ROOTSTOCKS AND PLANT GROWTH REGULATOR TO PROMOTE GROWTH OF GRAPEVINE SEEDLING CV. PRABU BESTARI

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ABSTRACT

Good quality seedling is the key to achieve potential of production and quality of fruit. Cuttings-grafting is a propagation method applied to obtain good quality plants, ones that have strong roots and are resistant to disease. This study aimed to describe the effect of rootstocks and plant growth regulator in promoting growth of grapevine seedling cv. Prabu Bestari. The study was conducted in Tlekung Experimental Garden, East Java. It employed factorial Completely Randomized Design with 2 factors and 3 replications. The first factor was the rootstock variation that consisted of 3 levels, namely Banjarsari 30, Banjarsari 5, and Banjarsari 8. The second factor was plant growth regulator consisting of 5 levels, namely Rootone-F, Shallot Extract, Young Coconut Water, Java Turmeric Extract, and Control. The findings showed that Banjarsari 30 as rootstock and Rootone-F as growth regulator gave the best response in growth of grapevine seedling cv. Prabu Bestari.

KEY WORDS

Rootone-F, cutting, grafting, root growth.

Indonesia is rich in biodiversity as well as various types of agro-ecosystems and agro-climate that have positive impact towards tropical and subtropical fruit commodities. Grape (*Vitis vinifera* L.) is an introduced plant species widely cultivated in East Java. Red Prince grape came from Australia and in Indonesia, the grape is known as Prabu Bestari. This variety is cultivated in both East Java and Bali. Prabu Bestari grape is reddish and shiny, slightly oval and sweet. One grapevine can produce between 10 and 30 kg of grapes. Furthermore, this grape can potentially be used as raw material for fruit juice (Andrini, 2006; Krismawati and Prahardini, 2011). Prabu Bestari grape business is quite promising in which the ratio between benefit and cost is 1.85 (Maulidah and Pratiwi, 2010).

Successful grapevine cultivation begins with good quality of seeds. The most frequent propagation method for grapevines is stem cuttings with 2-3 healthy buds, with success rate of more than 80% (Krismawati and Prahardini, 2011). In addition to cuttings, grafting is another propagation method widely practiced; grafting is to join grapevine's rootstock and its young shoots. Taking into account of the advantages and disadvantages of both techniques, experts in agriculture develop a propagation technique for grapevines by combining between cuttings (as rootstock) and grafting (as scion), this technique is known as cuttings-grafting. Some advantages of cuttings-grafting are using plants that have thick roots as rootstocks so that the plants can be planted firmly as well as promoting growth of fruit and production (Sugiyatno and Sukadi, 2017). It is important to pay a close attention to lower and upper stem compatibility. Sudjijo (2009) stated that compatibility between the rootstock and upper stem is the criterion for good grafting seed. Successful grafting is characterized by the joint between the upper and lower stem and growth rate of the seed.

Growth regulators are applied to promote growth of plant. Plant growth regulator (PGR) is a group of chemicals used to control plant growth or other physiological functions of the plant (Sharma, 2015). Based on its source, PGR can be divided into natural and synthetic PGR. Natural PGR is available in the nature and derived from organic materials such as coconut

water, dairy cow urine, green bean sprout extract, shallot tuber extract, bamboo shoot extract, and banana weevil extract (Leovici et al., 2014; Kurniati et al., 2017). As natural PGR, 20% of shallot extract was able to accelerate bud initiation time and increase length of grapevine roots (Diana, 2014), while 50% of shallot extract promoted length of shoots and number of leaf of grapevine (Utami et al., 2016). Besides shallot extract, it is reported that 20% of young coconut water promoted growth and accelerated bud initiation and all variables of Alphonso Laval grapevine vegetative growth (Wahyuningtyas et al., 2017). Curcumin extracted from turmeric has a fungicidal effect towards phytopathogenic fungi on a greenhouse scale (Kim et al., 2003) and in vitro culture (Upendra et al., 2011). However, none of the previous related studies discussed application of curcumin as a growth regulator.

Cutting-grafting method can be developed to accelerate production process and increase quality of Prabu Bestari grapevine seedling. This study discussed the effect of rootstocks and plant growth regulator in increasing Prabu Bestari grapevine growth.

