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Effect of grafting using wild eggplant as rootstock on growth and yield of four eggplant (*Solanum melongena* L.) cultivars

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Eggplant (*Solanum melongena* L.) is one of popular vegetable commodities. There is an increase in consumer demand for eggplant fruit every year. In 2016, eggplant production in Indonesia was decreased because short of harvest period and bacterial wilt disease. This study was conducted to determine eggplant grafting compatibility to the growth, yield and disease resistance. The treatments were using varieties of Pokak and Gelatik as rootstock and varieties of Prince, Antaboga, HijauKuat and Ratih Hijau as scions. The result of Pokak variety as rootstock with Antaboga variety as scion obtained harvest period 153 days, the bacterial wilt disease by 10, 42% and yield 28, 68 t ha^{-1}. In the cultivation of eggplant is suggested using Pokak variety (*Solanum torvum)* as rootstock in grafting treatment.

Keywords: rootstock, grafting compatibility, bacterial wilt, yield

INTRODUCTION

Eggplant (*Solanum melongena* L.) is one of popular vegetable commodities. Vegetable production need to be increase because the productions of agricultural products are useful as a source of nutrition in supporting public health and to increase the revenue of farmers. Based on data from the Central Bureau of Statistics in 2016, eggplant production in Indonesia were 509,749 tons. The amount was different compared to 2015 and 2014 that produced 514,332 tons and 557,646 tons, respectively. From the data there had been a decrease in eggplant production by 1% and 9% respectively, compared to 2015 and 2014.

The agribusiness prospect of eggplant cultivation because eggplant is one of vegetables favored by people from various circles, ranging from low income society to high income society. The demand for eggplant will increase steadily with the increasing number of people, the level of education and knowledge of the community and the increasing awareness of the community on the importance of diversifying vegetable foods to meet the nutrients and improve health (Firmanto, 2011). Eggplant is a vegetable that is easy to cultivate, but there are some obstacles to planted, such as the short harvesting period and bacterial wilt disease. Thus, we need the right solution to extend the life of harvest as to avoid price fluctuations. Eggplant diseases caused by *Verticillium, Fusarium* and *Meloidogyne sp* were decreasinng yield loss up to 78% (Bletsos et al., 2003). an effort to obtain plant with long harvesting time and resistant to several diseases is using grafting method. The eggplants that commonly planted by Kediri farmers are local eggplants with strong stem and disease resistant.

Grafting is an effective technique for inducing disease resistance and improving tolerance to abiotic stress (Errea et al., 2000; Lee et al., 2010), improving tolerant to high salinity (Huang et al.,

2010). This treatment were used to make the plant resistance to low and high temperatures (Rivero et al., 2003a; Venema et al., 2008), increase nutrient uptake and tolerance to high pH (Colla et al., 2010), increase endogenous hormone synthesis (Dong et al., 2008), increase the efficiency of water use (Rouphael et al., 2008), reduce the absorption of organic pollutants from farmland (Otani and Seike, 2007), increase the tolerance of alkalinity (Colla et al., 2010b), increase salt and flood tolerance (Martinez-Rodriguez et al., 2008; He et al., 2009) and reduce the negative effects of heavy metal poisoning (Savvas et al., 2010).

This study was determined to know the best grafting compatibility between the rootstock and scions on the growth, bacterial wilt disease resistance and yield components.

MATERIALS AND METHODS

This study was conducted from January until August 2017 in Bulu Village, Sub-district Kayen Kidul, Kediri, and East Java. This study was established using Randomized Block Design consisting of twelve treatments with three replications and comprising four varieties of eggplant as scions including: Antaboga, Prince, Ratih Hijau and Hijau Kuat, and the rootstock were using two varieties including; Pokak (*Solanum torvum*) and Gelatik.

The eggplant was planted manually with 60x70 cm plant spacing. The size of the experimental plot was 6.6x2.6 m, and the spacing between plots was 50 cm with spacing between groups was 50 cm. The total number of eggplant was 2160 plants.

The stage of this research was included grafting plant preparation. The rootstock of Pokak variety ready to be grafted at 50 DAP (Day after Planting) and the Gelatik at 30 DAP, while for the scions at 21 DAP. The grafted plant was placed on grafting chamber for 7 days and transfered to the field at 10 DAG (Day after Grafting). Plant maintenance was including weed control, fertilization, and pest diasease control.

