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SWEET CORN - CONVENTIONAL TILLAGE VS. NO-TILLAGE IN HUMID CONDITIONS

SUMMARY

The goal of the paper is to compare the impact of conventional tillage and no-tillage technology on the growth, the yield and yield components of sweet corn, cultivated on chromic luvisols. A field experiment with Super Sweet 71,12 R hybrid was carried out in 2014 in the region of Sofia, Bulgaria. The impact of both systems on the total fresh ear yield, marketable fresh ear yield, total ear number, marketable ear number, single marketable fresh ear mass, marketable ear row number, one row kernel number of a marketable ear, marketable fresh ear kernel mass, plant height, leaf number per plant, ear legth, and tassel length was established. Analysis of variance was applied to all data obtained. The experiment was carried out on chromic luvisols, in a temperate-continental climate and in a very humid year. The results showed that the conventional tillage in such nature conditions have had better performance than the no-tillage technology. The yield of marketable fresh ears under conventional tillage was twice higher than that under no-tillage, i.e. 8.5 Mg/ha vs. 4.2 Mg/ha; kernel mass of a single fresh ear was with 22.6% higher, i.e. 163.8 g vs. 133.6 g, the 1000-kernel mass was with 14.4% higher, i.e. 337.2 g vs. 293.0 g. Analogously, the plants were longer and had thicker stems with greater leaf number, resulting in 12.5% greater fresh-ear length – 20.7 cm. The total fresh biomass under conventional tillage reaches 633.0 g/plant vs. 414.6 g/plant under no-tillage and the dry matter - 145.6 g vs. 103.7 g/plant. The protein content was 13.8% vs. 12.7%. The production under conventional tillage was more profitable. The price of a marketable corn ear was much lower - 0.0358 EUR/pc vs. 0.0512 EUR/pc. No-till requires precise preliminary estimation of the nature conditions and weather prognoses and cannot be recommended to very humid areas and

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conditions. In very humid conditions it should be applied on weed-free areas after several-year control through herbicides.

Keywords: *No-till, Conventional tillage, Sweet corn, Yield, Yield components, Bulgaria*

INTRODUCTION

One of the strict requirements of market economy is high-quality and competitiveness of the agricultural products. The resource-saving and environmentally friendly agricultural technologies play a major role in meeting these issues. Recently, a new outlook to soil preservation by applying conservation tillage has gained popularity. The traditional systems of soil cultivation are regarded as causing soil degradation and being inconsistent with the environmentally friendly use of land. Any kind of conservation tillage (zero, strip, mulch, chisel, ridge and plow tillage, the latter with special plows that retain at least 30% plant residuals or plant mulch on the surface) provides safe land use from environmental, social and economic points of view. According to Derpsh (2009), if the farmers want to have the opportunity not only to survive, but also to achieve an environmentally sound and economically viable farming, they have to replace the traditional tillage with new tillage methods and farming. The conservation tillage technologies take control on water and wind erosion, preserve and improve soil fertility, improve the humus balance, reduce the loss of nutrients and moisture, improve crop productivity and labor efficiency, reduce the specific energy consumption and the production costs. These cultivation practices are considered as the most promising (Vrazhnov, 2013). Currently, 25% of the whole cultivated area in the world is under no-till. No-till is now practiced in all latitudes and altitudes, in extremely dry conditions and extremely rainy areas, in all kinds of farm sizes, in soils, in all crops as well. In the South American countries, Canada and the United States, 90% of the area sown with cereals is cultivated by conservation technologies, including up to 50-60% no-till (Calistu, Jităreanu, 2014). Despite its advantages, this technology is not yet widely used in Europe. The share of the conventional soil preparation technology is 70-75%, subsurface - 20-25%, while direct sowing in the untreated soil - less than 5%, (Gapon, 2014, Bulavin, 2016). The area of grain crops under no-tillage technology in Russia does not exceed 2% (Vrazhnov, 2013). According to Vrazhnov, (2013) a number of shortcomings hinder the widespread use of soil conservation technologies - disruption of the biological processes in the top soil layer, lack of N, unharmonious and weakened shoots, an increase of the weeds application of a large amount of herbicides additional application of N fertilizer, lack of necessary machines and tools, high cost of special stubble seeders. The direct seeding technology does not always ensure the growth of productivity and profitability (Bulavin, 2016)