METHODS OF RESEARCH

The study was conducted from March to June, 2016 in Tlekung Experimental Garden, Indonesian Citrus and Subtropical Fruits Research Institute, located at 900 m above sea level. The materials were Banjarsari 30, Banjarsari 5, and Banjarsari 8 grapevine stems for rootstock and Prabu Bestari grapevine stems for scion. These materials were collected from Banjarsari Experimental Garden, Indonesian Citrus and Subtropical Fruits Research Institute, located in Probolinggo, East Java. The growth regulating substances were Rootone-F, shallot extract, young coconut water, and java turmeric extract. The planting media were mixture of river sand deposits, manure, and husk with ratio of 2: 1: 1. The media were placed in a 13 cm x 20 cm polybag. Fungicide was applied onto the media 3 days before planting.

The experiment began by preparing the rootstock and upper stem for cuttings. The brown and woody branches were cut into a 20-25 cm long branch (3-4 buds) for the rootstock and a 5-10 cm long branch (1 bud) for the upper stem. Grafting was conducted by making a cut of 2-3 cm in the middle of the branch and slashing the rootstock for about 2-3 cm. The following procedure was to insert the upper stem cutting to rootstock and wrap them tightly with plastic. The upper stem was dipped into paraffin solution to reduce evaporation. Before planting, the cutting-grafting was dipped in PGR solution, namely Rootone-F paste, 10% shallot extract, 10% coconut water and 10% java turmeric extract. Shallot and java turmeric were put into a blender and sieved to get the shallot extract and java turmeric extract. The extract was a stock solution with concentration of 100%. Every 100 ml of the stock solution was diluted with 900 ml of water to make a solution with concentration of 10%. The young coconut water consisted of 100 ml of young coconut water and 900 ml of water. After being soaked in the PGR solution, the cutting-grafting was planted in polybags that were arranged on a shelf and covered with paranet.

The study employed factorial Completely Randomized Design where the first factor was the rootstock and the second factor was growth regulator. The rootstock consisted of 3 levels, namely Banjarsari 30, Banjarsari 5, and Banjarsari 8, while the growth regulator consisted of 5 levels, namely Rootone-F, shallot extract, young coconut water, java turmeric extract, and control (without PGR). There were 15 combinations in total and each combination was replicated 3 times. Each combination involved 4 plants making 180 plants in total. The data analysis method was F-test. When the result of the F-test was significant, Duncan's Multiple Range Test with 95% level of confidence was conducted. Statistical software used to analyze the data was SAS version 9.0.

The variables observed were bud bursting time, shoot length, number of leaves, shoot diameter, number of roots, root length, root weight, and percentage of successful grafting (grow and germinate). Plant growth observation was carried out every 2 weeks until 12 weeks after

planting (WAP). Observation of bud bursting time was carried out every day, while root length, root weight, and percentage of successful grafting were observed at the end of the study.

RESULTS OF STUDY

Observation towards growth of the grapevine showed that the rootstocks caused a significant increase in the shoot length from week 6. In addition, the growth regulator increased the shoot length, and number, length and weight of the roots starting from week 4. Interaction between the rootstocks and growth regulator increased the shoot length starting from week 4. However, neither the rootstocks nor growth regulator application and their interaction influence percentage of successful grafting, bud bursting time, number of leaves, and shoot diameter.

Without the growth regulator, percentage of successful grafting of Prabu Bestari grapevine with rootstocks of Banjarsari 30, Banjarsari 5 and Banjarsari 8 were 75.00%, 75.00% and 83.00%, respectively. Application of plant growth regulators changed the percentage of successful grafting into 77.25%, 91.50%, and 79.00%. Application of plant growth regulators combined either with Banjarsari 30 or Banjarsari 5 rootstocks help increasing percentage of successful grafting (Table 1).

Table 1 – Percentage of successful grafting and bud bursting time of Prabu Bestari grapevine with different rootstocks and PGR

Treatments	Percentage of Successful Grafting	Bud Burst (Days After Planting)
Rootstocks		
Banjarsari 30	76.67 ± 17.59	18.38 ± 7.66
Banjarsari 5	88.33 ± 18.58	20.68 ± 7.00
Banjarsari 8	80.00 ± 21.55	23.88 ± 6.71
PGR		
Rootone-F	77.78 ± 26.35	18.56 ± 8.05
Shallot	86.11 ± 13.18	23.76 ± 4.67
Coconut water	86.11 ± 18.16	20.90 ± 9.39
Java turmeric	80.56 ± 20.83	19.78 ± 8.13
Control (No PGR)	77.78 ± 19.54	21.91 ± 6.07
Interaction	ns	ns

Description: ns: not significant.

