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Effects of compost treatments on the dry matter-, ash-, total acidity-, sugar- and Vitamin C content of the integrated and organic produced Golden Delicious and Pinova apples

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Abstract

Compost treatments (1.5; 3.5 and 7.0 kg) were applied for 3 years in an apple orchard to trees with M26 rootstock and slender spindle crown shape, planted in 2008 with 1.5 m planting distance. The effect of the compost treatments was examined in case of two production technologies (integrated and organic) and two apple varieties (Borkh. Golden Delicious and Pinova). Nutritional differences were observed between the different production technologies year by year (the integrated orchard received basic mineral fertilization as well). The compost treatments had an effect not only on the soil parameters of the organic orchard, but the soil parameters of the integrated orchard as well. During the examined 3 years we came to a conclusion that the dry matter content of the fruit samples was primarily effected by the precipitation and the amount of the crop. The ash content of the apple samples was similar to their dry matter content. The sugar content of the fruit samples remained equalized all along. The total acid content of the organic apples showed a more extreme fluctuation over the years, than the total acid content of the integrated apples did. The Vitamin C content of the integrated cultured apples appeared to be more balanced, in contrast to the organic cultured apples. As for the varieties, in the Golden Delicious apples higher Vitamin-C content was measured, than in the Pinova apples.

Keywords: recycling; compost; orchards; apples; dry matter-, ash-, total acidity-, sugar-, Vitamin C content

1. Introduction

Nowadays recycling of the side-products produced by agriculture is getting more emphasis on (SIMÁNDI, 2008), because the amount of the produced biomass is around 30 million ton per year (OHT II, 2009).

With the application of the compost products in the horticulture, not only the recycling of biological degradable organic side-products and wastes originating from the agriculture, food industry, households and public places can be realised, but also the increase of soil fertility (ELFOUGHI et al., 2010), therefore the positive effect on the crop size and quality can be seen (GIGLIOTTI et al., 1966; KÁDÁR and MORVAI, 2007; KESERŰ, 2007).

The effect of different compost doses on the nutrient content (dry matter, ash, total acid, sugar and Vitamin C) of two apple varieties (*Malus domestica* Borkh., cv. *Golden Delicious* and *Pinova)* was measured in an organic and an integrated apple orchard between 2010 and 2012.

In the organic orchard only organic compost, while in the integrated orchard, a synthetic fertilizer was also applied. We were hoping that in the first case more healthy fruits (free of harmful materials) could be produced with similarly high nutrient content.

2. Material and methods

2.1. The location of the field experiment

The field experiment was carried out in the research station of Debrecen-Pallag on a humic sandy soil [pH($CaCl_2$) = 6.06] in organic and integrated apple orchards planted in 2008.

2.2. Characteristics of orchard

The main features of the trees of the orchard: installation in 2008, M26 rootstock, 1.5 m planting distance and slender spindle crown shape. The main characteristics of the orchards are summarized in **Table 1**.

Table 1: The characteristics the orchard

Studied orchards	**Organic**		**Integrated**	
Studied apple variety	***Golden D.***	***Pinova***	***Golden D.***	***Pinova***
Crown structure	slender spindle		slender spindle	
Plantation date	2008		2008	
Planting material	1 year old nursery material		1 year old nursery material	
Rootstock	M26		M26	
Distance between rows (m)	4		4	
Distance between trees (m)	1,5		1,5	
Number of trees (1 ha)	1666		1666	
Row orientation	NW-SE		NW-SE	
Irrigation	Drip		Drip	
Fertilizer application	wasn't		was	

2.3. The treatments applied in the experiment

The nitrate regulation (Government Decree No. 81/2007. (IV. 25.)) was considered at the determination of the compost doses, because the integrated cultured orchards were fertilized with basic mineral fertilizer in a uniform way: in autumn 2010, one portion of 300 kg ha^{-1} NPK (15:15:15), in spring 2011, divided portions of 200 kg ha^{-1} (34 % NH_4NO_3), as well as in spring 2012, 200 kg ha^{-1} (11:11:26) NPK mineral fertilizers were dispersed.

The total and easily uptakeable N content of the compost was examined (total N_{CaCl2} = 726 mg kg^{-1}), then the compost doses per m^2 were determined based on this. The N active substance (kg/ha) of the compost applied were the following: 0, 10, 25, and 50 while the corresponding quantities (kg/m^2) were: 0, 1.4, 3.5 and 6.9. These compost doses were applied for 7 trees per treatment (1 tree floor area per m^2). **Table 2** shows the amounts of the N-substance applied during the 3 years.

Table 2: The amount of N active substances applied with compost and with mineral fertilizer between 2010 and

