sustainability

MDPI

Article

Grafting Technology with Locally Selected Eggplant Rootstocks for Improvement in Tomato Performance

Evy Latifah [1,*], Sri Satya Antarlina [2], Sugiono Sugiono [1], Wahyu Handayati [1] and Joko Mariyono [3,*]

[1] Research Center for Horticulture and Plantation, Research Organization for Agriculture and Food, National Research and Innovation Agency (BRIN), Cibinong Science Center, Jl. Raya Jakarta-Bogor, KM. 46, Cibinong, Bogor 16911, Indonesia
[2] Research Center for Food Technology and Processing, Research Organization for Agriculture and Food, National Research and Innovation Agency (BRIN), JL. Jogja-Wonosari, KM 31, 5, Kec. Playen, 174 WNO, Gading II, Gading, Kec. Playen, Kabupaten Gunung Kidul, Jakarta Pusat 5586, Indonesia
[3] Agribusiness Study Program, Department of Agriculture, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang 50275, Indonesia
* Correspondence: epilatip08@gmail.com (E.L.); jokomariyono@lecturer.undip.ac.id (J.M.)

Abstract: Grafting technology is one of the best alternatives to mitigate limiting factors to tomato production (*Solanum lycopersicum* L). The study aimed to assess grafting combinations of tomato scions and rootstocks of eggplant (*S. melongena* L.) varieties Gelatik, EG203 line, and Takokak (*S. torvum* Sw.). Tomato varieties Cervo, Karina, and Timoty were used as scions. The grafted Cervo and Timoty yielded 30% more than non-grafted plants. The results show that grafted tomatoes suppressed disease incidence by more than 20%. The suppression resulted in higher shelf-life capacity and total dissolved solids of more than 10%, red colour intensity (a+) of more than 16%, lycopene content, fruit hardness level of more than 20%, and reduced water content by more than 1%. Vitamin C content was not affected by grafting technology. There is the potential for economic performance in the market for producers and consumers. Grafting technology in tomatoes using eggplants as rootstock could reduce disease incidence and improve agronomic aspects, product quality, and nutrient contents. Different cultivars of scions and rootstock showed different responses. Grafting technology could be disseminated to farmers for economic advantages during the off-season.

Keywords: hybrid tomatoes; local rootstocks; *Solanum lycopersicum*; soil-borne wilt diseases; quantity and quality of fruits

check for updates

Citation: Latifah, E.; Antarlina, S.S.; Sugiono, S.; Handayati, W.; Mariyono, J. Grafting Technology with Locally Selected Eggplant Rootstocks for Improvement in Tomato Performance. *Sustainability* **2023**, *15*, 855. https://doi.org/10.3390/su15010855

Academic Editors: Georgios Koubouris and Ralf Kaldenhoff

Received: 30 July 2022
Accepted: 31 October 2022
Published: 3 January 2023

Copyright: © 2023 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Tomato is one of the most highly valued vegetables grown in the world. In Indonesia, tomatoes have become necessary because they are complementary in the daily diet to other vegetables [1,2]. Production of tomato year-round guarantees adequate supply to meet the demand. However, the production of tomatoes tends to be seasonal. In the wet season, tomato production decreases. In tropical areas, biotic and abiotic challenges can reduce tomatoes' plant growth and productivity. Tomato is one of the vegetables produced with application of many pesticides. Production of organic tomatoes will satisfy stakeholders that harmful synthetic chemicals have not been used [3,4].

Reduced tomato production during the wet season is due to crop failure caused by disease, high humidity, high temperature, and a lack of standard production technology. The problems can be addressed through plant breeding and appropriate management. Farmers commonly adopt chemical measures to address biotic challenges to production [5]. However, agrochemicals have lost effectiveness and led to environmental pollution and human health problems [6]. Environmental contamination from intensive vegetable farming, including tomatoes, is a concern in Asia [7,8].

The safest and most effective solution to overcome problems of disease and environmental pressure is integrated pest management (IPM), applicable to various vegetable crops, including tomatoes, and it can minimise use of pesticides. Grafting technology can be an IPM component [9]. Grafting technology does not produce new characteristics of crops, but it combines two desirable crop characteristics to obtain the advantage of good plant characteristics from two crops [10].

Tomato scions combined with eggplant develop well and produce an acceptable yield [11,12]. The World Vegetable Research Centre developed eggplant accessions EG195 and EG203, which are compatible with most tomato scions and are resistant to waterlogging, salinity, high and low temperature, nematodes, and bacterial and fusarium wilt [7]. Some eggplant genotypes are resistant to waterlogging [13] and can protect against limited soil moisture because eggplant roots absorb water more efficiently than tomatoes [12]. Using eggplant as the rootstock may overcome wilting and rotten roots under waterlogged conditions [14].

The appropriate rootstock determines tomato quality [15]. Use of grafting could improve fruit and nutritional quality [9]. The number of fruit, total soluble solids (TSS) content, and vitamin C increased in fruit harvested from grafted plants [16]. Other research indicated that grafting does not affect fruit quality [17,18].

Adoption of grafting using resistant rootstocks, such as eggplant or tomatoes from other varieties whose roots are resistant to challenges, is well known and will provide information about the efficiency and effectiveness of grafting technology to achieve high-quality yields of tomatoes [19]. Some researchers have examined various grafting techniques to increase the effect of temperature and humidity by using controlled environmental conditions [20,21]. However, grafting using local resources is still limited in warm, humid agroecosystems. The study aimed to determine suitable combinations of tomato scions and local eggplant rootstocks for grafting. The combination was expected to optimise the quality and quantity of tomato production in a warm and humid agroecosystem, where a high incidence of wilt caused by bacterial and fungal diseases and waterlogging occurs.

2. Materials and Methods

This study was conducted from July to December 2016 at the Agricultural Extension Centre Experimental Garden, Sub-district Pare, Kediri, East Java, Indonesia at an altitude of about 132 m, with the average temperature around 26 °C, rainfall in the first month (80 mm) increasing steadily in following months (102, 123, 279, and 280 mm/month) until the end of the study. Scions were Cervo, Karina, and Timoty. Eggplant rootstocks were Gelatik, line EG203, and Takokak (*Solanum torvum*). The Takokak rootstock was ready to be grafted onto at 35 days after transplanting (DAT), and eggplants Gelatik and EG203 were ready at 21 DAT. Scions of tomato varieties Karina, Cervo, and Timoty were ready to be grafted at 15 DAT.

This experiment, arranged in a randomised block design (RBD), consisted of 12 treatments. Treatment consists of:

Control (without grafting)

Cervo = scion of Cervo tomatoes variety without grafting
Karina = scion of Karina tomatoes variety without grafting
Timoty = scion of Timoty tomatoes variety without grafting

Gelatik varieties of eggplant as a rootstocks

Cervo–Gelatik = scion of the tomato variety of Cervo with Gelatik as a rootstock
Karina–Gelatik = scion of the tomato variety of Karina with Gelatik as a rootstock
Timoty–Gelatik= scion of the tomato variety of Timoty with Gelatik as a rootstock

Line of EG 203 of eggplant as a rootstock

Cervo–line of EG203 = scion of the tomato variety of Cervo with line of EG203 as a rootstock

Karina–line of EG203 = scion of the tomato variety of Karina with line of EG203 as a rootstock

Timoty–line of EG203 = scion of the tomato variety of Timoty with line of EG203 as a rootstock

Takokak of eggplant as a rootstock

Cervo–Takokak = scion of the tomato variety of Cervo with Takokak as a rootstock

Karina–Takokak = scion of the tomato variety of Karina with Takokak as a rootstock

Timoty–Takokak = scion of the tomato variety of Timoty with Takokak as a rootstock

This study used three replications, with 12 × 3 = 36 units. Each treatment consisted of 40 plants, with a total number of 1440 grafted plants. This study used factorial analysis with three factors: grafted vs. non-grafted plants, different varieties, and observation time.

