THE EFFECT OF DAMAGE OF LEAF AREA ON THE YIELD OF SUGAR BEET (*BETA VULGARIS* L.)

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The root production of sugar beet and deposition of sugar in the root goes in various intensity through the whole growing season. Damage or loss of a part of leaves results in the fall of root yield and their sugar content, though leaves of sugar beet are regenerating fast from adventitious buds. Exact trials were established in the years 1991–1993 on three sites for exact determination of the relationship between level of damage, date of damage (phenological stage of plant) and fall of the yield. Highest losses (up to 31%) of sugar beet roots occurred at 100 % reduction of leaf area after 60–90 days from sowing. The decrease of leaf area soon after emergence (to the stage of 4–6 pairs of right leaves) is leading to low losses because plants in this period compensate fast the reduction of leaves by production of new ones. Maximum losses of the yield were found in the years with high precipitation when after loss of leaves their excessive regeneration was found to the detriment of root production.

sugar beet; reduction of leaves; root yields; sugar yields

INTRODUCTION

In the past 30 years the morphological and physiological characters of sugar beet (Pulkrábek, 1986; Kostrej, 1992) somewhat changed. Genetically single-germ varieties have mostly lower and more erect trash, higher share of the root biomass of the total biomass of plant, faster initial growth and better use nutrients (Šroller, 1992) in comparison with older multigerm varieties. Sugar beet stands are in the absolute majority established by exact sowings to a final row spacing when eventual interspace in crop markedly should affect the yield and quality of the harvest (Minx, 1976). In this connection an emphasis is laid on higher density and stand establishment, including keeping of the optimum leaf area in the period of highest productivity of plants. Relationships between damage of leaf area, date of damage and the level of losses are connected with the dynamics of the growth of sugar beet leaves which is highest in July and August (Orlovskij, 1961).

Hodáňová (1980) in this connection makes more precise the optimum of leaf-area index to the LAI values ranging from 4 to 5. The dry matter production after Fiedler (1974) at temperatures 18–20 °C also takes place very intensively. This knowledge has been also confirmed by Stehlík (1982) and Šebánek et al. (1983) who emphasise the sensitivity to the photoperiod because in longer day sugar beet has a greater velocity of CO_2 fixation.

Damage or reduction of assimilation apparatus results in the decline of sugar beet root yield as well as of polarization sugar what can be primarily related to relationships between integral leaf area and productivity of sugar beet stand (Minx, 1976). Langner (1997) also accentuates the importance of the range and date of damage to the level of decline of sugar production. The different level of losses at the identical degree of damage and date of damage is doubtless connected with the reaction of sugar beet to weather conditions. Schmidt et al. (1977) emphasize great differences in the yield (15–20–30%) in dependence on precipitation and temperatures.

This study has been aimed at determining the level of losses of root yield and polarization sugar at model damage (reduction) of the leaf apparatus of sugar beet. The results obtained may serve as a theory for making more exact models of plants and sugar beet stands in breeding, in practice for estimates of losses of stands, invasion by pests and diseases.

MATERIAL AND METHODS

Field trials were established in the years 1991-1993 on three sites in sugar beet-growing region of the Czech Republic on the experimental site Prague-Uhříněves, experimental site at Červený Újezd, the Kladno district and Agricultural Co-operative Velké Přílepy, the district Prague-East. KW Perla was an experimental variety.

Size of the experimental plot: 1.80 x 9 m, i.e. 16.20 m^2.

Number of replications on each plot: 2.

Arrangement of the trial: linear distribution of plots in rows with inclusion of the control (undamaged) variant for each experimental plot.

Dates of damage: after 10 days, starting on 30th day from emergence.

Degrees of damage: control 0, 20, 40, 60, 80, 100% loss of leaf area.

Way of damage: manual reduction of leaf area – proportional parts of leaves of the whole leaf rosette (of blades and petioles). The model of "mean plant" was tested by weighing of leaves from five plants as the control in each date, i.e. for keeping the relationships among degrees of damage. In addition, leaves taken from 10 plants of each degree of damage were weighed. Thus

proportions among different degrees of damage were succeeded to be preserved, the deviations found did not exceed 5%.

Plots were harvested manually, roots were cleaned and weighed. Sugar content was determined from average samples of 30 roots of each variant at the Research Institute of Sugar Production Modřany.

Results were statistically evaluated by correlation and regression analyses (Tab. I). Models of losses for different indicators: the degree of damage, date of damage and percentage of loss (decrease) of the root yield and polarization sugar were calculated from the values found.