Treatment	Production technology	Apple varieties	N active substance applied													
			2010				2011				2012				*In total during the 3 years*	
			Autumn				Spring				Spring					
			with Compost		with Fertilizer		with Compost		with Fertilizer		with Compost		with Fertilizer			
			kg ha^{-1}	kg m^{-2} (1 tree)	kg ha^{-1}	kg m^{-2} (1 tree)	kg ha^{-1}	kg m^{-2} (1 tree)	kg ha^{-1}	kg m^{-2} (1 tree)	kg ha^{-1}	kg m^{-2} (1 tree)	kg ha^{-1}	kg m^{-2} (1 tree)	kg ha^{-1}	kg m^{-2} (1 tree)
1	Organic	*Golden D.*	0.00	0.0000	-	-	0.00	0.0000	-	-	0.00	0.0000	-	-	***0.00***	***0.0000***
3			10.00	0.0010	-	-	10.00	0.0010	-	-	10.00	0.0010	-	-	***30.00***	***0.0030***
4			25.00	0.0025	-	-	25.00	0.0025	-	-	25.00	0.0025	-	-	***75.00***	***0.0075***
5			50.00	0.0050	-	-	50.00	0.0050	-	-	50.00	0.0050	-	-	***150.00***	***0.0150***
6		*Pinova*	0.00	0.0000	-	-	0.00	0.0000	-	-	0.00	0.0000	-	-	***0.00***	***0.0000***
8			10.00	0.0010	-	-	10.00	0.0010	-	-	10.00	0.0010	-	-	***30.00***	***0.0030***
9			25.00	0.0025	-	-	25.00	0.0025	-	-	25.00	0.0025	-	-	***75.00***	***0.0075***
10			50.00	0.0050	-	-	50.00	0.0050	-	-	50.00	0.0050	-	-	***150.00***	***0.0150***
11	Integrated	*Golden D.*	0.00	0.0000	45.00	0.0045	0.00	0.0000	68.00	0.0068	0.00	0.0000	22.00	0.0022	***135.00***	***0.0135***
12			10.00	0.0010	45.00	0.0045	10.00	0.0010	68.00	0.0068	10.00	0.0010	22.00	0.0022	***165.00***	***0.0165***
14			25.00	0.0025	45.00	0.0045	25.00	0.0025	68.00	0.0068	25.00	0.0025	22.00	0.0022	***210.00***	***0.0210***
15			50.00	0.0050	45.00	0.0045	50.00	0.0050	68.00	0.0068	50.00	0.0050	22.00	0.0022	***285.00***	***0.0285***
16		*Pinova*	0.00	0.0000	45.00	0.0045	0.00	0.0000	68.00	0.0068	0.00	0.0000	22.00	0.0022	***135.00***	***0.0135***
18			10.00	0.0010	45.00	0.0045	10.00	0.0010	68.00	0.0068	10.00	0.0010	22.00	0.0022	***165.00***	***0.0165***
19			25.00	0.0025	45.00	0.0045	25.00	0.0025	68.00	0.0068	25.00	0.0025	22.00	0.0022	***210.00***	***0.0210***
20			50.00	0.0050	45.00	0.0045	50.00	0.0050	68.00	0.0068	50.00	0.0050	22.00	0.0022	***285.00***	***0.0285***

2.4. Sampling

The **soil samples** were always taken before compost application (April-May) and the harvest (September) from 0-30 cm and 30-60 cm depth; they were analyzed in 4 replicates. The 0.01 M $CaCl_2$ and AL-soluble element contents were measured, as well as the plasticity index and humus content.

The **fruit samples** were taken in 3 replicates from control and the trees treated with the highest compost doses in case of both production technology (bio/eco and integrated), and both species (*Golden Delicious* and *Pinova*). The sampling times were the following: 12nd September 2010, 13th September 2011 and 16th September 2012. Subsequently, the most important fruit quality parameters were measured: dry matter-, ash-, total acid-, sugar- and Vitamin C contents.

2.5. Determination of the soil parameters

2.5.1. The determination of the plasticity index according to Arany of the soil samples

The physical type of the soils was determined based on the plasticity index according to Arany (K_A) (FILEP, 1995).

2.5.2. Determination of the total humus content of the soil samples

The humus content of the composts and the soil samples were determined according to SZÉKELY (1964). The clear solution was measured colorimetric with a METERTEK SP-850 spectrophotometer at 580 nm.

2.5.3. Determination of the H_2O and 0.01 M $CaCl_2$ pH of the soil samples

The **wet** and 0.01 M **$CaCl_2$ pH** of the soil samples were determined from the air dried samples according to the method of HOUBA et al. (1990). The measurement was performed with HANNA INSTRUMENTS HI-8521 digital pH measuring equipment after calibration.

2.5.4. Determination of the N forms of the soil samples with 0.01 M $CaCl_2$ soil extraction method

The soil samples were shaken with $CaCl_2$ extractant (soil:extractant ratio 1:10) according to the method of HOUBA et al. (1990) 0.01 M. The N forms of the extracts were measured with a continuous analyzer SCALAR SAN-PLUS SYSTEM.

2.5.5. Determination of the P, K, Mg and Mn content of the soil samples with 0.01 M $CaCl_2$ soil extraction method

The determination of the P, K, Mg and Mn contents of soil samples was done with 0.01 M $CaCl_2$ soil extraction method based on the method of HOUBA et al. (1990). The **K content** was determined with UNICAM SP95B AAS instrument via flame emission spectrophotometry. The **P-forms** were measured by CONTIFLOW ANALYSIS (CFA) Skalar tool. The determination of **Mg and Mn contents** of the extracts was performed with a VARIAN SPEKRAA 20 PLUS atomic absorption spectrophotometer.

2.5.6. Determination of the P, K, Ca and Mg content of the soil samples with AL extractant

The determination of the soluble P, K, Ca and Mg content of the samples was performed with ammonium lactate acidic (AL) extractant (1:20 soil:extractant ratio) based on the description of EGNER et al. (1960). The **determination of P** was conducted at 730 nm wavelength with a METERTEK SP-850 spectrophotometer, the **measurement of K** was performed at 740 nm via flame emission photometric method (FES) with a UNICAM SP90B AAS spectrophotometer, while the **determination of the Ca and Mg** was carried out with a VARIAN SPECTRAA 20 PLUS type atomic absorption spectrophotometer.