The grafting process started with preparing the scions and rootstocks using planting media consisting of soil and compost with a ratio of 3:1. The rootstocks and scions were planted in polybags with a diameter of 6 cm. Each polybag contains two seeds. Seedlings can be grafted after 2–3 true leaves have grown, about 14–16 days after planting. Rootstocks were cut over the cotyledons at a 30° angle, and then the tomato stems were cut at a 30° angle above the cotyledons or the first genuine leaf. By holding the upper stem piece, put a rubber tube slice into the scions and then push the rootstocks in the opposite direction such that the scion and rootstock joined. This study adopted the technique of splicing rubber pipe joints [22]. This technique is considered practical, and there is no need to remove the rubber tube from the grafted plant as the plant grows in the field. After grafting, immediately put into a shaded grafting chamber with a temperature of 25–32 °C. The grafting chamber door is closed to maintain high humidity. After 4–5 days, grafting occurs, hardening the grafting stem and preventing the entry of insect attacks. Maintain this condition for 2–3 days. Put the grafted plants outside the grafting chamber and place them in the greenhouse. Nine days after grafting, the seedlings were given foliar fertiliser and placed in the greenhouse for 7–8 days for further development.

During the study, high temperature and humidity provided a micro-climate that created susceptibility of tomatoes to bacterial and fusarium wilts. Varieties of tomatoes grown in lowlands are more likely to undergo some constraints due to susceptibility to bacterial wilt disease in a warm, humid environment [23]. The percentage of bacterial wilt and fusarium wilt was observed every two weeks using the formula:

$$P = a/b \times 100\%$$

where

P = percentage of bacterial wilt/fusarium wilt

a = number of wilted plants

b = number of plants in the treatment plot.

Grafting success was determined by the total percentage of surviving plants, percentage of wilted plants, flowering stage, number of flowers, fruit set, harvest period, number of fruits per plant, the weight of fruits per plant, and yield. Tomato fruits were picked two months after transplanting at 3-day intervals. Fruit length, width, diameter, weight per seed, and fruit hardness were determined. Vitamin C was measured using iodine titration. Iodine is an oxidising agent that oxidises vitamin C and uses starch as an indicator [24]. Total dissolved solids were measured using a refractometer. Red colour intensity (a+), to measure the colour using a colour reader Conica Minolta CR-10 and lycopene content determined. Lycopene level was estimated using a spectrophotometer [25,26].

This study analysed data using analysis of variance (ANOVA) to test the significant difference among the treatments. If the ANOVA shows significance at the 5% level, the test proceeds with a post hoc test using the least significant difference (LSD) tested at the 5% level [27]. The data were analysed using DSAASTAT software (Version 1. 101).

3. Results and Discussion

3.1. Dynamics of Disease Incidence

Different varieties showed different levels of disease incidence, as shown by ANOVA (see Table A1). The un-grafted tomatoes were affected by wilt diseases starting two weeks after transplanting (Figure 1). The disease incidence increased until 12 weeks after transplanting. The wilt incidence of grafted tomatoes (undotted lines) was much lower than the counterparts (dotted lines) during the same period.

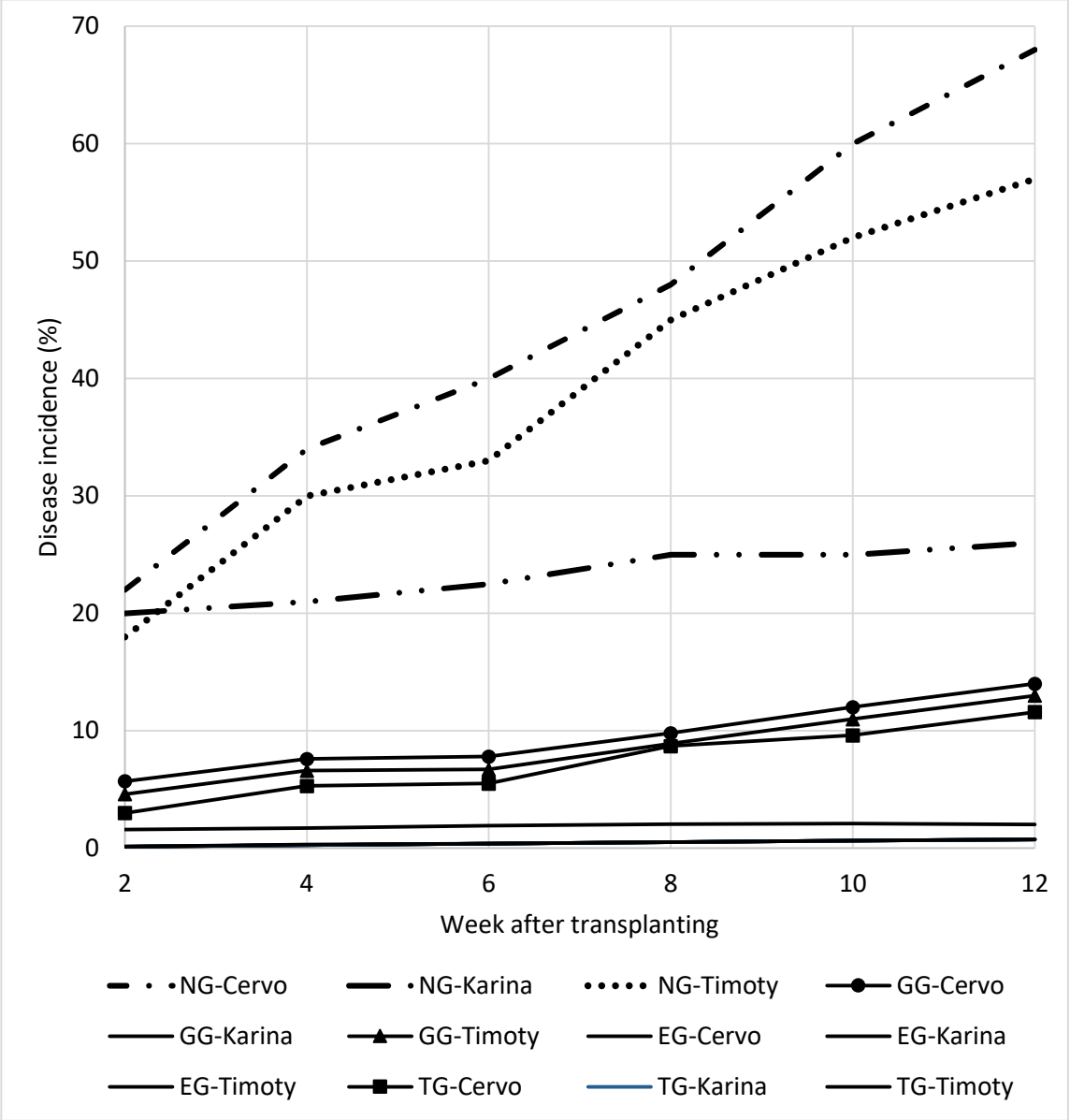

Figure 1. Dynamics of disease incidence of grafted and un-grafted tomato by treatments.

