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Effect of different rates of nitrogen fertilizer on growth and yield of sweet corn cobs

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Summary: The study presents the influence of nitrogen fertilization of sweet corn cobs on yield of kernels and the content of sugar (sucrose) in them. The dose of nitrogen ranged from 60 to 120 kg/ha. There was observed an increase of yield of sweet corn kernels and decrease of content of sucrose in the kernels.
Key words: sweet corn, nitrogen, fertilization.

INTRODUCTION

Sweet corn for processing is harvested at a relatively immature stage as compared to field corn. Processing of corn is used to increase its shelf life but as a consequence, a significant loss of nutrients may occur via heat degradation or leaching [19].

The high yield of suitable quality of sweet corn kernel requires the provision of a lot of nutrient elements to the plant, with nitrogen being the most important element for their growth. It exerts a great influence on the chemical composition, which determines the technological quality [2, 23]. Nitrogen in sweet corn growing is an important component influencing both the yield and aminoacids, which decide on the taste and nutrient value of kernels [4]. Sweet corn cobs constituting raw material for processing must be characterized by the highest quality of kernels. Kernel quality is defined not just by the chemical and sensory properties, but also by the mechanical parameters of kernels. This appears to fully justify joint consideration of all those properties. Sweet corn is probably a mutant of fodder corn [14]. The chemical composition of the kernels is related to the weather conditions, ripeness, and method of storage. According to data from the United States Department of Agriculture [8], the nutritional value of sweet corn kernels is related to the content of water (72,7%) and to the total content of solid parts (27,3%). Solid parts include hydrocarbons (81%), proteins (13%), lipids (3,5%), and others (2,5%). Starch is the dominant hydrocarbon component. Sweet corn has the highest nutritional value in the phase of milk ripeness. With progressing phase of ripeness, in the transition to the phase of wax ripeness the content of sugars decreases, accompanied by an increase in the content of starch [22]. In 100 g of kernels there is about 3,03 g of saccharine, 0,34 g of glucose and 0,31 g 1 of fructose. The content of saccharine increases, and that of reducing sugars decreases as the kernels reach the optimum ripeness . The content of proteins in the kernels decreases from the surface towards the centre of the kernel. The content of proteins, free aminoacids, water-soluble and insoluble hydrocarbons, increases up to the phase of wax ripeness, and then gradually decreases [1]. The amounts of the particular components in various cultivars and in various phases of ripeness variable.

The consumable quality of sweet corn depends on different factors such as: degree of maturity, genotype, variety, isolation of space, length and condition of post harvest storage, weather conditions, fertilization, irrigation and agrotechnics treatment [5, 6, 12, 21, 24].

The new cultivation trend is to balance mineral nutrition, which results in a high yield and reduces to the minimum the negative influence of nitrogen fertilization on the quality of yield and natural environment [9, 13, 15, 16]. In the praxis, nitrogen fertilization should be exactly determined on the basis of chemical sample of soil. It causes many problems because the nitrogen influence on the increase of kernels yield is two-sided and can have a negative influence on the final product [17, 18]. A high dose of nitrogen results in a decrease of the level of sugars in kernels and can cause danger to the natural environment because it is easily rinsed to soil [7, 10].

A high level of nitrogen fertilization creates a series of dangers related with negative influence on plant quality. This problem is especially meaningful in the growing of vegetable plants. Fertilization of nitrogen should be considered in view of a possibility of obtainment of high yield with low content of nitrates [11, 12, 20]. The rational proportion of nitrogen depends on soil condition, content of available nutrient, humidity and crop rotation [23]. The average provisional portion of nitrogen ranges from 60 to 300 kg/ha. Warzecha [25] stated that the supply of nitrogen should not exceed 90kg/ha. The Miao's study [11] showed that the increase of nitrogen fertilization influenced the increase of cob yield and protein content in kernels and decrease of oil and starch in kernels.

