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Application of magnetically treated water to tomatoes seedlings and studying the economic viability of its production

Aplicación de agua tratada magnéticamente a plantallas de tomate y estudio de viabilidad económica de la producción

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ABSTRACT

The technique of magnetizing irrigation water has been successfully adopted for producing seedlings of different varieties; however, in addition to the agronomic benefits, analyzing the economic viability is an important indicator affecting the producer's decision in acquiring this technology. This study aimed to evaluate the effect of magnetic treatment of irrigation water on the growth and development of tomato seedlings, and its economic viability. Experiments I, II and III were treated with quality water (magnetized and non-magnetized) and different substrates. The application of magnetically treated water in the three experiments did not reduce any variables. Furthermore, magnetic treatment of irrigation water proved to be advantageous because it improved the final emergence percentage by 32.19% and 19.28% in experiments II and III, respectively. The growth of tomato seedlings was verified by the 53.97% increase in shoot dry matter in experiment II and by 29.77% increase in shoot fresh matter in experiment III. The seedlings that received magnetically treated water observed 14.61% increase in the speed of germination index in experiment I. Studying the economic viability revealed that using magnetizer to produce tomato seedlings was financially viable, as it reduced the discounted payback from 4.18 to 1.87 years and increased the accumulated net present value of 5 years from US$ 1,814.00 to US$ 14,593.00.

Keywords: financial analysis, magnetized water, germination, shoot dry matter, *Solanum lycopersicum*.

RESUMEN

La técnica de magnetización del agua de riego ha sido utilizada con éxito para la producción de plántulas de diferentes variedades, sin embargo, además de los beneficios agronómicos, el análisis de viabilidad económica se convierte en un indicador importante para la toma de decisiones por parte del productor para adquirir esta tecnología. Este estudio tuvo como objetivo evaluar el efecto del tratamiento magnético del agua de riego sobre el crecimiento y desarrollo de plántulas de tomate y la viabilidad económica de esta tecnología. Los experimentos I, II y III se trataron con agua de calidad (magnetizada y no magnetizada) y diferentes sustratos. Ninguna variable se redujo con la aplicación de agua tratada magnéticamente en los tres experimentos realizados. El tratamiento magnético del agua de riego resultó ser una técnica ventajosa para mejorar el porcentaje final de la variable de germinación, aumentando en 32,19% y 19,28%, respectivamente, para el experimento II y III. El crecimiento de las plántulas de tomate aumentó la materia seca de los brotes en un 53,97% en el experimento II y el aumento de la materia fresca de los brotes en un 29,77% en el experimento III. Las plántulas que recibieron agua tratada magnéticamente tuvieron un aumento del 14,61% en el índice de velocidad de emergencia en el experimento I. El estudio de viabilidad económica mostró que el uso del magnetizador para la producción de plántulas de tomate es financieramente viable, ya que redujo la recuperación de la inversión con una tasa de 4,18. a 1,87 años y aumentó el valor presente neto acumulado de 5 años de US$ 1,814.00 a US$ 14,593.00.

Palabras clave: *análisis financiero, agua magnetizada, germinación, masa seca de brotes,* Solanum lycopersicum.

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Introduction

Tomatoes (*Solanum lycopersicum*), belong to the solanaceae family, which also includes peppers, eggplants, and scarlet eggplant, and its production conditions are similar to those of these crops (Díaz-Pérez and Eaton 2015). This vegetable is the second most consumed in Brazil after lettuce, which is used in daily meals, fast food, and snacks (CONAB 2019). According to the Food and Agriculture Organization (FAO), Brazil occupies the ninth position in the production of tomatoes globally, producing 3.9 million tons in 54,537 hectares, with an average productivity of 71.8 tons per hectare (FAO 2019). Two Brazilian states, Goiás and São Paulo, contribute collectively to 52.58% of the national production, wherein their individual production corresponds to 30.6% and 21.98%, respectively (CONAB 2019).

Irrigation is a technique used to produce seedlings, allowing the supply of seedlings throughout the year with homogeneity and genetic potential (Thebaldi *et al.* 2016). Magnetic treatment is a technology that has been introduced as an alternative to water saving, which can beneficially affect plants and soil (Surendran *et al.* 2016).