2.6. Nutritional examination of the fruits

2.6.1. Determination of the dry matter content of the apple samples

The determination of **dry matter content** of apple was performed according to the ISO 1026:2000 standard. The apple samples were dried in a LABOR MIM 122-1086 type oven.

2.6.2. Determination of the ash content of the apple samples

The determination of the **ash content** of the samples was performed according to the ISO 5520:1994 standard. The samples were incandesced in an OMSZÖV OH-63 type electric furnace.

2.6.3. Determination of the sugar content of the apple samples

A few grams of 3-3 apples per treatment were grated to a watch-glass, and a few drops of the juice of the samples were pressed onto the prism of the Universal Hand BRIX refractometer. The International Sugar Chemical Company (ISC) has developed a changeover table, which provided an opportunity to convert the refractometry determined water-soluble BRIX % value to **sugar content** given in g dm^{-3} (KÁLLAY, 2006).

2.6.4. Determination of the total acid content of the apple samples

Determination of the **total acidity** of the apple samples was done according to the ISO 750:2001 standard.

2.6.5. Determination of Vitamin C content of the apple samples

The determination of the **Vitamin C content** of the apple samples was performed according to BRUGOVITZKY (1956).

2.7. The statistical evaluation of the experimental data

The measured data were evaluated with a macro program written in Microsoft® Excel 2007 and developed by L. TOLNER with using two or three factor analysis of variance (AYDINALP et al., 2010).

3. Results

3.1. The soil parameters of the orchard

Table 3 contains the measured values of the compost product applied and the parameters of the 0-30 and 30-60 cm layers of the soil profile examined (2010).

Table 3: The measured parameters of the experimental soil and compost applied (2010)

Experimental soil and compost				
	Soil of Pallag		Compost	Unit
	0-30 cm	30-60 cm		
Hu	1.17	1.01	18.1	**%**
K_A	26	26	-	**-**
pH H_2O	-	-	7.2	**-**
pH $CaCl_2$	6.1	5.5	6.9	**-**
salt %	0.009	0.008	-	**-**
AL-P	118.9	54.9	7517.9	**mg kg^{-1}**
AL-P_2O_5	272.3	125.7	17216.2	**mg kg^{-1}**
AL-K	130.8	124.2	6170.8	**mg kg^{-1}**
AL-K_2O	158.3	150.3	7466.6	**mg kg^{-1}**
AL-Ca	864.5	805.5	50100.0	**mg kg^{-1}**
AL-Mg	142.5	103.1	4471.9	**mg kg^{-1}**
$CaCl_2$-N_{total}	5.9	4.7	725.5	**mg kg^{-1}**
$CaCl_2$-$N_{organic}$	4.5	4.3	265.7	**mg kg^{-1}**
$CaCl_2$-NO_3	0.7	0.4	459.8	**mg kg^{-1}**
$CaCl_2$-NH_4	0.7	0.0	0.0	**mg kg^{-1}**
$CaCl_2$-P	7.5	2.2	137.8	**mg kg^{-1}**
$CaCl_2$-K	53.9	63.7	2368.6	**mg kg^{-1}**
$CaCl_2$-Mg	105.3	63.6	765.8	**mg kg^{-1}**

The changes in the nutrient content of the soil in 2011 and 2012 due to the compost treatments are included in **Table 4**.

Table 4: Results of the soil examinations in connection with the compost treatments *(Debrecen-Pallag, 2011-2012)*

Year	cultured	Compost (N kg ha^{-1})	AL				$CaCl_2$							
			P	K	Ca	Mg	nitrate-N	ammonia-N	organic-N	*total-N*	pH	P	K	Mg
			mg kg^{-1}				mg kg^{-1}				-	mg kg^{-1}		
2011	organic	0	178.5	111.6	905.0	147.0	1.67	1.23	2.25	5.14	6.92	4.64	59.69	28.20
		10	208.1	147.3	890.0	157.0	1.32	1.54	2.32	5.18	6.78	7.50	78.64	30.70
		25	224.0	139.3	950.0	152.0	1.93	1.04	2.84	5.80	6.82	29.01	84.25	34.50
		50	280.1	203.5	1045.0	158.0	2.75	2.37	3.19	8.30	6.67	10.43	129.11	31.85
	integrated	0	186.3	125.5	1100.0	175.0	1.75	1.62	2.20	5.55	7.08	4.65	68.31	28.90
		10	196.9	147.3	1100.0	196.0	1.80	2.13	2.87	6.81	7.03	6.63	80.51	31.80
		25	188.6	115.5	1110.0	186.0	1.36	1.00	3.22	5.58	7.15	5.95	62.25	29.30
		50	270.5	175.3	1170.0	199.0	2.08	1.12	3.33	6.52	6.87	8.03	113.56	29.40
2012	organic	0	59.4	141.0	876.0	118.8	5.30	5.56	6.32	17.17	6.40	7.41	88.93	102.30
		10	67.0	165.8	956.0	135.6	2.71	6.19	8.15	17.05	6.48	9.86	101.91	127.20
		25	68.6	171.0	962.0	141.8	3.87	4.03	7.03	14.93	6.41	8.90	101.91	126.60
		50	99.8	208.7	1256.0	159.4	6.79	8.34	9.72	24.85	6.58	12.40	122.16	137.00
	integrated	0	86.4	258.4	2346.5	142.2	4.46	5.59	5.86	15.91	7.06	9.88	114.08	118.20
		10	98.5	272.1	2350.0	159.6	3.69	5.25	8.24	17.18	7.00	12.84	130.11	136.40
		25	102.5	290.1	2420.0	155.2	3.52	5.02	9.63	18.17	7.10	11.69	134.11	137.70
		50	136.3	325.7	2450.0	169.8	5.87	7.55	9.78	23.20	6.91	14.48	154.86	145.20