Sweet corn attains consumable maturity when the kernels are at milk stage of maturity and their moisture amount to 70-76%. In this stage, the kernels have the highest level of sugar, especially sucrose which influences the consumable quality of sweet corn kernels [3, 7, 12].

The aim of this study was to determine the influence of nitrogen fertilization of sweet corn on the yield of cut off kernels and their content of sucrose.

MATERIALS AND METHODS

The material was made up by sweet corn cobs of the following three super sweet varieties (*sh2*): Golda, Candle and Helena. Table 1 gives the physical and geometric properties of the sweet corn cobs.

Table 1. Means and standard deviations of physical and geometrical properties of sweet corn cobs.

Specification		Variety		
		Golda	Candle	Helena
Cob mass, g	$x_{śr}$	350,8	327,5	342,1
	SD	18,2	16,9	20,5
Cob lenght, mm	$x_{śr}$	21,7	20,1	20,3
	SD	4,7	3,8	4,2
Cob diameter*, mm	$x_{śr}$	50,2	48,7	49,8
	SD	0,8	1,2	1,0
Kernel length, mm	$x_{śr}$	9,5	8,1	8,7
	SD	1,5	1,2	1,7
Number of kernel per row, pcs.	$x_{śr}$	36,4	32,3	36,2
	SD	5,8	4,3	5,3
Number of kernel rows, pcs.	$x_{śr}$	18	14	16
	SD	2,8	3,3	3,2
Moisture of kernel, %	$x_{śr}$	76,8	73,2	74,4
	SD	2,6	2,1	2,4

$x_{śr}$ – mean value
SD – standard deviation
* measured in central part of cob

The varieties studied were characterized by a relatively low variation of the mean measurement values, which positively assisted the comparison. It was found that an increase in the mean physical and geometrical values of corncobs was related to an increase in their yield.

The fertilizer applied in the experimental was carbamide in the amount of: 0 (control), 60, 90,120 kgN/ha and organic fertilization – 30t/ha. The level of P_2O_5 and K_20 fertilization was constant and amounted to 80 kg P/ha in the form of triple superphosphate and 160 kg K/ha in form of kalium sulphate. The application was realized in two variants:

a) I – all dose of nitrogen fertilization was applied before sowing in amount: 0, 60, 90 and 120 N kg/ha,
b) II -the half of dose of nitrogen fertilization was applied before sowing in amount: 0, 30, 40 and 60 N kg/ha.

The experimental was realized on the plot of 50 m² area in split-block system for three factors: O – variety, N – dose of nitrogen, W – variant.

The yield of cut off kernels (Q_z) was determined according to the following formula:

$$Q_z = \frac{m_k - m_r}{m_k} \cdot Q_k \quad [t/ha]$$

where:
m_k – weight of dehusking cob, t
m_r – weight of cob core, t
Q_k – potential field of dehusking sweet corncob, t/ha.

Kernels were cut from sweet corncob core in the machine Corn Cutter SC-120 FMC FoodTech. The measurements were taken for the angular velocity of the cutter head from 167,5 rad/s and linear velocity of cob feeder 0,31 m/s.

The measurements of sucrose content were realized using hand refractometr with automatic compensation ATC – 1E at measurement range from 0,0 to 32% Brix and accuracy 0,2% according to norm PN-En 12143: 2000.

The yield of cut off kernels was determined on the sample of 100 sweet corncobs, the content of sucrose in 30 sweet corn cobs for each combination of doses of nitrogen and variant.

The measurements results were analyzed statistically at the significance level of a = 0,05.

THE ANALYSIS AND RESULTS

The tree-way analysis of variance to analyze the effect of three qualitative factors: variety (O), dose of nitrogen (N) and variant (W) on the dependent variable of the yield of kernels (Q_z) showed that O, N, W and interaction N-W were statistically significant while interaction O-N, O-W and O-N-W were not statistically significant (Table 1).