Aguilera and Martin (2016) studied the effect of magnetically treated water irrigation on seed germination and tomato seedling development, and concluded that the seedlings that received magnetically treated water germinated rapidly, with increased height and stem diameter when compared to those that received untreated water. Abedinpour and Rohani (2017) verified that magnetically treated water increased the final germination of corn seeds from 46.5% to 83%, and observed significant increases in the fresh and dry matter of the seedlings. Lorenzoni *et al.* (2021) observed that bell pepper seeds reached the highest germination percentage when treated with magnetized water. Álvaro *et al.* (2019) found that magnetically treated water increased the shoot fresh matter and shoot dry matter of eggplant seedlings.

Information about the economic aspects that assist producers with support and guidance regarding the structuring, management, monitoring, and evaluation of the activity and marketing of products is currently lacking (Sabbag *et al.* 2013). Studying the economic viability of the enterprise reveals its viability to the investor, in addition to quantitatively presenting the benefits of the investment, thereby assisting the producer in the decision-making process. Furthermore, for the agribusiness to be financially sustainable, it is necessary that the gains cover the operator's remuneration and other costs, and generate profit from the investment, in addition to allowing the system to adapt to the changes (Sabbag and Nicodemo 2011).

Therefore, this study aimed to evaluate the economic viability of magnetic water treatment and its effect on tomato seedling production.

Material and methods

This study was conducted at a rural producer's property in the municipality of Cristalina, Goiás, at 16º 45' 30'' Sul latitude and 47º 35' 50'' Oeste longitude, with an average altitude of 1233 m. Three experiments were performed: experiment I from 11/11/2020 to 12/15/2020, experiment II from 01/22/2021 to 02/16/2021, and experiment III from 02/23/2021 to 03/22/2021.

According to Köppen-Geiger, the local climate is considered tropical with a dry season (type Aw), having pleasant summers and mild winters with decreased rainfall (Cardoso *et al.* 2014). The maximum and minimum measurements of temperature and relative humidity of air were recorded using an equipment installed inside the protected environment that registered variations in the temperature from 12 to 45 ºC and relative humidity of air from 10 to 99%. The protected environment used for growing the seedlings consisted of an arched roof covered with polyethylene film (150 µm), which was 12 m long, 8.0 m wide, and 5.0 m high.

Two commercial substrates were used in the experiment: substrate 1 (S1) was composed of peat, vermiculite, organic residues, and NPK (Carolina Soil®); and substrate 2 (S2) was composed of earthworm humus. Chemical analysis performed on substrate 2 is as follows: K = 8.70 $cmol_c$ dm^{-3}, Ca^+ = 8.6 $cmol_c$ dm^{-3}, Mg^+ = 8.1 $cmol_c$ dm^{-3}, Al^{3+} = 0.0 $cmol_c$ dm^{-3}, H + Al = 1.20 $cmol_c$ dm^{-3}, $Pmeh^{-1}$ = 102.7 mg dm^{-3}.

The experimental design was completely randomized, with four repetitions. Each experimental plot comprised a 128-cell polyethylene tray that was filled with the desired substrate and contained only one tomato (Santa Clara cultivar) seed per cell.

Two factors, water quality and type of substrates, were tested in the three experiments, and the treatments applied were: 1) magnetically untreated water (A) + substrate 1 (S1); 2) magnetically untreated water (A) + substrate 2 (S2); 3) magnetically treated water (M) + substrate 1 (S1); 4) magnetically treated water (M) + substrate 2 (S2).

In the magnetic water treatment, 50 L water was kept for 1 h inside a 200 L plastic barrel containing a magnetizing device. According to the manufacturer, this device can magnetize 1000 liters per hour. The magnetizing device comprises a cylindrical piece with a height of 0.168 m and a diameter of 0.10 m, which is shielded in stainless steel with magnets inside. The device was suspended at a distance of 0.05 m from the bottom in a vertical position and centered on the plastic barrel.

