DIFFERENT NUTRIENT LEVELS' INVESTIGATION IN THE SELF-ROOTED AND GRAFTED WATERMELON PRODUCTION

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Abstract. *My work in the form of water-soluble fertilizers for self-rooted and grafted watermelon cultivation, applied simultaneously with irrigation, it concentrates on examining different nutrient levels during the growing season. Within that, I focused on the application of macronutrients - nitrogen, phosphorus, potassium. Therefore, I set up 4 different nutrient levels for both types of seedlings, in two replicates, of which I developed a phosphorus, a nitrogen, and a potassium overweight nutrient level, and a nutrient level in which all three nutrients were in equal proportions. The latter formed the control. In the case of both self-rooted and grafted seedlings, I was curious as to whether changes in the amount of nitrogen, phosphorus and potassium affect the yield in a positive or negative direction. I performed the cost calculations in order to determine whether the increased cultivation cost caused by the applied additional fertilizers may result in such an additional yield, and hence an increase in sales revenue that is worth increasing the amount of applied nutrients. My experiment showed that the yield of grafted plants at the beginning of the growing season, after planting, before or during the first flowering period, applied at the same time as irrigation amount of phosphorus has a positive effect, while for self-rooted plants the high potassium active ingredient applied during ripening results in the highest yield. As a result, these nutrient levels have proven to be the most profitable. In addition, the experiment demonstrated the importance of the nutrients applied through the drip tape.*

Keywords: *watermelon, drip irrigation, water-soluble fertilizer, grafted plant*

INTRODUCTION

Watermelon cultivation in Hungary has a history dating back decades. Irrigation and nutrient replenishment are essential to produce the best possible quality and quantity of goods, which can take the form of both organic and fertilizer. Irrigation is becoming increasingly important these days, mainly for the cultivation of vegetables in the field, due to extreme weather and prolonged periods of low rainfall. In addition, the importance of nutrients applied during irrigation is widespread. That's why, my work in the form of water-soluble fertilizers for self-rooted and grafted watermelon cultivation, applied simultaneously with irrigation, it concentrates on examining different nutrient levels during the growing season. In the case of both self-rooted and grafted seedlings, I wondered whether changes in the amount of nitrogen, phosphorus and potassium would affect, and if so, their yields in a positive or negative direction and, consequently, their profitability. Therefore, I set up 4 different nutrient levels for both types of seedlings, in two replicates, of which I developed a phosphorus, a nitrogen, and a potassium overweight nutrient level, and a nutrient level in which all three nutrients were in equal proportions. The latter formed the control. In the course of my experiment, I aimed to develop a nutrient replenishment technology that can be applied simultaneously with irrigation in both self-rooted and grafted watermelon cultivation, which has a positive effect on yield, and is therefore the most profitable. Respectively an important objective for me, to help my producing partners work with my examination.

The water requirement of watermelon is 400-500 mm (NAGY, 2005), the approx. during its 4-5 month growing season, thus it can be classified as a water-intensive vegetable plant (HODOSSI et al., 2004). For this reason, it cannot be successfully grown in Hungary without irrigation. It needs the greatest amount of water during germination, rapid shoot growth and during the period of crop development (NAGY, 1997).

Its transpiration coefficient is 600 (BALÁZS, 2004). In summer, the evaporation of watermelon can reach 1-2 liters per plant per day (NAGY, 2005).

Watermelons have a very suboptimal and higher water supply, both in plant development and in crop quality (NAGY, 1997).

In watermelon cultivation, July and August are the most critical months in terms of water supply (NAGY, 2005), as the lowest rainfall falls during the growing season, when the average temperature is the highest, so the evaporation of the melon and the development of the plant occur even the most water-demanding periods (NAGY, 1997).

During the growing season, 30-40 mm of water replacement irrigation is required several times, depending on the soil binding and the depth of rooting of the plant (HODOSSI et al., 2004).

The advantages of watermelon irrigation are that higher yield averages (100, 150 t / ha), higher yield safety, higher yield quality, and more balanced crop development and growth can be achieved (NAGY, 2005).

There are several aspects to consider when planning to irrigate a watermelon. It is very important that irrigation should be implemented differently on different soil types (KNOT, 1973). In addition, it is important to choose the right time and method of watering. Drip irrigation proved to be the best method, which was confirmed by experiments (NAGY, 2005).