RESULTS

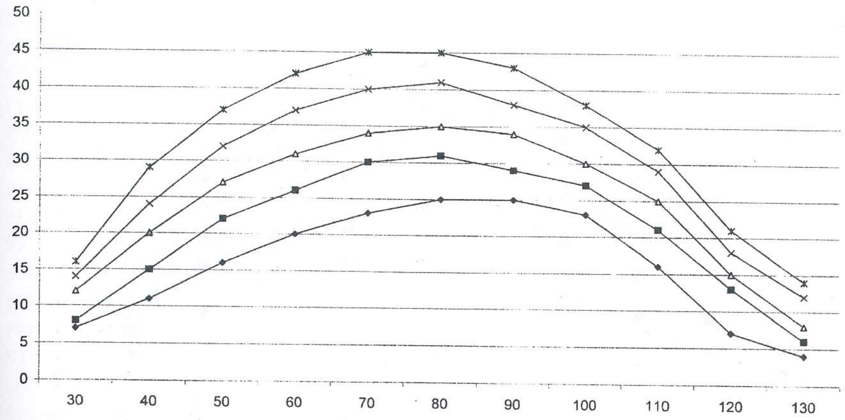
Extensive sets of initial data from three sites are processed in readable graphs (Figs. 1 and 2) and in Tab. I. Damage to leaf area had a significant impact on the decrease of the root and sugar yield. The yield depression was in direct proportionate to the degree of damage. The highest losses of root and sugar yield were found in the damage in the period between 60–90 days after sowing, the lowest ones were recorded at the beginning and end of the growing season (Fig. 1 – root yields, Fig. 2 – sugar yields). The level of losses at the identical degree of damage was different in different years. The highest losses in the yield of roots and polarization sugar were found in 1992, the lowest ones were in 1993. The level of losses was dependent on, except of the degree of the damage of leaves, the weather condition in the period following the damage of leaves. In 1992 heavy precipitation in August after previous drought supported excessive regeneration of leaves of damaged plants to the detriment of root production. Maximum losses of root yield in 1992 amounted to 31% at 100% damage of leaves, losses of the yield of polarization sugar were 45% in this year.

DISCUSSION

The size of leaf area of the sugar beet stand affects significantly the productivity of plant as well as the stand (Šroller, 1971). The damage or the loss of a part of leaves leads to their subsequent regeneration in dependence on the growth stage of a plant, while this also results in the decrease of the root and sugar yields. There are many reasons for it: elementary events, pests, diseases (Bachman, 1993; Langner, 1997). New technologies of sugar beet cultivation together with genetically single-germ varieties led to practical requirements – to quantify the level of losses at the damage of sugar beet leaves (Šroller, Pulkrábek, 1994). Model experiments investigating the effect of the degree of reduction of leaf area as affected the yield may

I. Statistical evaluation

Root yield						
Dep var: VBZ		*N*: 66		Multiple *R*: 0.821		Squared multiple *R*: 0.674
Adjusted squared multiple *R*: 0.669				Standard error of estimate: 8.047745		
Variable	Coefficient	STD error	STD coef.	Tolerance	T	P(2 TAIL)
Var. temp	0.058165	0.009058	1.841636	0.061903	6.42128	0.19E-0
Var. temp. temp	–0.003917	0.001019	–1.102425	0.061903	–3.84386	0.0002
Analysis of variance						
Source	Sum-of-squares	DF	Mean-square	*F*-ratio	*P*	
Regression	8574.479378	2	4287.239689	66.195636	0.999201E-15	
Residual	4145.036664	64	64.766198			
Sugar yield						
Dep var: VCZ		*N*: 66		Multiple *R*: 0.815		Squared multiple *R*: 0.665
Adjusted squared multiple *R*: 0.659				Standard error of estimate: 9.949130		
Variable	Coefficient	STD error	STD coef.	Tolerance	T	P(2 TAIL)
Var. temp	0.057378	0.011198	1.490933	0.061903	5.12378	0.30E-0
Var. temp. temp	–0.003109	0.001260	–0.718139	0.061903	–2.46798	0.0162
Analysis of variance						
Source	Sum-of-squares	DF	Mean-square	*F*-ratio	*P*	
Regression	0.125501E+05	2	6275.066201	63.393986	0.999201E-15	
Residual	6335.052638	64	98.985197			



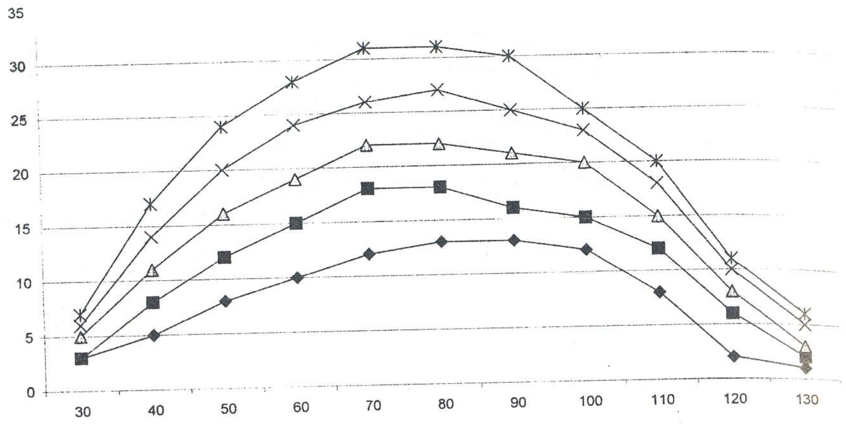
1. Losses of sugar yield in relative percentage after damage (maximum losses)

For Figs. 1 and 2:
x-axis – days of sowing; y-axis – percentage of losses
Damage of leaves: —◆— 20%, —■— 40%, —△— 60%, —×— 80%, —✳— 100%

give an answer not only to practical issues regarding the relationship among the degree of damage, phenological stage of the stand and the level of losses, but they also have a theoretical meaning for formation of the model of a plant and stand. These problems were perfectly presented by Minx (1976) and Pulkrábek (1987).