The seedlings were watered daily using a watering can at approximately 9 am. On rainy days, the trays remained moist due to the low evapotranspiration observed in the trays; in such cases, watering was suspended.

In experiments I and III, the trays were filled with the desired substrate, the seeds were sown, the trays were placed in the protected environment and subsequently irrigated by applying the respective water treatments.

In experiment II, the trays were filled with the desired substrate, following which the substrate in all plots was moistened with magnetically untreated water. After sowing the seeds, they were placed in an environment without light incidence for a period of 3 days, as performed by Aguilera and Martin (2016); finally, the trays were placed in the protected environment on day 4, and the respective water treatments were applied.

At the end of the experiment, the speed of germination index, final emergence percentage, shoot fresh matter, and shoot dry matter were evaluated. The speed of the germination index was determined according to Maguire's methodology (1962) using Equation 1.

$$SGI = \frac{NE_i}{D_i} + \frac{NE_{i+1}}{D_{i+1}} + \ldots \quad (1)$$

where SGI represents speed of germination index; NEi , $NEi{+}1$ denotes the number of seedlings emerged on the first day of counting, number of seedlings emerged on the second day of counting, respectively; $Di, Di{+}1$ represents first cout day = 1, second count day = 2, respectively.

The value of the final emergence percentage (FEP) was calculated using Equation 2, which was proposed by Abendinpour and Rohani (2017):

$$FED = \left(\frac{Total\ number\ of\ seedlings\ emerged}{Total\ number\ of\ seeds\ planted}\right) \text{x } 100 \quad (2)$$

The shoot fresh matter was determined by cutting the seedlings at the stem on the last day of the experiment and weighing them on a semi-analytical balance with a precision of 0.001 g. Shoot dry matter was determined by oven-drying the shoot fresh matter in a forced-oven at 60 ºC until it reached a constant level. After drying, the samples were weighed using a semi-analytical weighing balance.

The experimental data were subjected to analysis of variance by Tukey's test at a significance level of 1%, 5%, and 10% using the Sisvar Software (Ferreira 2014).

The economic viability analysis was performed based on the calculation of the net present value, discounted payback, internal rate of return, equilibrium point, and profitability index according to the methodology used by Nascimento and Santos (2013), which considered the sales indicators, fixed costs, variable costs, and profitability presented by the rural producer. All the collected quotations considered real as the currency. During the experiment, the monthly average of the commercial exchange rate Real(R$)/Dollar(US$) ranged from 5.42 to 5.65, that is, US$ 1.0 purchase would range from R$ 5.42 to R$ 5.65 (IPEA 2021). Therefore the commercial exchange rate Real(R$)/Dollar(US$) considered was 5.54.

The economic viability analysis was performed for two scenarios for a period of five years: scenario 1) initial investment in the structure that produces seedlings with magnetizing device and their germination was considered with the effect of magnetically treated water; scenario 2) initial investment in the structure that produces seedlings without the acquisition of the magnetizing device and germination of seedlings was considered without the effect of magnetically treated water.

The net present value is an indicator to analyze the financial viability of investments, with the present value of all future receipts generated by the investment. Payback is the period between the initial investment and the time when the accumulated profit equals the value of the initial investment, with the return on investment. The internal rate of return makes the NPV zero. The equilibrium point shows the number of units to be produced to cover the costs, and the values of units produced above the equilibrium point represents a company's profit. The profitability index is the ratio of the sum of the net present value to the initial investment, representing the return on the value applied.

The initial investment value for the enterprise was R$ 30,000.00 for building the protected environment (12 m × 8 m), R$ 10,000.00 for installing a micro-sprinkler irrigation system, R$ 10,000.00 for buying plant benches, and R$ 5,000.00 for the magnetizing device, which was considered only in scenario 1.

The price charged per unit produced (seedling) is R$ 0.50, which is R$ 64.00 considering 128 viable seedlings. The rural producer sells approximately 150 trays per month, resulting in 230.400 seedlings per year, considering 100% germination. In year 0, we considered the production for a period of six months because of the time taken for building the protected environmental and its market establishment.

