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Economic assessment of an optimised model of apple rootstock production

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Abstract

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A three-year study was conducted on the development of apple clonal rootstocks with somatic organogenesis origin in a stoolbed and different moisture-absorbing polymer quantity in the covering soil layer. An economic assessment of the production process was made based on the specific effects of the moisture-absorbing polymer on the quality of the resulting product.

The results from the study show that the M9 rootstock demonstrates an improved rooting with a higher number of roots shoots, as well as, increased revenue when applying the moisture-absorbing polymer in a doze of 3.5 kg/da.

The economic benefit from applying the same doze of moisture-absorbing polymer in the case of the MM106 rootstock failed to meet our expectations. The doze of 3.5 kg/da proved to be economically ineffective. The results from the economic analysis demonstrated that the application of such a doze from the moisture-absorbing polymer was not economically feasable in comparison to findings from the alternative doze of 1.5 kg/da.

Keywords: apple rootstocks; moisture-absorbing polymer; economic assessment

Introduction

Every economic activity has to be technically and economically viable in order to achieve sustainable long-term development. The technical efficiency is a proportionate measure taking into consideration the qualitative and quantitative outcomes of the economic activity, as well as, the utilised resources during the production process. The economic efficiency indicator compares the values of the production volume and the utilised factors of production, respectively. Larger values of the production volume per a unit of utilised resources proportionally indicate higher rate of economic efficiency (Mihaylov et al., 2002).

The current study analysed the technical and economic efficiency of the apple rootstock production process by taking into consideration the final quantitative and qualitative values and by accounting for the influence of the added moisture-absorbing polymer to the covering soil layer.

Materials and Methods

The experiment was conducted in the study field of the Department of Fruit Growing at the Agrarian University - Plovdiv, located on the territory of the village of Brestnik, Plovdiv region. The stoolbed plant was developed from the root shoots of the rootstocks M9 and MM106 in 2003 which had been respectively developed through somatic organogenesis of leaf explants at the Biotechnological Laboratory of the Plovdiv Institute of Fruit Growing (Dobrevska, 2008).

The experiment was conducted following the block method of Fisher (Zapryanov and Marinkov, 1978) - four replicates (with ten plants) for each combination.

After planting, the plants were cultivated according to the conventional stool bed technology including, among other things, multiple soil treatments performed with the respective agricultural equipment, most often with specialised equipment for orchards - disc harrows, cultivators and others.

As a source of energy, universal or specialised tractors were used (Todorov et al., 1974; Trachev et al., 1975). The most suitable technological solution for soil maintenance in the stoolbed, which is also the most typical in our country, is the so-called black fallow. In this respect, there were 5-7 shallow inter-row soil treatments leading to preservation of its fertility, water and air regime and destruction of weed vegetation. There was also a deeper inter-row autumn processing at a depth of 18-20 cm. During the vegetation, three additional soil covering procedures were also performed on the basis of the experimental plants, contributing to their better rooting (Vehov & Retinskaya, 1988; Dobrevska, 2013). Some growth manifestations of shoots covered by three types of soil were analysed: with no moisture-absorbing polymer and with moisture-absorbing polymer in two dozes – 1.5 kg/da and 3.5 kg/da (http://www.terawet.com). The moisture-absorbing polymer was introduced at the beginning of the vegetation period at the base of the root shoots during the initial covering at a plant height of 15-20 cm (Andreev, 1979). The economic assessment of the production process was based on the accessed results.

Results and Discussion

The quality of the rooted apple rootstocks demonstrates insignificant variations in respect to the three cultivated combinations and the positive effect of the moisture-absorbing polymer is evident. The effects are more profoundly expressed when taking into consideration the number of rooted M9 rootstocks per da. The use 1.5 kg/da of moisture-absorbing polymer leads to an increase in the number of the rooted plants with 1584 per da, while an increase of 2151 per da against the control group is achieved when 3.5 kg/da of moisture-absorbing polymer are applied. The MM106 rootstocks do not experience considerable changes from the application of the moisture-absorbing polymer; however, the still demonstrate an insignificant increase of 417 additional plants per dka in comparison to the control group when applying 1.5 kg/da of moisture-absorbing polymer. The increase of the moisture-absorbing polymer above this level is not feasible because the number of rooted rootstocks remains unchanged (Table 1).

The production technology reflects the way of organising and using the factors of production. It is determined by the ways of combining and transforming the resources into a valuable output. According to Debertin (2012a, b), the main goal of every producer is to maximise its financial profit, as measured by subtracting the production expenditures from the profits from the produced plant products. Therefore, the organisation and management of the production process aims at utilising a particular combination of resources which will allow for profit maximisation.

By taking into consideration the targeted product quality and the prices of the factors production, Dorfman (2016) acknowledges companies' inclination towards the choice of the cheapest combination of production factors leading to the desired output.

Depending on their dynamics in the production process, the factors of production are divided into two groups: fixed and variable. The fixed ones do not change during a given production cycle. Typically, fixed factors include land, buildings, equipment, perennials, etc. The variables factors may vary during a given production cycle; thereby influencing the production quantity. Common variable factors of production include seeds, fertilizers, fuel, energy, plant protection chemicals, water, etc.

