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The secondary effect of sunflower (*Helianthus annuus* L.) catch crop in sweet corn (*Zea mays* L. var. *saccharata*) cultivation

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ABSTRACT

A field experiment was carried out in central-eastern Poland (52°06'N, 22°55'E) to investigate the effect of a sunflower catch crop used as green manure sown on three different dates (21st July, 4th and 18th August) on sweet corn yield and growth. The 'Challenger F_1' and 'Sweet Wonder F_1' corn cultivars were cultivated in the first year following organic fertilization. Sunflower was plowed in the third week of October. The effect of the catch crop's green manure was compared to farmyard manure applied at a dose of 40 t ha^{-1} as well as a control without organic manuring. The biomass quantity and the amount of macroelements absorbed with the sunflower catch crop sown on the 21st of July was similar to the quantity absorbed with farmyard manure applied at a rate of 40 t ha^{-1}. The quantity of organic mass and macroelements absorbed with the sunflower sown on the 4th of August was smaller by 20%, and by 50% for the 18th of August set, compared with the corn treated with farmyard manure. The effects of farmyard manure and sunflower catch crop sown on the 21st of July on the yield were similar. The marketable yield of cobs of corn plants cultivated following farmyard manure treatment and catch crop sown on the 21st of July amounted to 12.6 and 12.4 t ha^{-1}, respectively. An application of sunflower sown as a green manure on the 2nd and 3rd date prior to corn cultivation decreased marketable cob yields by 8% and 25% as compared to the farmyard manure. The corn cobs cultivated following the sunflower sown on the 21st of July and treated with farmyard manure had the greatest mass. The corn cobs cultivated with farmyard manure were characterized by the highest biological productivity (72.1%); similar was the cob production of corn cultivated with catch crops sown on the 21st of July and the 4th of August. The 'Challenger F_1' and 'Sweet Wonder F_1' yields were similar. 'Challenger F_1' produced cobs with higher mass whereas 'Sweet Wonder F_1' produced cobs characterized by greater biological productivity.

Key words: green manure, organic manuring, yield

INTRODUCTION

Sweet corn is a valuable crop plant with many uses in human nutrition. Weather conditions, in particular air temperature during the growing season, have the greatest influence on sweet corn growth and yields (Kovaćecić and Culjat 1993, Stone 1999). Successful cultivation is also determined by agrotechnological factors, fertilization being one of the most significant. The application of farmyard manure is recommended in the autumn prior to sweet corn cultivation. Problems with supplying agriculture with farmyard manure and increasing prices have made farmers look for alternative sources of organic matter. In both horticulture and agriculture, catch crops used as green manure constitute a valuable source of organic matter. Catch crops also have a many-sided effect on biological, physical and chemical soil properties. They protect the forms of nutrients that are easily available for plants (in particular nitrogen) from leaching into deeper layers of the soil profile and groundwater (Clark et al. 2007, Collins et al. 2007). During the process of the mineralization of the catch crop, biomass nitrogen is gradually released and becomes available for the subsequent plants (Vos and van der Putten 2001). Many plant species cultivated as catch crops play a phytosanitary role of suppressing diseases that might infect the main crop (Davis et al. 1996). Numerous studies have indicated the possibility of using green manures in agricultural and horticultural cultivation (Creamer 1996, Hruszka 1996, Mwaja et al. 1996, Kołota and Adamczewska-Sowińska 2004, Elfstrand et al. 2007, Kramberger et al. 2009). The effectiveness of green manures depends to a large extent on the amount of incorporated plant mass, the rate of its mineralization as well as the climatic conditions (Brzeski et al. 1993).

The present work is an attempt to determine the effect of sunflower catch crop, sown at three dates and used as a green manure on sweet corn growth and yields. It is not always possible to sow plants for green manure at the optimal date. In the present study, different sunflower sowing dates were chosen to determine the effect of delayed sowing on sunflower yield and its value as a manure.

MATERIAL AND METHODS

Data analysed in the current paper were obtained from a field experiment carried out in 2004-2007 in central-eastern Poland. The experiment was located at the Experimental Farm in Zawady, 25 km east of Siedlce (52°06'N, 22°55'E).

In every year of the study, air temperatures in the area were on average 0.4-1.4°C higher than the long-term mean (1951-1990). Precipitation in the years 2004-2007 was lower than the long-term mean (1951-1990). The deviation ranged from 7.9 mm in 2007 to 161.3 mm in 2006 (Tab. 1).