Drip irrigation belongs to the group of micro-irrigation. It is generally characteristic of micro-irrigation that at low water pressure, in a short period of time, small cross-section water dispensing elements deliver the irrigation water directly to the root of the plants (TÓTH, 2006).

One of the main features of drip irrigation is that the use of irrigation water is economical, as it supplies it directly to the root zone of the irrigated plant, thus it can immediately compensate for the emerging water demand of the plant. In addition, in the cultivation of vegetables, nutrients are increasingly being applied in the form of water-soluble fertilizers during drip irrigation, thus enabling nutritious irrigation. The process of this can be fully automated (Z. KISS and RÉDAI, 2005).

Because of all this, it is favorably used in vegetable production. Initially, it was widespread in greenhouses and film tents (Z. Kiss and Rédai, 2005), but due to its advantages, it has been used more and more often in field vegetable production in recent years (BALÁZS, 2004).

Regarding the nutrient requirements of watermelon, it belongs to the group of high-nutrient vegetable species. It is particularly fond of organic fertilizer. Watermelons need 12.3kg of nitrogen, 3kg of phosphorus and 17.9kg of potassium to produce 10 tonnes. Of the macronutrients - in descending order of watermelon demand – watermelon needs: K, N, Ca, P and Mg. It requires the most potassium and the least magnesium (NAGY, 2000).

Among the micronutrients, the following are essential for watermelon: Fe, Mn, Zn, Ni, Cl, B, Mo (NAGY, 2005). An American study has also pointed to the paramount importance of zinc as well as its yield-enhancing effect in watermelon cultivation (LOCASCIO, 1966).

Watermelons belong to the group of the most high-nutrient vegetable species, so it is very important to pay attention to their nutrient supply in order to have the right amount and quality of fruit. With proper nutrient replenishment and irrigation, yields of up to 100-150 t / ha can be achieved (NAGY, 2005).

Many nutrients play an important role in watermelon cultivation. These include nitrogen, phosphorus, potassium, calcium, magnesium and molybdenum.

Nitrogen is one of the most important macronutrients for watermelons, as it determines the development, shoot growth, flowering, fruit attachment and development of plants

(Kertészek Áruháza). An experiment in Croatia in 2000-2001 also highlighted the importance of nitrogen in watermelon cultivation. In the experiment, increasing the nitrogen supply from 115 kg / ha to 275 kg / ha under optimal and less optimal growing conditions resulted in more intensive shoot growth in the 4th and 7th weeks after planting (GORETA et al., 2005).

A study in Florida also looked at the changes in watermelon cultivation caused by different amounts of *phosphorus* active ingredients. The largest change was between 0 kg / ha P and 25 kg / ha P nutrient levels, both in terms of average crop weight and yield per hectare. Further increase of phosphorus resulted in only minimal increase, but in some cases deteriorated yields (HOCHMUTH et al., 1993).

Potassium also plays an important role in watermelon cultivation, as it plays a very important role in the speed of ripening and in ensuring the quality of the crop (Kertészek Áruháza). In the case of potassium deficiency, the development of the plants is delayed (NAGY, 2000), the fruit will have a low sugar content, water taste and an uncharacteristic flesh color (Kertészek Áruháza).

Calcium has a very important role in the development and flowering of watermelons and also influences the quality of the crop (SCOTT-MCCRAW, 1990).

In the case of *magnesium* deficiency, yellowish-green spots initially appear on the leaves of the plant, and then the whole leaf turns yellow, whitens, and dies (NAGY, 2000).

Lack of *molybdenum* can lead to poor plant development, low yields and, in the worst case, plant death. It most commonly occurs on acidic soils (NAGY, 2000).

In the cultivation of watermelons we can also use basic fertilization, nest fertilization, starter fertilization, top fertilization and foliar fertilization. However, the importance of nutrient solution is also growing in the most modern plantations.

The nutrient solution is applied by water-soluble fertilizers via a drip system (ICL-Specialty Fertilizers, 2015). This is actually the application of the topsoil in dissolved form with irrigation water (NAGY, 1994).

It is used during the growing season in order to achieve a more efficient and even nutrient application, a continuous supply of nutrients to the plant and better yield data. Thus, yields of up to 50 tons per hectare can be achieved (NAGY, 2005). This is the most effective way of supplying nutrients in mulch cultivation.

Nutrients (mainly nitrogen) applied simultaneously with drip irrigation significantly increase the yield of watermelon, especially on looser soils (ROLBIECKI et al., 2020).

