Effect of rootstock variety, cut surface and grafting time on graft success of *Mangifera indica* L. var. wirasangka

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**Abstract.** *Mangifera indica* L. var. *wirasangka* is a local variety of Tegal Regency. It is rarely planted due to the limited number of seedling. The research aimed to develop an effective shoot grafting method. The study was conducted experimentally with a factorial completely randomized design of three factors. The first factor was mango variety for rootstock (*keong* mango and *santok* mango). The second factor was cut surface shape (cleft, splice, and side-veneer graft). The third was time of grafting (morning and afternoon). The observed were the number of shoots, the shoot length, the number of leaves, and the percentage of success graft. Data were analysed using Analyses of Variance and LSD test. The results showed that variety of rootstock did not affect the success graft, but affected the growth of scion. The cut surface affected the success graft and growth of scion. In contrast, grafting time did not affect the success graft and growth of scion. Cleft graft were most effective for grafting of *wirasangka* mango. Based on the result it was recommended that the success shoot grafting of *wirasangka* mango can use *keong* and *santok* varieties, grafted using the cleft surface and done in the morning or afternoon.

**1. Introduction**

Mango is one of the most popular fruit plants and is spread throughout the world. Mango consists of hundreds of varieties, each of which has specific properties [1]. The *wirasangka* mango is one of the many varieties mango in Indonesia. It has been declared by the Center of Variety Protection and Plant Registration of Agriculture Ministry of Republic of Indonesia as a local plant and belongs to the people of Tegal Regency, Central Java. However, only a few people of Tegal Regency plant it. The number of trees in the entire district area is only around 130 trees (observation results, 2020). This fact is caused by the difficulty of *wirasangka* mango to vegetative propagate. Generative reproduction is not desired by the community because it takes a long time to fruit.

Shoot grafting is a vegetative propagation technique that is proven effective on various types of fruit tree, including mangoes. The shoot grafting involves the joining of scion and rootstock where the rootstock develops into the root system while the scion develops the upper fruiting part of the grafted tree [2]. The success of mango shoot grafting is influenced by several kinds, including variety [3], the time [4-5], and the shape of the stem cut surface [6-8]. Alignment between scion and root stock is important in reducing the failure of shoot grafting [9].

There are various shapes of cut surface including cleft, splice, and side-veneer shapes. Various studies have shown different results from one to another. Generally, both the main and the interaction effects of grafting time with surface cut have a significant influence on days to graft success of mango
[2]. The veneer method is most suitable for mangoes with a stem diameter of 5 cm [4], whereas the cleft graft is better than the splice [6]. Three grafting techniques (cleft, splice and veneer) were evaluated for some indicators of shoot, leaf and graft success, and the results showed no significant difference [7]. The splice graft with 40-100 mm cut surface lengths results 80% of graft success for mango [9].

The optimal shoot grafting technique for wirasangka mango is currently unknown. This study aims to analyze the effect of variety of rootstock, cut surface shape and grafting time on wirasangka mango on the success of shoot grafting. The problems to be solved in this research were 1) the effect of rootstock variety, cut surface shape and grafting time on the success of shoot graft, 2) the effect of rootstock variety, cut surface shape and grafting time on scion growth, and 3) the effective treatment combinations for successful shoot grafting and growth of wirasangka mango scion. The results of this study are useful for obtaining large amounts of wirasangka mango seedling to increase the population so that it was suitable as an typical plant for Tegal Regency.

2. Methods
The plant material in this study were 1) wirasangka mango shoots as source of scion from trees grown at Procot, Slawi District, Tegal Regency, Central of Java; and 2) seedlings of keong and santok mangoes as source of rootstocks from Sidokerto Horticultural Development Center, Pati, Central of Java. The seedlings were grown from seeds, about 5 months old with a stem diameter of 8-9 mm and a height of about 50 cm. The research was conducted in a shady house in Semarang City in September – November 2020 or the rainy season; with an average temperature in the morning of 32.48°C and in the afternoon of 31.16°C, and humidity in the morning 54, 40% and 60.89% in the afternoon.