The trial was conducted on grey-brown podzolic soil characterized by an average organic carbon content ($C_{org.}$) of 0.95%, the humus layer reaching the depth of 30-40 cm, with a pH_{KCl} of 6.0. The soil had a sufficient quantity of $N\text{-}NO_3$ and average available phosphorus, potassium, calcium and magnesium contents. According to the FAO international system of soil classification, the soil was classified as a Luvisol (LV) (WRB 1998).

The experiment was established in a split-block design with four replications. The secondary effect of the sunflower (*Helianthus annuus* L.) catch crop on the growth and yields of sweet corn (*Zea mays* L. var. *saccharata*) was studied. Two corn cultivars were tested: 'Challenger F_1' and 'Sweet Wonder F_1'. Sunflower was sown as a summer catch crop in 2004-2006 on three different dates: the 21st of July (D1), 4th of August (D2) and 18th of August (D3). The sunflower seeding rate amounted to 30 kg ha^{-1}. Before sowing, mineral fertilization was applied at the following rates: 80 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 80 kg K_2O ha^{-1}. The green mass of the sunflower was plowed in the third week of October. The growing season of sunflower sown

Table 1. Comparison of the weather conditions in the study years with the average long-term mean

Year	Deviation from the average long-term sum of precipitation and mean air temperature			
		Growing period		
	I-XII	Catch crop		Sweet corn
		VII-X	VIII-X	V-VIII
	Precipitation (mm)			
1951-1990	514.9	210.6	140.0	254.0
2004	-84.4	-45.9	-24.3	-
2005	-161.3	-62.9	-78.8	-13.3
2006	-86.5	+76.1	+130.5	+53.4
2007	-7.9	-	-	-34.6
	Air temperature (ºC)			
1951-1990	7.5	13.8	12.5	16.0
2004	+0.4	+0.9	+1.2	-
2005	+0.5	+1.5	+1.1	+0.7
2006	+0.7	+2.6	+1.9	+1.8
2007	+1.4	-	-	+1.7

at the successive dates was: D1 − 92 days, D2 − 78 days, and D3 − 64 days, respectively. Directly before the catch crop incorporation, representative samples of plant material were taken (above-ground parts and roots) to assess the fresh and dry matter yields and perform chemical analyses to determine macroelement content.

The effect of the sunflower catch crop on yield was compared to the effect of farmyard manure (FYM) at a rate of 40 t ha^{-1} and the control without organic manuring (NOM). The farmyard manure was plowed together with the sunflower.

Sweet corn was cultivated in 2005-2007, in the first year after the incorporation of green manures and farmyard manure. The seeds were sown in mid-May at a spacing of 65 × 20 cm. The seeding rate of 'Challenger F_1' was 10 kg ha^{-1}, and 'Sweet Wonder was F_1' 6 kg ha^{-1}. Sowing was preceded by an application of mineral fertilization to all of the plots at the following rates: 110 kg N, 110 kg P_2O_5, and 180 kg K_2O per 1 ha. Mineral fertilizers for the catch crops and corn were in the form of ammonium nitrate, granular superphosphate and 60% potassium salt. The remaining cultivation operations were done in accordance with the generally accepted principles of the agrotechnology of sweet corn. The cobs were harvested at the stage of milk maturity of the kernels, which was at the end of August and the beginning of September. The total yield and the marketable yield of cobs were determined during the harvest. In addition, the following characteristics were determined: the average mass of marketable cobs, the average mass of grains per marketable cob, the biological productivity of cobs, the length and diameter of marketable cobs, and the number of kernel rows in a marketable cob.

All of the values were expressed as means obtained from measurements taken of 30 cobs.

The biological productivity of corn was calculated according to the following model:

$$P_b = \frac{m_c - m_p}{m_c} \cdot 100 \quad (\%)$$

where:

mc – mass of a cob without cover leaves (g),

mp – mass of a core (g) (Szymanek et al. 2007).

The entire plot area was 56 m^2. The entire experimental area was 0.26 ha. The results of the experiment were statistically analyzed by means of the analysis of variance following the mathematical model for the split-block design. Significance of differences was determined by the Tukey test at the significance level of $p = 0.05$.

