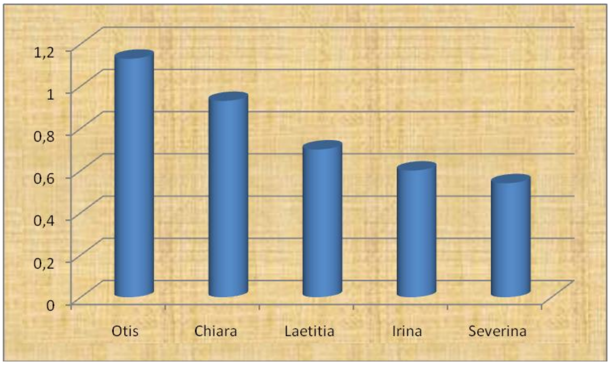

Figure 1. Average root mass (kg) of studied sugar beet varieties, 2007-2009.

Root yield. Three year yield average has been highest by Chiara, 72.58 t ha^{-1} as well as individual yield value (X_{max}= 84.00 t ha^{-1}) and it is shown on table 5 and figure 2.

Table 5. Descriptive statistic for sugar beet yield, t ha^{-1}

Variety	$\bar{X}$	X_{min}	X_{max}	$S_{\bar{x}}$	S	Cv (%)
Otis	64.55	37.50	78.83	4.91	15.52	24.04
Chiara	72.58	55.50	84.00	3.00	9.49	13.08
Laetitia	52.16	28.13	72.80	5.08	16.08	30.82
Irina	45.58	34.10	61.70	2.76	8.74	19.17
Severina	36.76	31.70	42.73	1.10	3.48	9.47

Varying of root yields by varieties was significant statistically. Highest yielding variety Chiara had 97% higher yield than Severina, 36.76 t ha^{-1}.

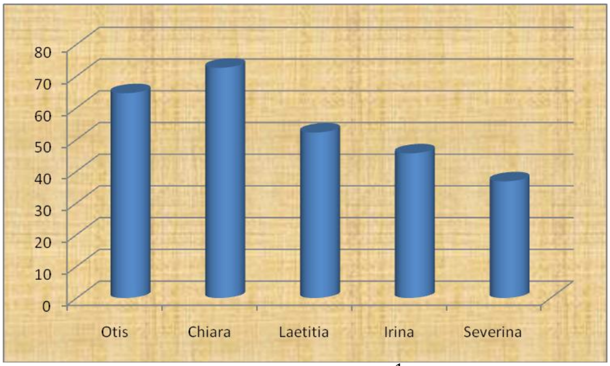

Figure 2. Average root yield (t ha^{-1}), of studied sugar beet varieties, 2007-2009.

The data varying within varieties was quite high which is shown by variation coefficient (Cv) interval that is between 9.47% < Cv < 30.82%. Highest dispersion of root yield value had Laetitia and it shows that this variety is most sensitive when yield is in matter, and lowest dispersion was at variety Severina (9.47%).

Total sugar content (digestion). Highest digestion had varieties Severina (18.79%) and Irina (18.19%). Severina also had highest individual percentage of sugar, X_{max}= 19.50 %, while Otis had lowest values of digestion ($\bar{X}$ = 13.43% and X_{min} = 12.88%). The data dispersion within varieties was low and it shows that material was homogeneous (table 6, figure 3).

Table 6. Descriptive statistics for digestion, %

Variety	$\bar{X}$	X_{min}	X_{max}	$S_{\bar{x}}$	S	Cv (%)
Otis	13.43	12.88	13.94	0.13	0.42	3.10
Chiara	16.26	15.52	17.24	0.16	0.50	3.10
Laetitia	14.88	13.84	17.03	0.30	0.94	6.33
Irina	18.19	17.30	18.78	0.14	0.46	2.52
Severina	18.79	17.83	19.50	0.18	0.58	3.07

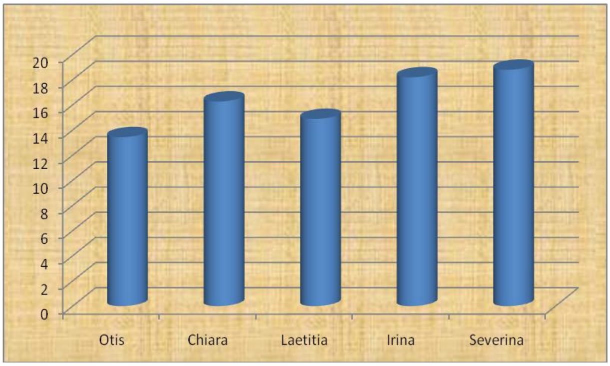

Figure 3. Average digestion (%), of studied sugar beet varieties, 2007-2009.

All varieties had stable digestion. Highest stability had variety Irina (Cv = 2.52%). Digestion variability measured by variation coefficient (Cv) was in interval of 2.52% < Cv < 6.33% (table 6).

Quality, named technological value of root was in high dependence of genotype. This research shows that coarseness of the root was in inverse proportion with sugar content. Variety Otis had extremely high yield but lowest digestion while varieties Severina and Irina had lowest root yield but highest digestion.

