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A Literature Survey on Plant Grafting Technology and Internet of Things Solutions

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Abstract

Hundreds of works have been reported related to the agricultural technology. This paper can be regarded as an initial effort to summarize great works performed by researcher and scientists. First, we provide the works on the effect of rootstock choices. Second, the budding factor is presented by summarizing the works on the field. Finally, the success rate and feasibility of each technique is presented.

Keywords*: agriculture, plantation, grafting, citrus, rootstock, IoT*

Abstrak

Ratusan karya ilmiah telah dilaporkan terkait dengan teknologi pertanian. Makalah ini dapat dikatakan sebagai upaya awal untuk merangkum karya-karya besar yang dilakukan oleh para peneliti dan ilmuwan. Pertama, kami memberikan karya tentang efek pilihan batang bawah. Kedua, faktor awal pertumbuhan sambungan dihadirkan dengan meringkas karya-karya ilmiah di bidang ini. Akhirnya, tingkat keberhasilan dan kelayakan setiap teknik penyambungan disajikan.

Kata kunci*: pertanian, perkebunan, okulasi, jeruk, batang bawah, IoT*

1. INTRODUCTION

As an agricultural country, Indonesia indicates that the agricultural sector plays an important role in the majority of national economy [1]. It can be easily seen from the number of citizen or workers who work in the agricultural sector. As an agricultural country, Indonesia is gifted with large number of natural resources. Moreover, Indonesia has a strategic location. The location is considered very strategic. From a geographical point of view, Indonesia is lied in a tropical area with high rainfall [2]. This condition makes Indonesia have fertile soil and many types of plants that can grow quickly. As a favorite fruit, orange or citrus has so many variants. This work present the summary of works related to technology usage for citrus plant treatment [3].

Indonesia is one of the countries with the largest population in the world. One of the important needs of people in Indonesia is food [4]. The development of agriculture and plantations in Indonesia is not only required to produce agricultural and plantation products that are highly competitive but also capable of developing regional growth and community empowerment [5].

The main obstacle in the agriculture and plantation sectors to provide raw materials for food-based industries is the limited land for plantation agriculture. In Indonesia, the problem is quite complicated. This is caused by several factors, including local products that do not meet the specifications of

the food industry, limited production, and changes in consumer tastes [6]. Whereas the availability of agricultural and plantation products needs to be maintained to support the continuity of food-based industries [7].

So far, the availability of citrus fruits in Indonesia has not been sufficient [8]. According to the Central Statistics Agency [7], Indonesia's citrus fruit production in 2012 was 1,611,784 tons, while in 2013 it decreased to only 1,411,229 tons. This is due to the decreasing availability of production land [7]. According to [9], the key to successful fruit development is largely determined by the availability of quality seeds. So far, the monitoring of grafting temperature and humidity has been done manually. To make it easier for farmers to monitor soil temperature and humidity around large plantations, a tool is needed that can inform these conditions. Internet of Things (IoT) has been widely used for agriculture like watering [10], soil monitoring [11], and harvesting [12].

2. RELATED WORKS

Article [3] grafted local citrus (Japanese Citroen) and Rough Lemon as rootstock. The use of Rough Lemon rootstock gave better results on the number of leaves, shoot length, bud break time, and shoot diameter than Japanese Citroen. Both rootstocks used gave the same effect on the percentage of growing Siam Madu orange seedlings.

The storage period of different shoots did not affect the growth of Siamese honey seedlings from grafting. The interaction between the type of rootstock and the storage period of the buds affected the bud break time of the Siam Honey citrus plant. The shoots using Rough Lemon rootstock are more compatible than using Japanese Citroen rootstock. According to Bramasto et al. [13] if the shoots used quickly adjust to the rootstock, the supply of nutrients and photosynthesis results runs smoothly so that plant growth becomes optimal.

Article [14] conducted a test with the aim of knowing the effect of the position of the sticky eye source book and the atonic concentration on the growth of grafted oranges (citrus sp) of the tejakula tangerine variety. The position of the eye patch book had no significant effect ($p>0.05$) on the percentage of live grafting. However, the tendency of the tip source book (Pu) to give the highest percentage of live grafting is 89.58%, or 1.4% higher tend to be compared to the position of the middle patch source book (Pt) which is 88.54% and the source book position. base eye patch (Pp) is 88.54%. This shows that the effect between the position of the sticky eye source book and the application of Atonic concentration does not work together in influencing the growth of citrus grafting shoots. If the effect of the different interactions is not significant, it is better if the position of the eye patch book position and the Atonic concentration are applied separately [15].

