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Economic Analysis, Growth and Yield of Grafting Tomato Varieties for *Solanum torvum* as a Rootstock

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Abstract—Tomato (*Lycopersicon esculentum* Mill.) is potential vegetables to develop, because it has high economic value and has the potential to be exported. There is a decrease in tomato productivity due to unfavorable growth conditions such as bacterial wilt, fusarium wilt, high humidity, high temperature and inappropriate production technology. Grafting technology is one alternative technology. In addition to being able to control the disease in the soil, grafting is also able to increase the growth and yield of production. Besides, it is also necessary to know the economic benefits if using grafting technology. A promising eggplant rootstock for tomato grafting is *Solanum torvum*. *S. torvum* is selected as a rootstock with high compatibility. The purpose of this research is to know the effect of grafting several varieties of tomatoes with *Solanum torvum* as a rootstock. The experiment was conducted in Agricultural Extension Center Pare. Experimental Garden of Pare Kediri sub-district from July to early December 2016. The materials used were tomato Cervo varieties, Karina, Timoty, and *Solanum torvum*. Economic analysis, growth, and yield including plant height, number of leaves, percentage of disease and tomato production were used as performance measures. The study showed that grafting tomato Timoty scion with *Solanum torvum* as rootstock had higher production. Financially, grafting tomato Timoty and Cervo scion had higher profit about. 28,6% and 16,3% compared to Timoty and Cervo variety treatment without grafting.

Keywords—Grafting technology, economic analysis, growth, yield of tomato, *Solanum torvum.*

I. Introduction

TOMATO (*Lycopersicon esculentum* Mill.) is a vegetable plant that is classified into Solanaceae family. Tomato is one of the vegetables, which is important to be improved because it has high economic value. Grafting is a technique to improve tomato yield. Grafted plants are used extensively to manage soil disease problems, which are widely applied because it can increase the resistance to bacterial wilt, fusarium wilt, adverse temperature which is too high or too low, and increase the uptake of plant nutrients [1]. Implementation of grafting is usually done in one species or intraspecies between the scions and rootstock. Some tomato species or strains are used as commercially tomato rootstocks that are tolerant to adverse temperature and salinity, but none are resistant to excessive water conditions [2], [3]. Eggplant is one family with tomatoes and that is the rootstock which is potentially resistant to disease to be grafted with tomatoes as onions, which has more disease-resistant and stronger roots. *Solanum torvum* is one of the most promising eggplant species included to wild plant species originating from the western tropics and India, which tolerates tropical climatic pressures [4]. This species is used as a medicinal plant and food crop, but this species is limited studies, so it does not have a clear description method for testing the seeds [5]. *Solanum torvum* has a strong root system and able to thrive in soils containing nematode and pathogenic fungi. Therefore, *Solanum torvum* is desirable as the rootstock of *Solanaceae* species, such as tomatoes and eggplant [6]. Eggplant grafted on to S.*torvum* and S. *sisymbriifolium* had positive on plant growth, yield, and reducing *V. dahliae* disease, but there was no significant difference in fruit quality. *Solanum torvum* is more resistant compared to *Solanum sisymbriifolium* on Verticillium wilt disease [7]. *Solanum torvum* was reported resistant to Verticillium, bacterial wilt, root-knot nematode, and mycoplasma [8]. In Italy, *S. torvum* was found between 20-27% from 87-100% of eggplants, that showed different symptoms caused by *V. dahliae* Kleb [9]. Pathogens could infect plants simultaneously in some conditions. Some cases of root-knot nematodes were found in tomatoes, eggplants, cotton plants, and peppermint were not resistant to *Fusarium/Verticillium wilt disease* [10]. Soil conditions will significantly affect plant growth, yield and quality of the eggplant grafted on *Solanum torvum*. Soils infected with two pathogens, such as *Verticillium wilt* and root-knot nematode are having synergistic effects and sometimes simultaneously could infect the eggplants and other plants [11]. Thus, *Solanum torvum* proved to have very resistant roots to the soil borne diseases. The common problem with *Solanum torvum* is the uniformity and low germination rate, that makes the initial plant growth becomes slowly [12]. According to [4], The problem of using S. *torvum* as a rootstock is slow germination caused by seed dormancy.