The observations were consist of growth and yield components. The growth component was observed non-destructively by using the sample plants of 16 plants per treatment at 14, 28, 42, 56 and 70 DAP included plant height, number of leaf, leaf area, number of branches per plant, rootstock diameter, scion diameter, flowers, flowering time, fruit set and percentage of bacterial wilt disease. The yield component was observed with 16 plant samples included number of fruit, fruit weight, fruit weight per plant, fruit yield per hectare, and harvesting periods. Supporting observations were the grafting compatibility at 10 DAG with magnification of 50 µm.

Statistical Data Analysis

Data observation were recorded and subjected to one way analysis of variance (ANOVA), if there is a significance difference will be continued by Fisher's Least Significant Differences (LSD) test at the 0.05 probability, to investigate the difference between treatments.

RESULTS

The observation data on varieties of Antaboga, Prince, Ratih Hijau and Hijau Kuat scions grafted onto varieties of Pokak and Gelatik rootstock had significant effect on plant height at 14, 28, 56 and 70 DAP and number of leaves at 14, 28, 42 and 56 DAP.

Data observations on Table 1, indicates that treatment between varieties of Ratih Hijau and Hijau Kuat scions grafted onto varieties of Pokak and Antaboga rootstock at 14 DAP produced higher plant height than control treatment, while varieties of Antaboga, Ratih Hijau and Hijau Kuat scions grafted onto variety of Gelatik rootstock produced higher plant than the control treatments (non-grafted eggplant scions). Variety of Prince scion grafted onto varieties of Pokak and Gelatik rootstocks was not significantly different from non-grafted (Prince variety control). Treatment on varieties of Antaboga, Prince, Ratih Hijau and Hijau Kuat scions at 28 DAP grafted onto variety of Pokak rootstock had higher plant height than control treatments (non-grafted four varieties of eggplant scions). A similar result was obtained from the four eggplant scions varieties grafted onto variety of Gelatik rootstock were having higher plant height than the control treatments.

Treatment of varieties of Antaboga, Ratih Hijau, Hijau Kuat and Prince scions at 56 DAP grafted onto variety of Gelatik rootstock were not significantly different from four eggplant scions varieties non-grafted (control treatment). Treatment varieties of Antaboga, Prince and Hijau Kuat scions grafted into variety of Pokak rootstock had higher plant height than control treatment. Contrary to what occured will all other treatment, variety of Ratih Hijau scions grafted into variety of Pokak rootstock was not significantly different from control. Treatment variety of Antaboga scions at 70 DAP grafted onto variety of Pokak rootstock had higher plant than control treatment (Antaboga control), whereas if variety of Antaboga

was grafted onto Gelatik rootstock, the results of plant height were not significantly different from the control. Treatment of Ratih Hijau grafted onto variety of Pokak rootstock were higher plants compared to non-grafted treatment (Ratih Hijau control), while Ratih Hijau variety was grafted onto Gelatik rootstock, the plant height result was not significantly different from non-grafted treatment (Ratih Hijau control).

Table 1 shows that grafting treatment between with variety of Antaboga scions grafted onto variety of Pokak rootstock at 14 DAP were having higher number of leaves than control treatment (Antaboga variety non-grafted). Similar result was also demonstrated on Antaboga variety was grafted onto the variety of Gelatik rootstock were resulted more leaves than the control treatment. The grafting treatment on Ratih Hijau, Prince and Hijau Kuat varieties had more leaves than control treatment (Ratih Hijau, Prince and Hijau Kuat varieties non-grafted), while the three eggplant varieties were grafted to the variety of Gelatik rootstock, it had more leaves than control. The grafting treatment between variety of Prince grafted onto variety of Pokak rootstock at 28 DAP had higher number of leaves than control (Prince variety non-grafted), whereas Prince variety was grafted to the Gelatik rootstock, it produced higher number of leaves than control. Similar result on treatment varieties of Ratih Hijau, Prince and Hijau Kuat scions grafted with Pokak and Gelatik rootstock could produce more leaves than the control (Ratih Hijau, Prince and Hijau Kuat varieties non-grafted).