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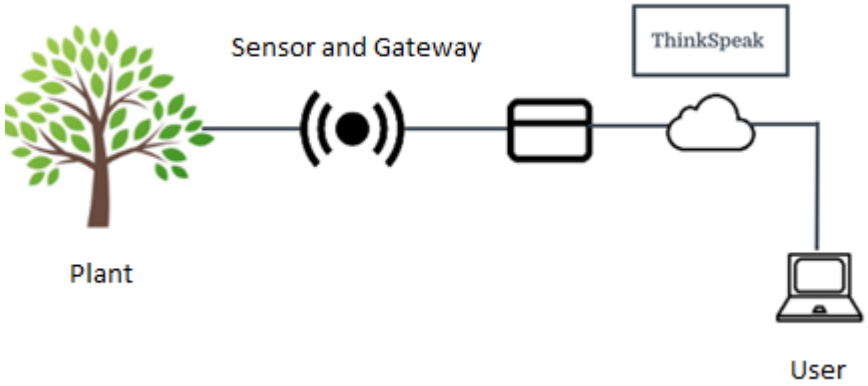

Figure 1. Typical IoT devices for plant monitoring [16]

Article [7] grafted the durian plant "Durio zibethinus Murr" with nasal shoots of the scion and how to cut the rootstock. The aims of this research were to study the exact origin of the shoots for successful grafting, to obtain the appropriate length of cutting rootstock to accelerate the growth of grafting shoots, and to obtain a match between the origin of the scion shoots and cutting the rootstock.

The best bud growth ability of grafting occurs when the stem shoots are used as scion. Cutting the rootstock by cutting 10 cm from the shoot will accelerate the growth of grafting shoots. There will be a match between the origin of the scion shoots and the cutting of the rootstock which encourage the growth of grafting shoots.

End Entres at the beginning of growth, grow faster than middle Entres and Base Entres. Middle Entres provide better growth than tip and base Entres when bud break, first leaf emergence, grafting shoot height, number of leaves, and number of grafts growing.

Article [8] conducted research on the growth of tangerine (Citrus nobilis) buds from grafting on various growing media and the age of Rough Lemon (C. jambhiri) rootstock. The purpose of this study was to evaluate the growth of tangerine (Citrus nobilis) buds from grafting on various growing media and rootstock age of rough lemon (C. jambhiri) using a Completely Randomized Block Design with 2 factors and 3 replications.

According to Manner et al. [17], citrus plants can grow well at pH 5-8. The interaction between the composition of the planting medium and rootstock age significantly affected the parameters of grafting success, namely the percentage of live grafting and the percentage of budding grafting, while the percentage of dormant grafting and shoot growth time were not affected. Live grafting around 37-100%, budding grafting around 33-98%.

The composition of the best growing media for the success of grafting, the increase in length of the scion and the growth of the tangerine scion

resulting from grafting was the planting medium (soil: husk charcoal: vermicompost 1:1:1 v/v/v).

Rough lemon rootstock aged 8 and 11 months resulted in better grafting success and tangerine shoot length growth than rough lemon rootstock aged 14 months. Rough lemon rootstocks aged 14 months produced the best grafted tangerine rootstock growth compared to rough lemon rootstocks aged 8 and 11 months.

Article [18] conducted a study on the effect of Indole Butyric Acid (IBA) and Naphthalene Acetic Acid (NAA) on the success of grafting nutmeg plants. The results showed that the auxin IBA and NAA treatments had a significant effect on the success rate of nutmeg grafting. The administration of IBA and NAA with a dose of 500 ppm each gave the highest grafting success rate, respectively 37.33 and 43.03% at the age of three months after grafting (BSG). Meanwhile, grafting seeds that were not given auxin had a success rate of only 6.73%.

The administration of IBA and NAA did not directly affect the growth of nutmeg plants (plant height, stem circumference and number of leaves) resulting from grafting, its growth was more influenced by the level of compatibility between shoots and rootstock. In compatible grafting results, assimilate translocations, water, hormones and enzymes run smoothly and metabolic processes are optimal so that it will encourage rapid plant growth [19], [20].

