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Improving off-season production through grafted tomato technology in East Java-Indonesia

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Abstract

Research was conducted at Kediri, East Java for studying the effect of grafted tomato on off season production (rainy season) of tomato. Experiment was laid out in factorial randomized block design with four treatment combinations *viz.*, ungrafted (G0) and Grafted (EG 203 eggplant rootstock) (G1) and variety Timothy (V1) and CLN 3024 (V2) were studied for their main and interaction effect. The results indicated that grafting had highly significant effect on wilt disease incidence. There was interaction between grafted and variety for viral diseases and the yield (number of tomatoes). Grafed plants of cv Timothy had low virus attack with a higher yield (65 fruits per plant), compared to ungrafted plants (29 fruits per plant).

Key words: Tomato, grafting, plant disease, rainy season, eggplant rootstock

Introduction

Tomato (*Lycopersicon esculentum* Mill.) has attained status of one of the most important vegetables due to its economic value and export potential. Tomato production in Indonesia is widespread within East Java, North Sumatra, Central Java, West Java, and Bali. The average yield of the crop is 16.65 t/ha (MOA, 2012) and using improved technology it could be up to 33-35 t/ha.

Most important obstacle faced in increasing the production of tomato is wilt disease, caused by the fungus *Fusarium oxysporum* f sp *lycopersici* (Fol) and bacteria (*Ralstonia solanacearum*). Both of these diseases are soil borne diseases that can be so deadly that tomato crop cannot be produced. According to Asrul (2003) yield loss caused by the bacterium *R. solanacearum* may reach 60-100%. Whereas, by Fusarium wilt, yield losses may be up to 50% (Vauzia *et al.*, 2012). For control of these diseases, farmers generally use pesticide continuously which cause pollution in soil and the environment, as well as the presence of residues in the products are noticed. The use of tolerant varieties may often avoid wilting. Novizan (2002) reported that soil borne diseases can be controlled by using resistant varieties, plastic mulch and seed treatment. However, these methods sometimes are not profitable.

Another wilt control approach can be using antagonist agents such as *Talaromyces flavus* which can suppress wilt disease caused by *Verticillium alboatrum* on tomato both in laboratories and greenhouse (Naraghi *et al.*, 2010). Korlina *et al.* (2014) also reported that the application of combined composts 2 t/ha + Trichoderma + *Pseudomonas fluorescens* can suppress the growth of both wilt, Fusarium disease and bacterial wilt in chili.

Luther *et al.* (2012) reported that in tomato planted during the rainy season with flooding condition and high temperature, disease management was difficult, thus causing decreased production. Alternative control, that is much easier and relatively cheap is grafting of tomato on resistant rootstock. The lack of tolerant cultivars to biotic or abiotic factors and restriction of using methyl bromide for soil disinfection, use of grafted plants has attracted attention of the world (Bletsos, 2005). The solution that can be implemented is by planting grafted tomato using rootstock of eggplant such as EG 203 which has been found wilt disease resistant in screening. Eggplant widely cultivated in both tropical and subtropical areas is used for producing grafted plants (Bletsos *et al.*, 2003). According to Davis *et al.* (2008) vegetables that is cultivated using the grafted method will have more resistance to diseases and pests, tolerance to abiotic factor, and improved uptake of water and nutrients.

Grafted plant can be grown in areas that are often flooded (Black, 2003). In many areas in Indonesia in vegetable production during the hot-wet months, high temperature, high humidity, frequent and intensive flooding, poor field drainage, and insect pest development collectively lead to lower productivity (Kuntoro, 2006). In Indonesia, soil borne disease control by use of grafted plants has not been reported so far. The study aims to determine the effect of grafting and varieties on disease development and production of tomato in rainy season.

Materials and methods

Research was conducted in Kediri, East Java from December 2013 to April 2014. The research used Randomized Block Design factorial consisted of 2 factors, namely:

Factor 1: Grafting (G0=Ungrafted, G1= Grafted (eggplant EG203 as rootstock)

Factor 2: Variety (V1=Timothy, V2= CLN 3024)

Preparation of scion and rootstock seedling: Eggplant seedlings were grown 2-3 weeks earlier than tomatoes. Eggplant plant was used as rootstock. While the tomato seeds for scion are also planted in the trays.

Grafting: The eggplant seedlings of EG203 were used as rootstock and tomato varieties Timothy and CLN 3024 were used as scion. Preparation of rootstock, scion and grafting was performed as outlined by Black *et al*. (2003). Environmental conditions for rearing the newly grafted plants was also as per Black *et al*. (2003).

Planting: Land that already had beds (width 1 m) were given basic manure, before the grafted plants acclimatized. Grafts were planted according to treatment with spacing of 50 x 70 cm. Planting process, including watering plants, removing wild shoots, supplementary fertilizing, weeding and pest and disease control on tomato plants were as per standard procedures.

Observations: The observation were taken on percentage plant diseases (wilt disease and virus), calculated based on visual symptoms of plant. Data was recorded one week after planting and repeated four times, once a week. Disease rate was computed using the Abbott's formula as follows:

$$I(\%) = (n/N) \times 100$$

Where, I= Percentage of disease incidence; n= Number of infected tomato plants wilting; N= Number of tomato plants observed

In addition to wilt disease and the virus, observations on pests and other diseases were also recorded during observations. As supporting data, plant growth (plant height and canopy width) on 10 plants from each plot was taken.

