AGRONOMICAL AND ENVIRONMENTAL FACTORS AFFECTING SUGAR BEET YIELDING IN CENTRAL AND EASTERN POLAND

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In many three year-factorial experiments and on-farm experiments the following agronomical factors: varieties, soil tillage, quality of seed material, kind and date of sowing, plant density, rate N, P, K, irrigation, foliar fertilization, harvest date, length of vegetation period were studied. Three traits of sugar beet crop: root yield, sucrose content, technological sucrose yield were observed. The factors which effects on investigation traits were the largest were: years, soil quality, length of vegetation period, sowing date and N rate. Relatively large effects were caused by plant density and its regularity. The results obtained on-farm experiments were similar to those proved in factorial experiments.

sugar beet; root yield; sucrose content

INTRODUCTION

To the most important factors controlling sugar beet yield and its quality belong sowing and harvest date affecting length of vegetation (Krasucki, 1981; Krzymuski, Laudanski, 1995; Roszkowska, 1998; Smit, 1993; Wyszynski, 1986, 1997), fertilization N, P, K (Dunham, 1991; Gutmanski, Nowakowski, 1994; Kalinowska-Zdun, 1974; Krzymuski, Laudanski, 1995; Nowakowski, Krüger, 1997; Pawelec, Malicki, 1987; Rozbicki, Kalinowska-Zdun, 1993) and plant density (Kalinowska-Zdun, 1974; Roszkowska, 1998; Rozbicki, Kalinowska-Zdun, 1991, 1993; Wyszynski, 1997).

In the Department of Crop Production at Warsaw Agricultural University the studies on sugar beet have been conducting since 1962. In this period many three year-factorial experiments and on-farm experiments were done. The most important factors like varieties, soil fertility, soil tillage, quality of seed material, kind and date of sowing, plant density, rate N, P, K, irrigation, foliar fertilization, harvest date, length of vegetation period were included. The following traits of sugar beet crop: root yield, sucrose content on technological sucrose yield were observed. In the paper effects of the most studied factors on three above mentioned traits are presented.

MATERIALS AND METHODS

The two-and three factorial field experiments have been carried out in split-plot design. The factorial 2^7 experiments have been arranged in an incomplete block single-replicated design. All the experiments have been located at Experimental Station in Chylice (52,2° N) in central Poland and conducted over three years. The soil of the experimental field is light clay, classified as a very good rye complex, with pH in KCl about 6.0, organic carbon content 0.9–1.0%, and total nitrogen content 0.10–0.11% in the top layer.

The on-farm experiments have been conducted over 7 years including totally 700 farms (plantations). They have been collected in two periods 1979–1981 and 1992–1995 and analyzed separately in the periods as well as for the total data set. These experiments were located in the central and north-eastern region of Poland. In the region of recording data the dominant soils are loam and sandy clay soil created from glacial deposits with pH in KCl ranging from 3.6 to 7.5.

Results from field factorial experiments were analyzed using the analysis of variance and multiple comparison Tukey's procedure. The on-farm experiments results were analyzed by multiple regression method.

RESULTS AND DISCUSSION

In order to present importance of the factors influence on sugar beet root yield effects of every factor, studied both in field and on-farm experiments, have been evaluated. Maximum observed effects of the significantly influenced factors determined as the largest difference between factor level means in relation to less mean are shown in Tabs. I and II. In the field factorial experiment 2^k where the numbers of factor levels are equal to 2 effects of every factor are presented, as the difference between both means in relation to less of them (Tab. I).

The factors which effects on investigated traits were the largest are: years, sowing date, length of vegetation period and N rate. Relatively large effects

I. Evaluation of the effects of agronomical factors on sugar beet root yield in Central Poland (factorial experiments)

Factor	Range of factor level	Effect of factors (%)
Years	1981–1983	31*
	1992–1994	21**
Sowing date	15.IV.–5.V.	16.2*
	14.IV.–28.IV.	12.7**
Harvest date	26.X.–12.X.	7.0**
	23.X.–9.X.	2.0*
Length of vegetation	195–167	19.1*
Fertilization		
N kg/ha	120–0	13.5**
	200–120	4.3*
P_2O_5 kg/ha	180–60	3.0*
K_2O kg/ha	200–100	3.0*
Plant density (thous. num/ha)	110–70	7.0*
	regular–irregular	4.3**

* the largest difference between factor level means in multifactorial experiments in relation to less mean in %

** the difference between factor level means in factorial 2^7 experiment in relation to less mean in %

were caused by plant density and its regularity (Tab. I). The effects of the most important factors studied on farm experiments are presented on the Tab. II. In this kind of experiments we have been able to establish the influence of soil quality (measured by soil class, soil pH).