Lots of factors have influence on yield and quality of sugar beet root: agro-climatic conditions, soil (the composition, structure and processing), irrigation, sowing, crops care and protection. Proper variety choice and plant nutrition have also great influence on yield growing without reducing the technological value of root.

Beside its adaptability to climatic conditions, sugar beet has quick response on meteorology factor changes which greatly have influence on root yield and sugar content. Good yield required mean temperature of 15.3-16.4°C. Klenter (2006) in his experiments, finds that optimum is 18°C, high temperature in July and August reduce final yield, but, at the and of season, plant growth does not depends of thermal conditions. Air surplus moisture leads to reduction of transpiration and productivity and in technological maturity period, it has negative influence on sugar accumulation. Sugar beet has great needs for water which provides over ¾ of its yield. It is considered that representation of sugar beet in crops rotation depends of reon humidity.

Sugar beet has great needs relative to soil. Stabile yields could be possible expected only in good nature fertility soils with favorable texture, deep topsoil layer, optimal physical and chemical properties, good water regime and neutral to slightly alkaline reaction. Using of machinery for soil and transport could bring structure damage and prolonged negative effect on next crop growing (Glamoclija, 1990).

Proper sort choice at certain production area, contribute higher and stabile production of grown plants. Some of easily visible differences between sugar beet sorts are growth rhythm and capability of using vegetation area for making higher sugar beet yield. They, at a great extent, differs in term of plant stature for its rentable processing in sugar. Some sorts have property to extend their period of vegetation and, in autumn, produce the great deal of organic matter.

From economic aspect, it is justified growth of sorts that belong to all of three types: normal types, types with high yield and types with high sugar content. In the proposition of production process for sugar beet, Stanacev (1976) proposed that in Vojvodina they should sow 25% of the high sugar content type, 40% of the normal type, and 35% of the high yield type. According to previous experience, high sugar content types are processed economically at the very beginning, normal type in the middle and high yield type near the end of the processing period. With the proposed ratio of the types in the total amount of sown surface, a possibility is created for beet to be gradually collected from the field and processed, according to its technological maturity for processing. That kind of combining of the types enables good digestion from the very beginning of the processing and at the same time a successive sowing of winter grains on the beet field.

In favourable weather conditions in autumn the growth of sugar beet and the amount of sugar in it are the highest in the high yield type, mediocre in normal, and the lowest in high sugar content type. For more cost-effective gradual growing and processing of beet it is necessary to grow varieties that have different maturity period. Participation of types in the total sown surface could be approximately like this: 20% of the high sugar content type, 50% of normal type and 30% of high yield type, but every producer has to independently determine the ratio based on his own organizational and economic possibilities (Stanacev, 1979).

For a type to show its best production results in various agro-ecological conditions it has to have higher adapting capability and value that ensures its representation on a wider area. Due to already featured need for successive extraction of sugar beet it is useful to test the dynamic of their technological maturing. Cambell and Kern (1982) state that the year has more influence on the quality parameters of sugar beet in relation to region, while the interactions of variety x year and variety x locality were very similar for the yield of root.

The quality of sugar beet is a complex feature conditioned by genetic differences between the varieties and various conditions of the outside environment in the region of the growing (Rosso and Condolo, 2001).

As with all grown plants there is a correlation between genotype and external environment (Cacic, 1997). The sugar and non-sugar material content depends on ecological conditions and applied agro-technology, but all these features are at the same time important characteristics of every variety (Cacic, 2000). By using the plants that are bio-technological altered, we can achieve higher yields, reduce the usage of pesticides, reduce erosion and improve the quality of underground waters (Stojsin, 2008). Thanks to the results of fundamental science, more often than in the other grown plants, in sugar beet there had been a few instances of complete changes of genetic composition of the grown variety of sugar beet. Every change led to increase of genetic potential for yielding for most important quantitative characteristics or to increase in cost-effectiveness and profitability of production. Breeding of the sugar beet in the Institute of Field and Vegetable Crops in Novi Sad, effectively followed European and world trends in the sense of creating variety that, by its characteristics, weren't lagging behind the varieties of multinational companies. In the past few years the increase in yield potential that is owed entirely to the improved genotype represents a huge success of domestic genetics and breeders of sugar beet.

One of the most important agro-technical measures in the production of sugar beet is sowing. The right sowing provides optimal crop density and high yield. In our region the sowing of sugar beet is done in second half of March. The thermal conditions can be unfavorable and unstable so it is necessary to know the features of seed and seedlings relative to possible unfavorable conditions in the soil during sowing time, germination and emergence of seedlings Glamoclija (1990).