Table 1. The analysis of variance to analyze the effect of qualitative factors (O, N, W) on dependent variable (Q_z)

Specification	Sum of square	Degree of freedom	Mean square erroe	Test F	Significance level
O	1,20	2	0,60	14,5	0,00
N	19,29	3	6,43	155,7	0,00
W	22,32	2	11,16	270,2	0,00
O-N	0,41	6	0,07	1,7	0,14
O-W	0,06	4	0,01	0,3	0,84
N-W	1,47	6	0,24	5,9	0,00
O-N-W	0,80	12	0,07	1,6	0,10

The mean value of yield of kernels at first variant at nitrogen fertilization from 0 to 120 N kg/ha ranged from 9,6 to 11,1 t/ha for Golda variety and adequately from 10,3 to 11,3 t/ha for Candle and from 10,2 to 11,4 Helena (Fig. 1). The highest mean value of kernels yield in range of nitrogen fertilization from 0 to 120 kg/N ha were recorded at Golda (14,9%) and the lowest at Candle (9,2%).

At the second variant, the mean value of kernels yield ranged from 10,7 to 11,9 t/ha (Golda), from 11,0 to 12,1 t/ha (Candle) and from 11,5 to 12,5 t/ha (Helena) (Fig. 2). The highest mean value of kernels yield ranged from 11,5% (Golda) to 6,5% (Helena).

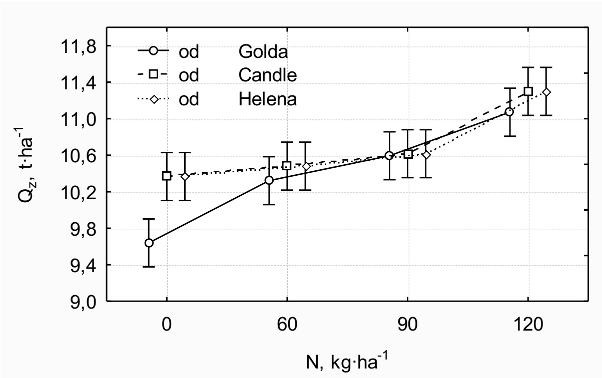
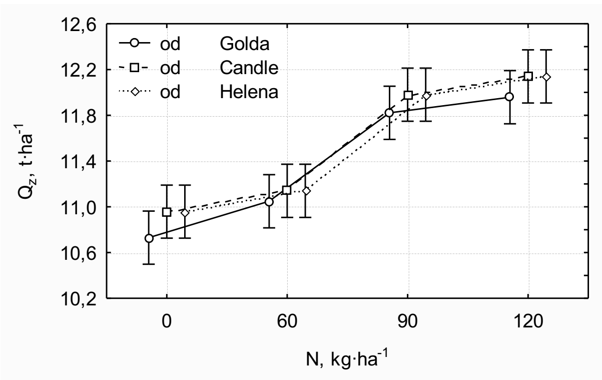


Fig. 1. The mean value of kernels yield (Q_z) with 0,95 confidence interval in relation to dose of nitrogen fertilization (N) at variant I



Rys. 2. The mean value of kernels yield (Q_z) with 0,95 confidence interval in relation to dose of nitrogen fertilization (N) at variant II

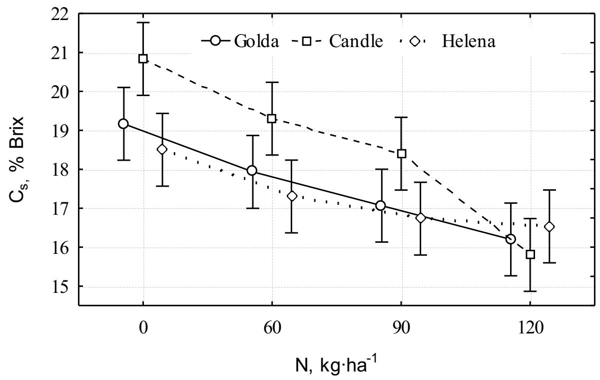
The analysis of variance to analyze the effect of three qualitative factors: variety (O), dose of nitrogen (N) and variant (W) on one dependent variable: the content of sucrose in kernels (C_s) showed that O, N, N and interaction of O-W were statistically significant while O-N, N-W and O-N-W were not statistically significant (Tab.2).