At the starting point of two weeks after transplanting, the un-grafted tomatoes suffered more highly from diseases than the grafted ones. For the case of un-grafted plants, the growth rate of disease incidence in the un-grafted Timoty and Karina was higher than in un-grafted Cervo, indicating that Timoty and Karina are more susceptible to soil-borne diseases than Cervo. The grafted tomatoes onto all the rootstocks showed a similar growth rate to un-grafted Cervo but were lower than un-grafted Timoty and Karina.

Grafted Cervo, Karina, and Timoty onto EG203 rootstock had higher resistance to wilt disease than the un-grafted, as did Karina and 'Tymoty' grafted onto Takokak rootstock.

The grafted plants using EG203 as a rootstock were resistant to *Pseudomonas* bacteria and *Bacillus* in the rhizosphere of about 105 cfug of dry soil weight [28]. This finding means that grafting technology works as expected, and this supports a study conducted in Taiwan that selected eggplant rootstocks suppress wilt disease incidence [29].

The disease incidence of Cervo grafted onto Takokak rootstock was low. When grafted with Gelatik rootstock, the incidence increased and decreased to deficient levels in Cervo with the EG203 line as a rootstock at 2 and 4 weeks after transplanting. Six weeks after transplanting, there was a difference between all the varieties of tomatoes grafted onto all the rootstocks compared to un-grafted Cervo and Timoty.

At 8, 10, and 12 weeks after transplanting either grafted or non-grafted, Karina almost wholly suppressed wilt disease. Un-grafted Karina exhibited resistance to wilt disease. Karina is resistant to wilt disease but susceptible to viruses for agronomic characteristics. Timoty grafted onto EG203 and Takokak rootstocks were not different from Cervo grafted onto the EG203 line, with almost total suppression of wilt disease. In contrast, Cervo grafted onto Gelatik and Takokak rootstock resulted in a slightly higher intensity of wilt disease and suppression of wilt disease from 8 to 10 weeks after transplanting. Timoty and Cervo grafted onto EG203 line rootstock almost completely suppressed wilt disease from 8–12 weeks after transplanting.

The differences in disease incidence by treatments indicate that soil-borne diseases play limiting factors in the study site. Laboratory tests showed that the soil contained the fungus *Fusarium* sp. and the bacterium *Ralstonia solanacearum*. Tested soil samples using the total plate count (TPC) method contained *Fusarium* sp. 3.4 × 106 Cfu/propagul·g^{-1} and *R. solanacearum* of 1.7 × 107 Cfu/propagul·g^{-1}. Fungal and bacterial populations were considered high. Fusarium wilt infection on more than 20% attacked susceptible varieties in the field due to a pathogenic propagule content range from 100 to 1200 CFU·g^{-1} of soil [30].

3.2. Generative Stages

Soil-borne diseases in the field significantly influenced plant development (see Table A2). At the flowering stage, un-grafted Cervo was significantly affected by wilt diseases, followed by un-grafted Timoty. Flowering was affected by treatment and variety. Timoty generally flowered more than others, especially non-grafted plants, because there is no inhibition to plant growth.

Table 1 shows that non-grafted Timoty flowered the most quickly and was not different from Timoty grafted onto Takokak rootstock or rootstocks of Gelatik. The longest time to the flowering stage was Karina grafted onto EG203 rootstock and Karina grafted onto Gelatik and Takokak rootstock. Karina scions had the most extended time flowering due to a virus attack that inhibits plant growth. The flowering period of Cervo grafted on EG203 rootstock was not different from un-grafted plants and not different from Cervo grafted on Gelatik and Takokak rootstock.

Timoty and Cervo grafted onto Gelatik and EG203 line had high flowering rates, which were not different from Timoty and Cervo onto Takokak. The number of flowers increased in Cervo and Timoty grafted onto Gelatik and the EG203 line. The number of flowers produced by plants grafted on eggplant rootstock is compatible because eggplant varieties have a strong root structure, which could improve plant hormone levels, causing an increase in photosynthesis [23,31].

Cervo scions grafted onto Gelatik or EG203 rootstock had a high fruit set, which was not different from Timoty grafted on Takokak rootstock. Cervo grafted onto Takokak was not different from Timoty grafted on Gelatik and the EG203 line. Cervo showed an improved fruit set if grafted on Gelatik, EG203, and Takokak rootstocks.

Table 1. Flowering period, number of flowers, and average fruit set. Tomato scions grafted onto eggplant rootstocks.

Treatment	[b] Flowering Period (DAT)		[b] Number of Flowers		[b] Fruit Set (%)	
Control (non-grafted)						
Cervo variety	27.00	bc	126.67	a	60.33	cd
Karina variety	29.00	cde	87.33	ab	38.33	a
Timoty variety	23.67	a	114.7	a–d	61.67	d
[a] RS Gelatik eggplant (grafted)						
Scion Cervo variety	28.67	cd	156	ef	85.33	i
Scion Karina variety	30.67	e	115	a–d	58.67	c
Scion Timoty variety	27.00	bc	150	def	75.33	f
[a] RS EG203 line (grafted)						
Scion Cervo variety	27.33	bc	161.7	f	86.33	i
Scion Karina variety	33.33	f	83	a	43.00	b
Scion Timoty variety	27.33	bc	173	f	73.33	e
[a] RS Takokak (grafted)						
Scion Cervo variety	28.33	c	124.3	c–e	79.00	g
Scion Karina variety	30.33	cde	92.3	a–c	41.67	b
Scion Timoty variety	26.00	b	123	b–e	83.33	h
LSD 5%	1.6		16.3		1.81	
CV	6.7		15.0		3.3	

[a] RS = rootstock; [b] values in the column followed by the same letter are not significantly different; LSD test at 5%.

3.3. Production of Tomatoes

The results of ANOVA show significant differences in production aspects (see Table A2). There was a significant difference in the first harvest time. Table 2 shows the differences in the first harvest, the number of fruits per plant, fruit weight per plant, and the yield of tomatoes with various varieties and treatments. The first harvest for Cervo, Karina, and Timoty grafted onto Gelatik rootstock was short. Cervo, Karina, and Timoty grafted onto Takokak rootstock were longer than un-grafted plants. Rapid harvest of the non-grafted Timoty and Cervo was not different from Timoty grafted onto Takokak. This phenomenon is possible because Takokak rootstock is compatible with Timoty scion, allowing the plants to grow faster than other combinations. Non-grafted Karina had a more extended harvest period, which was not different from Karina and Cervo grafted onto Gelatik, EG203 line, and Takokak rootstock, and Timoty grafted on Gelatik and Cervo rootstocks.

Grafted Cervo, Karina, and Timoty onto Gelatik or EG203 rootstock increased the number of fruits. Cervo and Timoty scions grafted onto Gelatik or Takokak rootstock increased the number of fruits. Cervo, Karina, and Timoty grafted onto EG203 also increased the number of fruits. Cervo and Timoty grafted onto Takokak increased the weight of fruit per plant.

The yield of Cervo grafted onto EG203 rootstock was higher than for Cervo grafted onto Gelatik and Takokak rootstock. Timoty grafted onto Gelatik, EG203, and Takokak had a good yield. Karina grafted onto Gelatik, EG203, and Takokak had a yield that was not different from un-grafted plants. In general, the yield of tomatoes increased when grafting technology using eggplant was applied. There was increasing crop yield with tomato grafted to 'Beaufort' eggplant rootstock [32]. Rootstock selection with high resistance and compatibility in grafting increases crop yield [33]. The higher yield of fruit from grafted tomato plants was most likely an effect of the robust root system of the rootstock and also due to enhanced water and mineral uptake [34,35]. Grafted plants can improve the quality of growth and yield, extend the harvest, and increase the efficiency of water use and nutrition [31,36]. The yield of Karina grafted onto Gelatik, EG203, and Takokak was not different from un-grafted Karina, which is resistant to bacterial wilt but not to viruses. This study supports this finding.