The variable production cost considering a 128-cell tray was R$ 2.50 for the acquisition of the tray (R$ 0.02 per seedling), R$ 2.00 for the commercial substrate (R$ 0.016 per seedling), and R$ 0.73 for the seeds (R$ 0.006 per seedling), which totaled to R$ 5.23 per tray (R$ 0.042 per seedling) and to R$ 9,414.00 per year.

The fixed cost for monthly production considered R$ 2,000.00 for one collaborator's salary, R$ 1,206.60 for wage charges, R$ 300.00 for electric energy, R$ 100.00 for system maintenance, and R$ 100.00 for general inputs, totaling to R$ 44,479.20 per year.

The rates considered for economic viability analysis were 6% for the minimum rate of return, 5% for the depreciation value of equipment and structure, and 15% for income tax.

Results and discussion

According to the analysis of variance, in experiment II, 53.97% increase in shoot dry matter was observed ($p < 0.05$) in seedlings receiving magnetically treated water, but no significant differences was observed for this variable in experiments I and III (Table 1). In experiment III, 29.77% increase in shoot fresh matter ($p < 0.10$) was observed when magnetically treated water was used. Álvaro *et al.* (2019) found that applying magnetically treated water increased shoot fresh matter and shoot dry matter by up to 88% and 88.2%, respectively.

The SGI increased by 14.61% ($p< 0.10$) when the water was magnetically treated (experiment I), whereas experiment III observed no significant difference for this variable. The SGI increased due to the acceleration of germination, requiring less cultivation time for seedling production, which increased production efficiency. Abedinpour and Rohani (2017) verified that maize seedlings that received magnetically treated water on an average germinated two days earlier than that of the control. The results presented by Lorenzoni *et al.* (2021) showed that applying magnetically treated water to bell pepper seeds promoted its germination one day prior to those irrigated without magnetic treatment.

Table 1 presents the significant differences in the final emergence percentage when the seedlings received magnetically treated water. The increase in germination was of the order of 32.19% and 19.28% for experiments II and III respectively, which indicated that although experiment I observed no significant difference, a higher mean value for these variables existed when the seedlings received magnetically treated water (Figure 1). Aguilera and Martin (2016) verified that the plants receiving magnetically treated water showed 97.5% germination at 12 days compared to 61.4% for those that received untreated water. These alterations may have occurred due to the magnetic treatment of water, which changes the physiochemical and biological properties of water, reduces soil pH, and increases membrane permeability (Aguilera and Martin 2016, Abedinpour and Rohani 2017).

According to the statistical unfolding, a significant increase in shoot dry matter of 13.54% and 64.47%, increased the germination index by 25.88% and 40.41%, which presented a final emergence percentage of 17.03% and 40.19% for experiments I and III , respectively, when magnetically treated water was applied to substrate 1 (Table 2). However, in experiment II, significant differences were observed in the magnetic treatment using substrate 2, with an increase of 83.57% in shoot dry matter and 53.50% in final emergence percentage. The variable shoot fresh matter significantly differed for substrate 1 in experiment III, with a 63.65% increase when the seedlings received magnetically treated water. Few authors have verified that cultivating seedlings with magnetically treated water can maintain a higher gravimetric moisture and a lower evaporation rate (Álvaro *et al.* 2019, Zolin Lorenzoni *et al.* 2021).

According to the statistical unfolding of variance in experiment I, substrate 1 surpassed

Table 1. Mean treatment values, F-value, coefficient of variation (C.V.), and general mean for the variables analyzed.