3.2. Nutritional values of the fruit samples

3.2.1. The dry matter content of the apple samples

The dry matter content of the organic cultured *Golden Delicious* and *Pinova* apples is shown in **Figure 1**.

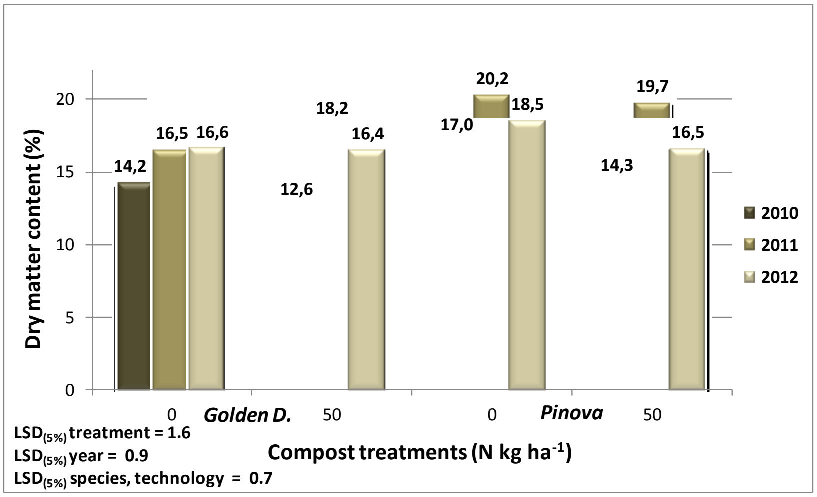

Figure 1: Dry matter content of the organic cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

The dry matter content of the integrated cultured *Golden Delicious* and *Pinova apples* is shown in **Figure 2**.

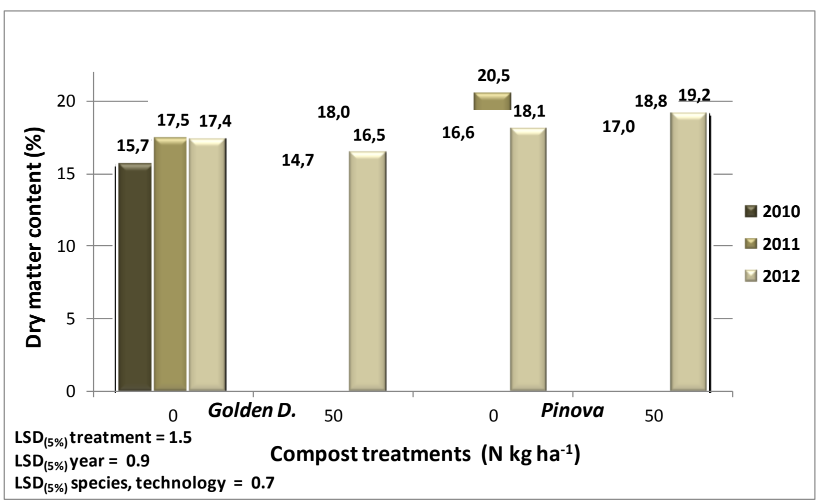

Figure 2: Dry matter content of the integrated cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

3.2.2. The ash content of the apple samples

The ash content of the organic cultured *Golden Delicious* and *Pinova apples* is illustrated in **Figure 3**.

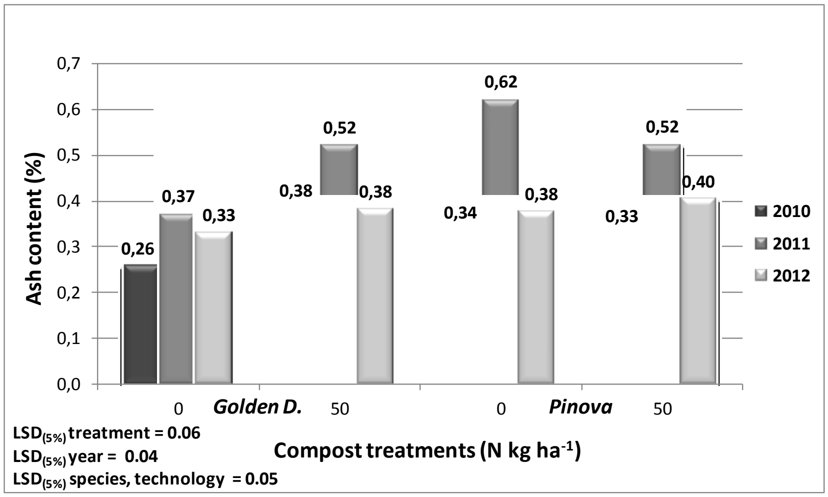

Figure 3: Ash content of the organic cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

The ash content of the integrated cultured *Golden Delicious* and *Pinova* apples is illustrated in **Figure 4**.