Sweet corn (*Zea mays saharata* Korn.) has gained popularity in Bulgaria over the past 10 years. Nowadays the consumers' demand for fresh sweet corn is strong. The crop is attractive for its excellent taste and nutritional value due to the high content of sugars. Though the crop is profitable and easily marketed, Bulgarian market of sweet corn is still underdeveloped. Production of sweet corn needs a production technology that provides maximum return and meets the environmental principles of the sustainable production (Sevov, 2014).

The goal of the paper is to compare the impact of conventional tillage and no-tillage technology on the growth and the yield and yield components of sweet corn, grown on chromic luvisols.

MATERIALS AND METHODS

A field experiment with Super Sweet 71,12 R hybrid was carried out in 2014 in the region of Sofia, Bulgaria. The site is near Sofia at 550 m a.s.l. The climate is temperate-continental and the region is one of the coldest and most humid in Bulgaria (Moteva et al., 2015). The experiment was put in a randomized complete block design in three replications. No-till vs. conventional tillage was tested. Conventional tillage consisted of deep plowing and repeating cultivation before sowing, while no-tillage consisted of direct sowing in a field with plant canola residues. Dicamba in a dose of 0.15-0.30 l/ha and working fluid 250-400 l/ha was applied against weeds during the 3-4 leaf stage (Tosheva, 2006). The N-fertilizer was divided into two portions - N_{60} before sowing and N_{60} as feeding up during the vegetation stage, totally 120 kg/ha. The following production elements were investigated – total fresh ear yield, marketable fresh ear yield, total ear number, marketable ear number, single marketable fresh ear mass, marketable ear row number, one row kernel number of a marketable ear, and marketable fresh ear kernel mass. Plant characteristics such as plant height, leaf number per plant, ear legth, and tassel length were read. Analysis of variance was applied to all data obtained.

According to air temperature, the conditions were average to cool. According to the rainfalls, the period was very humid. The May-August rainfall total was 444.7 mm and has 10% probability of exceedance (Table 1). The daily rainfalls were evenly distributed through all the season. No need in irrigation occurred. These very humid conditions hindered the weed control. Corn was sown on 10th May. The duration of the growing season was 103 days.

RESULTS AND DISCUSSION

The results from the analysis of variance showed that the yields obtained under no-till technology were statistically lower than the yields obtained under conventional tillage (Table 1).

The yield of the marketable fresh ears under conventional tillage was 8.530 Mg/ha, while under no-tillage - 4.229 Mg/ha, which was 102% less. The mass of the total fresh ears was 17% less respectively. The green biomass (vegetative mass plus ears) under conventional tillage was 35.3% less that the one under no-tillage. The yields in the experiment correspond to the reported in literature yields. (Tosheva, 2006; Jett, 2006; O’Neill, 2008).

Table 1. Yields

Tillage variant	Total green mass + ears			Fresh ears total			Marketable fresh ears		
	Yield	Difference		Yield	Difference		Yield	Difference	
	Mg/ha	Mg/ha	%	Mg/ha	Mg/ha	%	Mg/ha	Mg/ha	%
Conventional	25.365			11.565			8.530		
No-till	18.741^{00}	6.624	35.3	9.873^{00}	-1.692	-17.1	4.229^{0}	-4.307	-102.0
$GD_{5\%}$ Mg/ha	±2.082			±0.579			±2.847		
$GD_{1\%}$ Mg/ha	±4.802			±1.334			±6.566		
$GD_{0.1\%}$ Mg/ha	±15.289			±4.248			±20.903		

^{0}significant at P=5%, ^{00}significant at P=1%

Both tillage technologies affected the yield components similarly (Table 2). There were obtained 215.5 g vs. 177.9 g average weight per marketable ear, 163.8 g vs. 133.6 g average kernel mass of a marketable ear and 337.2 g vs. 293.9 g for 1000-kernel mass, respectively. Those differences were significant at P=5% and P=1%. The average number of kernels of an ear was not affected by tillage technologies.