Table 2. Production aspects of tomatoes grafted onto eggplant rootstocks.

Treatment	[b] First Harvest (DAT)		[b] Number of Fruits/Plant		[b] Weight of Fruit (kg/Plant)		[b] Yield ($t \cdot ha^{-1}$)	
Control (non-grafted)								
Cervo variety	59	b	76.4	bc	3.833	b	24.53	b
Karina variety	56	b	33.7	a	0.901	a	4.46	a
Timoty variety	51	a	70.9	bc	3.389	b	22.13	b
[a] RS Gelatik eggplant (grafted)								
Scion Cervo variety	60	c	133.8	e	5.913	c	34.27	de
Scion Karina variety	65	d	67.8	bc	1.042	a	4.51	a
Scion Timoty variety	60	c	113.3	de	5.654	c	29.47	c
[a] RS EG203 line (grafted)								
Scion Cervo variety	66	d	140.0	e	6.106	c	35.50	e
Scion Karina variety	66	d	36.0	a	1.153	a	4.57	a
Scion Timoty variety	60	c	127.3	e	5.472	c	30.12	c
[a] RS Takokak (grafted)								
Scion Cervo variety	64	d	98.7	cd	5.540	c	30.25	cd
Scion Karina variety	64	d	38.7	a	0.879	a	4.69	a
Scion Timoty variety	59	b	102.6	d	5.671	c	30.74	cd
LSD 5%	3.1		11.74		0.651		3.80	
CV	6.1		16.01		20		11.0	

[a] RS = rootstock; [b] values in columns followed by the same letter are not significantly different; LSD test at 5%.

3.4. Fruit Characteristics

Treatment affected fruit shape and size (see Table A3). Cervo is oval, and the size is more extensive than Timoty and Karina. Table 3 shows the fruit characteristics of tomatoes with different varieties and treatments. The fruit length of Cervo, Karina, and Timoty grafted on Gelatik differed from un-grafted plants. The fruit size and higher yields on grafted plants are likely due to their resistance to soil-borne diseases, robust root systems, and increased photosynthesis [37]. The yields were higher than un-grafted plants because the grafted plants have larger fruit sizes and a higher number of fruits per plant [38]. Cervo, Karina, and Timoty grafted onto Gelatik increased fruit diameter, and so did those grafted onto EG203 and Takokak rootstocks. As fruit diameter increases, fruit tends to be more rounded. Fruit shape becomes a determinant of quality in the selection of tomatoes [39]. Tomato fruit varies in size, shape, colour, hardness, taste, and content of solid ingredients. Physical characteristics affect the prevailing price. Oval and hard fruits are famous, making them easy to market [40]. In another study, grafting technology using selected eggplant rootstock improved the morphological characteristics of tomato fruits [41].

There was an increase in the fruit weight of Cervo and Karina grafted onto Takokak compared to un-grafted Cervo, Karina, and Timoty. The study found no difference among treatments against the control since weight loss measures tomato quality. Tomato fruit has a high water content, which determines its freshness and durability. The longer the tomatoes are stored, the lower the weight because water loss during storage reduces the freshness and durability of the fruit. Refs. [42,43] showed that tomatoes after harvest still respire, causing weight loss [44].

Varieties of scions affect size, yield, and quality, and the rootstock can affect characteristics. Different production environments, combinations of scions and rootstock, and harvest periods can affect responses [17]. Rootstock affects fruit shape, skin colour, texture, smoothness, and dissolved solid content [45].

Table 3. Tomato shape and size grafted onto eggplant rootstocks.

Treatment	[b] Fruit Length (cm)		[b] Fruit Width (cm)		[b] Fruit Weight (g)	
Control (non-grafted)						
Cervo variety	5.0	e	3.99	d	68.80	d
Karina variety	2.2	a	2.81	a	20.07	a
Timoty variety	3.9	c	2.90	a	53.33	c
[a] RS Gelatik eggplant (grafted)						
Cervo variety	4.5	d	4.29	e	69.30	d
Karina variety	2.3	a	2.81	a	21.33	a
Timoty variety	4.03	c	3.85	c	54.10	c
[a] RS EG203 line (grafted)						
Cervo variety	5.3	f	4.25	e	72.40	d
Karina variety	2.2	a	2.90	a	22.60	ab
Timoty variety	4.0	c	4.10	d	53.67	c
[a] RS Takokak (grafted)						
Cervo variety	5.4	f	4.80	f	78.83	e
Karina variety	2.7	b	3.20	b	27.33	b
Timoty variety	4.0	c	4.10	d	51.50	c
LSD 5%	0.2		0.11		4.80	
CV	8.1		3.36		5.60	

[a] RS = rootstock; [b] values in the column followed by the same letter are not significantly different; LSD test at 5%.

3.5. Fruit Contents

The nutrient contents of tomatoes were significantly different when the treatments and varieties were different (see Table A4). Table 4 indicates the level of differences in the contents of tomatoes. Brix content, fruit hardness, and lycopene content in other crops could increase due to grafting treatment [15]. Fruit quality (Brix, fruit hardness, fruit thickness, and fruit shape) was influenced by grafting [46], as was the case in this work. Grafting technology can be used to improve fruit quality [47]. Fruit from grafting plants could produce better quality than non-grafted depending on the type of rootstock [48]. Grafting, as a substitute for soil fumigation in control of pests and diseases, did not affect the concentration of dissolved solids of grafted and un-grafted plants [49].

The vitamin C contents of various treatments were not different. The vitamin C content decreased in tomato fruit of plants grafted onto 'Beaufort F1′ and 'Maxifort F1′ rootstocks compared to un-grafted plants [50,51].

Total dissolved solids is a chemical change that affects sweetness. The fruits contained most total solids in the form of sugar. Cervo grafted onto Gelatik had TDS values higher than un-grafted Cervo. When Timoty was grafted on Gelatik rootstock, there was no change in TDS. Compared to the control, Cervo scions grafted on the EG203 line increased TDS, but Timoty grafted on EG203 decreased TDS. Grafted Cervo and Timoty on Takokak could increase TDS. Grafted Karina had a TDS level similar to un-grafted.

Fruit texture softened during storage. Fruit hardness is an essential indicator in determining the maturity of tomatoes. Fruits that begin the maturation process tend to have fruit hardness softer than before the maturation process. Grafting Cervo, Karina, and Timoty onto Gelatik increased the fruit hardness levels; Gelatik has the highest fruit hardness [52]. Varieties of tomatoes grafted onto Gelatik also had high fruit hardness. This is because of no genetic exchange. It uses the rootstock as Gelatik and Takokak have roots that absorb nutrients and are robust, so the fruit of tomatoes becomes hard.

Grafting Cervo, Karina, and Timoty onto EG203 and Takokak increased the fruit hardness. Fruit hardness is related to water content. If tomato fruit has a high fruit hardness level, it indicates low water content; if there is high water content, the fruit will have a low hardness level. Consumers prefer a tomato with a high fruit hardness level and moderate water content [53]. The water content of fruit decreased when EG203 was used as a rootstock. The water contents of Cervo, Karina, and Timoty grafted on Takokak

decreased. A more mature fruit will increase in water content, total dissolved solids, red colour intensity, and fruit aroma and texture, but vitamin C content, total acid, and fruit hardness level will decrease [54].