The research was conducted experimentally using a three-factor factorial completely randomized design. The first factor was the mango variety for rootstock, consisting of two varieties, namely keong and santok. The second factor was the cut surface which consists of three types, namely cleft, splice and side-veenner (Figures 1A, 1B, 1C). The third was the implementation grafting time, consisted of two types, namely morning and afternoon. There were 12 kinds of treatment combinations. The experimental units were repeated three times.

The scions were selected from a parent tree of wirasangka mango which has superior characteristics in the form of young shoots that have complete buds. The young shoots had straight buds, the diameter was appropriate to the rootstock, and free from disease and pest attacks. They were cut 12 cm in length and the leaves were removed. Then the base of them was wrapped in wet cotton, and put in an airtight plastic wrap. The rootstocks of santok mango and keong mango were cut according to the surface treatment. The grafting process was carried out in the morning at 07.00-11.00 AM or in the afternoon at 15.00-18.00 PM according to the treatment. The scions were carefully attached to each rootstock so that the cambiums of the two can touch. After that, the two joints are tied with plastic wrap, covered with a transparent plastic bag to reduce evaporation and keep the air humidity around the joint. The experimental units were arranged randomly according to the experimental design and placed in a shady house. When the scion sprouts about 3 cm high, the plastic grafting cover was opened gradually. The rootstocks were maintained in moist conditions and watered sufficiently. The leaves growing on the rootstock were removed in order to focused food and energy on successful grafting and scion.

The data observed were the number of shoots, shoot height, number of leaves, and the percentage of successful grafting. Observations were made at week-9 after grafting. Data were analyzed using Analysis of Variance and the least significant difference (LSD) test.
3. Results and discussion
The results showed that the success of shoot grafting varied among treatment combinations. In general, rootstock varieties and grafting time have no effect, while the cut surface affects the success of shoot grafting. Cleft grafting carried out on the rootstock of santok mango in the morning or evening resulted in 100% success of shoot grafting at week 9. In contrast, grafting on keong mango variety with side-veneer grafts carried out in the afternoon did not show successful grafting until week 9 (Figure 2).

Rootstock varieties that had no effect on the success of grafting indicated that the both of santok and keong mangoes could be used as rootstocks for wirasangka mango shoot graft. This is possible because of the close kinship of those causing the anatomical structure of their stems to be similar and the fusion of the cambium can occur properly. The basic principle of successful shoot grafting is the fusion of the rootstock cambium and scion. For the formation of the fusion between the rootstock and scion, cambium is very important because it causes wound healing on the stem [10]. The fusion process includes the formation of callus in the scion cambium and rootstock, the formation and fusion of parenchyma cells, the differentiation of certain parenchyma cells to form cortical tissue, and the formation of new xylem and phloem by the cambium. As a result, water and nutrients can move from the rootstock and scion or vice versa [11]. Callus is a group of cells that actively carry out cell division and plasma addition. Therefore it can enlarge and form an organized cell mass. The formation of callus on the injured part is caused by the accumulation of the results of assimilation on the wound part of the two stems of the plant which still had the assimilation reserves from the previous parent plant [11].

The results showed that the number of shoots, shoot length, and the number of leaves formed on the wirasangka mango scion varied between treatment combinations. The results of the analysis showed that rootstock varieties affected the number of shoots, shoot length and number of leaves. In general, the number of shoots grown, shoot length and number of leaves on the scion with rootstock of
the *santok* variety were better than that of the *keong* varieties (Table 1, Figures 3A, 3B). In shoot grafting, the close kinship of the varieties used for rootstock affects the grafting. The close kinship causes the similarity of the anatomical and physiological structures of the plant, thereby facilitating the linkage process between the two stems [11-12].