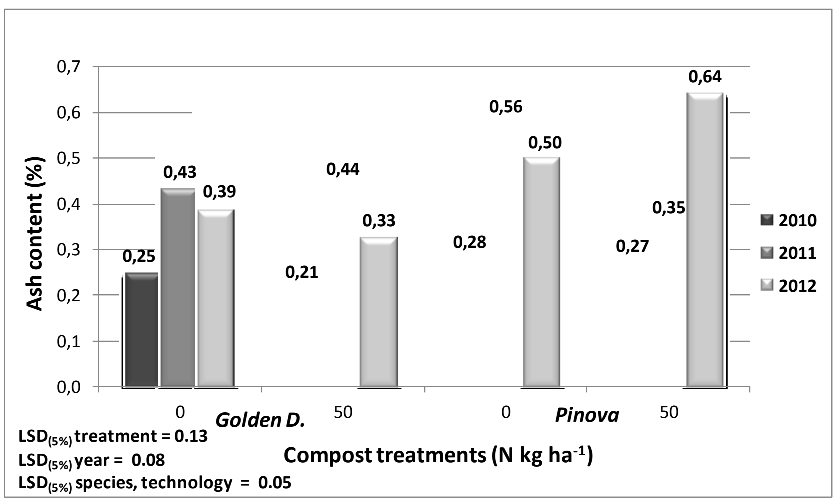

Figure 4: Ash content of the integrated cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

3.2.3. The sugar content of the apple samples

The sugar content of the organic cultured *Golden Delicious* and *Pinova* apples is shown in **Figure 5**.

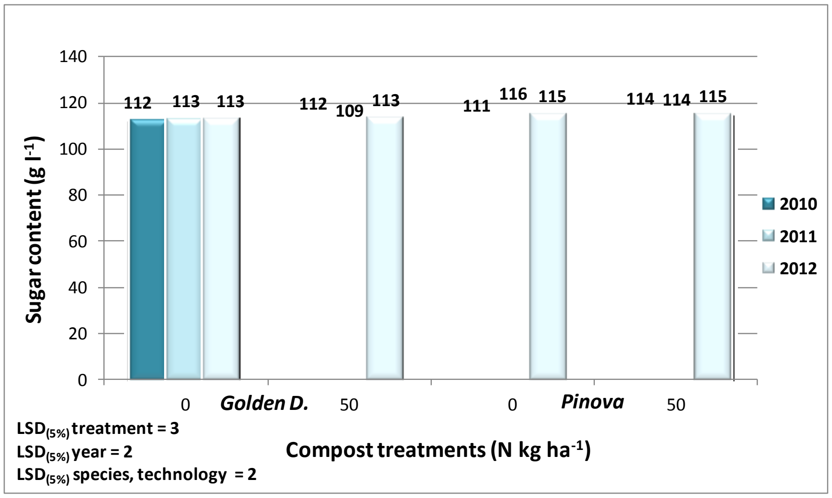

Figure 5: Sugar content of the organic cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

The sugar content of the integrated cultured *Golden Delicious* and *Pinova* apples is shown in **Figure 6.**

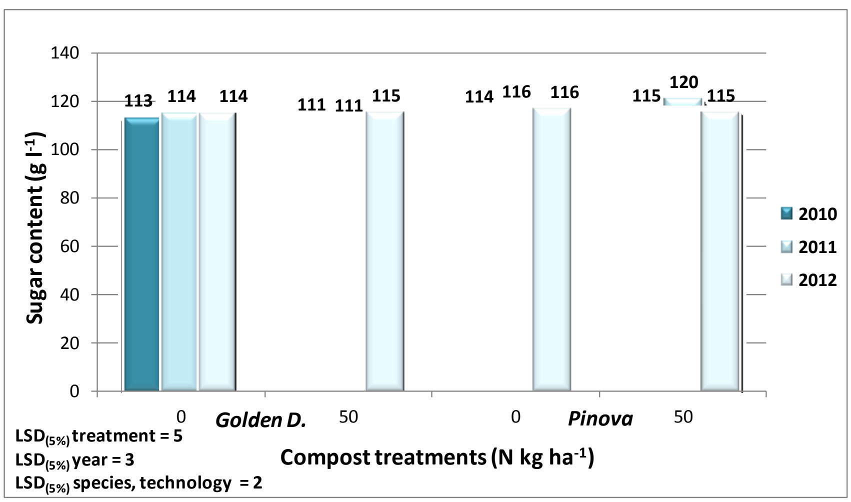

Figure 6: Sugar content of the integrated cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

3.2.4. The total acid content of the apple samples

The total acid content of the organic cultured *Golden Delicious* and *Pinova* apples is illustrated in **Figure 7**.