Table 4. Nutrient contents of tomato fruit grafted onto eggplant rootstocks.

Treatment	[b] Vit C Content (%)		[b] TDS (Brix)		[b] Fruit Hardness ($mm \cdot g^{-1} \cdot s^{-1}$)		[b] Water Content (%)		[b] Red Colour Intensity						[b] Lycopene Content (%)	
									L		a^+		b^+			
Control (Non-grafted)																
Cervo variety	0.23	ab	3	b	30.33	a	96.7	d	44.0	e	30.5	b	27.8	h	0.18	ab
Karina variety	0.27	a	5	e	31.67	ab	95.5	c	38.7	ab	31.6	bc	19.3	b	0.17	a
Timoty variety	0.53	a	3	b	31.67	ab	95.8	c	39.7	b	37.1	g	22.7	de	0.31	i
[a] RS Gelatik eggplant (grafted)																
Cervo variety	0.22	a	4.5	d	36.00	cde	93.8	a	39.3	ab	35.6	g	20.9	c	0.27	g
Karina variety	0.31	a	5	e	33.63	bc	94.6	b	38.5	a	28.1	a	16.6	a	0.21	de
Timoty variety	0.93	a	3	b	38.20	e	93.9	a	41.6	d	36.0	fg	23.2	de	0.24	f
[a] RS EG203 line (grafted)																
Cervo variety	0.25	a	3.3	c	37.07	de	94.3	b	41.7	d	34	ef	24.4	f	0.44	k
Karina variety	0.78	a	5	e	34.33	b-d	94.0	a	47.8	f	28.1	a	34.1	i	0.42	j
Timoty variety	0.65	a	2.8	a	32.60	ab	95.7	c	40.7	c	33.7	de	22.5	d	0.28	h
[a] RS Takokak (grafted)																
Cervo variety	0.16	a	5	e	38.57	e	94.1	b	41.7	d	33.2	cd	23.7	ef	0.2	cd
Karina variety	0.25	a	5	e	38.47	e	94.3	b	43.5	e	26.6	a	25.8	g	0.19	bc
Timoty variety	0.37	a	5	e	32.83	ab	95.6	c	41.4	cd	34.4	ef	24.4	f	0.22	e
LSD 5%	2.15		0.1		2.8		0.68		0.89		1.71		1.1		0.01	
CV	6.17		4.0		9.7		0.85		2.6		6.33		5.3		2.7	

[a] RS = rootstock; [b] values in columns followed by the same letter are not significantly different; LSD test at 5%.

The colour parameters include brightness (L), red and green colour intensity (a+), and yellow and blue colour intensity (b+). Higher L values result in a brighter or almost white colour, while higher a+ indicates red colour, and lower greenness and higher b+ indicate more yellow colour than blue. The longer the storage time, the smaller the value of L and b+. Grafting Cervo and Karina onto Gelatik caused darker fruit than the control or Cervo grafted onto the EG203 line and Takokak. Karina and Timoty grafted onto EG203 and Takokak rootstocks had higher brightness than Karina onto the same rootstocks. Freshness level is closely related to water content, which affects brightness. This finding is consistent with another study [55]. If the L value is >50, tomatoes are classified as bright; <50 tomatoes are classified as dull [56].

Cervo grafted with Gelatik, EG203 line, and Takokak tended to have a redder colour intensity (a+) than non-grafted Cervo. Karina and Timoty grafted on Gelatik, EG203, and Takokak had fruit with a tendency toward green colour compared to un-grafted Karina and Timoty. They had more yellowness than their counterparts. Lycopene is a bright red carotenoid pigment with antioxidant properties in tomatoes [43,57]. Likewise, Cervo and Karina grafted on Gelatik rootstock increased lycopene content. Cervo and Karina grafted on EG203 rootstock increased lycopene content. Cervo and Karina grafted on Takokak

rootstock had decreased lycopene content compared to un-grafted plants. The lycopene content in Timoty grafted onto Gelatik, EG203, and Takokak decreased. The findings support evidence that lycopene content was affected by genotype but not by the growing environment [58] and the grafting technology [59].

Grafting Cervo and Timoty onto EG203 was not different from Gelatik and Takokak in terms of disease incidence since rootstocks of Gelatik, EG 203, and Takokak are more resistant to disease. Grafting Gelatik on Takokak and EG203 suppressed plant disease compared to un-grafted plants. The EG203 line as a rootstock produced higher resistance to wilt disease than the control. Gelatik and Takokak rootstocks suppressed diseases compared to controls. Gelatik and Takokak were moderately resistant to wilt. Using Gelatik, Takokak, and EG203 as rootstocks with scions of Cervo produced higher quality because of increased fruit hardness, reduced water content, TDS, red colour intensity, and lycopene content. The EG203 line has limited availability, but it could be substituted with Gelatik and Takokak local and wild eggplants. Grafting technology applied in tomatoes using local eggplants as rootstocks improved crop performance in terms of reduction in disease incidence, agronomic aspects, quality and quantity of product, and nutrient contents. The agronomic performance simultaneously provides a potential for economic performance. During the rainy season, the prices of tomatoes and other vegetables are high because the off-season for vegetables is in the wet season when the incidences of diseases are high. Grafting technology can provide a plausible alternative for farmers to generate high profits during the off-season because the technology potentially reduces the incidences of soil-borne diseases of tomatoes.

4. Conclusions

Tomato is one of the highly valued vegetables in Indonesia. Production in tropical areas faces severe limiting factors from biotic and abiotic stresses. Grafting technology using local eggplants as a rootstock can potentially mitigate the stresses. Two local types of eggplants were compared to a recommended line of eggplant imported from The World Vegetable Center—Taiwan. Three high-yielding hybrid varieties of tomatoes were used as the scion. Tested in the field where wilt diseases and water logging problems persist, grafting technology worked as expected. The wilt disease incidence in grafted tomatoes was significantly lower than in un-grafted ones. Due to grafting technology, the healthy plants of tomatoes agronomically performed much better and produced fruits higher in terms of quality and quantity. This condition leads to economic advantages during the wet season, which is off-season for most vegetables. Farmers can potentially gain more return when they grow tomatoes using grafting technology during the off-season. It is recommended that the selected local rootstocks can substitute for imported ones. Other local potential rootstocks need to be tested to provide more alternatives.

Author Contributions: Conceptualisation, E.L. and J.M.; data curation, E.L., J.M. and S.S.A.; formal analysis, J.M. and E.L.; funding acquisition, E.L., W.H. and S.S.; investigation, J.M., S.S. and S.S.A.; methodology, E.L., J.M., W.H., S.S.A. and S.S.; project administration, E.L., W.H. and S.S.; resources, J.M. and S.S.A.; supervision, J.M. and S.S.A.; validation, S.S.; visualisation, J.M. and S.S.; writing—original draft, E.L. and J.M.; writing—review and editing, E.L., S.S. and J.M. All authors have read and agreed to the published version of the manuscript.

Funding: The field trials were conducted on infrastructure supported by a project from the Indonesian Ministry of Agriculture, financial support Number: 117.1/Kpts/KP.320/H.1/4/2017.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data presented in this study are available on request from the authors.

Acknowledgments: The project was financed by the Indonesian Ministry of Agriculture; the authors also thank Eko Widaryanto, Dawam Maghfoer, and Ariffin of Brawijaya University, who assisted provide feedbacks and constructive suggestions to this article. All interpretations and shortcomings are the responsibility of the authors.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Results of analysis of variance related to disease incidences.