Germination becomes a particular concern when using wild or exotic species as rootstocks. Some of *Solanum* species were having a slow germination process around 30 days to reach sprout with varying percentages ranging between 15% and 50% in *Solanum insanum* L, *Solanum torvum*, *Solanum integrifolium*, *Solanum surattense* Burm, *S. khasianum* CB Clarke, *S. Sanitwongsei* Craib and hybrids of *S. melongena* × *S. integrifolium* [13]. Therefore, the methods to create more regular and uniform germination is required to produce rootstock seedlings and synchronize the grafting between scions and rootstock. Besides the low rate of *S. torvum*germination, the cost of grafting is a major concern

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which makes this technology is difficult for farmers to accept [14], [15]. According to [16] the estimate cost of tomato grafting production is about 2.5-4.5 times higher than the control on research of the grafting plants production in United States.

Beside the cost of materials used, the cost of labor is swollen for the process of grafting between scions and rootstocks [17]. The feasibility of economic results was also found on grafting plants with infected nematodes that attack the roots [17].

Based on the research of [18] stated that tomato scions grafted onto eggplants as rootstocks show promising results for controlling some pathogens. However, there are still limited information about the effect of *Solanum torvum* as rootstock on plant growth, yield, and economic feasibility. Therefore, this study was conducted to determine the effect of several varieties of tomatoes grafted onto *Solanum torvum* as rootstock on the plant growth, yield and economic benefits.

II. Methodology

This study was conducted in BPP Pare Experimental Garden of Kediri Regency from July to early December 2016. The materials were used varieties of Cervo, Karina, Timoti and Takokak, cow manure, insecticides, fungicides, rubber band, razor blade, small polybags, ruler, analytical scale, digital camera, and stationery.

This experiment was established using randomized block design consisting of 6 treatments and 3 replications so there were 6 x 3 = 18 plots, each experimental plot comprising of 40 plants. Thus, the total grafted plant were 720 plants with plant spacing of 50 x 70 cm, bed width of 1 m, distance between beds were 50 cm, 10 plants per each line and 20 plants per each bed. The initial studies were performed by planting the Takokak as rootstocks earlier and ready to be grafted at 35 DAT, while the tomato scions varieties of Karina, Cervo and Timoty were ready at 15 DAT. Grafted plants were placed in grafting chamber for 10 days and moved into green house for 7 days for plant stability. Plant maintenance includes replanting, weeding, fertilization, and pest diseases control.

The parameters for initial observation were consist of percentage germination of takokak, while plant growth parameters include: plant height, leaf area, percentage of fusarium wilt attack, production (ton ha^{-1}) and analysis of farming business. According [19] the percentage of Fusarium wilt was calculated using the formula: P = a / b X 100%

Descriptions: P = Percentage of Fusarium-wilted plants, a = number of plants withered, b = number of plants observed. For the analysis of farming were using [20] Production costs include land lease, labor costs, and materials used.

A. Data Analysis

The data were recorded and subjected to one-way analysis of variance (ANOVA) at the significant level of 5%. If there was a significantly different, it will be continued by Least Significant Differences (LSD) test at the 0.05 probability to identify the difference between treatments [21]

III. Results and Discussion

Temperature is the most important factor that could affecting germination on the agroecosystem. Temperature has a dual role that affects dormancy and germination [22]. Some plant species have seeds that can grow easily in the regulation of light and temperature, in which there are some seed germination that sensitive to the light [23]. Alternative temperatures have a major impact on some processes to regulate seed germination abilities including membrane permeability, tissue activity, and cytosolic enzymes [24].

Table I shows that the fruit of *Solanum torvum* were determined by the oven drying method at 40^0 C for 6 days with percentage of successful seed germination of 99% higher than the other two treatments and 94% uniformity of seedlings. This is consistent with the research of [25], [26] stated that the seeds of seasonal crops, which exposed to high temperatures in summer could causing germination in the following seasons. Seeds of *Solanum torvum* dried under direct sunlight with fluctuations in high-temperature had resulted a low percentage of uniformity seedlings at rate of 50% and the factor in breaking dormancy make the percentage of successful seed germination was lower by 80%. Low germination rates are due to physicall dormancy, which is the inability of the seed coat to absorb water because of impermeable layers of the seeds , whereas chemical dormancy are due to the inhibitory in the pericarp that covering around the embryo by release pericarp layer, it will destroy its chemical dormancy [26]. *Solanum torvum* seeds were treated using oven drying temperature of 40^0 for 3 days on medium level had percentage of successful seed germination of 86% and the uniformity of seedlings rate of 78% slightly lower than *S. torvum* fruit treated in drying oven on temperature of 40^0 for 6 days because germination is influenced by moisture. Treatment of *S. torvum* on drying-oven including with the fruit skin and without fruit skin were having different effect on seed moisture. According [27], reported that germination is strongly influenced by environment such as quality and quantity of light, temperature, seed moisture, and availability of gases of CO_2 and O_2.