Treatment using varieties of Antaboga, Ratih Hijau, Prince and Hijau Kuat scions grafted onto Gelatik and Pokak rootstock at 42 DAP produced more leaves than control (the four varieties of scions). Grafting treatment using variety of Prince scions grafted onto Gelatik rootstock produced a significantly different number of leaves than the grafting treatment varieties of Antaboga and Ratih Hijau scions. Different result was demonstrated by the number of leaves from variety of Antaboga scions with Pokak rootstock that was significantly different from the treatment varieties of Ratih Hijau, Prince and Hijau Kuat scions. Grafting treatment at 56 DAP variety of Prince scion grafted onto Pokak rootstock resulted higher number of leaves than control (Prince variety non-grafted), while when grafted to the variety of Gelatik rootstock resulted a higher number of leaves than control treatment. The number of leaves resulted from varieties of Ratih Hijau, Prince and Hijau Kuat scions with Pokak and Gelatik rootstock were higher than the controls (Ratih Hijau, Prince and Hijau Kuat varieties non-grafted).

The results of analysis on the parameters of plant height (Table 1), shows a significant difference between treatments, both of non-grafted plant and grafted plant. It assumed that each type of scions and rootstocks varieties have different plant morphological characteristics. Variety of Pokak is an annual plant with height of up to 3 meter and local Gelatik eggplant has a plant height approximately 1 meter. Sudjijo (2008), stated that the difference in plant height were affected by the compatibility of the scions and the rootstock in channeling nutrient uptake from the roots to be transferred to the leaves for photosynthesis process to create photosynthate, and distributed to plant tissues. The difference growth rates especially plant height is an indicator, that the grafting process were successful. Furthermore, the genetic characteristics of each variety will affect the ability to produce parenchyma in the grafting process. It supported by the research of Miceli et al., (2014), that variety of Pokak as grafting material could enhance plant growth and productivity.

The parameter number of leaves on Table 1, shows that the highest number of leaves was found in the grafting treatment of Pokak rootstock with Antaboga variety (14 DAP) and Prince variety (28 and 56 DAP). The number of leaves on each variety were significantly different due to each variety has different characteristics, so the amount of minerals absorbed by plants in each varieties were not equal and the photosynthate result were not equal. Dong et al., (2008) stated that if the leaves and chlorophyll content is high, it will produce more photosynthate to be distributed through the plant organs including the leaves to allow the plant grow rapidly and the shoot height will also continue to grow. Hormone that contained in the rootstock is cytokine hormone which can stimulate to increasing the number and size of cells, differentiation of cells on the formation of leaf organs. According to Venema et al., (2010), each type of plant carries genes for certain characters, which plays a significant purpose to inherit the parent character to the offspring.Treatment between Ratih Hijau variety grafted onto Pokak rootstock were having faster flowering time than control (Ratih Hijau non-grafted), while the grafting treatment between Antaboga variety with Gelatik rootstock had flowering time 3 day faster than control (Antaboga varieties non-grafted).

Table 1. Plant Height and Number of Leaves on Various Varieties of Eggplant Scions grafted onto Two Type of Rootstocks