Source	Sum of Square	df	Mean Square	F	$p > F$
Model	77,831.555 [a]	72	1,080.994	431.469	0.000
Grafted	28,289.112	3	9,429.704	3,763.783	0.000
Variety	8,124.325	2	4,062.163	1,621.376	0.000
Grafted × Variety	12,819.812	6	2,136.635	852.819	0.000
Grafted × Time	3,185.523	15	212.368	84.765	0.000
Variety × Time	1,049.399	10	104.940	41.886	0.000
Grafted × Variety × Time	1,657.151	30	55.238	22.048	0.000
Error	360.775	144	2.505		
Total	78,192.330	216			

Note: the variable weeks after transplanting (T) is to be considered along with variety (V), and it is to be determined if the main effects or the T by V interaction controls the results. [a] R Squared = 0.995 (adjusted R squared = 0.993).

Table A2. Results of analysis of variance related to flowering and fruiting stages.

Source	Sum of Squares	df	Mean Square	F	$p > F$
Flowering age (DAT)					
Replication	21.0555556	2	10.52777778	4.606629834	
Varieties	202.8888889	11	18.44444444	8.070718232	1.9×10^{-5}
Error	50.2777778	22	2.28535354		
Total	274.2222222	35	7.83492064		
Number of Flower (Flower/plant)					
Replication	3,712.38889	2	1,856.194444	4.99122693	
Varieties	29,080.88889	11	2,643.717172	7.10884164	5.2×10^{-5}
Error	8,181.61111	22	371.891414		
Total	40,974.88889	35	1,170.711111		
Number Fruit Set (%)					
Replication	1.722222222	2	0.861111111	0.187671987	
Varieties	10,158.30556	11	923.4823232	201.2652724	2.0×10^{-19}
Error	100.9444444	22	4.588383838		
Total	10,260.97222	35	293.1706349		

Table A3. Results of analysis of variance related to yield aspects.

Source	Sum of Squares	df	Mean Square	F	$p > F$
Time to early age (DAT)					
Replication	40.05555556	2	20.02777778	1.636269858	
Varieties	636.2222222	11	57.83838384	4.725397153	0.000962
Error	269.2777778	22	12.23989899		
Total	945.5555556	35	27.01587302		

Table A3. *Cont.*

Source	Sum of Squares	df	Mean Square	F	$p > F$
Number of fruit/plant					
Replication	1497.625817	2	748.8129083	3.894014193	
Varieties	48612.3982	11	4419.308927	22.98151046	1.5×10^{-9}
Error	4230.565983	22	192.2984538		
Total	54340.59	35	1552.588286		
Weight of fruit (g/plant)					
Replication	7513428.222	2	3756714.111	6.3483301	
Varieties	162789261.2	11	14799023.75	25.00831448	6.7×10^{-10}
Error	13018811.11	22	591764.1414		
Total	183321500.6	35	5237757.159		
Yield ($t \cdot ha^{-1}$)					
Replication	29.20621667	2	14.60310833	2.793267704	
Varieties	5526.696408	11	502.4269462	96.10371509	5.8×10^{-16}
Error	115.01525	22	5.227965909		
Total	5670.917875	35	162.026225		

Table A4. Results of analysis of variance related to shape and size of fruit.

Source	Sum of Squares	df	Mean Square	F	$p > F$
Length of fruit (cm)					
Replication	46.87262222	11	4.261147475	45.51857117	
Varieties	1.152438889	2	0.576219444	6.1553105	0.00753243
Error	2.059494444	22	0.093613384		
Total	50.08455556	35	1.430987302		
Diameter of fruit (cm)					
Replication	14.89008889	11	1.353644444	81.7849656	
Varieties	0.320205556	2	0.160102778	9.673145874	0.000967937
Error	0.364127778	22	0.016551263		
Total	15.57442222	35	0.444983492		
Weight of fruit (g)					
Replication	2.451805556	2	1.225902778	0.158506513	
Varieties	15242.14576	11	1385.649615	179.1614247	7.1×10^{-19}
Error	170.1498611	22	7.734084596		
Total	15414.74743	35	440.4213552		

Table A5. Results of analysis of variance related to nutrient contents.

Source	Sum of Squares	df	Mean Square	F	$p > F$
Vitamin C content					
Replication	0.000682722	2	0.000341361	0.208282038	
Varieties	2.046082536	11	0.186007503	113.4927811	9.7×10^{-17}
Error	0.036056611	22	0.001638937		
Total	2.08282187	35	0.059509196		
TSS (Brix)					
Replication	0.166666667	2	0.083333333	3.14285714	
Varieties	33.5625	11	3.051136364	115.071429	8.4×10^{-17}
Error	0.583333333	22	0.026515152		
Total	34.3125	35	0.980357143		

Table A5. *Cont.*

Source	Sum of Squares	df	Mean Square	F	$p > F$
Hardness					
Replication	4.270555556	2	2.135277778	0.189933355	
Varieties	285.6830556	11	25.97118687	2.310141894	0.045541
Error	247.3294444	22	11.24224747		
Total	537.2830556	35	15.35094444		
Water content					
Replication	2.246666667	2	1.123333333	1.816266536	
Varieties	28.00666667	11	2.546060606	4.116609505	0.002307
Error	13.60666667	22	0.618484848		
Total	43.86	35	1.253142857		
Colour intensity (L)					
Replication	3.401666667	2	1.700833333	1.514197073	
Varieties	228.5941667	11	20.78128788	18.5009105	1.2×10^{-8}
Error	24.71166667	22	1.123257576		
Total	256.7075	35	7.3345		
Colour intensity (a^+)					
Replication	8.523888889	2	4.261944444	1.040658778	
Varieties	382.3947222	11	34.76315657	8.488281467	1.3×10^{-5}
Error	90.09944444	22	4.095429293		
Total	481.0180556	35	13.74337302		
Colour intensity (b^+)					
Replication	15.36347222	2	7.681736111	4.876608621	
Varieties	631.3407639	11	57.3946149	36.43591367	1.5×10^{-11}
Error	34.65486111	22	1.57522096		
Total	681.3590972	35	19.46740278		
Lycopene levels					
Replication	0.000193898	2	9.6949×10^{-5}	1.926509837	
Varieties	0.267789301	11	0.024344482	483.7572456	1.4×10^{-23}
Error	0.001107123	22	5.0324×10^{-5}		
Total	0.269090322	35	0.007688295		