TABLE I
Percentage of Solanum Torvum Seed Germination and Uniformity of Seedling

Treatment	Percentage (%)	
	The Success of Germination	Germination Uniform of Level
Seeds of *Solanum torvum* treated directly under the sun for 7 days	80	50
Seeds of *Solanum torvum* treated with drying oven on temperature 40^0 C for 3 days	86	78
Solanum torvum with fruit skin treated in drying oven on temperature of 40^0 for 6 days	99	94

Table II shows the growth of tomato that grafted onto *Solanum torvum* rootstock when the plant was 2 WAT was shorter than control because the initial growth of grafting tomato obstructed by process of making the cleft on grafting treatment. The plant growth of control (non-grafted) at 4 WAT were still increasing than grafted plant. At 6 WAT, control (non-grafted) plants was growing higher than grafted tomato plants. Tomato of Cervo variety grafted onto *S. torvum* rootstock was 7% lower than control (Cervo non-grafted), Karina scion grafted onto *S. torvum* was 6% lower than control (Karina non-grafted), and Timoty growth was reduced by 2% compared to control (Timoty non-grafted). There was a high increase of grafted Cervo and Timoty varieties compared to control (non-grafted) at 8 WAT by 50% and 40%. This result is consistent with the research of [28], [29] indicated that the effect of grafting was significantly different, if the combination of scions with rootstocks were used different variety.

TABLE II
PLANT HEIGHT OF TOMATO (CM)

Treatment	Plant age (WAT)							
	2		4		6		8	
Control (Non-grafted)								
Cervo variety	41	bc	85.8	cd	107	b	112	b
Karina variety	40.95	bc	61.27	a	59.57	a	59.33	a
Timoty variety	44.78	c	86.78	d	108	b	114	b
Takokak Rootstock								
Cervo variety	31.23	a	73.43	bc	96.57	b	126	b
Karina variety	33.99	ab	55	a	61.77	a	62.5	a
Timoty variety	33.32	ab	71	b	103.63	b	109.17	b
LSD	7.75		13.09		19.94		22.47	
CV	16.05		14.1		17.34		17.97	

Descriptions: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, RS = Rootstock; LSD = Least Significant Difference; CV = Coefficient of Variance

Leaf area of grafted tomato plants were inhibited so that the growth of leaf area had a lower development stage at 30 days after transplanting (DAT) (Table III).

Tomato of Cervo variety grafted onto *S. torvum* rootstock were having higher leaf area 4% compared to control (Cervo non-grafted). Karina variety scion grafted onto *S. torvum* rootstock were higher 0.13% and Timoty variety grafted onto *S. torvum* were higher 19% compared to control (Timoty non-grafted). The leaf area of tomatoes control (non-grafted) at 90 DAT were lower compared to grafted tomatoes, in which the leaf area of Cervo variety was increased 49%, Timoty variety was increased 40%, while Karina variety was decreased 60%.

Reference [29] stated that leaf area of grafted plant was significantly influenced by soil which had high pathogen content, but there was no significant difference of leaf area between the grafted and non-grafted plants.