Results that Glamoclija (1990) got show great dependence between yield of sugar beet and crop density. In above mentioned researches the density tested was 60.000, 80.000, 100.000, 120.000 and 140.000 plants per hectare, with 2 types of sugar beet with different levels of nutrition in plants. With the increase of crop density and the amount of mineral feed, the amount of sugar in root gradually decayed, while the amount of "harmful" nitrogen has increased. The types reacted differently on the increase in crop density and the level of nutrition, where with the increase of the root yield, the share of the root in the total yield decreased. Filipovic et al. (2007) deducted that the higher number of plants per unit of surface influenced the increase in yield of the root of sugar beet. Therefore at the highest density (120.000 plants per hectare) the highest yield was achieved, which was on average around 5.6% higher than the yield gotten at the lowest density. The highest yield of crystal sugar, 12.34 t ha-1, was at the density of 120.000 plants per hectare, and the lowest at the density of 100.000 plants per hectare.

For a good yield the proper protection of the crops is of utmost importance. The proper protection is made by repetitive usage of chemicals on the seeds and young plants. Repression with herbicides is justified only if it achieves high yields (Ivanovic et al., 1999). The most common diseases on sugar beet are caused by pathogens Cercospora and Rhizomania which have to be repressed with chemical compositions. In the absence of chemical treatments leaf mass can totally collapse which leads to total loss of the yield (Rossi, 2000). In our region during the larger attack of parasites the content of the plants is reduced by 1-2 (Stojsin, 2008). Kuzevski et al. (2000) in the experiments performed between 1996 and 1997 determined that at the intolerant variety the yield was lower by 30.94 t ha-1 and the sugar content by 3.31%. The listed researchers came to a conclusion that based on the monitoring of chemical composition of the root's juice an existence of Rhizomania attack can be affirmed, but this is not the most certain of indicators.

In numerous researches it is established that intensive nutrition of the plants, mainly with nitrogen, increases yield significantly, but also a large significance in the achievement of high yields has the right choice of genotype. When it comes to the intensity of nutrition with individual elements most authors agree that nitrogen is bearer of the root yield.

According to the results listed by Glamoclija (1986) by using 120 kg ha-1 of nitrogen the yield and technological value of root are greatly increased. In the works of Saric (1988) it is determined that the yield of root of sugar beet increases with increase of the nitrogen amount up to 150-160 kg ha-1 and further increase of this nutrient had for a consequence decrease of yield of root and specifically the sugar content in it.

For proper system of plant nutrition the most efficient as well as the most expensive agro-technical measure, it is necessary to properly determine the needed amount of some assimilative maters, types of mineral nutrients, method and time of usage, as well as to choose the most appropriate sorts for growing in agro-ecological conditions of our most important areas for sugar beet.

In choosing the right sorts for growing in a specific production area more types should be chosen, that differ in the time of maturity. Technological maturity period (period of optimal usage of sugar from beet) is not at the same time of year for every type. High sugar content types are cost-effectively processed earlier, so they can be extracted earlier. Normal type sorts are corresponding to a middle extraction period, while the high yield type reach optimal technological maturity near the end of the extraction period, so they should be extracted in the end (Stanacev, 1979)

CONCLUSIONS

– According to research results, highest root mass average ($\overline{X}$ = 1.13 kg), as well as highest value of root mass (X_{max} = 1.35 kg) was by variety Otis.

– Root yield vary a lot between examined sugar beet varieties. Highest individual (84.00 t ha^{-1}) and average (72.58 t ha^{-1}) value of root yield had Chiara. Lowest individual value of root yield (X_{min}= 28.13 t ha^{-1}) had Laetitia while lowest average value had *Severina* (36.76 t ha^{-1}).

– Highest digestion, average and individual, had varieties Severina and Irina, and smallest, in average, variety Otis. Highest digestion stability had variety Irina (Cv = 2.52%).

– Variety (genotype) had very significant influence on vary of sugar digestion, statistically.

– Quality, namely technical value of root, largely depends of genotype.

– This research has showed that coarseness of root was in inverse proportion with sugar content.

– Variety Otis have had very high sugar beet yield but also a smallest digestion, while varieties Severina and Irina have had lowest sugar yield but highest digestion.

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PARAMETRI RODNOSTI SORTI ŠEĆERNE REPE NA ZEMLJIŠTU TIPA KARBONATNI ČERNOZEM

SAŽETAK

U trogodišnjim ogledima ispitivan je prinos i kvalitet pet sorti šećerne repe. Prema dobijenim rezultatima istraživanja, najveća prosečna masa korena ($\overline{X}$ =1,13 kg), kao i najveća vrednost mase korena (X_{max}=1,35 kg) ostvarene su kod sorte Otis. Variranja prinosa korena po sortama bila su statistički značajna. Najprinosnije sorte bile su Chiara i Otis. Najprinosnija sorta Chiara dala je za 97 % veći prinos u odnosu na sortu Severina, 36,76 t ha^{-1}. Najveću digestiju pojedinačno i u proseku imale su sorte *Severina i Irina*, a najmanju, sorta *Otis*. Najveću stabilnost digestije imala je sorta Irina (Cv=2,52%).

Kvalitet, odnosno tehnološka vrednost korena u velikoj meri zavisi od sorte. Krupnoća korena bila je u obrnutoj proporciji sa sadržajem šećera.

Ključne reči: šećerna repa (*Beta vulgaris*), sorta, prinos, tehnološka vrednost korena.