References

1. Wijaya, A.F.; Kuntariningsih, A.; Sarwono, S.; Suryono, A. Malnutrition mitigation and community empowerment through the sustainable food reserve programme in Indonesia. *Dev. Pract.* **2021**, *31*, 37–48. [CrossRef]
2. Wijaya, A.F.; Kuntariningsih, A.; Sarwono, S.; Suryono, A. Role and contribution of vegetables in mitigating malnutrition through a sustainable food reserve program. *Int. J. Veg. Sci.* **2021**, *27*, 65–75. [CrossRef]
3. Gatahi, D.M. Challenges and Opportunities in Tomato Production Chain and Sustainable Standards. *Int. J. Hortic. Sci. Technol.* **2020**, *7*, 235–262.
4. Garrido, J.; Luque-Romero, J. *Integrated pest management in mediterranean greenhouses. European Crop Protection*; Cajamar: Almeria, Spain, 2014.
5. Mariyono, J.; Kompas, T.; Grafton, R.Q. Shifting from Green Revolution to environmentally sound policies: Technological change in Indonesian rice agriculture. *J. Asia Pac. Econ.* **2010**, *15*, 128–147. [CrossRef]
6. Mariyono, J. Socially inefficient use of pesticides due to negative externalities: A case of Indonesian rice agriculture. *Int. J. Ecol. Dev.* **2009**, *13*, 93–107.
7. De la Pena, R.; Hughes, J. Improving vegetable productivity in a variable and changing climate. *SAT eJournal* **2007**, *4*, 1–22.
8. Schreinemachers, P.; Afari-Sefa, V.; Heng, C.H.; Dung, P.T.M.; Praneetvatakul, S.; Srinivasan, R. Safe and sustainable crop protection in Southeast Asia: Status, challenges and policy options. *Env. Sci. Policy* **2015**, *54*, 357–366. [CrossRef]
9. Kyriacou, M.C.; Rouphael, Y.; Colla, G.; Zrenner, R.; Schwarz, D. Vegetable grafting: The implications of a growing agronomic imperative for vegetable fruit quality and nutritive value. *Front. Plant Sci.* **2017**, *8*, 741. [CrossRef]
10. Hartmann, H.T.; Kester, D.E.; Davies, F.T.; Geneve, R.L. *Plant Propagation: Principles and Practices*; Prentice Hall: New York, NY, USA, 2001.

11. Midmore, D.J.; Roan, Y.; Wu, M. Management Practices To Improve Lowland Subtropical Summer Tomato Production: Yields, Economic Returns And Risk. *Exp. Agric.* **1997**, *33*, 125–137. [CrossRef]
12. Schwarz, D.; Oztekin, G.; Tuzel, Y.; Brucknera, B.; Krumbeina, A. Rootstocks can enhance tomato growth and quality characteristics at low potassium supply. *Sci. Hort.* **2013**, *149*, 70–79. [CrossRef]
13. Petran, J.A. Interspecific Grafting of Tomato (*Solanum lycopersicum*) onto Wild Eggplant (*Solanum torvum*) for Increased Environmental Tolerances. Master's Thesis, University of Minnesota, Minneapolis, MN, USA, September 2013.
14. Kariada, K.; Aribawa, I. Grafting of tomato with eggplant rootstock at Panyabangan Village Payangan subdistrict of Gianyar Bali. In Proceedings of the 2nd International Conference on Sustainable Agriculture and Food Security: A Comprehensive Approach, Jatinangor, Indonesia, 12–13 October 2015.
15. Sánchez-Rodríguez, E.; Ruiz, J.M.; Ferreres, F.; Moreno, D.A. Phenolic profiles of cherry tomatoes as influenced by hydric stress and rootstock technique. *Food Chem.* **2012**, *134*, 775–782. [CrossRef] [PubMed]
16. Rahmatian, A.; Motjaba, D.; Reza, S. Effect of grafting on growth, yield and fruit quality of single and double stemmed tomato plants grown hydroponically. *Hortic. Environ. Biotechnol.* **2014**, *55*, 115–119. [CrossRef]
17. Davis, A.R.; Perkins-Veazie, P.; Hassell, R.; Levi, A.; King, S.R.; Zhang, W. Grafting effects on vegetable quality. *HortScience* **2008**, *43*, 1670–1672. [CrossRef]
18. Vrcek, I.V.; Samobor, V.; Bojic, M.; Medicsaric, M.; Vukobratovic, M.; Erhatic, R.; Horvat, D.; Matotan, Z. The effect of grafting on the antioxidant properties of tomato (*Solanum lycopersicum* L.). *Span. J. Agric. Res.* **2011**, *9*, 844–851. [CrossRef]
19. Yassin, H.; Hussen, S. Review on role of grafting on yield and quality of selected fruit vegetables. *Glob. J. Sci Front Res.* **2015**, *15*, 1–17.
20. Achim, G.; Botu, I. Results in walnut propagation using different methods. *Acta Hortic.* **2001**, *544*, 503–509. [CrossRef]
21. Ebrahimi, A.; Vahdati, K. Improved success of Persian walnut grafting under environmentally controlled conditions. *Int. J. Fruit Sci.* **2007**, *6*, 3–12. [CrossRef]
22. Lee, J.-M.; Kubota, C.; Tsao, S.J.; Bie, Z.; Echevarria, P.H.; Morra, L.; Oda, M. Current status of vegetable grafting: Diffusion, grafting techniques, automation. *Sci. Hort.* **2010**, *127*, 93–105. [CrossRef]
23. Som, P.B.; Madhava, S.R. Evaluation of tomato varieties for pest and disease adaptation and productivity in Botswana. *Int. J. Agric. Food Res.* **2013**, *2*, 20–29.
24. Nur Fitriana, Y.A.; Fitri, A.S. Analisis Kadar Vitamin C pada Buah Jeruk Menggunakan Metode Titrasi Iodometri (Analysis of Vooooitamin C Levels in Citrus Fruits Using the Iodometric Titration Method). *Sainteks* **2020**, *17*, 27–32. [CrossRef]
25. Sharma, S.K.; Sharma, S.K.; Le Maguer, M. Lycopene in Tomatoes and Tomato Pulp Fractions. *Ital. J. Food Sci.* **1996**, *8*, 107–113.
26. Regina, A.; Maimunah; dan Yovita, L. Penentuan Aktivitas Antioksidan, Kadar Fenolat Total dan Likopen pada Buah Tomat (*Solanum lycopersicum* L.). *J. Sains Dan Teknol. Farm.* **2008**, *13*, 31–37.
27. Gomez, K.A.; Gomez, A.A. *Statistical Procedures for Agriculture Research*, 2nd ed.; John Wiley Sons: Los Banos, Philippines, 1984.
28. Suhartiningsih. Penyakit Layu Bakteri Masih Ancam Petani Tomat. 2015. Available online: https://ugm.ac.id/id/berita/10002-penyakit.layu.bakteri.masih.ancam.petani.tomat (accessed on 28 March 2021).
29. Manickam, R.; Chen, J.-R.; Sotelo-Cardona, P.; Kenyon, L.; Srinivasan, R. Evaluation of Different Bacterial Wilt Resistant Eggplant Rootstocks for Grafting Tomato. *Plants* **2021**, *10*, 75. [CrossRef] [PubMed]
30. Zhou, X.G.; Everts, K.L. Races and inoculum density of Fusarium oxysporum f. sp. niveum in commercial watermelon fields in Maryland and Delaware. *Plant Dis.* **2003**, *87*, 692–698. [CrossRef]
31. Oztekin, G.B.; Tuzel, Y. Effects of Grafting on Organic Seedling Quality and Tomato Production in Greenhouse. *Tekirdağ Ziraat Fakültesi Dergisi* **2017**, 41–47.
32. Azis, A.A.H.; Al Omran, R.A.; Alqardaeai, T.; Razzak, A.H.; Khadejah, A.; Saad, M.; Obiad, A. Tomato grafting impacts on yield and fruit quality under water stress conditions. *J. Exp. Biol. Agric. Sci.* **2017**, *5*, 137–5147.
33. Melnyk, C.W.; Meyerowitz, E.M. Plant grafting. *Cur. Bio.* **2015**, *25*, 183–188. [CrossRef]
34. Lee, J.M.P. Cultivation of grafted plants, I. Current status, grafting methods and benefits. *HortScience* **1994**, *29*, 235–239. [CrossRef]
35. Turhan, A.; Ozmen, N.; Serbeci, M.; Seniz, V. Effects of grafting on different rootstocks on tomato fruit yield and quality. *Hortic. Sci.* **2011**, *38*, 142–149. [CrossRef]
36. Rouphael, Y.; Schwarz, D.; Krumbein, A.; Colla, G. Impact of grafting on product quality of fruit vegetables. *Sci. Hort.* **2010**, *127*, 172–179. [CrossRef]
37. Qi, H.; Li, T.; Liu, Y. Effects of grafting on photosynthesis characteristics, yield, and sugar content in melon. *J. Shenyang Agric. Univ.* **2006**, *37*, 155–158.
38. Salam, M.A.; Masum, A.S.M.H.; Chowdhury, S.S.; Dhar, M.; Saddeque, A.; Islam, M.R. Growth and yield of watermelon as influenced by grafting. *J. Biol. Sci.* **2002**, *2*, 298–299.
39. Murti, R.H.; Kurniawati, T.; Nasrullah. Pola pewarisan karakter buah tomat (Pattern of inheritance of tomato characters). *Zuriat J.* **2004**, *15*, 140–149.