Article [21] conducted a study on the effect of suitability of rootstock and scion on cashew grafting. The propagation of cashew plant seeds in Indonesia generally still uses seeds [22]. One of the improvements in cashew productivity is by grafting. For example, in India, low productivity of cashew nuts can be increased by replacing low-yielding crops with grafted seeds of high-yielding varieties. In this way cashew productivity increases by 100-140% [23]. This study included plant height, stem diameter, crown width, and number of branches. At the time of grafting, the scion was of the superior variety and the rootstock of the selected local type. The high success rate of grafting shows that the scion used has the ability (compatibility) to live and grow together into one complete plant [24]. In addition, the high percentage of success achieved in cashew grafting was due to the size and physiological conditions (cell mass and content of biochemical compounds such as carbohydrates, proteins and phytohormone) linked plant parts (entres and rootstock) under optimal conditions [25].

Article [26] conducted a study on the effect of IBA administration on side grafting of sugar apple plants. This study aims to determine the effect of giving IBA at different concentrations and knowing the right concentration in giving IBA to increase the success of side grafting in sugar apple. This study used a non-factorial Completely Randomized Design (CRD) consisting of 5 levels of IBA concentration, namely 0 (control), 50, 100, 150, and 200 ppm with 4 replications. The results showed that giving IBA had a significantly different effect on when shoots appeared. Giving IBA 100 ppm can increase

the number of leaves by 12.43 strands, shoot height by 14.62 cm, and the success of linkage by 95%. Environmental conditions (temperature and humidity) in vegetative propagation of plants greatly affect callus formation and seedling growth. Environmental conditions that are suitable for grafting will play a role in the linking process of rootstock and shoots and make the growth of seedlings develop properly. Temperature affects the growth of plant seeds, this will affect physiological processes in plant tissues [27]. The treatment of IBA with different concentrations on side grafting had a significant effect on the variables of time of shoot emergence, number of leaves, shoot height, percentage of dead shoots, and percentage of finished seedlings. Giving IBA 100 ppm is giving the right concentration to carry out grafting, besides that it also shows the best results on the variables of shoot emergence time, number of leaves, shoot height, and finished seedlings.

Article [28] conducted a study on the success of grafting on several types of scion and rootstock family of cacao (Theobroma cocoa L). Vegetative propagation of cacao plants is generally carried out by the grafting method. Good entres usually have three to four leaves and two to three buds [29]. The grafting is done by inserting entres or young twigs. as scion on other stems as rootstock [30]. Seedlings propagated by the grafting method generally showed different growth performance. The difference in seedling performance was thought to be influenced by the type of rootstock and scion clones used. The purpose of this study was to determine the differences in the performance of several types of rootstock families and several clones of cacao scion on grafted seedlings. The research was arranged in a split plot design. Differences in rootstock families affected the viability, linkage diameter, and shoot height, while the scion cloning factor affected all observed characters. The main parameters that support successful connection in cocoa are rootstock diameter and the ratio between scion and rootstock diameters.

Article [31] conducted a study on the compatibility of rootstock with scion on the grafting method of durian (Durio ziberthinus Murr). In this study using a factorial Randomized Block Design (RBD). Observation parameters include the relationship between the number of leaves and shoot length, the percentage of grafting success, the protein content of plant parts, and the point of connection of the connection. From the results of the study, the treatment of the kelud variety with an entre length of 10 cm gave a higher percentage of durian grafting success compared to other treatments. Based on the results of the analysis of the number of leaves and shoot length, there was no significant interaction, there was a positive and linear relationship between the number of leaves and shoot length.