It was proved that the soil quality very strongly modified the root yield. Other factors like sowing date, length of vegetation period and N rate influenced strongly the root yield as well. These results obtained on-farm experiments are similar to those proved in factorial experiments.

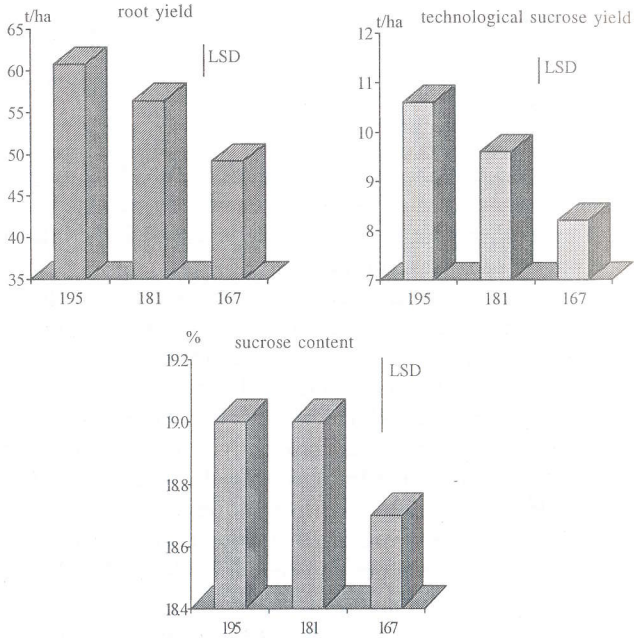
Environmental factors like soil and weather conditions mostly determined the possibility of exploring potential productivity of sugar beet. In the ecological conditions of Central and Eastern Poland length of vegetation period as affected by weather conditions determine strongly root yield, sucrose content and then technological sucrose yield of sugar beet. In Central and Eastern Poland the length of vegetation period is equal to about 200–210 days (number of days when frost does not occur).

In the factorial experiment we included 3 levels of vegetation period: 167, 181 and 195 days These levels of the factor differentiated significantly root yield, content sucrose and technological sucrose yield (Fig. 1).

II. Evaluation of the effects of agronomical factors on sugar beet root yield in Central and North-Eastern Poland (on-farms experiments)

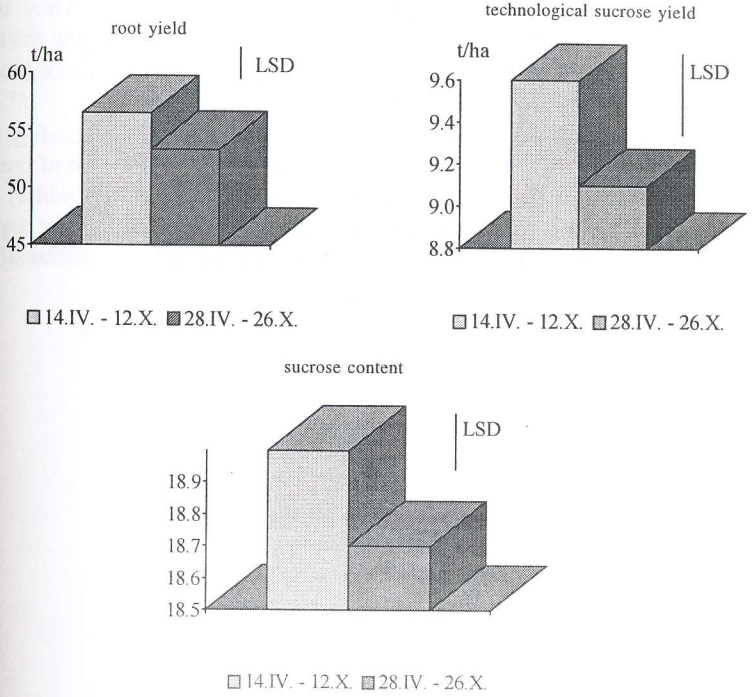
Factor	Range of factor level	Effects of factors* (%)
Years	1979–1981	37
	1992–1995	13
Soil class	IIIa – IVb	30–49
pH	>6,5 – <5,5	13
Forecrop	cereals – sugar beet	10
Sowing date	15.–20.IV. – 1.–5.V.	15–28
Length of vegetation	>180 – <160	22–35
Fertilization		
N kg/ha	(140–180) – <100	7–20
P_2O_5 kg/ha	(120–160) – <80	2–18
K_2O kg/ha	(160–200) – <120	2–10

* the largest difference between factor level means in relation to less mean in %