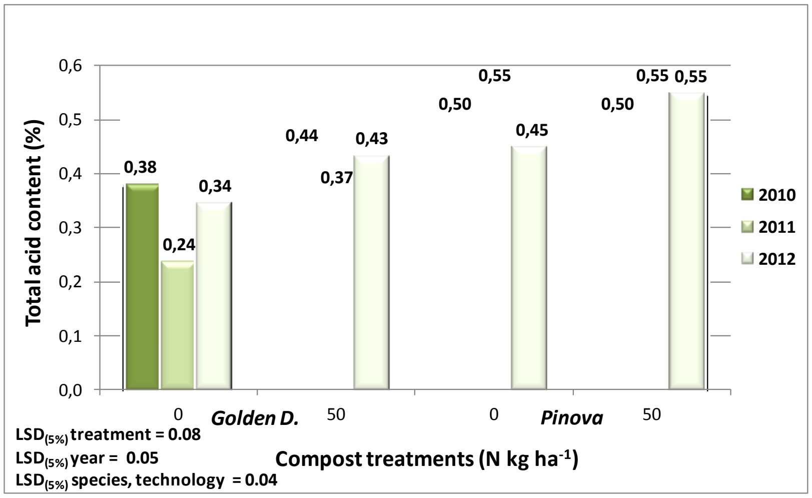

Figure 7: The total acid content of the organic cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

The total acid content of the integrated cultured *Golden Delicious* and *Pinova* apples is illustrated in **Figure 8**.

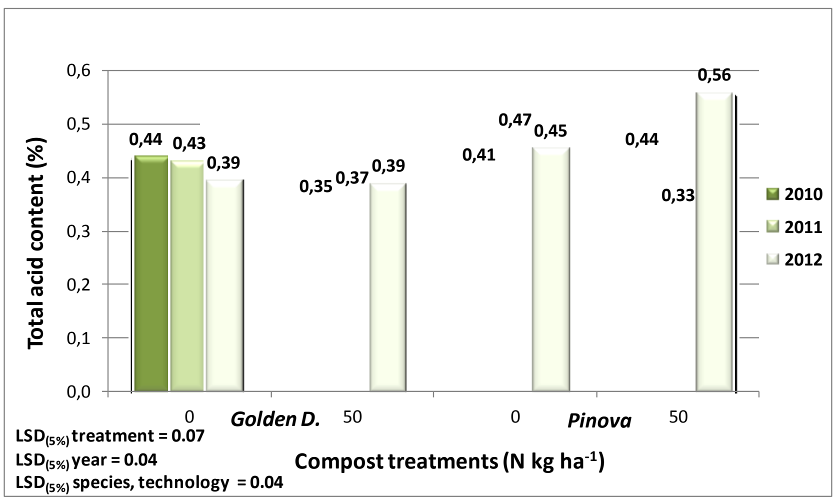

Figure 8: The total acid content of the integrated cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

3.2.5. The Vitamin C content of the apple samples

The Vitamin C content of the organic cultured *Golden Delicious* and *Pinova* apples is illustrated in **Figure 9**.

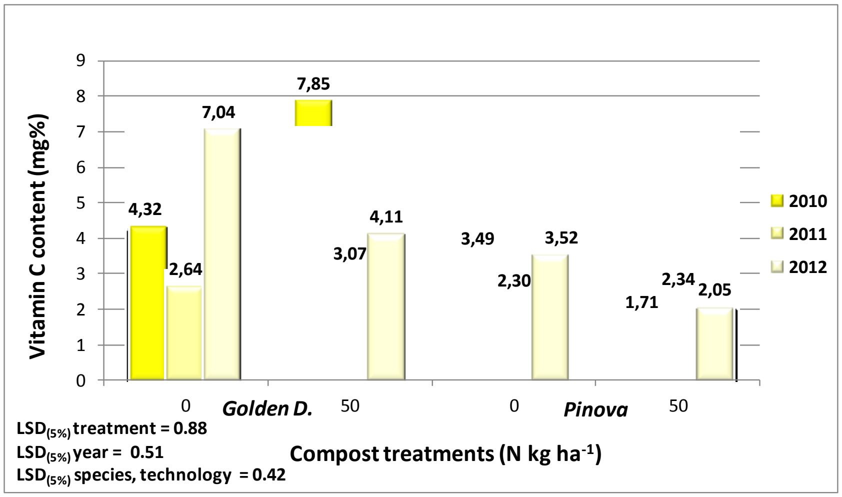

Figure 9: The Vitamin C content of the organic cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

The Vitamin C content of the integrated cultured *Golden Delicious* and *Pinova* apples is illustrated in **Figure 10**.

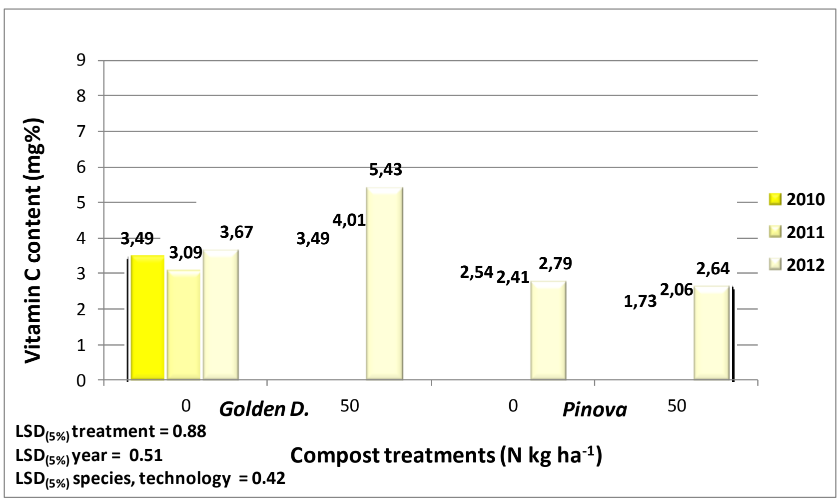

Figure 10: The Vitamin C content of the integrated cultured *Golden Delicious* and *Pinova* apples *(Debrecen-Pallag, 2010-2012)*