Article [32] conducted research on the effect of grafting reaction time and temperature on the process of making natural rubber (Maleated Natural Rubber). The purpose of this research is to study the effect of reaction time and temperature of the natural rubber grafting process. The best time in the grafting process is 12 minutes at a temperature of 160oC, with a grafting

degree percentage of 5.21%. The results showed that the reaction kinetics were arranged according to the first order and the highest speed constant of 0.004 min-1 was obtained at a temperature of 155 and 165oC. The activation energy is 6107 cal/mol and the collision frequency is Arrhenius: 4.65, so the equation is:

$$K = 4.65\, e^{-\frac{6071}{RT}} \quad (1)$$

Article [33], [34] conducted a study on the effect of clones and grafting time on the growth and survival percentage of grafting teak (Tectona grandis). The purpose of this study was to determine the effect of clones and grafting time on plant growth in the form of height, diameter, number of grafted leaves, and percentage of grafting life. Clones had a significant effect on the growth in diameter and the percentage of life significantly. The clone with the largest growth in diameter was clone 6 from Wonogiri and the clone with the largest percentage of life as a result of grafting was clone 18 from Wonogiri. The time of grafting had a significant effect on the height, diameter, number of leaves, and the percentage of grafting life. The best time for grafting is September rather than July. And there is no interaction between clones and grafting time.

Article [35] conducted research on the prospect of propagation of superior rubber seedlings by early grafting technique. Procurement of superior seeds by early grafting saves 61% costs compared to the chocolate grafting technique. Availability of water for watering, skilled grafting personnel, preparation of entres on time and in the right number, are the keys to the successful application of early grafting techniques. If these problems can be overcome, then the provision of superior seeds with early grafting techniques will be the best alternative to overcome the increasing demand for seeds. Genetically and physiologically, the quality of rubber seedlings resulting from early grafting remains high so that it can guarantee a high growth rate and yield, although physically the seeds have smaller shoot diameters compared to seeds from chocolate grafting. Availability of sufficient water for watering, skilled grafting personnel, preparation of entres on time and in number, are the keys to success in applying early grafting techniques. The time required to provide superior rubber seedlings from seed sowing until the seedlings are ready to be distributed using the early grafting technique is shorter and the cost of procuring seeds is cheaper than the chocolate grafting technique. Based on the technical and economic aspects, the preparation of superior rubber seeds with early grafting techniques is feasible to be developed on a wide scale so that it can help overcome problems in procuring superior rubber seeds.

Article [36] conducted a study on the effect of buds and clones on the success of grafting and shoot growth on green grafting in polybags. In this study observed the propagation of rubber plants by grafting. This study aims to determine the effect of the type of grafting eye on the percentage of success and growth of shoots produced by green grafting in polybags. The

results showed that for green grafting in polybags, the most suitable eye type was green scale eye (GSE). Although the percentage of success is high (90.5%), shoots growing from GSE are relatively smaller than other types of buds, so maintenance after grafting grows is very important to increase shoot growth. In the condition of insufficient GSE, green grafting in polybags can be done using brown scale eye (BSE) and green leaf eye (GLE) but it is not recommended to use brown leaf eye (BLE). From the results of statistical analysis, it is known that the clone type factor does not significantly affect the percentage of grafting success. For green grafting in polybags, the most suitable eye type is green scale eye (GSE). In conditions of insufficient GSE, green grafting in polybags can be done using brown scale eye (BSE) and GLE but it is not recommended to use BLE. Although the percentage of success is high, shoots growing from GSE are relatively smaller than other types of buds, so maintenance after grafting is very important to increase shoot growth. For large-scale purposes, GSE can be produced by rejuvenating grafted wood gardens.

Articles [37] and [38] conducted a study on the use of BAP on grafting of tangerines (citrus reticulata). The purpose of this study was to determine the effect of administration of BAP on the success of grafting and shoot growth in Borneo Prima and Garut Lowland tangerines. The study was arranged in a factorial complete randomized block design (CRBD) with two factors, namely scion varieties (Borneo Prima and Garut Lowlands) and BAP concentrations (0, 5, 10, 15 ppm), repeated 3 times so that there were 24 experimental units. The experimental data were analyzed statistically with the F test at a 5% significance level and followed by a DMRT follow-up test at a 5% significance level for significantly different values. The results showed that the application of BAP with low concentrations in two varieties of tangerine scion did not give significantly different results on the variables of grafting success and plant shoot growth. This study showed that the application of BAP and differences in scion varieties had no significant effect on the success of grafting tangerines. The interaction between the concentration of BAP and scion varieties also did not significantly affect the success of grafting. The application of BAP with several concentrations in the two varieties of scion showed no significant differences in the 4 parameters of grafting success, namely the percentage of finished grafting, the time to reach 50% of shoot growth, the percentage of dormant seedlings, and the percentage of dead seedlings. Administration of BAP by immersing the scion technique gave no significant results in grafting of tangerines of Borneo Prima and Garut Dataran Lowland varieties. Giving BAP to grafting with a low concentration has not been able to increase the success of grafting and stimulate the growth of buds from grafting.