Treatment	Plant Height (cm) at Observation Periods (DAP)					Number of Leaves at Observation Periods (DAP)				
	14	28	42	56	70	14	28	42	56	70
Control (Non-grafted)										
Antaboga Variety	18.52 c	33.45 bc	49.84 tn	72.67 abc	85.67 abc	4.35 c	8.04 ab	13.90 a	23.75 bc	29.68 tn
Ratih Hijau Variety	14.95 a	29.84 a	48.80 tn	81.51 ef	88.00 bcd	3.52 b	7.83 a	13.78 a	22.03 a	28.75 tn
Prince Variety	20.70 de	33.21 b	50.76 tn	71.46 ab	84.67 ab	4.34 c	8.39 bc	15.89 b	23.33 b	30.88 tn
Hijau Kuat Variety	16.84 b	29.90 a	52.08 tn	75.63 bcd	82.30 a	2.75 a	8.60 c	14.44 a	21.72 a	30.47 tn
RS Gelatik Eggplant										
Antaboga Variety	19.99 d	35.82 de	51.55 tn	75.00 bc	81.70 a	6.91 f	9.80 d	16.42 b	26.10 def	30.54 tn
Ratih Hijau Variety	21.47 ef	33.13 b	50.50 tn	81.00 def	92.00 de	5.87 d	10.85 f	16.53 b	26.91 efg	37.00 tn
Prince Variety	20.75 de	35.72 d	51.40 tn	68.66 a	81.67 a	6.47 e	9.76 d	18.45 c	28.33 h	30.54 tn
Hijau Kuat Variety	21.90 f	32.30 b	52.70 tn	77.63 bcd	87.00 abcd	5.74 d	10.02 de	18.28 c	25.83 de	40.59 tn
RS Pokak Eggplant										
Antaboga Variety	22.25 f	39.20 f	58.30 tn	81.30 efg	91.67 de	7.56 g	10.45 ef	18.83 cd	26.64 efg	30.27 tn
Ratih Hijau Variety	23.88 g	35.15 cd	55.20 tn	88.00 g	94.33 e	6.90 f	11.44 g	18.29 c	25.00 cd	38.67 tn
Prince Variety	21.64 ef	38.66 f	55.90 tn	77.67 cde	91.00 cde	7.25 fg	11.57 g	18.79 cd	27.28 fgh	30.64 tn
Hijau Kuat Variety	24.59 g	37.49 ef	53.10 tn	86.55 fg	89.00 cde	7.16 fg	10.61 f	19.54 d	27.85 gh	38.87 tn
LSD 5%	1.12	1.71	tn	5.58	5.63	0.41	0.49	1.16	1.29	tn
CV (%)	11.00	10.00	13.26	14.43	12.97	11.13	10.19	13.88	10.26	14.89

Description: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, DAP = Day after Planting; RS = Rootstock; LSD = Least Significant Differences; CV = Coefficient Variance.

Grafting treatment between four varieties of scions with variety of Pokak rootstock were having more number of flowers than control treatments with 54%, 50%, 49% and 45%, respectively. The four varieties of scions with Gelatik rootstock increased the number of flowers by 26%, 35%, 37% and 30%, respectively. Varieties of Antaboga, Prince, Ratih Hijau and Hijau Kuat grafted onto Pokak rootstock were having higher fruit sets than controls (the four varieties of scions non-grafted) with an increase of 35%, 22%, 6% and 12% respectively, while the grafting treatment between Antaboga and Prince varieties grafted onto Gelatik rootstock had higher fruit set than the controls with an increase of 29% and 22%. Treatment of Antaboga variety grafted onto variety of Pokak rootstock was having 72 days longer harvesting periods compared to Antaboga non-grafted, while using variety of Gelatik rootstock was having 31 days longer harvesting periods than control (Antaboga variety non-grafted). Varieties of Ratih Hijau, Prince and Hijau Kuat grafted onto Pokak rootstock were having longer harvest period of 54, 60 and 46 days compared to control treatment (Ratih Hijau, Prince and Hijau Kuat varieties non-grafted), while grafted using Gelatik rootstock was having longer harvesting period than the control of 45, 24 and 27 days.

The results shows that treatment between the Antaboga variety grafted onto Pokak rootstock had a higher fruit set than grafted onto Gelatik rootstock and the other control treatments (Table 2). The fruit set could be affected by the high amount of rainfall condition during the research periods. Suciantini (2015), stated that weather is an environmental factor that determine the succesful of plant cultivation

The interaction between weather as environmental factor and plant genetic will affect the growth and quality of the plant. Genetic factors are determined the characteristics of plant organ such as stem conditions, flower shape and leaf shape. Based on the research of Anwar *et al.* (2015), showed that rainfall is significantly impact the crop production because rainfall is a fluctuated climate element. The amount of rainfall is not only an important factor in determining the plant yield, and also the increasing temperature can decrease plant yield.