RESULTS AND DISCUSSION

The amount of farmyard manure and incorporated organic mass of sunflower sown at the successive dates and, in consequence, macroelements introduced into the soil, are shown in Table 2. The rate of 40 t ha^{-1} FYM supplied 10.3 t ha^{-1} dry matter and a total of 552.5 kg ha^{-1} macroelements (N + P + K + Ca + Mg) into the soil. Sunflower sown on the 21st of July (D1) produced the most fresh (40.4 t ha^{-1}) and dry matter (7.4 t ha^{-1}). Incorporation of sunflower sown on the 4th of August (D2) supplied less fresh (6.7 t ha^{-1}) and dry matter (1.5 t ha^{-1}). Sunflower planted on the 18th of August (D3) supplied 19.3 and 3.8 t ha^{-1} less fresh and dry matter. Schmid

Table 2. The quantity of organic matter and macroelements with farmyard manure and sunflower catch crop (average long-term mean 2004-2006)

	Farmyard manure	Sunflower – Date of catch crop sowing		
		21 VII (D1)	4 VIII (D2)	18 VIII (D3)
Organic matter (t ha^{-1})				
Fresh matter	40.0	40.4	33.7	21.1
Dry matter	10.3	7.4	5.9	3.6
Macroelements (kg ha^{-1})				
Nitrogen	143.0	117.5	91.9	56.0
Phosphorus	67.4	19.5	15.9	9.4
Potassium	203.1	239.4	192.8	117.1
Calcium	87.0	96.1	77.4	47.1
Magnesium	52.0	41.0	32.6	19.8
N+P+K+Ca+Mg	552.5	513.5	410.6	249.4

Table 3. Sweet corn yielding

Differentiating factors	Total yield of cob (t ha^{-1})			Marketable yield of cob (t ha^{-1})		
	Cultivar		$\bar{x}$	Cultivar		$\bar{x}$
	'Challenger F_1'	'Sweet Wonder F_1'		'Challenger F_1'	'Sweet Wonder F_1'	
Organic manuring						
Control (NOF)*	14.6	14.6	14.6	9.2	9.9	9.5
Farmyard manure	17.7	17.7	17.7	12.6	12.6	12.6
Sunflower (D1)	17.3	18.2	17.8	11.8	13.0	12.4
Sunflower (D2)	16.4	16.9	16.7	10.6	12.1	11.4
Sunflower (D3)	13.7	14.1	13.9	8.9	9.5	9.2
Mean	15.9	16.3	16.1	10.6	11.4	11.0
Years						
2005	16.3			11.5		
2006	14.7			8.7		
2007	17.4			12.8		
$NIR_{0.05}$ for:						
years	1.9			1.4		
organic manuring	1.3			1.0		
cultivar	n.s.			n.s.		

*NOF - without organic manuring
D1 - date of sowing 21 VII
D2 - date of sowing 4 VIII
D3 - date of sowing 18 VIII

and Klay (1984) report that the quantity of organic matter introduced into the soil with green manures corresponds to the quantity incorporated with farmyard manure applied at a rate of 22-32 t ha^{-1}, with the amount of incorporated dry matter ranging between 4.5 and 5.5 t ha^{-1}.

40 tonnes of farmyard manure per ha supplied the same amount of macroelements as the sunflower catch crop sown on the 21st of July (D1). It contented less nitrogen, phosphorus and magnesium but more potassium and calcium than FYM. The total amount of macroelements incorporated with these catch crops (N + P + K + Ca + Mg) equalled 513.5 kg per 1 ha. The quantity of macroelements incorporated with the sunflower planted at the 2nd (D2) and 3rd (D3) sowing date was, respectively, 20 and 51% lower compared with the 1st date of incorporation (D1). However, it should be noted that, unlike FYM, sunflower was not a source of minerals, as it took them up from the soil and returned them after incorporation, so the favourable effect of the catch crops was predominantly based on the temporary immobilization and protection of nutrients from leaching into the deeper layers of the soil profile.