Table 2 – Shoot length of Prabu Bestari grapevine seedling with different rootstocks and PGR

Treatment	Plant Age (Weeks After Planting)					
	2	4	6	8	10	12
	Shoot Length (cm)					
Rootstocks						
Banjarsari 30	0.72 ± 1.17	3.07 ± 2.25	4.45 ± 1.79 a	6.18 ± 2.60 a	8.51 ± 3.15 a	10.86 ± 3.64 a
Banjarsari 5	0.93 ± 0.81	2.42 ± 1.27	3.70 ± 1.43 ab	5.32 ± 1.56 b	7.31 ± 1.85 b	9.57 ± 2.27 b
Banjarsari 8	0.83 ± 0.77	2.20 ± 1.18	3.63 ± 1.04 b	5.04 ± 1.07 b	6.81 ± 1.04 b	8.62 ± 0.88 c
PGR						
Rootone-F	1.36 ± 1.25	3.95 ± 2.14 a	5.00 ± 1.44 a	7.33 ± 2.13 a	9.77 ± 2.63 a	12.24 ± 3.09 a
Shallot	1.15 ± 0.87	3.11 ± 2.01 ab	4.75 ± 1.98 a	6.20 ± 2.36 b	8.49 ± 2.76 b	10.95 ± 3.31 b
Coconut water	0.45 ± 0.61	2.16 ± 0.49 bc	3.52 ± 0.82 b	4.50 ± 0.39 cd	6.39 ± 0.60 c	8.50 ± 0.73 c
Java turmeric	0.56 ± 0.66	1.97 ± 0.71 bc	3.42 ± 0.85 b	5.25 ± 0.82 c	7.00 ± 0.85 c	8.84 ± 0.63 c
Control (No PGR)	0.62 ± 0.87	1.61 ± 1.19 c	2.94 ± 0.90 b	4.29 ± 1.11 d	6.08 ± 1.25 c	7.86 ± 1.21 c
Interaction	ns	**	**	**	**	**

Description: Values followed by the same letter at the same column were not significantly different based on DMRT with 95% level of confidence.; ns: not significant; **: significant based on DMRT with 99% level of confidence.

Buds of Prabu Bestari grapevine with rootstock of either Banjarsari 30, Banjarsari 5, or Banjarsari 8 combined without PGR bursted at 23.89, 16.33, and 25.50 days after planting

(DAP) consecutively. With PGR, their bud bursted at 17.00, 21.77, and 23.47 DAP respectively. Combination of PGR either with Banjarsari 30 or Banjarsari 8 rootstocks accelerated bud burst (Table 1).

The rootstocks, application of plant growth regulator and combination between the two have positive influence towards the length of Prabu Bestari grapevine shoot. Banjarsari 30 as rootstock and Rootone-F as PGR resulted in the longest shoot in the 8, 10, and 12 WAP (Table 2). Banjarsari 30 and the shallot extract grew the shoot up to 15.00 cm in the 12 WAP; however, the result does not have significant difference from those of the combination between Rootone-F and Banjarsari 30 or Banjarsari 5; the last two combinations grew the shoot to 14.76 cm and 13.48 cm, respectively (Table 3).

Table 3 – Interaction between different rootstocks and PGR towards shoot length of Prabu Bestari grapevine seedling