Table 2. Yield components of the marketable ears

			Tillage variant		$GD_{5\%}$	$GD_{1\%}$	$GD_{0.1\%}$
			Conventional	No-till	g, pcs	g, pcs	g, pcs
Single ear	Mass	g	215.5	177.9^{0}	±12.3	±28.4	±90.3
	Difference	g		-37.7			
		%		-21.2			
Kemel mass of a single ear	Mass	g	163.8	133.6^{0}	±14.6	±33.7	±107.2
	Difference	g		-30.2			
		%		-22.6			
Kemel number of a single ear	Pieces	pcs	485.7	454.2	±66.7	±153.8	±489.8
	Difference	pcs		-31.5			
		%		-6.9			
1000-kemel mass	Mass	g	337.2	293.9^{0}	±40.4	±93.2	±296.6
	Difference	g		-43.2			
		%		-1.47			

^{0}significant at P=5%, ^{00}significant at P=1%

Twice as many marketable ears per 100 plants (80 pcs) were obtained under conventional tillage, compared with those under the no-tillage technology (Table 3).

The tiller number was much higher - 14 pcs vs. 1 pcs, respectively. The number of non-marketable ears was the same under both tillage technologies. The total number of ears under conventional tillage (142 pcs) was greater vs. those obtained under no-tillage. Plant height and the height of betting of the first ear were significantly influenced by the tillage technology.

Table 3. Number of tillers and ears

	Tillage variant	Per 100 plants	Per hectare
Marketable ears	Conventional tillage	80	36000
Non marketable ears		60	26850
Number of tillers		14	4050
Total number of ears		142	62850
Marketable ears	No-till	48	36000
Non marketable ears		66	29550
Number of tillers		1	450
Total number of ears		113	51000

The plants affected by no-till are significantly shorter – less by 21.5 cm, and the height of betting of the first ear - less by 6.4 cm (Table 4). The number of leaves and length of the tassel showed no differences. The ear under no-till was significantly shorter – 18.4 cm vs. 20.7 cm.

Table 4. Analysis of variance for the biometric characteristics

			Tillage variant		$GD_{5\%}$	$GD_{1\%}$	$GD_{0.1\%}$
			Conventional tillage	No-till	cm, pcs	cm, pcs	cm, pcs
Plant height	Height	cm	137.3	158.0^{0}	±9.4	±21.6	±68.9
	Difference	cm		-21.5			
		%		-18.6			
Height of betting of the first ear	Height	cm	26.3	19.9^{0}	±4.7	±10.9	±34.6
	Difference	cm		-6.4			
		%		-32.2			
Leaves number	Number	pcs	7.6	7.2^{0}	±2.19	±5.05	±16.09
	Difference	pcs		-0.3			
		%		-4.6			
Tassel length	Length	cm	31.2	30.2^{0}	±5.43	±12.53	±39.87
	Difference	cm		-1.0			
		%		-3.3			
Fresh ear length	Length	cm	20.7	18.4^{00}	±1.0	±2.2	±7.0
	Difference	cm		-2.3			
		%		-12.5			

^{0}significant at P=5%, ^{00}significant at P=1%

The absolute growth of plant height, leave number, tassel length and fresh ear length was greater under the conventional soil tillage. The maximum plant height was read at harvesting - 137.3 cm vs. 115.8 cm (Fig. 1a). The maximum number of leaves under both tillage technologies was reached for about 75 DAS and was 7.6 vs. 7.2 (Table 4 and Fig 1b).