Table IV shows various varieties of tomatoes as scions were grafted onto *S. torvum* rootstock proved to have more resistance to fusarium wilt attacks than control (non-grafted). For tomato control of varieties, varieties of Cervo and Timoty non-grafted showed a significantly infected with bacteria and fungus. At 2 WAT, varieties of Cervo, Karina and Timoty were grafted onto *S. torvum* rootstock able to suppress fusarium wilt attack by 85%, 93% and 99% compared to control (non-grafted). Tomatoes varieties of Cervo and Timoty were grafted with *S. torvum* rootstock at 4 WAT could decreased fusarium wilt attack by 84% and 99%, when grafted plants at 6 WAT of Cervo and Timoty scions were grafted onto *S. torvum* rootstock able to suppress fusarium wilt attack of 98%, 95% and at 8 WAT could suppressed to 74%, 99% compared to controls (Cervo and Timoty non-grafted). Based on the research of [30] found that *S. torvum* was the most resistant to bacterial wilt, followed by *S. kasiasium*, while *S. surathense* and *S. xanthocarpum* were more susceptible to bacterial wilt. Interspecific tomato grafted plants have higher disease resistance than intraspecific or grafted with other species of tomato rootstocks [28], [31]. Tomato of Karina variety ranging from 4 to 8 WAT were not found fusarium wilt attack either grafting or control, which means Karina is a tomato variety that resistant to fusarium wilt but highly susceptible to viruses. Based on the research of [32] showed that the varieties of Karina had low-intensity plant disease and enhance brown spots disease resistance.

TABLE III
LEAF WIDE (CM^2)

Treatment	Plant age (WAT)					
	30		60		90	
Control (Non-grafted)						
Cervo variety	404.7	d	1196.7	b	776.3	c
Karina variety	215.7	c	732	a	431.3	b
Timoty variety	486.5	e	1209.3	bc	773.3	c
Takokak Rootstock						
Cervo variety	141	b	1247.3	bc	1164.2	d
Karina variety	79.7	a	733	a	168.7	a
Timoty variety	375	d	1440.3	c	1083.4	d
LSD	45.1		204.9		156.5	
CV	12.4		14.6		16.6	

Descriptions: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, RS = Rootstock; LSD = Least Significant Difference; CV = Coefficient of Variance

TABLE IV
WILD DISEASE (%)

Treatment	Plant age (WAT)							
	2		4		6		8	
Control (Non-grafted)								
Cervo variety	8.67	e	4.97	c	2.47	c	3.32	c
Karina variety	0.8	bc	0.05	a	0.05	a	0.05	a
Timoty variety	7.33	d	4.77	c	1.10	b	4.73	d
RS S.torvum								
Cervo variety	1.33	c	0.79	b	0.05	a	0.87	b
Karina variety	0.05	a	0.05	a	0.05	a	0.05	a
Timoty variety	0.05	a	0.05	a	0.05	a	0.05	a
LSD	0.62		0.52				0.35	
CV	15.79		22.57				18.05	

Descriptions: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, RS = Rootstock; LSD = Least Significant Difference; CV = Coefficient of Variance.

Table V shows data of yields tomatoes varieties of Cervo, Karina and Timoty grafted with *S. torvum* rootstock increased by 37%, 12% and 43% compared to controls (Cervo, Karina and Timoty non-grafted). Grafted tomatoes could increase the weight of fruit, diameter and fruit size compared to non-grafted plants [33]-[35]. Production of tomato conducted during the rainy season could make a high market price Rp. 3600. Thus, the consideration of total cost for tomatoes grafting still provide a fairly high profit.

TABLE V
YIELD (KG/PLOT)

Treatment	Yield	
Control (Non-grafted)		
Cervo variety	62.67	b
Karina variety	18.73	a
Timoty variety	61.33	b
Takokak Rootstock		
Cervo variety	85.67	c
Karina variety	21	a
Timoty variety	87.67	c
LSD	7.8	
CV	14,7	

Descriptions: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, RS = Rootstock; LSD = Least Significant Difference; CV = Coefficient of Variance.

Table VI shows the economic aspects of each treatment. Tomato varieties of Timoty was grafted onto *S. torvum* could produce the highest revenue and profit. In addition, it is also capable of producing the highest R-C ratio. Although the production cost incurred was higher than the control (tomato non-grafted). Based on Table VI shows an increase in the expenditure of tomato grafting seeds, in which the price varieties of Cervo, Karina and Timoty non-grafted were Rp. 300, Rp 275, and Rp.275, - and after being grafted with *S. Torvum* were Rp. 700, Rp.600 and Rp.650,- per plant, repectively. This data is in line with [36], the cost of tomato grafting increased by one-fold when compared with non-grafted in Morocco with market price U$ 0.38 and U$ 0.19 per plant. According to [16], found that the cost of tomatoes in Noth Carolina reached from 4 to 5 times higher compared with the cost of tomato non-grafted treatment. This is because the price of rootstock is quite high because it is derived from the rootstock breeding technology in United States, so reducing the price of rootstocks to reduce production costs are needed [15; 14]. The rootstock as grafting material have a high price and not affordable by farmers, thus it requires special cultivars [37]. Currently the number of commercial rootstocks offered by breeding companies are numerous and not only limited to the rootstock of *Solanum lycopersicum* L. species but also from interspecific hybrids such as *S. lycopersicum* x *Solanum habrochaites* S. Knapp & D.M. Spooner [37]. In this study, *S. torvum* is a wild species that is commonly found in the vacant fields, so that application of *S. torvum* rootstock can reduce production costs.