Treatment		Plant Age (Weeks After Planting)									
Rootstocks	PGR	4		6		8		10		12	
Banjarsari 30	Rootone-F	6.33 ± 0.47	a	6.27 ± 0.53	a	8.91 ± 0.66	a	11.91 ± 1.44	a	14.76 ± 0.84	a
		4.73 ± 0.83	a	6.42 ± 0.32	a	9.15 ± 1.20	a	11.90 ± 1.50	a	15.00 ± 1.75	a
	Shallot	2.00 ± 0.20	c	3.64 ± 1.09	b	4.37 ± 0.69	cd	6.75 ± 0.63	b	9.03 ± 0.80	b
		1.53 ± 0.71	c	3.58 ± 0.98	b	5.34 ± 0.24	bc	7.37 ± 0.60	b	9.08 ± 0.35	b
	Coconut water	0.75 ± 0.65	d	2.35 ± 0.46	c	3.10 ± 0.42	d	4.59 ± 0.35	c	6.40 ± 0.39	c
		0.71 ± 0.65	d	0.98 ± 0.46	c	0.24 ± 0.42	d	0.60 ± 0.35	c	0.35 ± 0.39	c
Banjarsari 5	Rootone-F	3.30 ± 0.70	b	5.34 ± 0.25	a	8.19 ± 0.05	a	10.59 ± 1.16	a	13.48 ± 1.46	a
		2.23 ± 2.75	c	3.86 ± 2.48	b	4.68 ± 0.90	bc	6.69 ± 1.17	b	9.12 ± 1.84	b
	Shallot	2.49 ± 0.53	c	3.41 ± 0.91	b	4.60 ± 0.09	bc	6.36 ± 0.36	b	8.35 ± 0.81	b
		2.05 ± 0.96	c	2.68 ± 0.09	c	4.38 ± 0.33	cd	6.07 ± 0.19	b	8.13 ± 0.25	b
	Coconut water	2.00 ± 0.59	c	3.20 ± 1.03	c	4.77 ± 0.76	bc	6.86 ± 0.59	b	8.76 ± 0.48	b
		0.59 ± 1.80	d	1.03 ± 1.08	c	0.76 ± 0.96	bc	0.59 ± 0.87	b	0.48 ± 0.80	b
Banjarsari 8	Rootone-F	2.22 ± 1.98	c	3.40 ± 1.23	b	4.90 ± 1.99	bc	6.82 ± 1.84	b	8.50 ± 1.60	b
		2.36 ± 1.39	c	3.95 ± 1.77	b	4.77 ± 0.70	bc	6.87 ± 0.82	b	8.74 ± 0.79	b
	Shallot	2.00 ± 0.62	c	3.51 ± 0.77	b	4.52 ± 0.28	bc	6.05 ± 0.73	b	8.12 ± 0.41	b
		2.32 ± 0.37	c	4.02 ± 0.73	b	6.02 ± 0.73	b	7.54 ± 0.73	b	9.31 ± 0.47	b
	Coconut water	2.07 ± 1.80	c	3.26 ± 1.08	c	5.00 ± 0.96	bc	6.78 ± 0.87	b	8.42 ± 0.80	b
		1.80 ± 1.80	d	1.08 ± 1.08	c	0.96 ± 0.96	bc	0.87 ± 0.87	b	0.80 ± 0.80	b

Description: Values followed by the same letter at the same column were not significantly different based on DMRT with 95% level of confidence.

Application of the growth regulators resulted in number of leaves of Prabu Bestari seedling in the 12 WAP were 11.52, 12.51, and 12.21, consecutively. Without the growth regulator, number of leaves of the Prabu Bestari grapevine with Banjarsari 30, Banjarsari 5, and Banjarsari 8 rootstocks in the 12 WAP were 10.33, 13.00, and 10.11, respectively. In general, application of growth regulator either with Banjarsari 30 or Banjarsari 8 rootstocks increased the number of Prabu Bestari grapevine seedlings leaves (Figure 1).

Figure 1 – Number of leaves of the Prabu Bestari grapevine seedling affected by different rootstocks and PGR WAP: Weeks After Planting

Without the growth regulators, Prabu Bestari grapevine seedling with Banjarsari 30, Banjarsari 5, and Banjarsari 8 rootstock had shoot with diameters of 3.12, 3.58, and 3.67 mm respectively on 12 WAP. With application of the growth regulators, the shoot diameters on 12 WAP were 3.55, 3.59, and 3.55 consecutively (Figure 2). The findings are at the opposite of Köse et al., (2014) and Somkuwar et al. (2014; 2015)'s that certain type of rootstocks increase grapevine diameter. Bidabadi et al. (2018) reported that combination between auxin and cytokinin increase rootstock diameter.

At the end of the experiment, application of growth regulator increase number of roots as well as length and weight of the roots. Rootone-F, shallot extract and coconut water enable seedling roots to grow longer compared to those without any growth regulator application. Java turmeric extract cannot increase number, length and weight of Prabu Bestari seedling roots (Table 4).

Figure 2 – Shoot diameter of Prabu Bestari grapevine seedling affected by different rootstocks and PGR
WAP: Weeks After Planting

Table 4 – Characteristics of Prabu Bestari grapevine roots with different rootstocks and PGR

Treatment	Number of Roots	Root Length (cm)	Root Weight (g)
Rootstocks			
Banjarsari 30	28.01 ± 7.56	25.04 ± 7.23	15.05 ± 3.65
Banjarsari 5	26.03 ± 6.20	25.63 ± 4.06	14.50 ± 2.78
Banjarsari 8	27.41 ± 4.75	23.14 ± 4.78	15.01 ± 4.38
PGR			
Rootone-F	29.83 ± 6.41 a	26.93 ± 6.25 ab	16.45 ± 4.49 a
Shallot	29.63 ± 7.90 a	28.41 ± 5.77 a	16.01 ± 4.45 a
Coconut water	29.82 ± 4.61 a	25.32 ± 2.74 ab	16.05 ± 2.33 a
Java turmeric	24.68 ± 4.24 ab	22.88 ± 3.92 bc	14.04 ± 1.47 ab
Control (No PGR)	21.78 ± 2.32 b	19.47 ± 3.91 c	11.72 ± 2.33 b
Interaction	ns	ns	ns

Description: Values followed by the same letter at the same column were not significantly different based on DMRT with 95% level of confidence; ns: not significant.