Table 2. Flowering Time, Number of Flowers, Fruit Set and Harvesting Period on Various Varieties of Eggplant Scions grafted onto Two Type of Rootstocks

Treatment	Flowering Time (DAP)	Number of Flowers	Fruit Set (%)	Harvesting Period (Days)
Control (Non-grafted)				
Antaboga Variety	47.00 bc	21.00 b	55.57 a	81.00 a
Ratih Hijau Variety	47.33 bc	17.67 a	75.75 cde	79.33 a
Prince Variety	48.00 bcde	18.67 ab	64.17 b	79.67 a
Hijau Kuat Variety	50.33 e	18.33 a	72.06 c	78.33 a
RS Gelatik Eggplant				
Antaboga Variety	50.00 de	28.33 cd	78.78 def	112.00 c
Ratih Hijau Variety	49.33 cde	27.33 cd	80.00 ef	124.00 d
Prince Variety	47.67 bcd	29.67 d	82.86 fg	103.33 b
Hijau Kuat Variety	48.67 bcde	26.00 c	75.43 cd	105.33 b
RS Pokak Eggplant				
Antaboga Variety	48.33 bcde	46.33 g	85.83 g	153.30 g
Ratih Hijau Variety	44.33 a	35.33 ef	80.81 f	133.00 e
Prince Variety	46.67 ab	34.00 e	85.19 g	139.33 f
Hijau Kuat Variety	49.00 bcde	37.00 f	82.03 fg	124.33 d
LSD 5%	2.46	2.53	4.30	6.13
CV (%)	10.32	18.06	11.32	11.30

Description: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, DAP = Day after Planting; RS = Rootstock; LSD = Least Significant Differences; CV = Coefficient Variance. * = harvesting period is calculated from the first day of harvest until the last day of harvest.

Table 3. Intensity of Bacterial Wilt Disease on Various Varieties of Eggplant Scions grafted onto Two Type of Rootstocks

Treatment	Intensity of Bacterial Wilt Disease (%) at Observation Periods (DAP)			
	28 DAP	**42 DAP**	**56 DAP**	**70 DAP**
Control (Non-grafted)				
Antaboga Variety	15,08 g	27,67 h	37,58 f	42,33 g
Ratih Hijau Variety	13,00 ef	24,67 g	39,58 f	44,33 g
Prince Variety	14,00 fg	25,00 g	37,50 f	50,67 h
Hijau Kuat Variety	14,25 fg	30,00 i	28,25 e	34,75 f
RSGelatik Eggplant				
Antaboga Variety	12,33 de	16,25 f	19,83 d	22,25 d
Ratih Hijau Variety	10,04 c	12,42 d	20,83 d	22,92 d
Prince Variety	10,00 c	13,33 de	27,08 e	27,00 e
Hijau Kuat Variety	11,33 d	14,58 ef	16,67 c	20,83 cd
RS Pokak Eggplant				
Antaboga Variety	1,33 a	2,08 a	4,17 a	10,42 a
Ratih Hijau Variety	3,33 b	8,33 c	8,67 b	18,75 c
Prince Variety	3,67 b	4,17 ab	8,33 b	12,50 ab
Hijau Kuat Variety	4,33 b	6,25 bc	6,25 ab	14,58 b
LSD 5%	1,28	2,12	2,60	2,25
CV (%)	27,54	27,80	24,74	16,32

Description: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, DAP = Day After Planting; RS = Rootstock; LSD = Least Significant Differences; CV = Coefficient Variance.

Table 3 shows that varieties of Antaboga, Ratih Hijau, Prince and Hijau Kuat as scions grafted onto variety of Pokak rootstock could decrease the intensity of bacterial wilt disease compared to control treatment with disease suppression of 91%, 74%, 73 % and 69% (28 DAP); 92%, 66%, 83% and 79% (42 DAP); 89%, 78%, 77% and 79% (56 DAP) and 75%, 57%, 58% and 75% (70 DAP). Different results were showed by the treatment varieties of Antaboga, Ratih Hijau, Prince and Hijau Kuat scions grafted onto Gelatik rootstock compared to the controls with emphasis percentage of 18%, 23%, 28% and 20% (28 DAP); 41%, 49%, 46% and 51% (42 DAP), 47%, 48%, 27% and 40% (56 DAP); 45%, 48%, 47% and 40% (70 DAP).