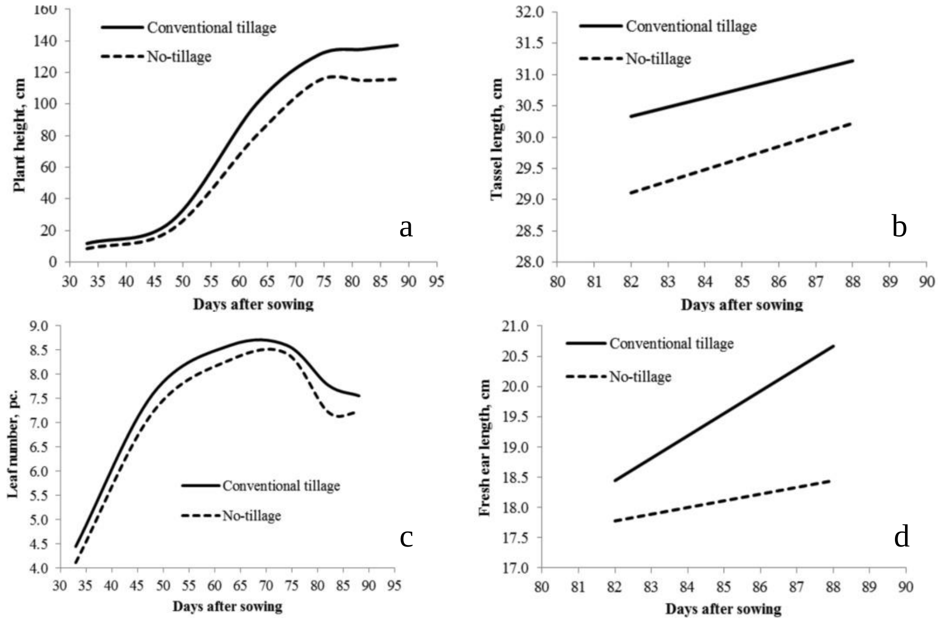

Figure 1. Absolute growth of biometric characteristics: a) plant height; b) leaf number; c) tassel length; d) fresh ear length

The rate of growth was most intensive in the period from 48th to 75th DAS (stem elongation stage) and the formation of leaf mass - from 35th to 50th DAS. The latter completed with the appearance of 8th leaf under conventional tillage vs. 7th leaf under no-tillage (Fig 1ab). Leaf number was 8.5 on the 75th DAS under both tillage technologies. The tassels and the ears increased their length to the end of the vegetation period (Fig. 1cd).

The accumulation of fresh biomass was most intensive during the period 60th-75th after sowing in the course of stem elongation stage (Fig. 2).

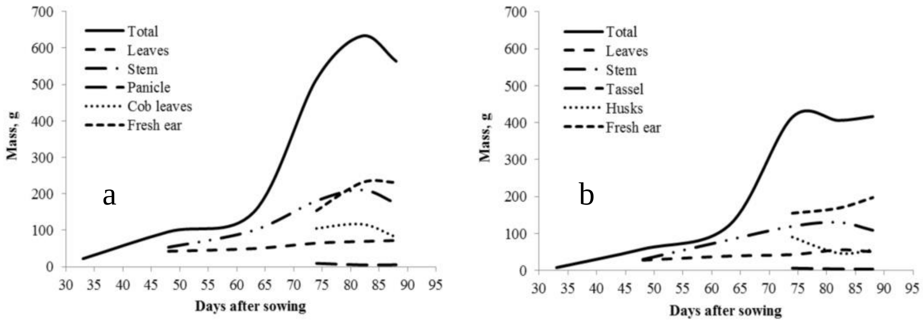

Figure 2. Fresh biomass accumulation under:
a) conventional tillage; b) no-tillage

The greates part of the biomass was accumulated in the stems and in the ears. Least mass was accumulated in the husks and tassel. The total fresh biomass was greatest at the stage of tasseling under conventional tillage - 633.0 g/plant. Dry matter reached 145.6 g vs. 103.7 g/plant, respectively (Fig. 3).