Other advantages are that the composition and amount of nutrients can be formulated and delivered according to the current phenological stage of the plant, and that it allows immediate intervention in the event of a nutrient deficiency (ICL-SPECIALTY FERTILIZERS, 2015).

The advantages of using watermelon grafting is that watermelon becomes much more resistant to various environmental effects, has a positive effect on nutrient and water uptake, as well as the quantity, weight and quality of the crop, and the harvesting season can be better extended to grafted plants. In addition, grafting watermelons is also a solution for controlling infectious pathogens (*Verticillium*, *Fusarium*) and pests (*Meloidogyne* spp.) From various soils. Due to this, watermelons can be grown in the area for up to several years (BALÁZS, 2013; Davis et al., 2008).

MATERIAL AND METHODS

My experiment was carried out in Medgyesegyháza in 2020-2021 on an area of 1000 m^2, during which I examined the effect of different nutrient levels applied simultaneously with irrigation on the yield of self-rooted and grafted watermelon. The experiment took place in the same area for both years. In the experiment, I also examined the Rubin F1 watermelon variety included in the Syngenta variety selection list for the self-rooted and grafted seedling types, which is illustrated in *Figure 1*.

Fig. 1: Rubin F1 watermelon variety *(Photo: Patrik Krizsán)*

I developed a total of 16 experimental plots of about 20 m^2 in the whole area. Each plot consisted of 2 adjacent rows. I examined 3-3 seedlings in both rows, so a total of 6 seedlings were placed in one plot. The plant spacing within the plots was 120 cm between each seedling. From the product of the seedling distance and the 250cm row spacing, it can be stated that one plant had 3m^2 of growing area.

The 16 plots were distributed in the area by examining the grafted seedlings in 8 plots and also the self-rooted seedlings in 8 plots. The 8 plots were composed of a control, a phosphorus overweight, a nitrogen overweight, and a potassium overweight nutrient level, which I examined in duplicate.

I distinguished the 16 experimental plots by marking them, which are illustrated in *Table 1*. The entire experimental area and the location of the treatments are shown in *Figure 2*.

The area did not receive basic fertilization in any of the years to avoid inaccuracy in the experiment.

Nitrogen, phosphorus, and potassium applications were also performed in the most appropriate phenological phases of the plant. For each treatment, all three nutrients were applied in the same period, I only changed their amount to suit the nutrient level. Phosphorus application after planting, before and during the first flowering period; nitrogen application after fruit set during crop growth; and potassium application was taken during the ripening period. Each excess active ingredient was administered in several smaller doses, for better absorption and utilization. I used various water-soluble fertilizers to apply the active ingredients, which I applied simultaneously with irrigation. The water needed for irrigation and fertilizer dissolution was taken from a 11 meter deep well in the experimental area using a pump. However, the salinity of the water obtained from it proved to be high at 1.09 mS / cm and 1.24 mS / cm, which was revealed by the salinity measurements of the water samples taken in the spring.

Table 1

Treatments and their labeling

	Repeat 1	Repeat 2
Grafted seedlings, **control** treatment	O/1/I.	O/1/II.
Grafted seedlings, **phosphorus overweight** treatment	O/2/I.	O/2/II.
Grafted seedlings, **nitrogen overweight** treatment	O/3/I.	O/3/II.
Grafted seedlings, **potassium overweight** treatment	O/4/I.	O/4/II.
Self-rooted seedlings, **control** treatment	S/1/I.	S/1/II.
Self-rooted seedlings, **phosphorus overweight** treatment	S/2/I.	S/2/II.
Self-rooted seedlings, **nitrogen overweight** treatment	S/3/I.	S/3/II.
Self-rooted seedlings, **potassium overweight** treatment	S/4/I.	S/4/II.