The mean total yield of sweet corn cobs in 2005-2007 amounted to 16.1 t ha^{-1}, with 11.0 t ha^{-1} marketable yield (Tab. 3). The highest total yield (17.4 t ha^{-1}) was obtained in 2007, with a similar yield recorded in 2005 (16.3 t ha^{-1}). The total yield of cobs in 2006 amounted to 14.7 t ha^{-1} and was significantly lower than in 2007. The marketable yields of cobs obtained in 2007 (12.8 t ha^{-1}) and 2005 (11.5 t ha^{-1}) were significantly higher than in 2006 (8.7 t ha^{-1}). A decrease in corn cob yields, in particular a lower marketable yield, in 2006 compared with 2005 and 2007 (by 25 and 32%) was caused by adverse weather conditions in August. Due to heavy rainfall (227.6 mm) coupled with high air temperatures, corn plants (tassels and developed cobs) were rapidly infected by corn smut (*Ustilago maydis*). In addition, rainfall shortages in the preceding months (May – 14.7 mm, June – 45.3 mm, July – 54.4 mm, compared with the long-term mean) influenced sweet corn growth and development and therefore yield. Michałojć et al. (1996) and Waligóra and Kruczek (2003 a) report that seed germination and flowering are the critical periods of highest corn demand for water. Also, weather conditions in the individual years of the study affected the decomposition rate of the incorporated organic manures and, as a result, the ability of corn take up the nutrients released during the decomposition. According to Brzeski et al. (1993) and Szymankiewicz (1993), the effect of green manures on yield depends not only on weather conditions in the period of their decomposition, but also during the period of growth of the subsequent plants.

Analysis of the study results showed a significant influence of organic manures on sweet corn yields. The highest total yield of cobs was obtained for corn cultivated treated with FYM (17.7 t ha^{-1}) and the sunflower catch crop sown on the 21st of July (D1) (17.8 t ha^{-1}). A similar total yield of cobs, which was within the limits of statistical error, was recorded following sunflower catch crop D2 (16.7 t ha^{-1}). Significantly lower yields were recorded for sweet corn cultivated in the control treatment NOM (14.6 t ha^{-1}) and following sunflower catch crop D3. The same pattern was observed for the marketable yield of cobs. The highest was the yield following FYM (12.6 t ha^{-1}) and sunflower D1 (12.4 t ha^{-1}). Significantly lower was the marketable yield of cobs obtained from corn plants cultivated following sunflower catch crop D2 (11.4 t ha^{-1}); the significantly lowest was the yield of cobs harvested from the control NOM (9.5 t ha^{-1}) and the treatment in which the sunflower D3 biomass had been incorporated (9.2 t ha^{-1}).

The yield level of sweet corn cobs cultivated after organic manures was proportional to the amount of biomass and macroelements they introduced into the soil. According to Brzeski et al. (1993), the quantity of organic mass incorporated with green manures is one of the main factors influencing their successive effect on yield. In the present experiment, the most dry matter and macroelements were incorporated with FYM and slightly less with the sunflower catch crop sown on the 21st of July (D1). Delayed sowing dates of the catch crop (shorter growing season of sunflower) decreased the amount of biomass and accumulated components. Tejada et al. (2008) found that the more organic mass was introduced into the soil with green manures (red clover and rape), the higher the corn yield was. In the cultivation of sweet corn, Jabłońska-Ceglarek and Rosa (2005) observed a similar production effect of farmyard manure and green manures of field pea and vetch sown alone and in a mixture. In an experiment with cover crops, Konopiński and Kęsik (2000) examined white mustard and oat catch crops in corn cultivation and recorded a higher total yield of cobs after white mustard as compared to the oats. In the study by Ott and Dabney (1989), a crimson clover catch crop increased corn seed yields compared with cultivation without the catch crop. A positive effect of green manures on the yields of other vegetable species was also found by Wadas (1998), Franczuk (2003), and Kołota and Winiarska (2003). A secondary effect of leguminous catch crops on soil and plants (including corn) is quite favourable. However, studies on the application of non-legumes have yielded ambiguous results. Kuo and Jellum (2002) noted that non-legumes have low N content and a high C/N ratio and, as a result, their influence on subsequent crops is rarely positive. Other authors pointed to allelopathy as the factor behind the unfavourable effect of some plants on subsequent crops (Raimbault et al. 1990, Choi and Daimon 2008).

In the present experiment, both tested sweet corn cultivars produced similar yields. Compared with 'Challenger F_1', 'Sweet Wonder F_1' showed a small tendency towards increasing yields.

The mean mass of a marketable cob was significantly influenced by the weather conditions during the study and the kind of organic manures applied (Tab. 4). Cob mass depended on the cultivar as well. The mass of marketable cobs with cover leaves amounted to 327.1 g in 2005 and 328.2 g in 2007. Cobs with significantly lower mass (271.1 g) were harvested in 2006. Sunflower D1 green manure had the most favourable effect on the mass of cobs with cover leaves. The cob mass amounted to 338.1 g. A similar effect was found following FYM (cob mass 325.7 g). Cobs with significantly lower mass were produced by corn plants cultivated following the sunflower catch crop D2 (301.4 g) and D3 (298.5 g), and also in the control NOM (280.5 g). FYM incorporation significantly increased the mass of cobs with cover leaves compared to the sunflower catch crop D3 and the control NOM. 'Challenger F_1' cobs with cover leaves weighed 7% more than the cobs and cover leaves of 'Sweet Wonder F_1'.