Article [39] conducted a study on the effect of storage period treatment and entres wrapping materials on the initial growth of citrus seedlings (Citrus sp.) by grafting. The purpose of this study was to determine the appropriate storage period and packaging materials for the growth of grafted

citrus seedlings, as well as to determine the interaction between storage period and packaging materials on the growth of grafting seedlings. This study was conducted based on a factorial experiment with a completely randomized design (CRD), repeated three times. The treatment consisted of two factors, namely storage period (0, 1, 2, and 3 days) and packaging materials (aluminum foil, banana midrib, and ginger slices), so that 12 treatment combinations were obtained. Observation variables included the percentage of finished grafting, bud break time, shoot length, number of leaves, and the percentage of growing grafting. The results showed that the storage of temulawak slices was able to produce the highest growing grafting seedlings reaching 78%. Entry wrapping materials with aluminum foil, banana fronds and slices of ginger did not significantly differ on the growth of the initial seedlings of citrus seedlings by grafting and the interaction between the storage period and the entres wrapping material did not affect the growth of grafting shoots.

Article [14], [40] conducted a study on the effect of sticky eye source book and atonic concentration on the growth of grafting seedlings of citrus (Citrus sp.) tejakula tangerine variety. The influence of the position of the source book of the stick did not significantly affect the oven-dry weight of the scion shoots. The effect of Atonic concentration significantly affected the oven-dry weight of scion shoots per plant. The results of the regression analysis of the relationship between Atonic concentration (X) and oven-dry weight of scion shoots per plant (Ŷ) showed a quadratic relationship with the equation, which is defined as:

$$\hat{Y} = 1.8978 + 2.48x - 2.6667x^2 \quad (2)$$

The model above results in coefficient of determination (R^2) = 0 ,2 0.3 Atonic concentration ml.l-1 solution 0.4 9 0.8787; so that $Xopt = 0.46\, ml$.l-1 solution and max = 2.47 g. The interaction between the atonic concentration and the position of the sticky eye source book had no significant effect on all observed variables.

3. EFFECT OF ROOTSTOCK

The articles [3], [41] conducted a study on the differences in rootstock and entres storage time on the grafting growth of Siam Honey (Citrus nobilis) seedlings. Article [42] conducted a study on the effect of administration of growth regulators on bud dormancy breaking of citrus (Citrus sp.) buds from grafting. The purpose of this study was to determine the effect of giving growth regulators on breaking dormancy. The results showed that there was a significant difference in the percentage of shoots observed at 28 and 84 Days After Treatment (DAT) with young coconut treatment 3 times spraying which showed the highest yield. Parameters observed for bud break rate, shoot height, number of leaves, and shoot diameter showed results that were not significantly different from PGR treatment. Provision of Growth Regulators (ZPT) was able to have an effect on breaking dormancy of buds

produced by grafting citrus plants, as evidenced by the percentage of bud breakage reaching 83.33% which was able to increase 39% of the control produced. The ZPT treatment did not have a significant effect on the bud break rate parameters of citrus plants. In general, the ZPT treatment did not have a significant effect on the vegetative growth characters, namely shoot height, number of leaves, shoot diameter, and rootstock diameter.

Article [43] conducted a study on the grafting growth of the brastepu tangerine (Citrus nobilis Var. Brastepu) using tamarind as rootstock. Tamarind oranges aged 7 months are very good as rootstock grafting of Brastepu tangerines. The success of the rootstock parent plant blending with the patch eye is strongly influenced by the age of the bud stick and the length of storage of the patch eye. Optimum conditions for growth and development of Brastepu tangerines were obtained using bud sticks from relatively young healthy plants, and grafting was carried out directly on the day when the eye patch was taken to produce seedlings with longer shoots, more leaves, and more branches.