TABLE VI
FINANCIAL ASPECTS (PER 0,1 HA BASIS)

Description	Cost (Rp)					
	Control (Non-grafted)			Rootstock (*S. torvum*)		
	Cervo variety	Karina variety	Timoty variety	Cervo variety	Karina variety	Timoty variety
Total Cost	4755000	4455000	4705000	5555000	5355000	5455000
Revenue	8830800	1605600	8640000	10890000	1688400	11066400
Profit	4075800	-2849400	3935000	5335000	-3666600	5611400
R-C Ratio	1,86	0.36	1.84	1.96	0.31	2.03

The production cost of grafting varieties Cervo, Karina and Timoty onto *S. torvum* were higher by 17%; 20%; 16%, respectively compared to non-grafted. There was a slight increase in production costs but the profit of tomatoes of Timoty varieties grafted with *S. torvum* rootstock increased by 43% and Cervo varieties by 31%. Thus, grafting treatment using *S. torvum* which is a wild species may provide higher profit economically and higher advantage from its invention. According to [37], [38], stated that grafting could be important as soil-borne diseases control organically and provide economic benefits. Tomato variety of Karina was attacked by virus and a loss of Rp. 2,849,400 and the application of grafting treatment make the losses was increased due to higher production costs became Rp. 3,666,600, even though the revenue was a slightly increase by 5% compared to control (Karina non-grafted). Grafting treatment of the Timothy variety with *S. torvum* rootstock had the highest R-C ratio of 2.03 and Cervo variety grafted onto *S. torvum* rootstock had R-C ratio of 1.96. Tomato of Karina variety as control had R-C ratio of 0.36 indicates that from 100% production cost only 36% of revenue that can be earned and loss of 64%. While, Karina variety grafted onto *S. torvum* rootstock were having lower revenue obtained of 31% and loss of 69%.

IV. CONCLUSION

1. *Solanum torvum* is a wild plant species that is very resistant to soil-borne diseases. Low germination is a constraint for *S. torvum* growth. The results of this research found that treatment of *S. torvum* fruits on drying-oven at 40^o for 6 days resulted germination success of 99% and uniformity of seedlings 94% higher than *S. torvum* seeds on drying-oven at 40^o for 3 days at medium level had germination success of 86% and uniformityof seedlings 78%. In addition, the first treatment of *S. torvum* seed dried under the sun for 7 were having germination success of 80% and uniformity of seedlings of 50%.
2. Growth of height and leaf area at the beginning of plant

growth which is connected with *S.torvum* experiencing of obstacle because of the process of opening during grinding and healing and at the end of observation there is no significant difference between tomatoes being grafting or not.

TABLE VII.A
COMPONENT OF COST TREATMENT A, B, C

Description	A (Cervo non grafted)			B (Karina non grafted)			C (Timoty non grafted)		
	Volume	Value (Rp)	Total value (Rp)	Volume	Value (Rp)	Total value (Rp)	Volume	Value (Rp)	Total value (Rp)
Rental land	1000	500	500000	1000	500	500000	1000	500	500000
Land preparation	8	35000	280000	8	35000	280000	8	35000	280000
Herbisida	5	70000	350000	5	70000	350000	5	70000	350000
Organic fertilizer (zak)	10	23000	230000	10	23000	230000	10	23000	230000
Plastic mulch	20	22000	440000	20	22000	440000	20	22000	440000
Labor for mulching	5	35000	175000	5	35000	175000	5	35000	175000
Bamboo stick	2000	200	400000	2000	200	400000	2000	200	400000
Seedling for tomato grafting	0	0	0	0	0	0	0	0	0
Seedling tomato	2000	300	600000	2000	150	300000	2000	275	550000
Labor for planting	7	35000	245000	7	35000	245000	7	35000	245000
Phonska fertilizer	2	120000	240000	2	120000	240000	2	120000	240000
Labor for harvest	5	35000	175000	5	35000	175000	5	35000	175000
Benlox 50 WP 50 gram	0	24000	0	0	24000	0	0	24000	0
Pestisida Confidor 1 btl 60cc	3	45000	135000	3	45000	135000	3	45000	135000
Labor for spraying	3	35000	105000	3	35000	105000	3	35000	105000
Labor for weeding	10	35000	350000	10	35000	350000	10	35000	350000
Irrigation cost	10	25000	250000	10	25000	250000	10	25000	250000
Rope and labor	8	35000	280000	8	35000	280000	8	35000	280000
Total Cost	0	0	4755000	0	0	4455000	0		4705000
Production (KG)	2453	**3600**	8830800	446	**3600**	1605600	2400	**3600**	8640000
Price	6132.5	0	0	1115	0	0	6000	0	14400000
Profit	0	0	4075800	0	0	-2849400		0	3935000
R-C Ratio	0	0	1.857	0	0	0.360	0	0	1.836