Table 2. The analysis of variance to analyze the effect of qualitative factors (O, N, W) on dependent variable (C_s)

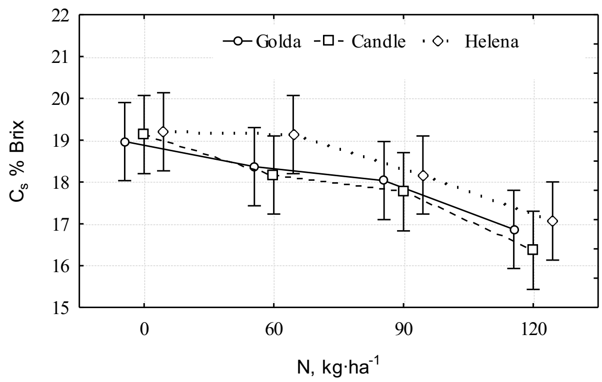
Specification	Sum of square	Degree of freedom	Mean square erroe	Test F	Significance level
O	7,18	2	3,59	5,45	0,00
N	114,68	3	38,23	58,00	0,00
W	58,54	2	29,27	44,41	0,00
O-N	6,65	6	1,11	1,68	0,13
O-W	11,86	4	2,97	4,50	0,00
N-W	3,36	6	0,56	0,85	0,53
O-N-W	6,18	12	0,52	0,78	0,66

The increase of dose of nitrogen fertilization in the range from 0 to 120 kg N/ha effected the decrease of sucrose in kernels from 19,1 to 16,2% (Golda), from 20,8 to 15,8% (Candle) and from 18,5 to 16,5% (Helena) at the first variant (Fig. 3) and from 19,0 to 16,9%(Golda), from 19,1 to 16,4% (Candle) and from 19,2 to 17,1% (Helena) at the second variant (Fig. 4).

The highest decrease of sucrose content was recorded at Candle variety (24,0%) at first and 14,0% at second variant and the lowest at Helena (10,8%) at first variant and at (Golda and Helena) 11,0%.



Rys. 3. The mean value of sucrose content (C_s) with 0,95 confidence interval in relation to dose of nitrogen fertilization (N) at variant I



Rys. 4. The mean value of sucrose content (C_s) with 0,95 confidence interval in relation to dose of nitrogen fertilization (N) at variant II

CONCLUSIONS

1. The yield and content of sucrose in kernels are statistically significantly differentiated with regard to the dose of nitrogen fertilization and its variant of application.
2. The change of nitrogen dose from 0 to 120 kg/ha effected the increase of yield kernels in the range from 4,0 (Helena) to 15% (Golda) and decrease of sucrose content in kernels from 24 (Candle) to 11,0% (Helena) at the first variant and, correspondingly, from 10,0 to 12% and from 15,0 to 4%.

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WPŁYW INTENSYWNOŚCI NAWOŻENIA AZOTOWEGO KUKURYDZY CUKROWEJ NA PLON ZIARNA ORAZ ZAWARTOŚĆ W NIM SACHAROZY

Streszczenie. Przedstawiono wpływ nawożenia azotowego kukurydzy cukrowej na plon ziarna oraz zawartość w nim sacharozy. Badania realizowano dla dwóch wariantów nawożenia w zakresie od 0 (kontrola) do 120 kg/ha. W wariancie I aplikowano całą dawkę przed siewem, a w wariancie II połowę dawki przed siewem i połowę pogłównie. W badanym przedziale zmiana dawki nawożenia wpływała na wzrost plonu ziarna od 15% (odmiana Golda) do około 11% (odmiana Helena) oraz spadek zawartości sacharozy od około 31% (Candle) do około 12% (Golda) w pierwszym wariancie i odpowiednio dla II wariantu od 11% (Golda) do 7% (Helena), i od 20% (Candle) do 11%(Helena).

Słowa kluczowe: Słodka kukurydza, azot, nawożenie.