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ECONOMIC EFFECT OF SUSTAINABLE APPLE PRODUCTION

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Abstract

The experiment was carried out during the period 2014-2016 at the Institute of Agriculture - Kyustendil using 'Florina' and 'Freedom' cvs. grafted on seedling rootstocks of Winter Gold Pearmain and wild apple cultivated in a high density plantation with trees of the same cultivars on clonal rootstocks MM 106 (in the row) and M 9 and Marga Hndzor (MH) (between the rows). The soil is chromic luvisols. In order to study the influence of the intercropping on the growth and production of the trees, there are 3 experiments – cultivar-rootstock trail without intercrop, cultivar-rootstock trail with intercrop in rows and inter rows spacing. The production costs required for the cultivation of one hectar apple tree orchard of the studied combinations range from 1900 euro/ha from Freedom of Winter Gold Pearmain to 282 euro /ha at Freedom on Winter Gold Pearmain with interplants on MM 106 and M9. Cost differences are the result of the number of trees per hectar, the average yields and the associated costs of collecting the additional fruit production. The average yields and the resulting gross output have a significant impact on the net profit. In 'Florina' variety, the most effective combination of wild apple rootstock with in row intercrop of MM 106, and in the inter row of MH. For Freedom, better results have been obtained using a Winter Gold Pearmain with intercrop on M9 rootstock, indicating that for the different varieties it is necessary to select suitable rootstocks.

Key words*: apple, rootstock, yield, quality, economic analysis.*

INTRODUCTION

Numerous studies in apple plantations have shown that optimal planting density is the dominant factor for yields per unit area. A decisive role in increasing the density of apple plantation has two main factors - rootstock and variety.

Trees of 'Johnagold' variety on MM 106 of the following planting distances were tested: 4 x 1, 4 x 1.5, 4 x 2, 4 x 2.5 and 4 x 3 m, with the largest cross-sectional area of the stem, the largest crown volume and the highest yield being obtained at a distance of 4 × 3 m. The results show that planting distances have a negligible effect on the quality of the fruit but are important for the coloring (Kiprijanovski et al., 2009). In an experiment in Ireland with an M9 rootstock at a planting density of 672, 961 and 1,492 trees/ha, and M27 at a density of 1,279, 1,492 and 1,957, it was found that M9 had the highest yield at the highest density (Mac an Saoir et al., 2014). In Romania, an experiment with the apple 'Florina' and 'Auriu de Bistriţa' cvs., grafted on M9 and using a different planting density (1,666,500 and 5,000 trees/hectare) formed in the 'V' system, it was found that the density of the trees and the variety influence total

yield. So, for 'Auriu de Bistrita' cv., the yield at density 2,500 exceeds control with 53% and for 5,000 with 112% and for 'Florina' cv. with 69.3 and 135.5%, respectively (Platon et al., 2014).

The use of dwarf rootstock allows intercropping of the area, early fruiting of trees, sustainable productivity, good fruit quality and high economic efficiency (Dyankov, 1995; Domozetov and Radomirska, 2009).

In the analysis of the economic performance of apple plantation grown at three planting densities, an optimal density of 2,500 trees/ha was established (Fett and Waquil, 2001).

The aim of the this study is to make a comparative analysis of variety-rootstock combinations grown as an intercrop apple plantation.

MATERIALS AND METHODS

To investigate the effect of the use of intercrops in apple plantations with different rootstocks, three planting experiments were established in the spring of 1998, with 'Florina' and 'Freedom' trees grafted on the seedlings of

Winter Gold Pearmain (WGP) and wild apple (WA) and on the vegetative rootstocks - MM106, M9 and Marga Hondzor (MH):

1. Variety-rootstock trail without intercrop - the planting distance between rows is 8 m and in the row 7 m or 179 trees/ha;
2. Variety-rootstock trail with intercrop in the row - on the seed rootstock (main trees) the planting distances are 8 x 7 m or 179 trees/ha. Trees - intercrop in the row on vegetative rootstock MM106 are planted (over one of the main trees) at 7 m (8 m x 7 m or 179 trees/ha). A total of 358 trees/ha;
3. Variety-rootstock trail with intercrop in rows and between rows - on seed rootstock (main trees) planting distances are 8 x 7 m or 179 trees/ha. Trees - intercrops in rows on vegetative rootstock MM 106 are planted (over one of the main trees) at 7 m distance (8 m x 7 m or 179 trees/ha) and between rows on vegetative rootstock M9 and MH - 2 m (8 x 2 m) or 625 trees/ha. Total of 980 trees/ha.