4. Discussion

4.1. Changes in the soil parameters of the orchard

In the starting year (2010) the soil type in the examined depth was sand, the plasticity index according to Arany was 26. Considering the growing site category it was sandy soil. The soil of the experimental are is mildly acidic, the pH($CaCl_2$) decreased with the depth. The organic matter content of the soil was low, humus content decreased with the depth. Its nitrogen supply capacity based on its humus content was medium. The AL soluble P supply of the topsoil (0-30 cm) was quite good, which halved with the depth. The AL soluble K supply is quite good; the amount shows a slight decrease with depth. Nitrogen and phosphorus data suggested that the majority of nutrients applied with fertilization concentrated in the topsoil. The vertical movement of the nutrients between the layers was low in spite of the sandy structure. The magnesium content of the soil was very good. The salinity of the soil was < 0.1 %, which should not be considered salty **(Table 3)**.

Nutritional differences were observed between the different production technologies year by year (the integrated orchard received basic mineral fertilization as well, while the organic orchard received compost treatments only). It was experienced that the compost treatments affected the soil parameters not only in the integrated orchard, but the organic orchard as well. Primarily, the amount of easily available nutrients (such as nitrate-, ammonia-, organic-N, $CaCl_2$ Mg) was increased or held at level by them, but they also increased the AL-K and Ca-reserve of the soil **(Table 4)**.

4.2. Changes in the dry matter content of the apples

In 2010, in case of the organic *Golden Delicious* orchard, a significant decrease in the dry matter content of the apple samples was experienced in parallel with the increase of the amount of compost applied **(Figure 1)**. Due to the abundant precipitation the dry matter content of the apples diluted. In 2011 significantly increasing, while in 2012 stagnant values were measured comparing to the control. In case of the Pinova apples, in 2010 and 2012 a significant decrease, and in 2011 stagnation could be observed due to the compost dose. Within the certain treatments a similar trend could be observed which was related to the amount of crop and the effects of vintage elements. In a rainy year with a relatively low amount of crop (2010), apples with low, in a drought year with a large amount of crop (2012), apples with medium and in a year with average precipitation and crop shortage (2011), apples with high dry matter content were collected.

In 2010 and 2012, a slight decrease in the dry matter content of the integrated Golden Delicious culture could be observed in parallel with the increase of the compost doses., while in 2011 stagnation was experienced **(Figure 2)**. The dry matter content of the Pinova apples slightly increased in 2010 and 2012, while in 2011 it reduced. Within each treatments a more or the less similar tendency was thought to have discovered: that the dry matter content showed correlation with the vintage effect.

4.3. Changes in the ash content of the apple samples

In 2010 and 2011, a significant increase in the ash content of the integrated cultured *Golden Delicious* apples could be observed due to the effect of the compost applied **(Figure 3)**. In 2012, the increase was slight comparing to the control. In case of the *Pinova* apples no difference between the treated and non-treated apples was experienced, while in 2011 a significant decrease could be observed in the ash content of the apples treated with compost. Within the certain treatments the effect of the vintage could be discovered, and the fact that the changes in the ash content and the dry matter content were comparable **(Figure 1)**. Due to the much rainfall in 2010 low, in the less rainy year of 2011 more concentrated, and in the dry year of 2012 intermediate ash contents were measured. This was probably related to the load of the treas. 2011 was a crop deficient year; therefore the less crop had higher ash content.
No statistically proven difference between the ash content of the integrated *Golden Delicious* apple samples could be observed due to the increase of the compost doses **(Figure 4)**. In case of the *Pinova* apples no decrease in 2010 and a significant decrease in 2011 was experienced, while in 2012 a proven higher value was measured comparing to the control. Within the different treatments the vintage effect could possibly be observed, similarly to the changes in the dry matter content **(Table 2)**. The extremely high value measured in the *Pinova* apples treated with compost was presumably a measurement error, as the dry matter content was relatively high but not in such a high extent.

4.4. Changes in the sugar content of the apple samples

In case of the organic cultured *Golden Delicious* apples, no statistically proven differences were experienced in parallel with the increase of the compost doses in any of the examined years **(Figure 5)**. In case of the *Pinova* apples the only significant increase in the sugar content was measured in the year of 2010. Within each treatments it could be stated that there was no remarkable change in the sugar content of the apples.

Increasing the compost doses, no significant changes in the *Golden Delicious* or the *Pinova* integrated orchard were experienced **(Figure 6)**. Within the treatments, no justifiable changes in the sugar content of the apples could be stated

4.5. Changes in the total acid content of the apples

In case of the organic cultured *Golden Delicious* the total acid content of the apples increased slightly in 2010 and 1011, then significantly in 2012 due to the compost dose **(Figure 7)**. In case of the *Pinova* apples the values stagnated in 2010 and 2011, then in 2012 they increased significantly comparing to the control. Within the different treatments it could be stated that the total acid content of the *Golden Delicious* apples was the highest in 2010, the lowest in 2011, and in 2012, intermediate values were measured. In contrast, the highest values were measured in 2011 in case of the *Pinova* apples. In the further two years no justified conclusions could be drawn.