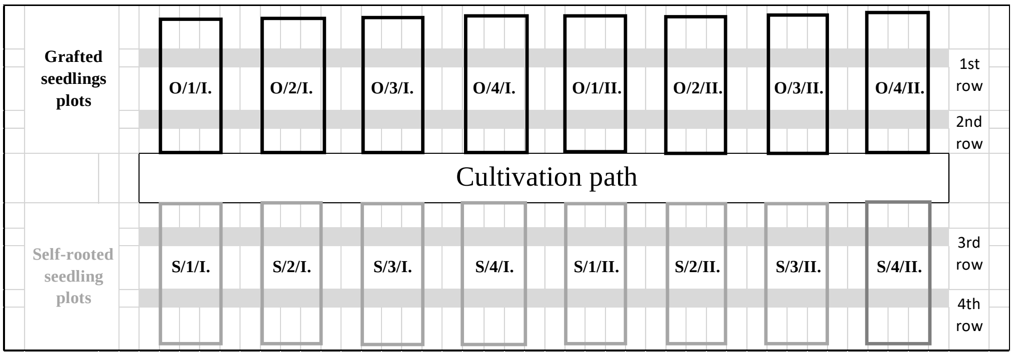

Fig. 2: Diagram of the experimental area and arrangement of treatments

The application of the additional active ingredients was carried out in such a way that the amount of active ingredient dispensed in the additional treatments was approx it should be 6 times that applied in the control plot. During the experiment, the nutrients could only be applied in the form of complex water-soluble fertilizers, which is why the amount of the other two nutrients increased minimally when the additional active ingredients were dispensed. For this reason, when formulating the fertilizers, I constantly made sure that the 1:2:1 ratio was maintained in favor of the given additional active substance. The total amount of NPK active ingredients applied to the treatments during the whole growing period is shown in *Table 2*.

Table 2

Amount of total NPK active ingredients applied per plot during the growing season 2020-2021

	Control plots (S/1/I., S/1/II., O/1/I., O/1/II.)	**Phosphorus overweight plots (S/2/I., S/2/II., O/2/I., O/2/II.)**	**Nitrogen overweight plots (S/3/I., S/3/II., O/3/I., O/3/II.)**	**Potassium overweight plots (S/4/I., S/4/II., O/4/I., O/4/II.)**
N	24,93g	66,63g	**144,58g**	63,67g
P	21,48g	**132,48g**	60,52g	59,25g
K	21,35g	59,05g	65,64g	**136,35g**

Uniform and optimal amounts of fertilizers for the treatments were dispensed through a drip belt using an irrigation system. On the other hand, the application of the additional active substances was carried out in several smaller doses, with an irrigation can, irrigated to the watermelon stems, because this was the only way to carry it out due to the high pressure of the irrigation system. For each plot, I dissolved the excess fertilizers in 5 liters of water and distributed this amount among the 6 seedlings inside the plot. Accurate measurement of fertilizer doses was performed using a gram balance.

In addition to nitrogen, phosphorus and potassium, I also applied calcium and various trace elements (iron, manganese, boron, copper, zinc, molybdenum) during the development of watermelon.

In order to examine the utilization of the applied nutrients, I performed measurements and calculations related to the yield during the growing season. At each harvest, I harvested, weigned and recorded all the ripe crops within the plots on a plot-by-plot basis. Thus, by the end of the experiment, I found out the yields of all the treatments. I performed the cost calculations in order to determine whether the increased cultivation cost of the applied additional fertilizers could result in such an additional yield, and hence an increase in the sales revenue, that it would be worthwhile to increase the amount of applied nutrients.

RESULTS AND DISCUSSION

The results of the measurements, tests and calculations performed in both years of my experiment (2020, 2021) will be described in this chapter in accordance with the development of the watermelon. The weather in the 2020 pilot year made it very difficult for different work processes as well as nutrient deliveries. In addition, the extreme vintage had an adverse effect on both the development and yields of the watermelon, which is why I mostly relied on the average results of the year 2021 and the two experimental years to judge the conclusions.

When processing the results for all measurements, tests and calculations, both for self-rooted and grafted treatments, I used the average of the two replicates for ease of reference.

Based on the *yield data (Figure 3, Table 3)* of the two experimental years, it can be said that the unfavorable weather in 2020 resulted in a lower yield for each treatment. However, in the year 2021 - due to the favorable weather - I have already experienced higher yields, especially in the case of grafted treatments, where a significant increase in yield was observed compared to the 2020 data. There was no significant difference in yield between the two years for self-rooted treatments. In addition, it can be stated that the yields of the grafted treatments were always higher than those of the self-rooted ones.

Based on the average of the data of the two years, O/2. resulted in the highest yield of the grafted treatments. The other treatments also showed some increase in yield, but not to a significant extent.

For self-rooted treatments, only S/4. resulted in a small amount yield increase. In S/2. treatment – unlike O/2. - there was also a minimal decrease in yield. There was no significant change in S/3.