During the fruiting period, the main economic indicators are calculated annually: gross output, euro/ha; production costs, euro/ha; net income, euro/ha; rate of profitability, %. The necessary means of production are established on the actual costs incurred on the basis of the norms and tariffs for manual and mechanized works in the Institute of Agriculture - Kyustendil and the prices of the raw materials and supplies. The valuation of the output was made at the actual realization prices during each year.

RESULTS AND DISCUSSIONS

The values for the average stem diameter are constantly increasing for trees of all variants for both varieties. In 2014, the largest diameter of the stem was the 'Florina' tree on the WGP without intercrops and pruning - 21.60 cm and the smallest with a intercrop of MH - 11.40 cm (Table 1). In the 'Freedom' cv.with the highest thickness are the trees grafted on WGP, but with a intercrop - 17.5 cm, and the smallest at M9 - 11 cm. Trends in 'Florina' are preserved in the years 2015, 2016 and 2017, with the growth of the stem being greatest in the trees grafted on wild apple with a intercrop - 1.36 cm and smallest on those with intercrop on M9 - 0.54 cm. In 'Freedom' cv., this trend is preserved except for trees grafted on MM106. The influence of the kind of the rootstock is clearly expressed, taking into account the average values of the stem diameter of all variants. Trees of both varieties on seed rootstocks have a larger stem diameter than those on MM 106, M9 and MH. Difference was found for both types of seed rootstocks in variants with and without intercrops. The differences with Winter Gold Pearmain are statistically proven. The thicker tree stem is explained by the growth force of the seed rootstock, which induces a stronger thickening of the tree stem of the used grafts. When comparing the influence of the variety on the thickening of the stem, it can be seen that the 'Florina' trees have a thicker stems than those of 'Freedom' and the different types of rootstocks, except for MM106 and MH.

The crown height data for both varieties shows that trees on seed rootstock tended to have a higher crown height than those of the MM 106, M9 and MH clone rootstocks. Trees of 'Florina' cv. on different types of rootstocks have a larger crown volume than those of 'Freedom' (Table 2).

Average, for the period 2014-2016, tree yield for non-intercrop variants is highest in 'Florina' on a WGP rootstock that amounts to 122.77 kg/tree, followed by trees on a wild apple rootstock - 89.4 kg/tree (Table 3).

Table 3. Yield, mean weight and fruit quality

Planting combination	Variety	Rootstock	Yield per tree, kg	Average fruit weight, g	Quality, %		
					Extra	I	II
Main trees without intercrop	'Florina'	WGP	122.77	115.67	54.95	30.00	15.05
		WA	89.40	116.67	63.17	24.55	12.28
	'Freedom'	WGP	61.80	116.67	69.53	15.28	15.19
		WA	64.23	115.67	66.75	18.00	15.25
Main trees with intercrop	'Florina'	WGP	44.80	124.33	72.50	18.59	8.90
		WA	68.73	126.33	82.97	12.24	4.79
	'Freedom'	WGP	60.60	91.33	47.84	24.19	27.97
		WA	49.50	118.67	76.86	12.66	10.48
Trees - intercrops	'Florina'	MM 106	42.97	113.83	63.51	24.36	12.13
		M 9	20.17	115.00	54.67	29.83	15.50
		MH	18.40	124.00	73.12	19.76	7.12
	'Freedom	MM 106	50.55	80.67	33.02	23.42	43.56
		M 9	40,23	92,33	53,58	19,22	27,20
		MH	31,97	70,00	21,27	24,54	54,19