The level of losses in the model damage should not exactly correspond to the values at actual natural disaster which is usually combined with a high air moisture with a possibility of subsequent expansion of fungal diseases. Despite it, model experiments in this sphere define exactly relationships among the loss of a part of leaf area and decrease of the yield. These considerations are also presented by Bachman (1993) who was finding the effect of damages after actual hailstorm in sugar beet stands. At 80% damage of leaves in August he determined the loss of the root yield to 25% what is in congruency with our results taken from model experiments.

The dependence between the losses and phenological stage of growth can be explained by a different dynamics of the growth of leaves and roots. The beet firstly utilizes assimilates above all for production of new leaves and losses of these leaves in early stages of growth can be replaced very quickly. Approximately after formation of 20h to 25th leaves the weight ratio of roots and leaves is balanced and further increments of root prevail (Šroller, 1971). A major part of the economic result is forming in the later period. In



2. Losses of root yield in relative percentage after damage (maximum losses)

this period the reduction of leaf area has a maximum influence on the reduction of the yield. In September and October, before the harvest when intensity of solar radiation is falling, the yield is not significantly affected by the lower reduction of leaf area. It is necessary to mention that an actual level of losses of the yield at the damage of leaves will be always dependent on the weather condition and will not be identical in different years (Šroller, Pulkrábek, 1994).

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ŠROLLER, J. – PULKRÁBEK, J. (Česká zemědělská univerzita, Agronomická fakulta, Praha, Česká republika):

Vliv poškození listové plochy na výnos cukrovky (*Beta vulgaris* L.).

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Poškození, případně ztráta listů cukrové řepy má za následek nejprve regeneraci listového aparátu, přičemž výsledkem je vždy pokles výnosu bulev a cukru. Příčin poškození listů může být více – živelní události (krupobití), škůdci, choroby. Modelové pokusy zkoumající vliv velikosti listové plochy a její redukce v průběhu vegetace na výnos (Chartier, 1969) mohou dát odpověď na otázky praktické, týkající se vztahů mezi stupněm poškození, fenologickou fází a výší ztrát. Dále mají tyto pokusy i význam teoretický, neboť přinejmenším dobře charakterizují nutnou úroveň pokryvnosti listoví ve vztahu k fenologické fázi a tvorbě výnosu (Pulkrábek, 1987).

Současné jednoklíčkové odrůdy cukrovky se od starších víceklíčkových odrůd liší především nižším podílem chrástu v poměru k bulvám, rychlejším počátečním růstem

i lepším využitím živin. Nynější pěstitelské technologie rovněž kladou důraz na vyšší hustotu porostu (M i n x , 1976).

Cílem práce bylo stanovení výše ztrát výnosu při modelovém poškození listů, které nejvíce odpovídá ztrátám při skutečné živelní pohromě. Zároveň je nutné zdůraznit, že ztráty při modelovém poškození nebudou přesně takové, jako jsou ztráty při každé jednotlivé skutečné situaci, spíše mohou představovat určitý průměr. Živelní pohroma (krupobití) může mít za následek i šíření houbových chorob, erozi půdy apod. Naproti tomu modelové poškození poměrně přesně kvantifikuje vztahy mezi ztrátou části listové plochy a poklesem výnosu bulev. Tyto úvahy uvádí i B a c h m a n (1993), který zjišťoval účinek škod po skutečném krupobití v porostech cukrovky.

V letech 1991–1993 byl v přesných polních pokusech na třech stanovištích zkoumán vliv redukce listové plochy cukrové řepy na výnos bulev a polarizačního cukru. V desetidenních intervalech byla redukována část listové plochy rostlin v rozsahu od nuly (kontrola) do 100 %, přičemž stupeň redukce byl průběžně kontrolován vážením odebraných částí listů. Výsledky byly vyhodnoceny statisticky – korelační a regresní analýzou – a zpracovány do grafů zobrazujících zjištěné úrovně ztrát výnosu oproti nepoškozené kontrole.

Nejvyšší ztráty výnosu bulev a cukru byly zjištěny při maximální redukci listové plochy v období mezi 60–90 dny po výsevu, nejnižší ztráty byly na počátku a na konci vegetace. Maximální ztráty výnosu bulev dosáhly 31 % při 100% poškození listů, ztráty polarizačního cukru činily v tomto případě 45 %. Ke srovnatelným výsledkům dospěl i B a c h m a n (1993), který zjišťoval výši škod po skutečném poškození cukrové řepy krupobitím.

cukrová řepa; redukce listů; výnosy bulev; výnosy cukru

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