TABLE VII.B
COMPONENT OF COST TREATMENT D, E, F

Description	D (Cervo with *S. torvum* as a rootstock)			E (Karina with *S. torvum as a rootstock)*			F (Timoty with *S. torvum* as a rootstock)		
	Volume	Value (Rp)	Total value (Rp)	Volume	Value (Rp)	Total value (Rp)	Volume	Value (Rp)	Total value (Rp)
Rental land	1000	500	500000	1000	500	500000	1000	500	500000
Land preparation	8	35000	280000	8	35000	280000	8	35000	280000
Herbisida	5	70000	350000	5	70000	350000	5	70000	350000
Organic fertilizer (zak)	10	23000	230000	10	23000	230000	10	23000	230000
Plastic mulch	20	22000	440000	20	22000	440000	20	22000	440000
Labor for mulching	5	35000	175000	5	35000	175000	5	35000	175000
Bamboo stick	2000	200	400000	2000	200	400000	2000	200	400000
Seedling for tomato grafting	0	700	1400000	2000	600	1200000	2000	650	1300000
Seedling tomato	2000	0	0	2000	0	0	2000	0	0
Labor for planting	7	35000	245000	7	35000	245000	7	35000	245000
Phonska fertilizer	2	120000	240000	2	120000	240000	2	120000	240000
Labor for harvest	5	35000	175000	5	35000	175000	5	35000	175000
Benlox 50 WP 50 gram	0	24000	0	0	24000	0	0	24000	0
Pestisida Confidor 1 btl 60cc	3	45000	135000	3	45000	135000	3	45000	135000
Labor for spraying	3	35000	105000	3	35000	105000	3	35000	105000
Labor for weeding	10	35000	350000	10	35000	350000	10	35000	350000
Irrigation cost	10	25000	250000	10	25000	250000	10	25000	250000
Rope and labor	8	35000	280000	8	35000	280000	8	35000	280000
Total Cost	0		5555000	0		5355000	0		5455000
Production (KG)	3025	**3600**	10890000	469	**3600**	1688400	3074	**3600**	11066400
Price	7562.5	0	18150000	1172.5	0	2814000	7685	0	18444000
Profit		0	5335000	0	0	-3666600	0	0	5611400
R-C Ratio	0	0	1.960	0	0	0.315	0	0	2.028

3. Tomato varieties grafting with rootstock *S.torvum* proved to have resistance to *fusarium wilt* attacks compared to control (without grafting). When plants of 2 WAT appear varieties Cervo, Karina and Timoty digrafting able to suppress fusarium wilt attack by 85%, 93% and 99. Similarly, when 4 WAT tomatoes Cervo and Timoty grafting suppress fusarium wilt of 84% and 99%, 6 WAT of 98%, 95% and at 8 WAT were pressed to 74%, 99% compared to control (Cervo and Timoty without grafting).
4. Tomato varieties of Timoty grafted onto *S. torvum* produced the highest revenue, profit and R-C ratio, although the production cost was higher than the control treatment. The high cost of grafting still provides enough profit, if this technology is applied at off season so thoat the selling price is high enough. This is not only increasing profit but also the use of grafting is able to control the diseases organically. To reduce the production cost of grafting in this study were using accessible and affrdable rootstocks such as *S. torvum,* which is a wild plant species found mostly in vacant lands or plantations.

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