After the removal of cover leaves, a higher mean mass was recorded for cobs harvested in 2007 (289.0 g), significantly lower in 2005 (261.5 g), and significantly lowest (178.5 g) in 2006. The higher mass of cobs without cover leaves was achieved in the cultivation including incorporation of sunflower catch crops D1 (312.9 g) and FYM (311.7 g). Cobs characterized by lower mass were harvested from the remaining combinations of organic manuring. The mass of 'Challenger F_1' cobs with removed cover leaves was 46% higher than the mass of 'Sweet Wonder F_1' cobs.

The mass of kernels from the marketable cobs of corn cultivated in 2005-2007 averaged 157.8 g (Tab. 5). The highest mass (208.8 g) was recorded in 2007, it was significantly lower (143.1 g) in 2005 and significantly lowest (121.4 g) in 2006. In terms of kernel mass, the most favourable was

Table 4. The average mass of marketable cobs

Differentiating factors	Mass of a cob with cover leaves (g)			Mass of a cob without cover leaves (g)		
	Cultivar		$\bar{x}$	Cultivar		$\bar{x}$
	'Challenger F_1'	'Sweet Wonder F_1'		'Challenger F_1'	'Sweet Wonder F_1'	
Organic manuring						
Control (NOF)*	288.3	272.6	280.5	226.1	158.9	272.2
Farmyard manure	330.0	321.3	325.7	268.4	186.8	311.7
Sunflower (D1)	353.1	323.0	338.1	295.6	198.8	312.9
Sunflower (D2)	310.2	292.5	301.4	265.9	174.8	273.5
Sunflower (D3)	313.3	283.7	298.5	251.5	173.4	274.6
Mean	319.0	298.7	308.8	261.5	178.5	289.0
Years						
2005	327.1			261.5		
2006	271.1			178.5		
2007	328.2			289.0		
$NIR_{0.05}$ for:						
years	10.3			10.5		
organic manuring	26.8			24.0		
cultivar	6.7			6.9		

*Explanations: see Table 3

Table 5. The biological productivity of corn

Differentiating factors	The average mass of grains per 1 marketable cob (g)			The biological productivity of corn (%)		
	Cultivar		$\bar{x}$	Cultivar		$\bar{x}$
	'Challenger F_1'	'Sweet Wonder F_1'		'Challenger F_1'	'Sweet Wonder F_1'	
Organic manuring						
Control (NOF)*	135.6	147.6	141.6	63.2	71.7	67.5
Farmyard manure	174.6	178.0	176.3	71.0	73.1	72.1
Sunflower (D1)	169.1	179.0	174.0	63.9	72.3	68.1
Sunflower (D2)	155.7	154.3	155.0	67.6	70.5	69.1
Sunflower (D3)	138.0	145.9	142.0	59.5	67.6	63.5
Mean	154.6	161.0	157.8	65.0	71.0	68.0
Years						
2005	143.1			61.1		
2006	121.4			69.5		
2007	208.8			73.5		
$NIR_{0.05}$ for:						
years	8.2			4.5		
organic manuring	12.8			6.5		
cultivar	5.6			3.0		
organic manuring × cultivar	8.9			4.6		

*Explanations: see Table 3

corn cultivation following farmyard manure and sunflower catch crop sown on the 21st of July (D1). The kernel mass amounted to 176.3 g and 174.0 g. A significantly lower mass (155.0 g) was recorded for kernels from the cobs of corn cultivated after sunflower D2, and significantly lowest (142.0 g) after sunflower D3 and in the control NOM (141.6 g). The mass of kernels from 'Sweet Wonder F_1' marketable cobs was 6.4 g higher than from 'Challenger F_1'. The difference was significant.