Variable	Mean treatment value				F-value	C.V. (%)	General mean
	Water		Substrate				
	A	M	S1	S2	Water × Substrate		
Experiment I							
Shoot dry matter (g)	17.90A	18.13 A ns	23.42 a	12.61 B***	Water/S1* Water/S2 ns Substrate/A*** Substrate/M***	12.26	18.02
Speed of germination index	11.15 a	12.78 B*	15.31 A	8.62 B***	Water/S1** Water/S2 ns Substrate/A*** Substrate/M***	14.76	11.97
Final emergence percentage (%)	59.27 A	63.28 a ns	74.60 A	47.94 B***	Water/S1** Water/S2 ns Substrate/A*** Substrate/M***	10.35	61.27
Experiment II							
Shoot dry matter (g)	9.82 A	15.12 B**	11.47 a	13.47 a ns	Water/S1 ns Water/S2** Substrate/A ns Substrate/M*	30.18	12.47
Final emergence percentage (%)	60.35 A	79.78 B**	65.62 A	74.51 a ns	Water/S1 ns Water/S2** Substrate/A ns Substrate/M ns	25.28	70.06
Experiment III							
Shoot fresh matter (g)	172.5 A	223.87 B*	185.87 A	210.5 A ns	Water/S1** Water/S2 ns Substrate/A ns Substrate/M ns	28.25	198.18
Shoot dry matter (g)	15.21 A	19.90 A ns	17.49 a	17.62 A ns	Water/S1* Water/S2 ns Substrate/A ns Substrate/M ns	34.33	17.56
Speed of germination index	12.83 A	15.38 a ns	14.04 a	14.17 a ns	Water/S1* Water/S2 ns Substrate/A ns Substrate/M ns	23.41	14.10
Final emergence percentage (%)	72.94 A	87.01 B*	77.63 A	82.32 A ns	Water/S1** Water/S2 ns Substrate/A ns Substrate/M ns	20.14	79.98

Different letters on the same line indicate significant differences by Tukey's test. **significant at 0.01 of probability, ** significant at 0.05 of probability, * significant at 0.10 of probability; ns - not significant ($p > 0.10$).

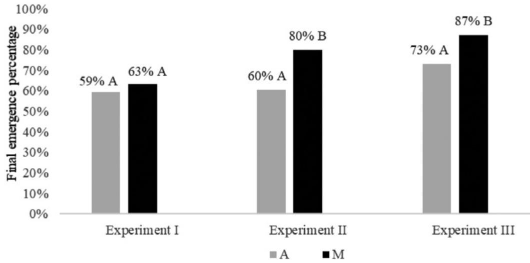

Figure 1. Final emergence percentage for tomato seeds receiving (M) magnetically-treated water and (A) untreated water for three cycles.

substrate 2 in terms of shoot dry matter, SGI, and final emergence percentage, regardless of the water treatment (Table 2). In experiment II, applying magnetically untreated water presented no significant differences in shoot dry matter and the final emergence percentage between the two substrates. However, substrate 2 presented an increase of 36.25% and 30.14% for shoot dry matter and final emergence percentage, respectively, when receiving magnetically treated water. Finally, in

Table 2. Mean values of the treatments, F-value, coefficient of variation, and general average for the analyzed variable.

Experiment	Variable	Statistic unfolding	A	M	S1	S2
I	Shoot dry matter (g)	Water/S1 *	21.93	24.9		
		Water/S2 ns	13.87	11.35		
		Substrate/A***			21.93	13.87
		Substrate/M***			24.9	11.35
	Speed of germination index	Water/S1**	13.56	17.07		
		Water/S2 ns	8.75	8.5		
		Substrate/A***			13.56	8.75
		Substrate/M***			17.07	8.5
	Final emergence percentage (%)	Water/S1**	68.75	80.46		
		Water/S2 ns	49.8	46.09		
		Substrate/A***			68.75	49.8
		Substrate/M***			80.46	46.09
II	Shoot dry matter (g)	Water/S1 ns	10.14	12.8		
		Water/S2 **	9.5	17.44		
		Substrate/A ns			10.14	9.5
		Substrate/M *			12.8	17.44
	Final emergence percentage (%)	Water/S1 ns	61.91	69.33		
		Water/S2 **	58.78	90.23		
		Substrate/A ns			61.91	58.78
		Substrate/M ns			69.33	90.23
III	Shoot fresh matter (g)	Water/S1 **	141	230.75		
		Water/S2 ns	204	217		
		Substrate/A ns			141	204
		Substrate/M ns			230.75	217
	Shoot dry matter (g)	Water/S1 *	13.23	21.76		
		Water/S2 ns	17.2	18.04		
		Substrate/A ns			13.23	17.2
		Substrate/M ns			21.76	18.04
	Speed of germination index	Water/S1 *	11.68	16.4		
		Water/S2 ns	13.98	14.36		
		Substrate/A ns			11.68	13.98
		Substrate/M ns			16.4	14.36
	Final emergence percentage (%)	Water/S1 **	64.64	90.62		
		Water/S2 ns	81.25	83.39		
		Substrate/A ns			64.64	81.25
		Substrate/M ns			90.62	83.39