Results and discussion

Plant Growth: Differences in the growth as an influence of the treatment was recorded on plant height and canopy width (Table 1). Statistical analysis revealed no significant differences among the treatments for plant height and canopy width, but grafted tomato plants tended to have higher mean values than those which were not grafted. This is consistent with the results of the study by Khah *et al*. (2006) who reported higher growth of grafted tomato plants than control with tomato grafts on rootstock resistant to nematode and *Verticillium*. Another study also mentions that grafted plants have a positive effect on the appearance of vegetative growth of melon plants, due to the deeper root vigour, making them easier to absorb water and nutrients (Radhouani and Ferchichi, 2010). Similar results were reported by Lee (1994) and Ioannou *et al*. (2002) that the grafted plants have a larger trunk diameter.

Differences in height of tomato varieties at 28 days after planting was significant. The grafted Timothy variety had a higher growth than the CLN 3024 introduced from AVRDC. However, at the end of growing season (42 DAP), both the tomato varieties had the same plant height. Statistical analysis results showed no interaction between grafting treatment and varieties on plant height and width of the canopy.

Table 1. Plant height and canopy width of tomato at different days after planting

Treatment	Plant height		Width of canopy	
	28 DAP*	42 DAP	28 DAP	42 DAP
Grafted (G)				
G0 Ungrafted	59.68a**	71.69a	46.54a	48.14a
G1 Grafted	56.45a	77.52a	45.64a	52.99a
Tomato variety (V)				
V1 Timothy	60.73b	75.04a	47.20a	47.15a
V2 CLN 3024	55.40a	74.18a	44.98a	54.08a
Grafted x Variety				
G0V1	59.35ab	69.76a	47.20a	40.05a
G0V2	60.00ab	73.64ab	45.88a	56.24a
G1V1	62.10a	80.32b	47.20a	54.06a
G1V2	50.80b	74.72ab	44.08a	51.91a

* DAP= Days after planting

** Value followed by the same letters are not significantly different (P=0.05) according to DMRT (Duncan's Multiple Range Test)

Disease development on tomato: Emerging disease on tomato plants are wilting, leaf spot (*Alternaria solani*) and viruses. Statistical analysis of wilt disease showed no interaction between grafting and varieties. However, grafting significantly influenced wilt disease incidence as compared with ungrafted ones (Table 2). Based on wilt disease observation, it is clear that plants which were not grafted had higher wilt disease percentage than the grafted ones (Fig. 1). Wilting started 14 days after planting (DAP) up to 56 DAP, and the percentage increased with the increasing age of tomato plants. The effect of the resistant rootstock (EG 203 eggplant) to wilt was significantly apparent. Keatinge *et al*. (2014) reported EG 203 eggplant resistant to bacterial wilt and recommended it as a rootstock for biotic stress conditions. Other reports show *Pseudomonas fluorescens* in EG 203 eggplant rhizosphere which can inhibit the wilt disease caused by *Ralstonia solanacearum in vitro* (Nurcahyanti *et al*., 2013). While there was no difference in tolerance between the tomato varieties.

The viral disease symptoms on the leaves were expressed in the form of mosaic or malformations or curly leaf. Results on virus infection symptoms revealed interaction between grafting and varieties of tomato plants at 14 DAP (Table 3). In Table 3 it can

Fig. 1. Growth of grafted and ungrafted on tomato plants

Table 2. Effect of graft and variety to wilt disease on tomato

Treatments	Wilt disease (%)			
	14 DAP*	28 DAP	42 DAP	56 DAP
Grafted (G)				
G0 Ungrafted	26.25b**	46.25b	70.63b	93.13b
G1 Grafted	3.75a	3.13a	5.00a	14.38a
Tomato variety (V)				
V1 Timothy	16.88a	31.88b	36.25a	57.50a
V2 CLN 3024	13.13a	17.50a	39.38a	50.00a
Grafted x Variety				
G0V1	30.00c	35.00c	72.50d	91.25cd
G0V2	22.50b	57.50d	68.75cd	95.00d
G1V1	3.75a	0.00a	0.00a	23.75b
G1V2	3.75a	6.25b	10.00b	5.00a

* DAP = Days after planting

** Value followed by the same letters are not significantly different (P=0.05) according to DMRT (Duncan's Multiple Range Test)

be seen that grafted tomatoes of CLN 3024 showed higher virus attacks (27.48%) and significantly different with ungrafted tomato CLN 302. Whereas, on grafted Timothy tomato symptoms of the virus were less however on ungrafted tomato Timothy the attack was 7.77%. In general, grafted plants expressed more virus infestation than ungrafted. While differences in varieties can invite virus attack that varies depending on the resilience of variety of tomato. In this case CLN 3024 showed higher virus attack than Timothy variety (Table 4). According Sutarya *et al*. (2014), CLN 3024 is more resistant to virus than Timothy variety with 22% and 5% infestation, respectively. In addition to wilt disease and viruses, other diseases observed was dry leaf spot (Table 5). Based on statistical analysis of symptoms data, there was no difference among both treatments, grafting and varieties, and interaction. Dry spot disease is a disease which can cause leaf blight, stem rot and cause spots on the fruit (Naswha and El Yousr, 2012).