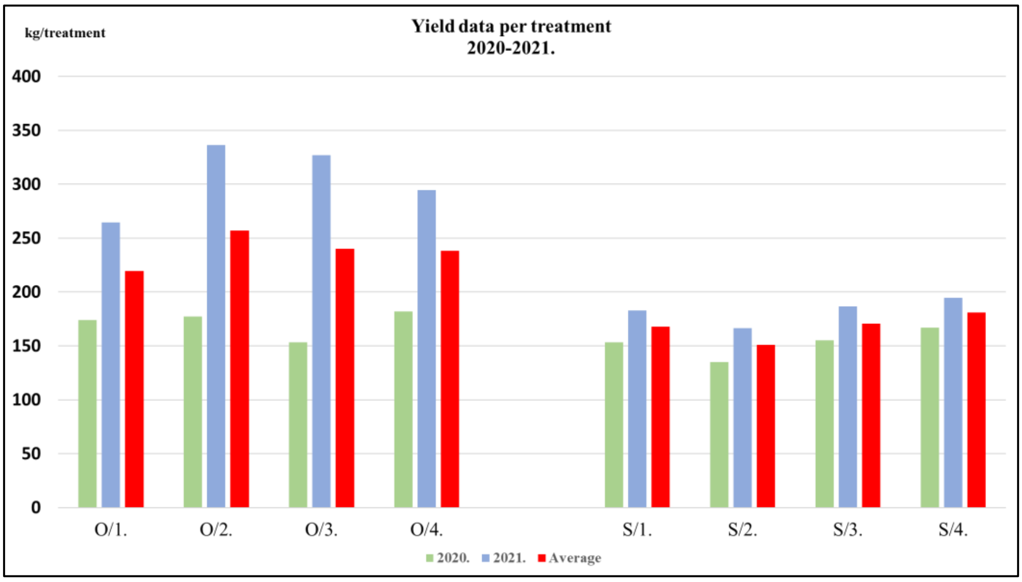

Fig. 3: Average yield data per treatment (2020, 2021) and average of data for two years

Table 3

Yields per square meter in the different treatments (2020-2021) and the average and standard deviation of the data of the two years

kg/m^2	**2020.**	**2021.**	**Average**	**Deviation**
O/1.	8,71	13,23	10,97	*1,26*
O/2.	8,87	16,83	**12,85**	*2,07*
O/3.	7,66	16,35	12	*2,21*
O/4.	9,1	14,72	11,91	*1,43*
S/1.	7,66	9,15	8,41	*0,45*
S/2.	6,75	8,32	7,54	*0,53*
S/3.	7,75	9,32	8,54	*0,47*
S/4.	8,35	9,74	**9,05**	*0,59*

In order to examine the profitability of different nutrient levels, I performed *cost calculations* for all self-rooted and gtafted treatments. I performed the cost calculations based on the setup and workflows of the experiment I presented. By this I mean the row and stem distances, the amount of seedlings, the application of different cover foils (ground cover, line spacing and tunnel foil), and the costs of plant protection. In addition, the area already had a well before the experiment, from which the irrigation took place, and no land rent had to be paid through its own land. Changing these are all factors that modify the cost of cultivation. I performed the calculations on the basis of the cultivation costs of the given treatment and the income resulting from the yield obtained in it. The calculations were based on the average of the expenditures and revenues of the two experimental years for each treatment. The cultivation costs were calculated for the area of the treatments (20 m^2), for I can provide accurate data on the yields of an area of this size. In terms of crop sales, I calculated an average net sales price of 60 Ft/kg everywhere.

Based on the cost calculation of the *grafted treatments*, it can be seen that each excess active ingredient nutrient level resulted in a higher cultivation cost but also a higher profit than the control treatment *(Table 4)*. However, of all, O/2. treatment had the highest profit, despite the highest total cost of fertilizers applied. In this treatment, approx I saw a 25% increase in profit compared to the control.

For *self-rooted treatments*, only S/3. and S/4. nutrient levels resulted in higher profits compared to controls *(Table 5)*. In the S/2. treatment, approx I saw a 23% drop in profit.

Comparing both tables, it is very clear that the cultivation costs of grafted treatments are always higher due to grafted seedlings. Nonetheless - against self-rooted plants - yet they result in higher profits, mainly due to their higher productivity and better resilience.