Dividing the production factors of fixed and variable is quite arbitrary; however, it is possible to determine the optimal quantity of the applied variable factor in order to maximise the economic outcomes, if it is assumed that all factors of production are fixed except for moisture-absorbent which is considered to be the only variable factor in this case. Profit maximisation is expressed through the use of the variable factor which is calculated as the difference between the received revenue from the sold production and the expenditures for acquiring the polymer, as expressed by the following formula:

$$TFI = TFR - TFC \Rightarrow \max,$$

where: *TFI* – total income received from the use of the production factor

TFR – total revenue from selling the products

TFC – total expense from the acquisition of the production factor

Table 1. Number of rooted shoots with different cultivation scenarios

Rooted shoots	Control group (no moisture-absorbing polymer)		Combination 1 (with moisture-absorbing polymer – 1.5 kg/da)		Combination 2 (with moisture-absorbing polymer – 3.5 kg/da)	
	Number of shoots/plants	unit/da	Number of shoots/plants	unit/da	Number of shoots/plants	unit/da
M9	8.52	14 202	9.47	15 786	9.81	16 353
MM106	15.75	26 255	16.00	26 672	16.00	672

The total income from the use of the production factor increases when every additional unit added to the production process has a contributing effect. The economic outcome will continue to increase as long as the marginal income related to the factor of production under consideration continues to be positive:

$$MI = MR – MC > 0,$$

where: *MI* – marginal income from the factor of production
MR – marginal revenue from the factor of production
MC – marginal cost (the price of the last used unit from the factor of production);

$$MR = MPP. P_y,$$

where: *MPP* – marginal physical output; and P_y – the price of a product unit;

$$MPP = \Delta TPP/\Delta x;$$

ΔTPP – changes in the total physical product;
Δx – changes in the quantity of the variable factor (Mihailov et al., 2002).

The economic outcomes from the studied three combinations of the moisture-absorbing polymer in the case of M9 rootstock are presented by Table 2 and Figure 1.

In both combinations with moisture-absorbing polymer, the marginal income is a positive number which demonstrates the cost effectiveness of applying the polymer. Considering the control group, the value of the produced rootstocks is 5680.8 lv/da (14 202 units X 0.4 lv). After applying 1.5 kg/da of the moisture-absorbing polymer, the value increases to 6314.4 lv/da (15 786 units X 0.4 lv) meaning that TFR = 6314.4 – 5680.8 = 633.6 lv/da. TC or the cost of acquiring the moisture-absorbing polymer is 16.9 lv/da (1.5 kg X 45 lv = 67.5 lv/da but it is done once every four years; hence the cost is 16.9 lv/da per year). Given this information, the economic effect from the application of the moisture-absorbing polymer can be calculated. It is TFI = TFR – TFC = = 633.6 – 16.9 = 616.7 lv/da.

Considering the combination with 3.5 kg/da of moisture-absorbing polymer, the production value increases to 6541.2 lv/da (16 353 units X 0.4 lv) meaning that TFR = 6541.2 – 5680.8 = 860.4 lv/da. TC or the expenses for acquiring the moisture-absorbing polymer is 39.4 lv/da (3.5 kg X 45 lv = = 157.5 lv/da but it is done once every four years; hence the cost is 39.4 lv/da per year). Given this information, the economic effect from the application of the moisture-absorbing polymer can be calculated. It is TFI = TFR – TFC = 860.4 – 39.4 = 821 lv/da.

Consequently, considering the case with rootstock M9, the economically most effective decision is to apply 3.5 kg/da of moisture-absorbing polymer (combination 2). The eco-

Table 2. Economic outcomes from the use of the moisture-absorbing polymer with M9 rootstock

	X_1	TPP	P_x	MC	MPP	P_y	MR	MI
Rootstock M9	Moisture-abs.	Units/da	lv/kg	lv/da		lv/unit.	lv/da	lv/da
Control group	0	14 202	45.0	0	0	0.4	0	0
Combination 1	1.5	15 786		16.9	1056.0		422.4	405.5 > 0
Combination 2	3.5	16 353		39.4	283.5		113.4	74.0 > 0

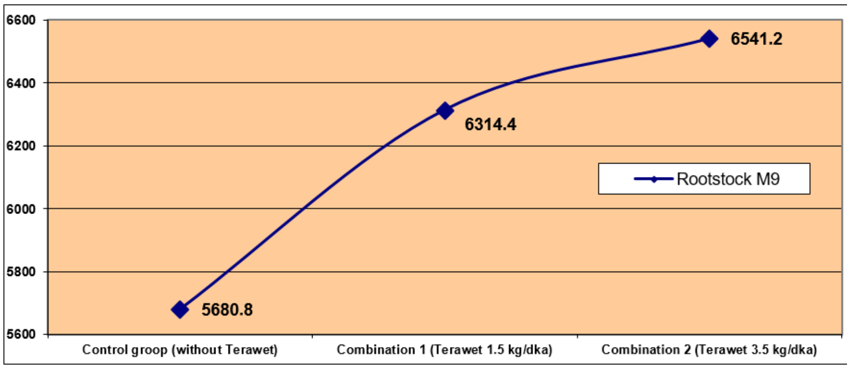

Fig. 1. Revenue (lv/da) from selling apple rootstocks M9 considering different scenarios of moisture-absorbing polymer application