Article [41] conducted a study on the effect of nursery media composition and watering interval on the growth of Siamese orange (Citrus nobilis) grafting seedlings. The purpose of this study was to determine the most suitable watering interval for the growth of Siamese citrus grafting seedlings, as well as to determine the composition of the nursery media that was most suitable for the growth of Siamese citrus grafting seedlings. To determine the growth of Siamese grafting seedlings in this study as a result of watering interval treatment and nursery media composition, data were collected on seedling height, seedling stem diameter, number of primary branches, number of secondary branches, number of leaves, leaf dry weight and stem dry weight. The composition of the best seedling medium for grafting Siamese orange seedlings is top soil: humus 1: 2. The best watering interval for grafting Siamese orange seedlings is once every two days.

Article [44] conducted research on the propagation of tangerine (Citrus Nabilus Lour) plants by grafting technique. The purpose of this study was to increase the propagation of tangerines (Citrus Nabilus Lour) by grafting techniques and to develop an understanding of how to grafting on tangerines (Citrus Nabilus Lour). The stages of propagation of citrus plants with grafting techniques carried out are: providing rootstock, taking patch eyes, implementing grafting and maintaining grafting results. The grafting technique used was a slice model because it was easy to do and had a high growth rate, while the rootstock used was JC (Japaneche Citroen) with Siem orange, Tawangmangu tangerine and Grabag tangerine. The success of the attachment depends on the compatibility between the rootstock and the scion, the skill of the implementer, the growing environmental conditions, the time of grafting, the tools used, the way the buds are tied, and the way of inserting the sticks. Citrus plant propagation by grafting is carried out with the aim of producing high-quality seeds so that they have a high selling value.

4. FACTOR OF BUDDING

The article [45] conducted a study on the experimental chip budding grafting technique on citrus plants. The purpose of this study was to determine and explain the effect of rootstock age and grafting method on the success of citrus plants (Citrus sp). Article [46] conducted a study on the elimination of Citrus Tristeza virus from Washington Navel Orange (Citrus sinensis [L.] Osbeck) via Shoot-tip Grafting. This research was conducted to produce plants free of citrus tristeza virus (CTV).

Article [47] conducted a study on the effect of pyraclostrobin and azoxystrobin on the growth and health of tangerine (Citrus reticulata L.) seedlings by grafting and inoculation techniques of phytopthora sp. Article [44], [48], [49] conducted research on the growth of citrus seedlings from kuok grafted at various levels of shade and rootstock age. Treatment of 0% shade level or no shade gave the best results on the growth of kuok citrus seedlings resulting from grafting. The treatment of rootstock age of 4 months gave the best results on the growth of kuok citrus seedlings resulting from grafting. There is an interaction between 0% shade level and the use of 12 months rootstock age on the growth of kuok citrus seedlings resulting from grafting.

Article [50] conducted a study on the production of siompu tangerine (Citrus nobilis L.) seedlings through in vitro micro grafting. The purpose of this study was to obtain the best medium for acclimatization and micrografted plantlets for citrus plantlets from micrografting. The experiments were arranged according to a completely randomized design, consisting of a combination of IBA (0, 0.5, and 1 mg l-1) and BAP (0, 1, and 2 mg l-1) in MS medium with four replications. The variables measured were the number of survival scions, the number of dormant stems, and the number of scions that formed leaves.

The IBA and BAP treatments did not show a significant interaction effect. MS medium with the addition of 1 mg l-1 IBA and 2 mg l-1 BAP is a good medium for the growth of micrografted plantlets. Micrografting technique can be used as a Siompu tangerine propagation technique.

The article [49] conducted a study on the growth potential of tangerine seedlings by grafting using different types of rootstock and eye patches. This study aims to determine the growth power of citrus seedlings resulting from grafting propagation systems using different rootstocks and eye patches. The method used is an experimental method using a Split Plot Design with 5 replications. The main plot is rootstock (B), namely: b1 = RL (Rough Lemon), b2 = JC (Japanese Citroen). The subplots are patch points (M), namely: m1 = Garut 1, m2 = Terigas, m3 = Madura, m4 = Batu 55, and m5 = Tejakula.

The results showed that there was no interaction between rootstock and eye patch treatment on the growth power of grafting citrus seedlings, but independently there was a significant difference. The rootstock of JC (Japanese Citroen) had the best effect on plant height at 60 DAP and the attachment points of Terigas, Madura, Batu 55, Tejakula had the best effect

on the percentage of growth, while on other parameters the rootstock and patch eye treatment had no significant effect. Rootstock and eye patch significantly affect the percentage of growth. Treatment of rootstock b2 (Japanese Citroen) gave the best average value for shoot height. The treatment of m2 (Terigas), m3 (Madura), m4 (Batu 55) and m5 (Tejakula) patches gave a higher average growth percentage compared to Garut patch eyes.