![Figure 3. Shoot growth on the wirasangka mango scion. (a) Using *santok* mango rootstock, (b) Using mango *keong* rootstock](image)

The result of data analysis showed that the cut surface affected shoot growth, shoot length and number of leaves. In general, the number of shoot, shoot length and number of leaves in the cleft graft treatment was best compared to other treatments (Table 1). The cleft graft make a very secure graft with a lot of surface area contact between the scion and rootstock. It is used to connect thin pieces of stock and scion, usually roughly pencil-thick. Compared to the splice graft, the cleft graft was stronger, because the interlocking tongues are held under compression by the natural elasticity of the wood of both the stock and scion. This naturally generates the pressure needed for the graft union formation. The additional length of the vascular cambium exposed along the cut surfaces of a cleft graft is much greater than the length of cambium exposed by only splice graft. This results in greater cambial contact between stock and scion of a cleft than of a splice graft [6, 13, 14]. The alignment of the cambium tissue between the scion and the rootstock is important in reducing the failure of shoot grafting techniques [9, 15]. The same diameter size of the scion and rootstock causes the cambium of both to adhere perfectly through the formation of callus so that the process of joining the tissues of the two stems is more perfect and the process of nutrient flow from the rootstock is good.

The grafting time had no effect on number of shoot, shoot length and number of leaves. Several scion growth variables performed in the morning were not significantly different from those performed in the afternoon. Presumably this was because the environmental conditions in the morning and evening are relatively the same.

The other studies show the opposite results. The higher number of shoots is obtained in the afternoon grafting time compared to morning (10, 15). The low percentage of grafting in the morning was related to the large transpiration rate compared to grafting in the afternoon. The transpiration rate in the morning to noon takes place at high rate, as a result the scion cells or tissues reduce the amount of water and their turgor. However, the implementation of this study was in the rainy season, so that the transpiration rate was not high and almost the same as in the afternoon. Therefore, the water potential in the scion connected in the morning was not significantly different from the afternoon.

Based on such results it can be stated that the both *santok* mango and *keong* mango can be used as the rootstock for grafting *wirasangka* mango, even though the rate of scion growth is different. The cleft cut was the best or suitable for successful shoot grafting and scion growth. The implementation time in the morning and evening resulted in the success of grafting and scion growth which were not significantly different. Based on the result it was stated that to achieve mango 'wirasangka' success shoot grafting was recommended to use *keong* and *santok* mango varieties as rootstocks, grafted using the cleft surface and done in the morning or afternoon at rainy weather.
Table 1. The number of shoots, shoot length, number of leaves at the 9th week.

| Variety of rootstock (V) | Grafting time (T) | Cut surface form (S) | Mean of shoot number/scion | Mean of shoot length (cm) | Mean of leaf number/scion |
|-------------------------|-------------------|---------------------|-----------------------------|---------------------------|---------------------------|
|                         |                   | Cleft (S1)          | Splice (S2)                  | Side veneer (S3)          |                           |
| Santok (V1)             | Morning (T1)      | 1.00 Aa             | 0.67 Ab                     | 0.33 Bc                   |                           |
|                         | Afternoon (T2)    | 1.33 Aa             | 0.67 Ab                     | 0.67 Ab                   |                           |
| Keong (V2)              | Morning (T1)      | 0.33 Ca             | 0.33 Ba                     | 0.33 Ba                   |                           |
|                         | Afternoon (T2)    | 0.67 Ba             | 0.33 Bb                     | 0.00 Cc                   |                           |
| Santok                  | Morning (T1)      | 5.03 Aa             | 2.97 Ab                     | 0.23 Cb                   |                           |
|                         | Afternoon (T2)    | 5.47 Aa             | 2.60 Ab                     | 3.27 Ab                   |                           |
| Keong                   | Morning (T1)      | 1.67 Ba             | 0.17 Bc                     | 1.00 Bb                   |                           |
|                         | Afternoon (T2)    | 2.17 Ba             | 0.27 Bb                     | 0.00 Cb                   |                           |

Data followed by the same uppercase in a column within the same parameter were not significantly different at 0.05
Data followed by the same lowercase in a row were not significantly different at 0.05

4. Conclusion
It was concluded that the variety of rootstock did not affect the success graft, but affected the growth of scion. The cut surface affected the success graft and growth of scion. In contrast, grafting time did not affect the success graft and growth of scion. Cleft graft were the most effective for grafting of wirasangka mango.

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