DISCUSSION OF RESULTS

Suitable rootstocks increase plant response towards biotic and abiotic stress (Toumi et al., 2007; Somkuwar et al., 2014). Rootstocks connect the upper stem and the soil and also influence their connection. Strong and disease-resistant rootstocks can support shoot growth and increase yield (Pulko et al., 2012; Aly et al., 2015). It is reported that growth hormone can influence growth of seeds and flowering (Khurshid et al., 1992), increase production (Kassem et al., 2011), and improve quality of fruits (Ovadia et al., 2013; Dimovska et al., 2014). Rootone-F is a synthetic growth regulator which consists of IBA and NAA as the active ingredients and is categorized as auxin hormone. Shallot extract contains auxin and a little cytokinin, gibberellins and abscisic acid (Okukpe et al., 2012) while coconut water contains phytohormone of, based on the highest to the lowest concentration, auxin, gibberellin, abscisic acid and cytokinin (Tan et al., 2014).

Once the rootstocks touched the upper stem, the cambial area conducts meristematic activity that produces callus and parenchymal tissue which fills space between the rootstocks and upper stem (Wang and Kollmann, 1996). Higher percentage of successful grafting may be due to actively-developed meristem stage in both the rootstocks and the shoot, forming callus. Vascular connection between the rootstocks and the shoot can determine water and nutrients translocation, influence other physiological characteristics, and increase successful rate of grafting (Martínez-Ballesta et al., 2010; Vršič et al., 2015). Bidabadi et al. (2018) combined auxin and cytokinin to increase callus formation in grapevine cuttings. Köse and Güleriyüz (2006) reported that auxin application reduced growth rate of grapevine cuttings while, cytokinin increased callus formation in the area where the rootstocks and the shoot met. Auxin was unable to increase callus formation and therefore, decreasing the growth of plant. In this study, application of plant growth regulator is done to promote growth of the grapevine roots and then support growth of the upper stem.

Bud burst is influenced by nutrients in the shoot that act as supply and help the shoot growing more particularly in the early stage of its growth (El-Gendy, 2013; Somkuwar et al., 2015). Findings of Aly et al. (2015) who studied Flame seedless, Superior seedless, and Thompson seedless grapes are in line with this study in which different rootstocks did not have any influence towards the bud burst.

Grapevine seed growth is different depending on the level of callus and roots development, as well as rootstock genotype. Genetically, characteristics of rootstock have influence towards vegetative growth through root distribution, water efficiency and nutrient uptake (Basheer-Salimia dan Hamdan, 2009). Çelik (2000) explained that length of upper stem shoot determines quality of the grafting process and quality of grafted seedling. Application of auxin and cytokinin increase the shoot length of Asgari seedless grapevine (Bidabadi et al., 2018). Java turmeric extract, coconut water and control treatments produced grapevine shoot of the same length. In contrast to the findings of this study, coconut water increased the shoot length of Alphonso Laval grapevine (Wahyuningtyas et al., 2017) while shallot extract did not have influence towards the shoot length of grapevines (Utami et al., 2016).

Hifny et al. (2016)'s study is in line with the study where rootstocks did not have any influence towards number of leaves. Nevertheless, Mahmoudzadeh (2015) and Somkuwar et al. (2015) reported that rootstocks increased number of leaves and leaf surface area. Coconut water and shallot can increase number of grapevine seedlings leaves (Diana, 2014; Wahyuningtyas et al., 2017).

Auxin plays a role in cell lengthening and division. It is also used to stimulate rooting quickly and productively in various types of cuttings, for example woody plants, shrubs and bushes (Rademacher, 2015; Bisht et al., 2018). Shallot and coconut water increased number and length of grapevine roots (Diana, 2014; Wahyuningtyas et al., 2017). Application of IBA and NAA also increased quality of grapevine roots (Köse and Güleriyüz, 2006).

In conclusion, Banjarsari 30 as rootstocks and Rootone-F as growth regulator increased grapevine seedling var. Prabu Bestari's growth. Java turmeric extract was unable to promote the growth of the grapevine seedling var. Prabu Bestari's growth.

ACKNOWLEDGMENTS

The authors would like to thank Mr. Sukadi, a technician at Indonesian Citrus and Subtropical Fruits Research Institute for his assistance during data collection and technical plant management.

CONFLICT OF INTERESTS

The authors report no conflict of interests.

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