*** significant at 0.01 of probability, ** significant at 0.05 of probability; * significant at 0.10 of probability, ns - not significant ($p > 0.10$), according to the Tukey test.

experiment III, no significant differences were observed between the substrates regardless of the water treatment. In a study performed with maize seedlings that received magnetically treated water, an increase of 25.9% was observed in shoot dry matter (Nikbakht *et al.* 2015). Abedinpour and Rohani (2017) verified that magnetic treatment of corn seedlings presented a 7.2% increase in fresh matter and 13.95% increase in dry matter, and increased the availability of nitrogen and phosphorus in water when compared to that of the control. According to the authors, the magnetic treatment of water affects N and P desorption from the P adsorbed in the soil, increasing its availability to plants, thereby facilitating higher growth.

According to Figure 2, in experiments I and III, germination efficiently occurred in trays that received magnetically treated water. This

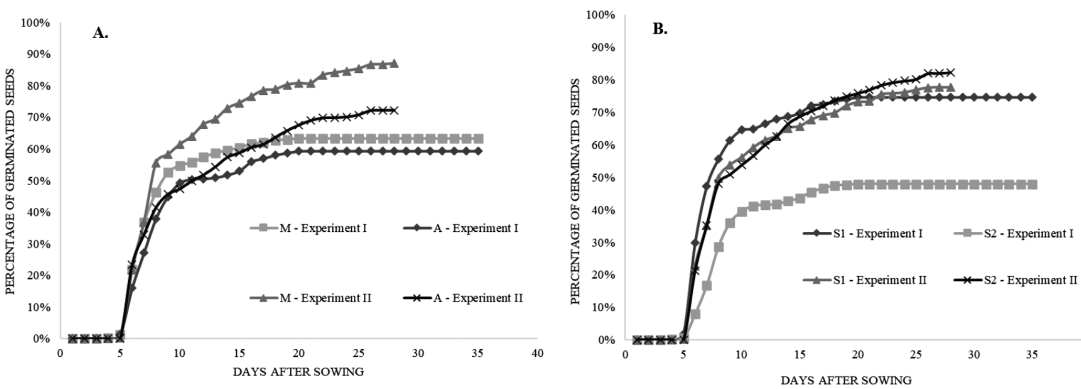

Figure 2. Percentage of germinated seeds of tomato for treatments receiving (M) magnetically-treated water and (A) untreated water for different substrates (S1 and S2).

result was also consistent with Abedinpour and Rohani (2017), who found that applying magnetically treated water to corn seedlings reduced germination duration. According to the authors, this may occur due to changes in ionic concentration and osmotic pressure that regulates water entering the seeds.

For the economic viability analysis, we considered the average between the values of final emergence percentage from experiments II and III, which was 83.4% germination (192,130 seedlings per year) for scenario 1 (magnetically treated water), and 66.6% germination (153,446 seedlings per year) for scenario 2 (magnetically untreated water).

From Table 3, investing in the business of tomato seedling production by acquiring the magnetizer is advantageous, because it reduces the discounted payback from 4.18 to 1.87 years. The net present value for scenarios 1 and 2 was above zero, indicating the viability of the business for both scenarios. The accumulated net present value of scenario 1 for 5 years is US$ 14,593.00, surpassing scenario 2 at US$ 1,814.00.