Treatment Antaboga variety grafted onto Pokak rootstock could decrease the intensity of bacterial wilt disease than grafted onto Gelatik rootstock and control treatments (Table 3). Bacterial wilt disease is an economically disadvantageous disease because there is no effective chemical control for integrated pest management progress. (Borrero et al., 2004).

Bacterial wilt disease is caused by *Ralstonia solanacearum* and occurs in tropical, subtropical and warm climates. Pathogens were born in the soil entering into the plant through injured roots and progressively invade the stem vascular tissue and could inhibit plant growth until plant mortality. It also can cause yield loss ranging from 50 to 100% (King et al.,2010).

The wild eggplant relatives that can be used to increase genetic variability such as *Solanum torvum* (Pokak variety) which is useful for disease resistance introgression (Collonier et al., 2001). *S. torvum* has been identified as carrying endurance properties against the most serious diseases of eggplant, particularly bacterial wilt disease, fungi and nematode (Stravata et al., 2000; Collonier et al., 2001). The grafting treatment for vegetable crops is used to provide plant resistance to pest and soil pathogens, also increasing the strength of the rootstock (Lee, 1994; Lee and Oda, 2003; Rivero et al., 2003; Davis et al., 2008a, 2008b; King et al., 2008, 2010;).

Eggplant is widely cultivated in tropical and temperate regions around the world and suitable to be planted by using the grafting method (Bletsos et al., 2003; Daunay, 2008). Some of the rootstocks were reported to be resistant to soil pathogens or similar with Pokak variety, which has resistance to soil pathogenic (*Verticillium dahliae* Klebahn and *Ralstonia solanacearum* are recommended for eggplant grafting) (Bletsos et al., 2003; Daunay, 2008; King et al., 2010).

Ideally, the rootstock should improve the yield and product quality. This can be achieved by using rootstock that have resistance to soil or pest diseases, tolerance of abiotic stress, selective absorption on soil nutrients (Lee, 1994; Lee and Oda, 2003; Rivero et al., 2003; Davis et al., 2008a, 2008b). The strong eggplant rootstocks are very important on the grafting method becuse it helps the plants absorbed nutrients easily, if the plants get sufficient nutrients and the environmental conditions were supported, the eggplant plant will grow optimumly. This statement is supported by the research of Gisbert et al. (2010), the strength of eggplant roots that grafted onto Pokak rootstock was higher than non-grafted treatment because the strong roots could absorb nutrients easily, so the plant growing optimumly and has a longer harvesting period than the non-grafted plants.

Table 4 shows that varieties of Antaboga, Ratih Hijau, Prince and Hijau Kuat scions grafted onto Pokak rootstock could increased the number of fruit by 62%, 52%, 54% and 44%, respectively, while grafting tratment with variety of Gelatik rootstock could increase the number of fruits compared to control treatments with an increase of 41%, 34%, 44% and 35% respectively. Treatment varieties of Prince and Hijau Kuat scions grafted onto Pokak rootstock resulted in higher fruit weight (g fruit^{-1}) than the controls (Prince and Hijau Kuat varieties non-grafted) with 17% and 13% fruit weight increase.

Table 4. Yield Component on Various Varieties of Eggplant Scions grafted onto Two Type of Rootstocks

Treatment	Amount of Fruit (fruit)	Fruit Weight (g fruit^{-1})	Fruit Weight (kg plant^{-1})	Yield (t ha^{-1})
Control (Non-grafted)				
Antaboga Variety	10,67 a	190,11 ab	2,02 a	14,81 a
Ratih Hijau Variety	12,67 c	194,65 ab	2,47 b	17,23 b
Prince Variety	11,33 ab	176,84 a	2,00 a	13,64 a
Hijau Kuat Variety	12,33 bc	210,68 b	2,59 b	17,40 b
RS Gelatik Eggplant				
Antaboga Variety	18,33 d	196,13 ab	3,60 c	22,51 cd
Ratih Hijau Variety	19,34 de	207,72 b	4,00 d	22,22 c
Prince Variety	20,33 e	199,07 ab	4,07 d	21,35 c
Hijau Kuat Variety	19,00 d	210,92 b	4,05 d	21,35 c
RS Pokak Eggplant				
Antaboga Variety	28,67 h	212,18 b	6,13 g	28,68 g
Ratih Hijau Variety	26,33 g	210,04 b	5,47 e	23,98 de
Prince Variety	27,67 h	213,00 b	5,87 f	26,02 f
Hijau Kuat Variety	22,33 f	242,72 c	5,40 e	24,56 ef
LSD 5%	1,13	28,99	0,21	1,59
CV (%)	11,89	28,48	10,58	15,17