1. Main effects of vegetation period length concerning root yield, technological sucrose yield and sucrose content

The largest root yield in amount of 60,8 tons per ha was observed using the longest vegetation period (195 days). The lowest root yield was proved when the vegetation period was the shortest (167 days). The difference between yield means of these vegetation periods was equal to 19.1% of the shortest vegetation period mean. Parallely to the largest root yield for the longest vegetation period, the mean sucrose content in this case was the highest (19%); the N α-amino and K and Na content were the lowest (results are not presented here). Therefore for this longest vegetation period the technological sucrose yield was the highest and was equal to average 10.6 t/ha which was larger 22.8% as compared to the shortest vegetation period mean. The differentiation of the investigated traits caused by the same vegetation period 181 days but located in direction to longer or to shorter days in the year is presented in Fig. 2. It was proved that the larger root yield and its better quality had been in a case of earlier sowing and harvest dates as



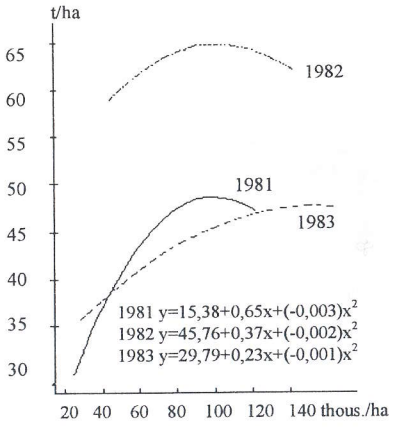
2. Root and technological sucrose yield and sucrose content after 181 vegetation days as affected by different sowing and harvest date

compared to the later sowing and harvest dates. Root yield and technological sucrose yield were differed about 5% mean (Fig. 2).

Early sowing date is a factor limitating a negative influence of short vegetation period because of the possibility for earlier performance of LAI and root system what causes better use of winter and spring rainfall as compared to later sowing date. Using the early sowing date the plants can accumulate more effectively dry matter for a longer time when the days are longer. It is important additionally because the photosynthesis is more intensive than respiration in that time. In Polish conditions often used in practice late sowing date is a limiting factor for yielding sugar beet and technological sucrose yield.

Recently, in Poland another very important factor in sugar beet cropping there has been become plant density and its regularity. It is connected with the modern technology using precise sowing. Results obtained on farm-experiments show that plant density in farms is very different. It ranges from 40–50 thousand of plants per ha to over 100 thousands of plants per ha. In factorial experiments different plant densities were compared. They were obtained by using sowing seeds every 8, 12 and 15 cm in a row without thinning and every 8 cm with thinning. As an optimal plant density proved to be that from 90 to 110 thousand per ha (Fig. 3).

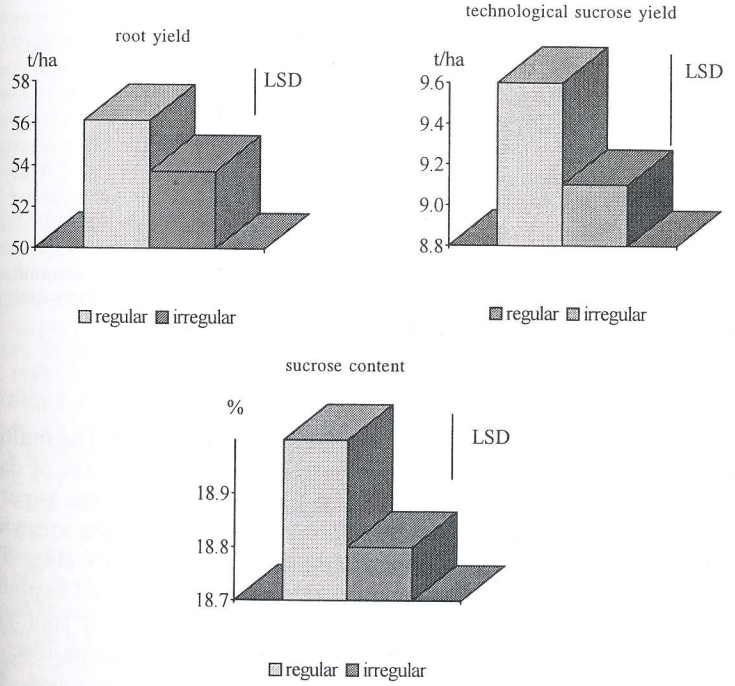
Decreasing plant density to 70–50 thousand/ha caused decreasing root yield about 7% as compared to high plant density (Tab. I). In a case of precise sowing (final sowing) when plant density is high (90–120 thousand/ha) it is possible to increase the root yield and its quality by application of the regular seed sowing in a row. The effect of regular and irregular plant density is presented in Fig. 4.