The effect of organic manuring on kernel mass depended on the corn cultivar. ‘Challenger F_1’ had the highest kernel mass when it was cultivated after FYM (174.6 g) and sunflower catch crop D1 (169.1 g). Significantly lower (155.7 g) was the kernel mass of corn cultivated after sunflower D2. The significantly lowest kernel mass, which did not exceed 140 g, was recorded for corn cobs following sunflower D3 and in the control NOM. ‘Sweet Wonder F_1’ produced cobs with the highest kernel mass when it was cultivated after the green manure of sunflower D1 (179.0 g) and after FYM (178.0 g). The mass of the kernels in the cobs of this cultivar from the remaining combinations of organic manuring was significantly lower, and ranged from 145.9 g to 154.3 g.

The biological productivity of cobs was determined on the basis of the mass of kernels manually separated from the core (Tab. 5). The highest mass amounted to 73.5% and was recorded for the cobs obtained in 2007. Similar productivity (69.5%) was determined for corn cobs harvested in 2006 and was significantly lower (61.1%) for cobs harvested in 2005. The biological productivity of cobs depended on the organic manuring applied and the corn cultivar. The highest productivity, exceeding 72%, was determined for corn cultivated after FYM, and significantly lower (63.5%) after sunflower catch crop D3. The biological productivity of corn from the remaining combinations of organic manuring ranged from 67.5 to 69.1% and did not differ significantly. ‘Sweet Wonder F_1’ cobs had 6% higher biological productivity than ‘Challenger F_1’ cobs. An interaction of organic manuring and corn cultivars had a significant influence on the biological productivity of cobs as well. ‘Challenger F_1’ cultivated after FYM produced cobs characterised by the highest productivity (71.0%). A similar productivity (67.5%) was determined for cobs of corn cultivated after sunflower catch crop D2. Corn cobs from the remaining treatments had significantly lower productivity than the cobs of corn cultivated after farmyard manure. Sunflower catch crop D3 significantly decreased the biological productivity of cobs compared with catch crop D2. ‘Sweet Wonder F_1’ produced cobs with the highest biological productivity in the treatments using FYM and sunflower catch crop D1. The productivity amounted to 73.1% and 72.3%, respectively. Significantly lower biological productivity values were found for the cobs of corn cultivated following sunflower green manure D3. The productivity values of corn cobs cultivated in the control NOM and after sunflower catch crop D2 amounted to 71.1% and 70.5%, respectively, and they did not differ significantly from the values obtained for the remaining treatments.

Longer and thicker cobs with a greater number of kernel rows were harvested in 2005 and 2007 as compared to 2006 (Tab. 6).

Table 6. The length and diameter of marketable cobs and number of kernel rows in cob

Differentiating factors	The length of cob (cm)			The diameter of cob (cm)			An average number of kernel rows		
	Cultivar		$\bar{x}$	Cultivar		$\bar{x}$	Cultivar		$\bar{x}$
	‘Challenger F_1’	‘Sweet Wonder F_1’		‘Challenger F_1’	‘Sweet Wonder F_1’		‘Challenger F_1’	‘Sweet Wonder F_1’	
Organic manuring									
Control (NOF)*	19.3	19.7	19.5	4.5	4.5	4.5	15.9	16.3	16.1
Farmyard manure	20.8	21.0	20.9	4.8	4.8	4.8	17.0	17.1	17.0
Sunflower (D1)	20.8	20.5	20.7	4.8	4.9	4.8	16.7	17.2	17.0
Sunflower (D2)	19.9	20.2	20.0	4.5	4.7	4.6	16.1	16.9	16.5
Sunflower (D3)	20.1	20.1	20.1	4.6	4.5	4.6	17.0	16.0	16.5
Mean	20.2	20.3	20.2	4.7	4.7	4.7	16.5	16.7	16.6
Years									
2005	21.4			5.0			16.9		
2006	18.2			4.1			16.0		
2007	21.2			5.0			16.9		
$NIR_{0.05}$ for:									
years	0.5			0.4			0.4		
organic manuring	0.9			0.4			0.8		
cultivar	n.s.			n.s.			n.s.		

*Explanations: see Table 3

The mean length of cobs amounted to 20.2 cm. The longest cobs were produced by corn plants cultivated after FYM (20.9 cm) and sunflower catch crop D1 (20.7 cm). The cobs harvested in the control NOM were significantly shorter (19.5 cm). Cobs with the greatest diameter (4.9 cm) were produced by corn sown following sunflower catch crop D1 and they were significantly smaller (4.5 cm) in the control NOM. The highest mean number of kernel rows in a cob (17) was characteristic of corn cultivated after FYM and sunflower catch crop sown on the 21st of July; it was significantly lower (16.1) after organic manuring. The cultivars tested in the experiment did not differ in terms of the examined cob parameters.