Description: Means followed by the same letter at the same age on the column showed no significant difference based on LSD test at level 5%, DAP = Day After Planting; RS = Rootstock; LSD = Least Significant Differences; CV = Coefficient Variance.

* = harvest period is calculated from the first harvest until the last harvest

The treatment between the rootstock of Antaboga, Ratih Hijau, Prince and Hijau Kuat varieties grafted onto variety of Pokak rootstock had higher fruit weight (kg plant^{-1}) than the control treatment (all eggplants scions non-grafted) with an increase of 67%, 54 %, 66% and 52%, respectively, while grafted with variety of Gelatik rootstock could increased the fruit weight (kg plant^{-1}) by 44%, 38%, 51% and 52%, respectively, compared to control treatment (Table 4).

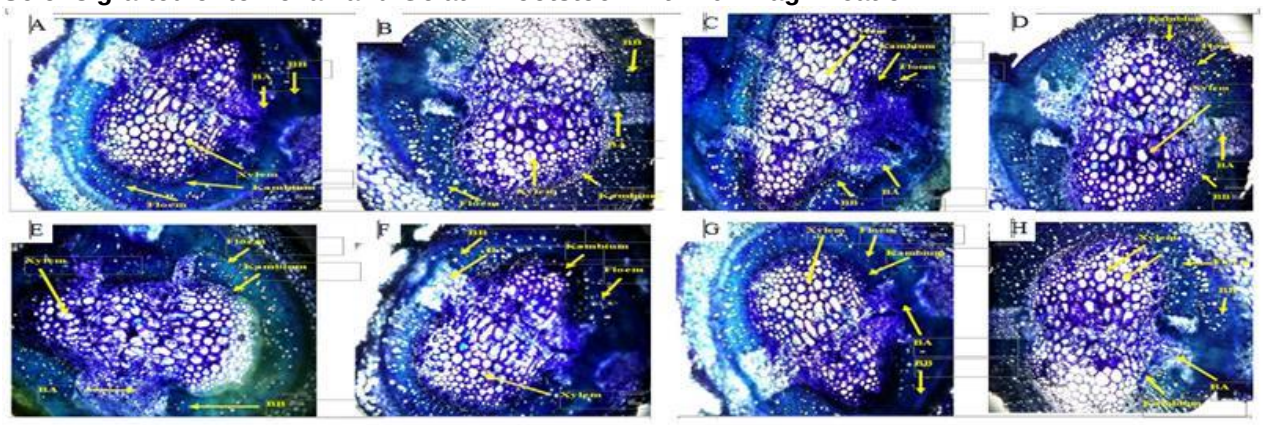
Table 4 indicates that varieties of Antaboga, Ratih Hijau, Prince and Hijau Kuat scions grafted onto variety of Pokak rootstock had higher yield (t ha^{-1}) than the control treatment with yield increase 44%, 28%, 47% and 29%, respectively. Different results were shown in the grafting treatment on variety of Gelatik as rootstock could increase of yield (t ha^{-1}) by 34%, 22%, 36% and 19%, respectively.

According to Lee and Oda (2003), stated that grafting method can increase fruit yield in some vegetables such as tomatoes, cucumbers, melons, peppers and eggplants. The use of the Pokak eggplant could increase the plant resistance and tolerance to the weather, because the root of the Pokak variety has a high absorption nutrients efficiency even at low temperatures (Bogoescu and Doltu, 2015). Based on recent research to Miceli et al., (2014), stated that the application of Pokak variety as rootstock material for grafting can increase crop productivity.