Table 4

Calculation of the cost of different grafted treatments in an area of 20 m^2

Cost description	Prices (broken down by treatments)			
	O/1.	**O/2.**	**O/3.**	**O/4.**
Soil work costs (autumn basic cultivation, spring combinatorization)	100 Ft	100 Ft	100 Ft	100 Ft
Ground cover foil	134 Ft	134 Ft	134 Ft	134 Ft
Tunnel foil	240 Ft	240 Ft	240 Ft	240 Ft
Line spacing foil	240 Ft	240 Ft	240 Ft	240 Ft
Drip tape	145 Ft	145 Ft	145 Ft	145 Ft
Costs of machine laying of ground cover foil and drip tape	100 Ft	100 Ft	100 Ft	100 Ft
Seedling (seed + cultivation)	1 020 Ft	1 020 Ft	1 020 Ft	1 020 Ft
Irrigation costs (eg.: petrol, mixed oil, irrigation system parts)	650 Ft	650 Ft	650 Ft	650 Ft
Fertilizer	171 Ft	416 Ft	266 Ft	349 Ft
Costs of plant protection (pesticides, application costs)	778 Ft	778 Ft	778 Ft	778 Ft
Harvesting and transport costs	950 Ft	950 Ft	950 Ft	950 Ft
Stock liquidation costs	400 Ft	400 Ft	400 Ft	400 Ft
Other cultivation costs	130 Ft	130 Ft	130 Ft	130 Ft
Total expenses:	**5 058 Ft**	**5 303 Ft**	**5 153 Ft**	**5 236 Ft**
Total revenue:	**13 165 Ft**	**15 417 Ft**	**14 406 Ft**	**14 289 Ft**
Profit:	**8 107 Ft**	**10 114 Ft**	**9 253 Ft**	**9 053 Ft**

Table 5

Calculation of the cost of different self-rooted treatments in an area of 20 m^2

Cost description	Prices (broken down by treatments)			
	S/1.	S/2.	S/3.	S/4.
Soil work costs (autumn basic cultivation, spring combinatorization)	100 Ft	100 Ft	100 Ft	100 Ft
Ground cover foil	134 Ft	134 Ft	134 Ft	134 Ft
Tunnel foil	240 Ft	240 Ft	240 Ft	240 Ft
Line spacing foil	240 Ft	240 Ft	240 Ft	240 Ft
Drip tape	145 Ft	145 Ft	145 Ft	145 Ft
Costs of machine laying of ground cover foil and drip tape	100 Ft	100 Ft	100 Ft	100 Ft
Seedling (seed + cultivation)	420 Ft	420 Ft	420 Ft	420 Ft
Irrigation costs (eg.: petrol, mixed oil, irrigation system parts)	650 Ft	650 Ft	650 Ft	650 Ft
Fertilizer	171 Ft	416 Ft	266 Ft	349 Ft
Costs of plant protection (pesticides, application costs)	778 Ft	778 Ft	778 Ft	778 Ft
Harvesting and transport costs	950 Ft	950 Ft	950 Ft	950 Ft
Stock liquidation costs	400 Ft	400 Ft	400 Ft	400 Ft
Other cultivation costs	130 Ft	130 Ft	130 Ft	130 Ft
Total expenses:	**4 458 Ft**	**4 703 Ft**	**4 553 Ft**	**4 636 Ft**
Total revenue:	**10 082 Ft**	**9 045 Ft**	**10 244 Ft**	**10 852 Ft**
Profit:	**5 624 Ft**	**4 342 Ft**	**5 691 Ft**	**6 216 Ft**

CONCLUSIONS

My experiment showed that at the beginning of the growing season, before or during the first flowering period, higher amounts of phosphorus applied simultaneously with irrigation have a positive effect on the yield of *grafted plants* throughout the growing season.

In addition, I was convinced that in the case of *self-rooted plants* it has a positive effect on the results of the higher amount of potassium active substance applied during the ripening period, also during irrigation, in terms of yield.

All of this proves that it is really necessary to use different nutrient replenishment in the cultivation of self-rooted and grafted plants.

My experiment also pointed to the fact that grafted seedlings result in higher yields compared to self-rooted plants. As a result, they are more profitable to grow, despite their higher cultivation costs.

In addition to the results obtained, the experiment demonstrated the importance of the nutrients applied during drip irrigation in terms of yield. Respectively, the efficiency of irrigation is greatly influenced by the vintage effect, which can also manifest itself in the yield.

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