In 2010 a significant decrease, in 2011 a slight decrease, and in 2012 stagnation could be observed in the total acid content of the integrated cultured *Golden Delicious* apples **(Figure 8)**. The total acid content of the *Pinova* apples increased slightly in 2010, decreased significantly in 2011, and increased demonstrably in 2012 comparing to the control. Within each treatments different tendencies could be stated, therefore no clear statements could be made about the changes in the total acid content.

4.6. Changes in the Vitamin C content of the apple samples

In case of the organic cultured *Golden Delicious* apples, in 2010 significantly higher, in 2011 statistically equal, while in 2012 certifiably lower Vitamin C contents were measured comparing to the control samples **(Figure 9)**. A significant decrease in the Vitamin C content of the *Pinova* apples could be observed in 2010 and 2012, while in 2011 stagnation was experienced. Within the treatments no clear conclusion could be drawn from the changes in the amount of Vitamin C.

The Vitamin C content of the integrated cultured *Golden Delicious* apples stagnated in 2010 and significantly increased in 2011 and 2012 due to the compost **(Figure 10)**. The Vitamin C content of the *Pinova* apples slightly reduced every year. Within the treatments no clear conclusion could be drawn as the years passed by, however the similarity between the changes in the Vitamin C content of the control *Pinova* and *Golden Delicious* apples and the treated *Pinova* and *Golden Delicious* apples within the same production technology was noticeable.

5. Conclusions

5.1. Dry matter content

The optimal dry matter content of the apples is between 10-20 % according to BÍRÓ and LINDER (1999). According to RODLER (2006) the water content of apple is 90.5 g/100 g, while TUOMI et al. (2007) found it was 84 g /100 g. Based on our data we can make a statement that the amount of precipitation plays more important role than the treatment or the production technology. In case of both the *Golden Delicious* and *Pinova* apples the lowest dry matter contents (≈14 %) were measured in 2010 and the highest (≈17 %) in 2011. In 2012, the nutrition uptake was inhibited according to the previous year, in spite of the irrigation. The smooth growth of the fruits was reduced by thermal stress. The *Pinova* apples had a higher dry matter content than the *Golden Delicious* apples. In terms of technologies it could be stated that the dry matter content of the apples grown in the integrated orchard was higher (≈17.5 %), and due to the effect of the fertilizer its changes seemed to be more balanced than in case of the organic apples (≈16.5 %).

5.2. Ash content

The ash content of the apples changed similarly to their dry matter content. According to RODLER (2006) and BÍRÓ and LINDER (1999) the average ash content of the domestic apple varieties is 0.4 %. The ash content of our experimental apples was equal to this in 2012, lower in 2010 (≈0.3 %) and higher in 2011 (≈0.5 %). The average ash content of the organic apples was significantly higher comparing to the ash content of the integrated apples, furthermore the higher ash content of the *Pinova* variety has to be emphasized.

5.3. Sugar content

The sugar content values of the apples were uniformly balanced in each cases (≈13 BRIX%). According to KÁLLAY (2010) the sugars causing the sweet taste of the apple (depending on the variety and the ripening status) give the average 12 % of the fresh fruit pulp of the edible part. TIMOUMI et al. (2007) found that the average sugar content of the apples is 13 g /100 g. According to HOEHN et al. (2003) in order to have acceptable eating quality, the soluble sugar content of the *Golden Delicious* apples has to reach at least 12 BRIX %. The sugar content of the integrated apples is slightly higher (≈114 g l^{-1}) than the nutrient content of the organic apples (≈112 g l^{-1}). Among the varieties the sugar content of the *Pinova* seemed to be somewhat higher than the sugar content of the *Golden Delicious* apples. It is important to note that the harvest was carried out at the same time to ensure that the samples were comparable. The optimal harvest time of the different varieties, however, did not coincide.

5.4. Total acid content

In our experiment, the effect of the compost treatment and the vintage on the total acid content of the apples did not appear in the integrated orchard and appeared only occasionally in the organic orchard. The total acid content of the integrated apples was more balanced (≈0.4 acid %), than the total acid content of the organic apples (0.3-0.5 acid %) was.

This presumably shows a slight correlation with the amount of crop per year. According to RODLER (2006) the average acid content of the apples is 0.4 g/100 g edible part. HOEHN et al. (2003) found that the minimal acid content of the *Golden Delicious* apples with acceptable eating quality was 3.2 g. Among the varieties the total acid content of the *Pinova* was slightly higher than the total acid content of the *Golden Delicious*, which could be felt in the taste. The samples were collected at the same time; however the optimal harvest time of the two varieties did not coincide, causing the differences in the total acid content.

5.5. Vitamin C content

According to the measured Vitamin C content of the apples the following conclusions could be made: the effect of the vintage on the Vitamin C content was slightly noticeable in the integrated orchard, and conditionally noticeable in the organic orchard. Among the technologies the Vitamin C content of the integrated cultured apples has to be emphasized, which appeared to be balanced (2-4 mg %), free of extremes in contrast with the Vitamin C content of the organic apples (2-6 mg %). According to BÍRÓ and LINDER (1999) the apple can be considered as a fruit with a significantly high Vitamin C content of 10-15 mg/100 g. RODLER (2006) found it was 5 mg/100 g, while according to the data of TIMOUMI et al. (2007) it was 0.005g / 100 g. Among the varieties, higher Vitamin C content was measured in the *Golden Delicious* apples (3-7 mg %) than in the *Pinova* apples (1-3 mg %). The differences in the Vitamin C content of the two varieties arised from their different optimal harvest time presumably.

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