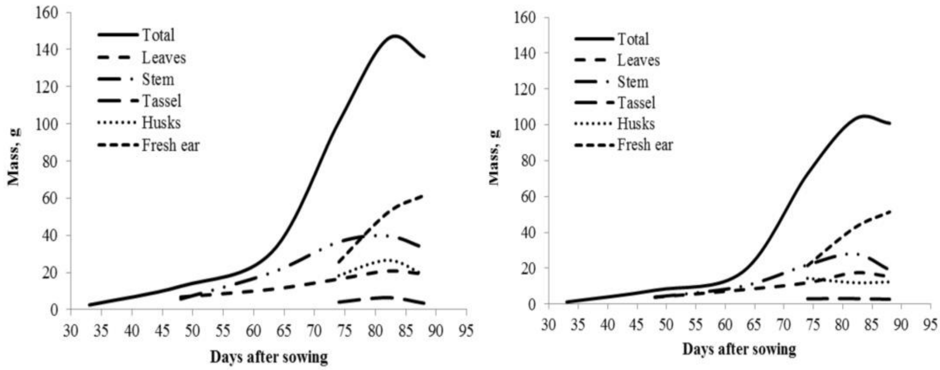

Figure 3. Dry biomass accumulation under:
a)conventional tillage; b) no-tillage

Regardless of the absolute values of biomass distribution, the relative values of fresh and dry biomass at tasseling under both tillage technologies were similar. The ear constituted 53-55% of the whole plant fresh biomass, the stem - 32-33% and the leaves – 11-14%. The ratio between the biomass of the husks and the fresh ear was more favorable at no-tillage. The conventional tillage contributed for a greater mass of the husk leaves - 18.4% vs. 11.6% and for smaller kernels+cob mass – 36.5% vs. 41.6%, respectively. The tendencies in the dry mass were like those of the fresh biomass. The proportion of the relative dry weight of the kernels to the cob under the impact of both tillage methods was the same - about 74% kernel mass and 26% cob mass (Table 5).

Table 5. Proportions in the fresh and dry biomass per organs, %

Plant organs	Fresh biomass		Dry biomass	
	Conventional	No-till	Conventional	No-till
Leaves	11.0	13.7	14.3	16.9
Stem	33.3	32.1	27.2	27.2
Tassel	0.8	1.0	4.5	2.9
Ear, incl.:	54.9	53.2	54.0	52.9
Kernels+cob	*36.5*	*41.6*	*35.8*	*41.3*
Husks	*18.4*	*11.6*	*18.3*	*11.6*
Total	100.0	100.0	100.0	100.0

Table 6. Distribution of the dry biomass in the fresh ear

Component	Conventional		No-till	
	g	%	g	%
Fresh ear, incl.:	61.5	100	51.4	100
Kernels	*45.3*	*73.6*	*37.9*	*73.8*
Cob	*16.2*	*26.4*	*13.5*	*26.2*

Table 7. Proteins and fat at 71.1% average humidity of the kernel (weighing percent)

Tillage technology	Proteins	Fat
Conventional	13.80	5.02
No-till	12.70	6.00

The protein content in the grain under conventional tillage was higher than of that of no tillage - 13.8% vs. 12.70% (of the abs. dry matter at 71.1% moisture of the kernels) (Table 6) and the fat content was less - 5.02% vs. 6.00% (Table 7). The production of sweet corn under conventional tillage was more profitable. The rate of profitability under conventional tillage was around 150% higher and the cost price per piece was 0.00154 EUR lower. The price under conventional tillage amounted to 0.0358 EUR/pc. vs. 0.0512 EUR/pc. under no-tillage (Table 8).