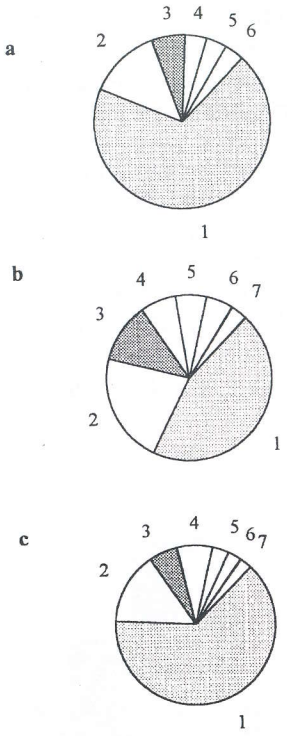
3. Relationship between the final stand of plants and the yield of roots against the background of years

This relationship was studied when the plant density was equal to about 90–110 thousand/ha. Regular plant density in a row gave the mean root yield and technological sucrose yield which were greater about 5% as compared to the means of these traits calculated for irregular distribution of plants in a row.

In conditions of central and eastern Poland where most soils have rather poor fertility the mineral N, P, K fertilization may be effective. On the base of the experimental results conducted in Poland and in our Department it was proved that the optimal N rate to obtain high root yield and good technological quality of roots had been in a range of 80 to 120 kg N/ha. In agricultural practice the proper N rate proved to be equal to about 120–160 kg N/ha. The important role of N, P, K fertilization in sugar beet production was confirmed in statistical analysis of on-farm experiments data. The three multiple regres-



4. Root and technological sucrose yield and sucrose content depending on regular and irregular plant density



5. The cumulative contribution of significant independent variables in multiple determination coefficient for sugar beet yield obtained on the base of data sets for years 1979–1981 (a), 1992–1995 (b) and the total data set (c) using stepwise regression analysis

sion analysis for data obtained over many years were conducted. The multiple polynomial regression functions were estimated in each of the case of data.

The independent variables mentioned at the beginning of the paper as investigated factors were included. The dependent variable was the root yield. The multiple determination coefficients were equal to about 30% (Fig. 5).

It means that the important agronomical factors determined and explained only about 30% of root yield variation. The rest about 70% of root yield variation in the studied region was caused by weather conditions over the years and other factors both controlled and uncontrolled in practice. It is worth to underline that among the significant independent variables were always fertilization rate of N, P and K.

CONCLUSIONS

The most important factors for root yield of sugar beet and its quality were as follows: environmental conditions like weather, soil properties and agronomical factors like vegetation period (depended on weather) sowing date, plant density, and its regularity and N rate.

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Agronomické a environmentální faktory ovlivňující výnos cukrovky ve středním a východním Polsku.

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Výzkum cukrové řepy se na katedře rostlinné výroby Varšavské zemědělské univerzity uskutečňuje od roku 1962. V tomto období byla provedena řada tříletých faktoriálních a polních pokusů. Byly sledovány tyto faktory: odrůdy, zpracování půdy, kvalita sadby, typ a datum výsevu, hustota porostu, dávky N, P, K, zavlažování, foliární hnojení, datum sklizně a délka vegetačního období. Pokud jde o sklizeň, byly sledovány: výnos bulev, obsah sacharózy a výnos technologické sacharózy. Dvoj- a třífaktorové pokusy se prováděly ve formě dělených parcel, faktoriálních pokusů 2^7 během tří let v neúplném blokovém uspořádání s jedním opakováním. Pokusy na jednotlivých farmách byly prováděny během sedmi let, v celkovém počtu 700 farem (vysazených ploch). Výsledky z polních faktoriálních pokusů byly analyzovány variační analýzou a četnými srovnávacími testy. U analýz výsledků polních pokusů byla použita metoda vícenásobné regrese.

Faktory ovlivňující sledované ukazatele: roky, kvalita půdy, délka vegetačního období, datum výsevu a dávka N. Relativně velký vliv měla hustota porostu a jeho pravidelnost. Výsledky polních pokusů byly podobné výsledkům získaným ve faktoriálních pokusech.

Nejdůležitější z agrotechnických faktorů byla délka vegetačního období. Nejvyšší výnos bulev (60,8 t/ha) byl zjištěn u nejdelšího vegetačního období (195 dní). Nejnižší výnos bulev byl u nejkratšího vegetačního období (167 dní). Rozdíl mezi průměrnými výnosy během těchto vegetačních období byl 19,1 %. Paralelně k nejvyššímu výnosu bulev za nejdelší vegetační období byl v tomto případě nejvyšší obsah sacharózy (19 %); obsahy N α-amino a K a N byly nejnižší. Proto v tomto vegetačním období byl rovněž nejvyšší výnos technologické sacharózy (10,6 t/ha), což bylo o 22,8 % více ve srovnání s nejkratším vegetačním období.

cukrová řepa; výnos bulev; obsah sacharózy

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