Article [51] conducted a study on the success of grafting sweet orange varieties at various doses of NPK compound fertilizer. This study aims to determine the effect of varieties and doses of niposca compound fertilizer on the success of grafting citrus plants. This study used a factorial randomized block design (RAK) consisting of two factors. The first factor is the sweet orange variety which consists of 2 kinds, namely the Siem Madu variety (V1) and the Siem Banjar variety (V2). The second factor is the dose of niposca compound fertilizer which consists of 4 levels, namely: without niposca compound fertilizer (N1), 5 g niposca compound fertilizer (N2), 10 g niposca compound fertilizer (N3), 15 g niposca compound fertilizer (N3), so that 8 treatment combinations were obtained which were repeated three times and the total experiment was 24 experimental units.

The results showed that the varietal treatment had no significant effect on the success rate of grafting on sweet oranges. The dose of compound fertilizer niposca 15 g gave time to reach 50% of shoot growth, percentage of finished grafting, percentage of dead seedlings, shoot length, number of leaves on shoots, and shoot diameter. better grafting compared to other doses.

4. SUCCESS RATE AND FEASIBILITY

Article [52] conducted a study on the success rate of grafting of So E tangerine varieties and Tejakula tangerines at various doses of organic fertilizer. This study aims to determine the effect of varieties and doses of granulated organic fertilizer on the success of grafting on citrus plants. This study used a factorial randomized block design (RAK) consisting of two factors. The first factor is the citrus variety which consists of 2 kinds, namely the Keprok So E variety and the Keprok Tejakula variety. The second factor is the dose of granule organic fertilizer which consists of 4 levels, namely: without granular organic fertilizer, 200 g granule organic fertilizer, 400 g granulated organic fertilizer, and 600 g granule organic fertilizer, so that 8 treatment combinations were repeated three times and a total of experiment was 24 experimental units.

The results showed that the Keprok So E variety gave better shoot growth time of up to 50%. Granule organic fertilizer dose of 200 g gave 50% time to grow shoots, percentage of finished grafting, percentage of dead seedlings, shoot length, number of leaves on shoots, and better shoot diameter compared to other doses. There was an interaction between

varietal treatment and the dose of granule organic fertilizer on shoot length, number of leaves on shoots, and bud diameter of 12 MSO grafting.

Article [8] conducted a study on the growth of buds of tangerine (Citrus nobilis) grafted on various growing media and the age of rootstock of rough lemon (C. jambhiri). The purpose of this study was to evaluate the growth of tangerine (Citrus nobilis) buds from grafting on various growing media and rootstock age of rough lemon (C. jambhiri) using a Completely Randomized Block Design with 2 factors and 3 replications. The planting medium consisted of a mixture of soil, husk charcoal, sheep manure, compost, and vermicompost. Rough lemon rootstock age consisted of 8, 11, and 14 months.

The composition of the best growing media for the success of grafting, the increase in length of the scion and the growth of the scion of tangerines from grafting was the planting medium (soil: husk charcoal: vermicompost 1:1:1 v/v/v). Rough lemon rootstock aged 8 and 11 months resulted in better grafting success and tangerine shoot length growth than rough lemon rootstock aged 14 months. Rough lemon rootstocks aged 14 months produced the best grafted tangerine rootstock growth compared to rough lemon rootstocks aged 8 and 11 months. Article [53] conducted a study on the feasibility analysis of Banjar Siamese orange (Citrus Suhuensis Tan.) seeding by grafting. Article [54] conducted a study on seasonal changes in mineral nutrition in T-fruits of navel orange plants grafted on trifoliate and citrange oranges. Article [28] conducted a study on managing intramolecular energy transfer in well-defined polyfluorene grafting of one/two orange emission groups on the central or terminal fluorene unit. The article [55] conducted a study on the effect of grafting and gradual rootstock substitution on gas exchange of citrus seedlings under high atmospheric evaporation demand. Interstocked seedlings were produced by making two successive grafts.

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