Table 1. Diameter of stem, cm

'Florina'	2014	2015	2016	2017	Growth, cm
WA without intercrop (st)	19.42	19.94	20.17	20.55	1.13
WGP without intercrop	21.33 ++	21.86 ++	22.13 ++	22.47 ++	1.14
WGP without pruning	21.60 ++	21.87 ++	22.29 ++	22.62 ++	1.02
WA with intercrop	18.86	19,24	19.68	20.22	1.36
WGP with intercrop	18,19 +	18.49 +	19.01	19.09 +	0.90
MM 106 – in row intercrop	14.27	14.61	14.85	15.05	0.78
M 9 – between row intercrop	12.30	12.58	12.66	12.84	0.54
MH – between row intercrop	11.40	11.60	11.76	11.98	0.58
Sd	**0.5004**	**0.5565**	**0.5853**	**0.5567**	
Gd 0.5	**1.09**	**1.213**	**1.275**	**1.213**	
f	**17.4407**	**15.1577**	**12.7847**	**14.8716**	
'Freedom'	2014	2015	2016	2017	Growth, cm
WA without intercrop (st)	16.64	16.76	17.48	18.15	1.51
WGP without intercrop	16.72	17.24	17.96	18.19	1.47
WA with intercrop	17.16	17.36	18.31	18.75	1.59
WGP with intercrop	17.52	17.88	18.35	18.75	1.23
MM 106 – in row intercrop	15.16	14.77	15.05	15.13	0.72
M 9 – between row intercrop	11.03	11.22	11.42	11.90	0.87
MH – between row intercrop	11.80	11.98	12.30	12.74	0.94
Sd	**0.8850**	**0.7926**	**0.9327**	**0.9597**	
Gd 0.5	**2**	**1.791**	**2.107**	**2.168**	
f	**0.4309**	**0.6703**	**0.3778**	**0.2420**	

Table 2. Size and volume of the crown

Variety	2014			2015			2016			2017		
	h-height, m	d-width, length, m	V - volume, m^3	h - height, m	d-width, length, m	V-volume, m^3	h-height, m	d-width, length, m	V-volume, m^3	h-height, m	d-width, length, m	V-volume, m^3
'Florina'												
WA without intercrop (st)	3.65	3.86	14.23	3.31	4.10	14.56	3.75	3.79	14.09	3.18	4.04	13.58
WGP without intercrop	3.92	4.12	17.41 ++	4.07	4.40	20.62 ++	3.92	4.23	18.35 +	3.94	4.75	23.26 +++
WGP without pruning	3.82	4.13	17.05 +	3.75	4.36	18.65 +	4.22	4.47	22.06 ++	3.56	4.40	18.03 ++
WA with intercrop	3.62	3.22	9.82 ++	3.50	3.25	9.67 +	3.88	3.34	11.32	3.20	3.31	9.17 ++
WGP with intercrop	3.38	3.13	8.66 +++	2.75	3.06	6.74 +++	3.52	3.10	8.85 +	3.09	3.26	8.59 ++
MM 106 – in row intercrop	2.95	2.79	6.01	2.61	2.69	4.94	3.08	2.74	6.05	2.86	2.86	6.12
M 9 – between row intercrop	2.29	2.32	3.22	2.35	2.30	3.25	2.66	2.22	3.43	2.28	2.27	3.07
MH – between row intercrop	2.40	2.14	2.88	2.39	2.15	2.89	2.59	2.11	3.02	2.02	2.04	2.20
Sd			**1.0266**			**1.6722**			**1.8897**			**1.2637**
Gd 0.5			**2.237**			**3.645**			**4.119**			**2.754**
f			**30.8976**			**24.9451**			**16.0754**			**48.4594**
'Freedom'												
WA without intercrop (st)	3.02	3.05	7.35	2.90	3.40	8.77	3.02	3.10	7.59	2.62	3.26	7.29
WGP without intercrop	3.28	3.02	7.83	2.75	3.18	7.28	3.35	3.05	8.15	3.12	3.38	9.51
WA with intercrop	3.35	3.19	8.92	3.10	3.28	8,73	3.68	3.04	8.90	3.08	3.49	9,82
WGP with intercrop	3.08	3.12	7.84	2.70	3.18	7.14	3.35	3.06	8.21	3.08	3.40	9.32
MM 106 – in row intercrop	3.05	2.79	6.21	2.65	2.88	5.75	3.30	2.70	6.29	3.00	3.14	7.74
M 9 – between row intercrop	2.75	2.16	3.36	2.50	2.26	3.34	2.78	1.95	2.77	2.92	2.49	4.74
MH – between row intercrop	2.59	2.27	3.49	2.46	2.20	3.12	2.76	2.10	3.18	2.72	2.46	4.31
Sd			**1.0259**			**1.2636**			**0.9618**			**1.2418**
Gd 0.5			**2.318**			**2.855**			**2.173**			**2.806**
f			**0.8864**			**1.0298**			**0.5139**			**1.4218**

The difference in tree yield at 'Florina' cv. under the influence of seed rootstocks is 33.37 kg and 'Freedom' cv. 2.43 kg. Compared to 'Florina', the 'Freedom' yields are lower with 25 kg/tree on WA rootstocks and 60.97 kg/tree on WGP. In the variants with intercrops, better results have been obtained with WA rootstock for 'Florina' - 68.73 kg/tree, and for 'Freedom' with WGP - 60.60 kg/tree.