Production: Observations on production (fruit number and weight) was compilation of four harvests. Yield of grafted tomato was higher than ungrafted ones, both on the variety Timothy and CLN 3024. This indicates that if the tomato plant as scions is grafted with rootstock (eggplant EG 203), will produce more fruit. This is because grafted tomato plant were stronger and lived longer.

Observation of the fruit number and weight of tomatoes per plant from a single treatment of grafting and varieties is presented in Table 6. It appears that grafted tomato plants produce more fruit in number and weight. This is due to the fact that ungrafted plants wither and die. This condition is in accordance with the

Table 3. Interaction grafted and variety on viral disease on tomato at 14 days after planting

Treatment	Viral disease (%)*
G0V1 Timothy variety ungrafted	7.77a**
G0V2. CLN 3024 ungrafted	11.48a
G1V1 Timothy grafted	4.05a
G1V2. CLN 3024 grafted	27.48b

* DAP = Days after planting

** Value followed by the same letters are not significantly different (P=0,05) according to DMRT (Duncan's Multiple Range Test)

Table 4. Effect of single factor grafted and variety to viral disease on tomato

Treatments	Viral disease (%)		
	14 DAP*	28 DAP	42 DAP
Grafted (G)			
G0 Ungrafted	9.62a**	21.78a	13.02a
G1 Grafted	15.76a	46.36b	40.21b
Tomato variety (V)			
V1 Timothy	5.91a	33.64a	13.44a
V2 CLN 3024	19.48b	34.50a	39.79b

* DAP = Days after planting

** Value followed by the same letters are not significantly different (P=0,05) according to DMRT (Duncan's Multiple Range Test)

Table 5. Effect of grafted and variety to early blight (*Alternaria solani)* on tomato

Treatment	Early blight (%)	
	28 DAP*	42 DAP
Grafted (G)		
G0 Ungrafted	32.00b**	21.75a
G1 Grafted	21.00a	33.75a
Tomato variety (V)		
V1 Timothy	24.50a	32.25a
V2 CLN 3024	28.50a	23.25a
Grafted x Variety		
G0V1	29.00ab	23.00a
G0V2	35.00b	20.50a
G1V1	20.00a	41.50a
G1V2	22.00a	26.00a

* DAP = Days after planting

** Value followed by the same letters are not significantly different (P=0,05) according to DMRT (Duncan's Multiple Range Test)

Table 6. Effect single factor grafted and variety on the number and weight on tomato fruits

Treatments	Production of tomato per plant	
	Number	Weight (g)
Grafted (G)		
G0. Ungrafted	15.32a*	262.50a
G1 Grafted	37.33b	1111.40b
Tomato variety (V)		
V1 Timothy	47.26b	978.00b
V2 CLN 3024	5.39a	395.90a

* Value followed by the same letters are not significantly different (P=0,05) according to DMRT (Duncan's Multiple Range Test)

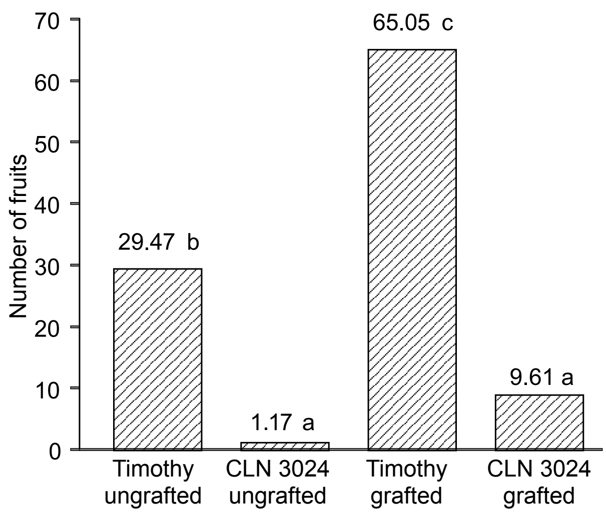

Fig. 2. Interaction grafted and variety to the number of tomato fruits

results of Ibrahim *et al*. (2014), that grafted tomato plants either planted in the greenhouse or in open field produced more fruit and weight than ungrafted ones. Aganon *et al*. (2002) reported that the varieties Apollo and CLN 5915 which were grafted with EG 203 eggplant produced higher crop yield. Pagonyi *et al*. (2005) reported that Lemance F1 tomato production can be increased when grafted on Beaufor rootstock. Timothy had more number of fruits and weight than CLN 3024. This happend because CLN 3024 was more susceptible to viruses.

It is evident from the study that grafting had significant influence on wilt disease. An interaction between grafting and varieties against virus attack was observed. Timothy could avoid virus attacks, while if not grafted, 7.77% incidence occurred. Both varieties grafted on EG 203 produced higher yield as compared to ungrafted tomato.

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