Both scenarios observed a negative balance of cash flow in the first year, but the invested amount was recovered in both scenarios. From the analysis, the point of equilibrium of scenario 1 and 2 was 98,623 and 101,400 seedlings, respectively, which indicates that the quantity of seedlings sold is sufficient to pay its costs. Based on these results, Scenario 1 is more advantageous, because with a smaller quantity of seedlings sold per year, the business can generate profit for the rural producer. This is also verified in the equilibrium revenue, which is lower for scenario 1 compared to that of scenario 2, that is, less money is required to pay the costs.

The internal rate of return obtained for the 5th year in both scenarios was higher than that of the attractiveness rate of 6%, which indicates the viability of both scenarios; however, scenario 1 is more advantageous when compared to scenario 2. The profitability index presents the proportion of gross revenue, that is, profit after covering the costs, which during the 5th year was 25.17% and 15.93% for scenarios 1 and 2, respectively, implying that for each US$ 100.00 real received from the company, US$ 25.17 and US$ 15.93 returns as profit for scenario 1 and 2, respectively, evidencing that the system of producing tomato seedlings can be profitable on small property.

Conclusions

Magnetic treatment of irrigation water proved to be an advantageous technique for the production of tomato seedlings, which can benefit growth variables such as shoot fresh matter, shoot dry matter, speed of germination index, and final emergence percentage. Magnetic water treatment did not adversely affect the growth of tomato seedlings.

The economic viability analysis showed that the acquisition of the magnetizer was viable for the tomato seedling production enterprise, reducing the discounted payback for the total business investment from 4.18 to 1.87 years and increasing the accumulated net present value of 5 years from US$ 1,814.00 to US$ 14,593.00.

Table 3. Cash flow from 0 to 5 years during tomato seedling production.

Item	Scenario 1 (with magnetizing device)						Scenario 2 (without magnetizing device)					
	Years											
	0	1	2	3	4	5	0	1	2	3	4	5
Total seedlings produced	17340	34680	34680	34680	34680	34680	13848	27697	27697	27697	27697	27697
Total received (US$*)	8670	17340	17340	17340	17340	17340	6924	13848	13848	13848	13848	13848
Fixed cost (US$*)	8028	8028	8028	8028	8028	8028	8028	8028	8028	8028	8028	8028
Variable cost (US$*)	849	1699	1699	1699	1699	1699	849	1699	1699	1699	1699	1699
Total cost (US$*)	8878	9727	9727	9727	9727	9727	8878	9727	9727	9727	9727	9727
EBITDA (US$*)	–208	7612	7612	7612	7612	7612	–1953	4120	4120	4120	4120	4120
Depreciation (US$*)	0	496	496	496	496	496	0	496	496	496	496	496
EBIT (US$*)	–208	7115	7115	7115	7115	7115	–1953	3669	3669	3669	3669	3669
Income tax(15%)real profit(US$*)	0	1036	1067	1067	1067	1067	0	257	550	550	550	550
Income tax (15%) presumed profit (8% of turn over) (US$*)		103	208	208	208	208		83	166	166	166	166
Investment (US$*)	9927						9025					
Cash flow with income tax (US$*)	–208	7011	6907	6907	6907	6907	–1953	3586	3503	3503	3503	3503
Net cash flow (US$*)	–10136	5975	5840	5840	5840	5840	–10979	3329	2953	2953	2953	2953
Cumulative cash flow (US$*)	–10136	–4160	1680	7520	13361	19201	–10979	–7650	–4696	–1743	1209	4162
Net present value (US$*)	–10136	5637	5198	4903	4626	4364	–10979	3140	2628	2479	2339	2206
Cumulative net present value (US$*)	–10136	–4498	699	5603	10229	14593	–10979	–7838	–5210	–2730	–391	1814
Payback (anos)	1.71						3.59					
Discounted payback (anos)	1.87						4.18					
Internal rate of return (%)		–41,0	10,9	34,0	45,0	50,6		–69,7	–30,8	–8,3	4,4	12,0
Profitability index (%)		32,51	29,98	28,28	26,68	25,17		22,68	18,98	17,90	16,89	15,93
Equilibrium point (seedling)	98623						101400					
Equilibrium revenue (US$*)	8901						9151					

*Commercial exchange rate Real(R$)/Dollar(US$) considered was 5.54 (IPEA 2021).

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