1 lv = 0.51 €;1 da = 1000 m²

Table 3. Economic outcomes from the application of moisture-absorbing polymer with MM106 rootstock

Rootstock MM106	X_1	TPP	P_x	MC	MPP	P_y	MR	MI
	moisture-abs.	units/da	lv/kg	lv/kg		lv/unit	lv/da	lv/da
Control group	0	26 255	45.0	0	0	0.4	0	0
Combination 1	1.5	26 672		16.9	278.0		111.2	94.3>0
Combination 2	3.5	26 672		39.4	0.0		0.0	-39.4<0

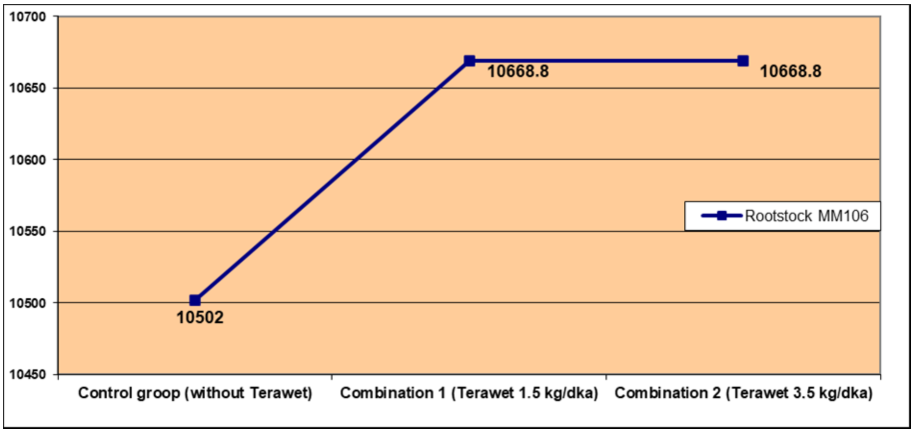

Fig. 2. Revenue (lv/da) from selling apple rootstocks MM106 considering different scenarios of moisture-absorbing polymer application

nomic outcomes from the studied three combinations of the moisture-absorbing polymer in the case of M9 rootstock are presented by Table 3 and Figure 2.

In this case, a positive marginal income is observed only in combination 1; thereby demonstrating the cost-effectiveness of applying the moisture-absorbing polymer. In the combination with 3.5 kg./da, the marginal income is (-39.4) lv/da which shows that the application of such quantity of the moisture-absorbing polymer per da is not economically viable.

Considering the control group, the value of the produced rootstocks is 10 502 lv/da (26 255 units X 0.4 lv). After applying 1.5 kg/da of the moisture-absorbing polymer, the value increases to 10 688.8 lv/da (26 672 units X 0.4 lv) meaning that TFR = 10 688 – 10 502 = 166.8 lv/da. TC or the expenses of acquiring the moisture-absorbing polymer is 16.9 lv/da (1.5 kg X 45 lv = 67.5 lv/da but it is done once every four years; hence, the cost is 16.9 lv./dka per year). Given this information, the economic effect from the application of the moisture-absorbing polymer can be calculated. It is TFI = TFR – TFC = 166.8 – 16.9 = 149.9 lv/da.

Considering the combination with 3.5 kg/da of moisture-absorbing polymer, the value of the produced rootstocks remains 10 502 lv/da (26 255 units X 0.4 lv) meaning that TFR = 10 668.8 – 10 502 = 166.8 lv/da. TC or the expenses for acquiring the moisture-absorbing polymer is 39.4 lv/da (3.5 kg X 45 lv = 157.5 lv/da but it is done once every four years; hence the cost is 39.4 lv/da per year). Given this information, the economic effect from the application of the moisture-absorbing polymer is lower than the case of combination 1. Respectively, it is TFI = TFR – TFC = 166.8 – 39.4 = 127.4 lv/da.

Consequently, considering the case with rootstock MM106, the economically most effective decision is to apply 1.5 kg/da of moisture-absorbing polymer (combination 1).

Conclusion

Several conclusions are drawn based on the conducted three-year study of the development of apple clonal rootstocks with somatic organogenesis origin in a stoolbed and different moisture-absorbing polymer quantity. Based on the findings from the economic assessment of the specific effects of the moisture-absorbing polymer, the results from the study show that the M9 rootstock demonstrates an improved rooting with a higher number of roots shoots, as well as, increased revenue when applying the moisture-absorbing polymer in a doze of 3.5 kg/da.

The economic benefit from applying the same doze of moisture-absorbing polymer in the case of the MM106 rootstock failed to meet our expectations. The doze of 3.5 kg/da proved to be economically ineffective. The results from the economic analysis demonstrated that the application of such a doze from the moisture-absorbing polymer was not economically feasable in comparison to findings from the alternative doze of 1.5 kg/da.

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