Cobs characterised by the best parameters were harvested from the treatments in which organic manures introduced the most biomass and macroelements into the soil. A similar relationship was identified by Jabłońska-Ceglarek and Rosa (2005) in studies regarding the influence of green manures on sweet corn yields. The authors harvested the longest and heaviest cobs characterised by the greatest diameter from corn plants cultivated following farmyard manure and leguminous green manures. In addition, Waligóra and Kruczek (2003 b) reported that increased fertilizer nitrogen rates supplied to the soil resulted in increased length and diameter in sweet corn cobs.

CONCLUSIONS

The present study showed that sunflower catch crops may become an alternative to farmyard manure in sweet corn cultivation. Their secondary effect on yield depends to a large extent on the sowing date. In our experiment, the best results were achieved when the catch crops were sown on the 21st of July. However, sowing at this date may sometimes be difficult due to the fact that the main crop has not been removed from the field yet. Delaying the catch crop sowing date by 14 days did not significant reduce the total yield or the marketable yield of cobs compared with farmyard manure and sunflower catch crop sown at the 1st date. The sunflower catch crop sown 14 days later (18th of August) was characterised by a significantly poorer effect on yield compared with the farmyard manure and catch crops sown on the 21st of July and 4th of August. It seems that there is no point in sowing catch crops at this date, especially as the yields of sweet corn cultivated following these catch crops do not differ significantly or are even lower compared with the yields of corn cultivated without organic fertilization. Weather is a very important factor influencing corn growth. Climatic conditions also condition growth, and sunflower catch crops planted at individual dates as well as their influence on yields of subsequent plants. As a result it seems justified to test the possibility of using catch crops in sweet corn cultivation in other climatic regions.

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DZIAŁANIE NASTĘPCZE MIĘDZYPLONU SŁONECZNIKA (*HELIANTHUS ANNUUS* L.) W UPRAWIE KUKURYDZY CUKROWEJ (*ZEA MAYS* L. VAR. *SACCHARATA*)

Streszczenie: Eksperyment polowy przeprowadzono w środkowo-wschodniej Polsce (52°06'N, 22°55'E). Badano wpływ nawozów zielonych w postaci międzyplonu słonecznika, wysiewanego w trzech terminach (21 lipca, 4 i 18 sierpnia), na plonowanie i wzrost kukurydzy cukrowej. Kukurydzę odmian 'Challenger F_1' i 'Sweet Wonder F_1' uprawiano w pierwszym roku po nawożeniu organicznym. Słonecznik przyorywano w trzeciej dekadzie października. Efekty stosowania międzyplonowych nawozów zielonych porównano z obornikiem w dawce 40 t ha^{-1} oraz obiektem kontrolnym bez nawożenia organicznego. Ilość biomasy i makroskładników przyorana z międzyplonem słonecznika wysianym 21 lipca była zbliżona do ilości, jaką wniósł obornik w dawce 40 t ha^{-1}. Ilość masy organicznej i makroskładników przyorana ze słonecznikiem posianym 4 sierpnia była o ok. 20%, a z posianym 18 sierpnia o 50% mniejsza w porównaniu z przyoranymi z obornikiem. Działanie plonotwórcze obornika i międzyplonu słonecznika posianego 21 lipca było zbliżone. Plon handlowy kolb kukurydzy wyniósł odpowiednio 12,6 t ha^{-1} i 12,4 t ha^{-1}. Zastosowanie pod kukurydzę nawozu zielonego w postaci słonecznika posianego 4 i 18 sierpnia powodowało spadek plonu handlowego kolb o 8% i 25% w porównaniu do uzyskanych po oborniku. Największą masę miały kolby w uprawie po międzyplonie słonecznika wysianym 21 lipca oraz po oborniku. Kolby kukurydzy uprawianej po oborniku charakteryzowały się najwyższą wydajnością biologiczną (72,1%), zbliżoną do nich miały kolby kukurydzy uprawianej po międzyplonach wysianych 21 lipca i 4 sierpnia. Odmiany 'Chalenger F_1' i 'Sweet Wonder F_1' plonowały na podobnym poziomie. Odmiana 'Challenger F_1' wykształciła kolby o większej masie, a odmiana 'Sweet Wonder F_1' o wyższej wydajności biologicznej.

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