Table 8. Economic indices

	Yield	Production (x 0.30 EUR/pc.)	Expences	Income	Cost price	Rate of profitability
	pcs/ha	EUR/ha	EUR/ha	EUR/ha	EUR/pc	%
Conventional	36000	552.645	1,217.87	4,308.58	0.0358	353.8
No-till	21450	329.284	1,120.64	2,172.20	0.0512	193.8

CONCLUSION

An experiment that was carried out with sweet corn on chromic luvisols in a temperate-continental climate and in a very humid year, showed better results for the conventional tillage technology than for the no-tillage one. The yield of the marketable fresh ears was twice higher – 8.5 Mg/ha vs. 4.2 Mg/ha, the kernel mass of a single fresh ear was with 22.6% higher – 163.8 g vs. 133.6 g, 1000-kernel mass was with 14.4% higher – 337.2 g vs. 293.0 g. Analogously, the plants were longer and had thicker stems with greater leave number, resulting in 12.5% greater length of a single fresh-ear – 20.7 cm vs. 18.4 cm. The total fresh biomass under conventional tillage reached 633.0 g/plant in the stage of tasseling, while under no-tillage reached 414.6 g/plant. Dry matter reached 145.6 g vs. 103.7 g/plant, respectively. The protein content was 13.8% vs. 12.7%.

The production was more profitable under conventional tillage and according to that, the price of a marketable corn ear was much lower - 0.0358 EUR/pc. vs. 0.0512 EUR/pc. In high humidity conditions, despite of spraying, no-tillage didn't guarantee clear fields and the weeds have probably affected the production results. No-till in very humid conditions should be applied on weed-free areas after several-year control on them with herbicides.

REFERENCES

Bulavin, L.A., A.P. Gvozdov, S.S. Nebishinetz. (2010). Minimizing tillage: Reality and Perspectives. Belarus Agriculture http://old.agriculture.by/archives/1615 Accessed on 18.03.2016

Calistru, A.E., G. Jitareanu (2014). No-tillage around the world. Journal "Life Sciencies, a Challenge for the Future", Seria Agronomie, 57, 2, Ed. "Ion Ionescu de la Brad", Iasi, Romania, (11-16)

Derpsh, R. (2009). The main steps for the implementation of no-tillage. http://no-till.ru/view_articles.php?id=11 Accessed on 1/03/2016

Gapon, N. (2014). Classical tillage technology, http://agroinfo.com/selxoztexnika-2/ Accessed on 01/03/2016

Growing Guide: Sweet Corn Growers Handbook. (2005). Queensland Government, www.deedi.qld.gov.au Accessed on 18/03/2016

Jett, L. W. (2006). Growing Sweet Corn in Missouri. http://extension.missouri.edu/p/G6390 Accessed on 18/03/2016

Moteva, M., V. Kazadjiev, V. Georgieva (2015) Climatological and Meteorological Information for Future Sustainable Agriculture in Bulgaria. In: Environment, Ecology and Sustainability at the Beginning of 21st Century, Chief ed. Prof. Recep Efe, St. Kliment Ohridski University Press, Sofia, Bulgaria, (91-111)

O'Neill, C. J., E. Humphreys, J. Louis, A. Katupitiya. (2008). Maize productivity in southern New South Wales under furrow and pressurised irrigation. Australian Journal of Experimental Agriculture, Vol. 48 (3), (285–295)

Sevov, A., B. Yankov, P. Zorovski, E. Valcheva, R. Popova, N. Palagacheva, D. Stoychev. (2014). A Technology for Sweet Corn Production. Acad. Ed. Agrarian University, Plovdiv, Bulgaria

Tosheva, T. (2006). Technologies for Growing and Processing of Sweet and Popcorn. PublishSaiSet, Sofia, Bulgaria

Vrazhnov, A.V. (2013). Efficiency of minimizing of tillage. Journal "Zauralie fields", Vol. 9(109), October 2013, http://svetich.info/publikacii/agronauka/yeffektivnost-minimalizacii-obrabotki-po.html, Accessed on 01/03/2016