40. Ambarwati, E.; Maya, G.A.P.; Trinowati, S.; Murti, R.H. Mutu buah tomat dua galur harapan keturunan "GM3" dengan Gondol Putih. (Fruit quality of two tomato lines "GM3" with Gondol Putih). In Proceedings of the Seminar Nasional Hasil Penelitian Pertanian dan Perikanan "Peranan Penelitian Bidang Pertanian dan Perikanan dalam Mewujudkan Kedaulatan Pangan untuk Kesejahteraan Petani dan Masyarakat" (National Seminar on Agriculture and Fisheries Research Results on The Role of Research in Agriculture and Fisheries in Achieving Food Sovereignty for the Welfare of Farmers and Communities), Yogyakarta, Indonesia, 1–2 September 2012.
41. Musa, I.; Rafii, M.Y.; Ahmad, K.; Ramlee, S.I.; Md Hatta, M.A.; Oladosu, Y.; Muhammad, I.; Chukwu, S.C.; Mat Sulaiman, N.N.; Ayanda, A.F.; et al. Effects of Grafting on Morphophysiological and Yield Characteristic of Eggplant (*Solanum melongena* L.) Grafted onto Wild Relative Rootstocks. *Plants* **2020**, *9*, 1583. [CrossRef]
42. Mohammed, M.; Wilson, L.A.; Gomes, P.L. Postharvest sensory and physiochemical attributes of processing and non-processing tomato cultivar. *J. Food Qual.* **1999**, *22*, 167–182. [CrossRef]
43. Tigist, M.; Tilahun, S.W.; Kebede, W. Effects of variety on the quality of tomato stored under ambient conditions. *J. Food Sci. Technol.* **2013**, *50*, 477–486. [CrossRef]
44. Saiduna; Madkar, O.R. Pengaruh Suhu dan Tingkat Kematangan Buah terhadap Mutu dan Lama Simpan Tomat (*Lycopersicum esculentum* Mill.). *J. Agroswagati* **2013**, *1*, 43–50.
45. Zhu, J.; Bie, Z.L.; Huang, Y.; Han, X.Y. Effects of different grafting methods on the grafting work efficiency and growth of cucumber seedlings. *China Veg.* **2006**, *15*, 24–25.
46. Yetisir, H.; Sari, N.; Yncel, S. Rootstock resistance to Fusarium wilt and effect on water melon fruit yield and quality. *Phytoparasitica* **2003**, *31*, 163–169. [CrossRef]
47. Martínez-Ballesta, M.C.; López-Pérez, L.; Hernández, M.; López-Berenguer, C.; Fernández-García, N.; Carvajal, M. Agriculture practices for enhanced human health. *Phytochem. Rev.* **2008**, *7*, 251–260. [CrossRef]
48. Fernández-García, N.; Martinez, V.; Carvajal, M. Effect of salinity on growth, mineral composition, and water relations of grafted tomato plants. *J. Plant Nutr. Soil Sci.* **2004**, *167*, 616–622. [CrossRef]
49. Miguel, A.; Maroto, J.; Bautista, A.S.; Baixauli, C.; Cebolla, V.; Pascual, B.; López, S.; Guardiola, J. The grafting of triploid watermelon is an advantageous alternative to soil fumigation by methyl bromide for control of *Fusarium* wilt. *Sci. Hort.* **2004**, *103*, 9–17. [CrossRef]
50. Di Gioia, F.; Serio, F.; Buttaro, D.; Ayala, O.; Santamaria, P. Vegetative growth, yield, and fruit quality of 'Cuore di Bue', an heirloom tomato, as influenced by rootstock. *J. Hort. Sci. Biotechnol.* **2010**, *85*, 477–482. [CrossRef]
51. Ellenberger, J.; Bulut, A.; Blömeke, P.; Röhlen-Schmittgen, S. Novel *S. pennellii* × *S. lycopersicum* Hybrid Rootstocks for Tomato Production with Reduced Water and Nutrient Supply. *Horticulturae* **2021**, *7*, 355. [CrossRef]
52. Sahid, O.T.; Murti, R.H.; Trisnowati, S. Hasil dan mutu enam galur terung (*Solanum melongena* L.) (Yield and quality of six eggplants (*Solanum melongena* L.) lines). *Vegetalika* **2014**, *3*, 45–58.
53. Ryall, M.; Lipton, L. Tomatoes commodity requirements of ryie fruits handling. In *Transportation and Storage of Fruit and Vegetables*; The AVI Publ. Con.: West Point, CT, USA, 1972.
54. Julianti, E. Pengaruh tingkat kematangan dan suhu penyimpanan terhadap mutu buah terong belanda (Effect of maturity and temperature storage on quality of Dutch eggplant) (*Cyphomandra betacea*). *J. Hort. Indones.* **2011**, *2*, 14–20. [CrossRef]
55. Arthur, J.D.; Li, T.; Lalk, G.T.; Bi, G. High Tunnel Production of Containerized Hybrid and Heirloom Tomatoes Using Grafted Plants with Two Types of Rootstocks. *Horticulturae* **2021**, *7*, 319. [CrossRef]
56. Wuryani, S.; Heti, H.; Dedik, S. Respon kualitas hasil tomat cherry (*Lycopersicon cerasiforme* Mill.) terhadap penggunaan teknologi sonic bloom dengan berbagai pupuk daun (Quality response of cherry tomato (*Lycopersicon cerasiforme* Mill.) toward use of sonic bloom technology with various foliar fertilizers). *Agrivet* **2014**, *18*, 1–5.
57. Woodall, A.A.; Lee, S.W.; Weesie, R.J.; Jackson, M.J.; Britton, G. Oxidation of carotenoids by free radicals, relationship between structure and reactivity. *Biochim. Biophys. Acta* **1997**, *1336*, 33–42. [CrossRef]
58. Rana, N.; Kumar, M.; Walia, A.; Sharma, S. Tomato fruit quality under protected environment and open field conditions. *Int. J. Bio-Resour. Stress Manag.* **2014**, *5*, 422–426. [CrossRef]
59. Naik, S.; Hongal, S.; Harshavardhan, M.; Chandan, K.; Kumar, A.; Ashok; Kyriacou, M.; Rouphael, Y.; Kumar, P. Productive Characteristics and Fruit Quality Traits of Cherry Tomato Hybrids as Modulated by Grafting on Different *Solanum* spp. Rootstocks under *Ralstonia solanacearum* Infested Greenhouse Soil. *Agronomy* **2021**, *11*, 1311. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.