In Figure 1 shows that the stem anatomical tissues structure consists of phloem, xylem and cambium. A cambium is is a tissue layer that provides partially undifferentiated cells for phloem and xylem. The inside part of the cambium is called xylem (wooden vessel), which has function to transport water and mineral nutrients from the roots to shoots and leaves. Phloem is the innermost layer of the bark, that transport the soluble organic compounds made during photosynthesis known as photosyntathes, to parts of the plant organ where needed. For successful grafting to take place, the vascular cambium tissues of the stock and scion plants must be placed in contact with each other, so there is no scarring on the plant tissues from the joint. After the scions and rootstock were already grafted, then stored on grafting chamber for 7 days, so the plant remains in good condition. Grafting compatibility observation was performed at 10 DAG because at this period the plant will started adapt to the environment,

The linkage mechanisms of scions and rootstock according to Stravato et al., (2000), as follows: 1) The cambium of each plant cell are forming callus tissue in the form of parenchyma cells, 2) Parenchyma cells of the scions and rootstock are inosculated successfully, 3) Parenchyma cells are formed to differentiate to a new cambium as a continuation of the scion cambium layer and the rootstock. The vascular cambium of the scion and rootstock should be tightly pressed together and oriented in the direction of normal growth. Proper alignment and pressure encourages the tissues to join quickly, allowing nutrients and water to transfer from the rootstock to the scion.

Figure 1. Transverse Incision displaying the Joint of the Grafting on Four Varietis of Eggplant Scions grafted onto Pokak and Gelatik Rootstock with 40x Magnification



Description: A = Grafting between Pokak and Ratih Hijau; B = Grafting between Pokak and Hijau Kuat; C = Grafting between Pokak and Antaboga; D = Grafting between Pokak and Prince; E = Grafting between Gelatik and Ratih Hijau; F = Grafting between Gelatik and Hijau Kuat; G = Grafting between Gelatik and Antaboga and H = Grafting between Gelatik and Prince.

The success of a grafting is determined when the phloem and xylem are compatible between the two connecting surfaces (Gokbayrak et al., 2007). There are five steps that determine the unification of a grafting: (1) formation of the necrotic layer, (2) the development of callus bridging the two connecting surfaces, (3) differentiation of new cambium tissue, (4) new vascular tissue restoration, and (5) continuous restoration in outer epidermal tissue in the plant grafts connection area (Luna et al., 2002). According to Pina & Errea (2005), stated that the formation of callus tissue on the surface of the joint is the initial response that can be found in the grafting process, so that the grafting failure can be characterized by the absence of callus between the two surfaces of the joint and causing gradual plant growth inhibition. Callus formation on both surfaces of the joint forms a vascular network that allows water to flow from the rootstock to the scions. When the linking of the vascular tissue between the scions and the rootstock was not fused, then it could decrease the water absorption, thereby it could decreasing the conductance of the stomata and inhibit the plant growth (Ballesta et al., 2010).

Gokbayrak et al., (2007), stated that the exact and tightly pressed cambium between the two stems are affects the success of the grafting. According to Riodevrizo (2010) that cambium cells are meristematic, which means it is able to divide and form new cells. Grafting compatibility involves the joining of vascular tissues between the scion and rootstock. The grafting is completed at a time when the scion and stock are capable of producing callus and other wound-response tissues. The unsuccessful grafting were described as low life percentage, different growth rate between scions and unbalanced rootstock, vegetative growth between scions and rootstock are not simultaneous, leaves turns to yellow, and the plants die faster (Hartmann et al., 1990).

CONCLUSION

Treatment of Antaboga variety non-grafted resulted 81 days of harvesting period, the bacterial wilt disease by 42,33% and yield 14,81 t ha^{-1}. Treatment using variety of Antaboga scions and variety of Gelatik rootstock were having 124 days of harvesting period, the bacterial wilt disease of 22,25%, with yield 22,51 t ha^{-1}. Sugesstion grafting material for Kediri farmers is treatment Antaboga variety grafted onto Pokak rootstock, that were having 153 days of harvesting period, the bacterial wilt disease of 10,42% and yield 28,68 t ha^{-1}

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest".

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AUTHOR CONTRIBUTIONS

EP: designing, conducting research and writing manuscripts

MDM: as a supervisor, correcting and justifying the manuscript

EW: as a supervisor, correcting and perfecting the manuscript

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