Using vegetative rootstocks the best yielding is 'Freedom' grafted on MM 106, followed by 'Florina' on MM 106, with yield difference of 7.6 kg. The lowest average yield per tree was obtained at 'Florina' grafted on MH - 18.4 kg.

In the studied variety-rootstock combinations, the average fruit weight of both types of seed rootstocks was not significantly influenced by the variety and the rootstock and ranged of 91 - 126 g. In trees on vegetative rootstocks, it is larger for 'Florina' than for 'Freedom'.

The highest percentage of extra quality of fruit from 'Florina' on WA- 82.97 %, followed by 'Freedom' on WA - 76.86 %, and with the lowest 'Freedom' on MH - 21.27 %. On both seed rootstocks the quantity of extra-quality 'Florina' fruit is higher in the variants with intercrops. The same trend has not been established for 'Freedom' variety. At all vegetative rootstocks on 'Florina' more than 50 % of the quality fruits are obtained, while in 'Freedom' variant only on M9 rootstock.

The received gross production of variants of 'Florina' cv. has the highest value in the combination of wild apple with intercrop in the row on MM 106 and between rows on MH - 12402 euro/ha. In this indicator 'Freedom' cv. is grafted on a WGP rootstock with intercrop in row on MM106 and between row on M9 - 12065 euro/ha (Figure 1).

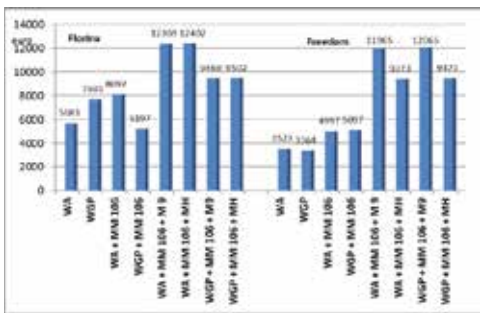

Figure 1. Gross production, euro/ha

The lowest value is the 'Freedom' cv. grafted on WGP.

The production costs required to grow one apple plantation from the studied combinations ranged from 1900 euro/ha at 'Freedom' on WGP to 2817 euro/ha at 'Freedom' on WGP with intercrops MM 106 and M9 (Figure 2).

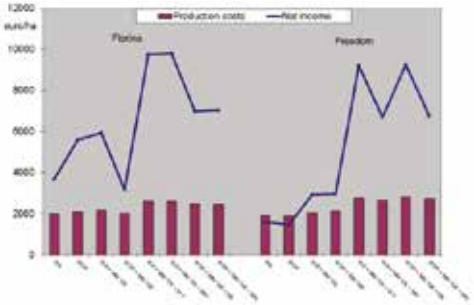

Figure 2. Production costs and net income, euro/ha

Differences in costs are a result of the number of trees per hectare, the quantity of the average yield and the associated costs of harvesting additional fruit production.

Quantity of the average yields and the gross output obtained have a significant impact on the amount of net income. In the 'Florina' cv., the most effective combination is WA rootstock with intercrop in rows on MM 106, and between rows on MH. For `Freedom`cv., better results are obtained using WGP with intercrops on M9 rootstock, indicating that it is necessary to choose suitable rootstocks for the individual varieties.

CONCLUSIONS

Trees of both varieties on seed rootstock have a larger stem diameter than those of MM 106, M9 and MH. Difference was found for both types of seed rootstocks in variants with and without intercrops. The thicker tree stem is explained by the growth force of the seed rootstocks, which induces a stronger thickening of the tree stem of the used grafts.

Trees of the 'Florina' cv.on different types of rootstocks have a larger crown volume than those of 'Freedom' cv.

The production costs required to grow one hectare of apple plantation from the combinations studied range from 1900 euro/ha

to 2817 euro/ha. Cost differences are the result of the number of trees per hectare, the quantity of the average yield and the associated costs of harvesting additional fruit production.
In 'Florina' cv., the most effective combination of a rootstock wild apple with in row intercrops on MM 106, and between rows on MH.
For 'Freedom' cv., better results are obtained using a WGP with intercrop on M9 rootstocks, indicating that it is necessary to select suitable rootstocks for the individual varieties.

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