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# Interspecific and Intraspecific Rootstock Suitability for Vegetative Propagation of Petai (*Parkia speciosa*, Hassak.)

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**Abstract**

The intraspecific and interspecific suitability of five species as rootstocks for the vegetative propagation of petai (*Parkia speciosa*, Hassak.) was tested in a two-step study testing budwood and top grafting methods. Stage 1 used rootstock of lamtoro (*Leucaena leucocephala*), flamboyant (*Delonix regia*) and petai (as a control). The results showed that the petai-lamtoro and petai-flamboyant graft combinations all died within two weeks of grafting. The petai-petai combination demonstrated 25% survival one month after grafting. Stage 2 again tested lamtoro and petai (as a control), as well as sengon (*Paraserianthes falcataria*) and kedawung (*Parkia timoriana*) as rootstocks. Similar to Stage 1 results, the petai-lamtoro and petai-sengon combinations suffered 100% mortality two weeks after grafting. The petai-kedawung and petai-petai combinations demonstrated 40% and 50% survival, respectively, one month after grafting. Based on results it is concluded that kedawung and petai are suitable rootstocks for petai scion with the budwood and top grafting methods, but lamtoro, sengon and flamboyant are incompatible. Examination during the study indicated that grafts of the dead specimen were discoloured and dried. Furthermore, all the species in the study have thin cambiums that are sensitive to high temperature, low humidity and desiccation. Recommendations are provided to reduce the vulnerability of petai grafts to desiccation during scion harvesting, pre-grafting nursery management, grafting operations and post-grafting management. An alternative for multiplying small numbers of high-yielding petai individuals and varieties is suggested.

**Keywords:** petai vegetative propagation, interspecific and intraspecific compatibility, smallholder appropriate grafting techniques

## 1. Introduction

*Parkia speciosa* Hassak is a member of the Leguminosae family and the Mimosoideae subfamily. Native to Southeast Asia, the species has multiple medicinal, wood and shade tree uses. Most notably, the seed is a valued component of regional cuisine. Called stink bean in English, the common name for the species in Indonesia, Malaysia and Singapore is petai or petai, sator or sataw in Thailand, u'pang in the Philippines, and yongchak in India (Kamisah et al., 2013). The species is most suitable to grow at an elevation of 500-1000 m above sea level. It commonly grows to a diameter of 15-50 cm, with diameters of 100 cm possible; height is 15-30 m (Wiradinata & Bamroongrugsa, 1994). Petai seed is an agroforestry product with strong demand and is common in local to national markets in Indonesia and Malaysia (Fujita, 1988). Apart from being widely utilized in Indonesia, Malaysia, Singapore and the Philippines petai seed is also traded to Saudi Arabia (Fujita, 1988). Farmers sell pods in local market, to neighbours or to traders who amass and grade the commodity for further sale up the value-chain.

Petai pods are shiny green with a width of 2-6 cm and length of 30-40 cm. In general, the seeds from the pods are peeled and used for vegetables either cooked or raw, the taste is bitter and the aroma so pungent, that some people cannot bear the smell. Every 100 g of petai contains 71 g of water, 11 g of carbohydrates, 8 g of protein, 8 g of fat, 76 mg of Ca, 83 mg of P, 1 mg of Fe, 724 IU of vitamin A, 0.1 mg vitamin B1, 0.01 mg vitamin B2, 01 mg niacin and 6 mg vitamin C (Wiradinata & Bamroongrugsa, 1994). The wood can be used as building material and firewood. Petai is used as a traditional medicine for diabetes, kidney and high blood pressure and as an anti-oxidant (Kamisah et al., 2013).

Petai has been identified as a priority species for smallholder domestication in Southeast Asia (Roshetko & Evans, 1999; Gunasena & Roshetko, 2000). In Indonesia, petai is widely cultivated in Sumatra, Java, Kalimantan, and other parts of country. In South Sulawesi petai is grown by farmers in tree gardens as shade for cocoa, coffee and other crops. In West Java, Central Java and Sumatra, the petai is cultivated as one component of multi-species tree gardens to diversify production and reduce risks by producing multiple commodities for both household use and market sale. Petai is also planted along borders as a property marker.

Propagation of this plant is generally by seed, with progeny resembling their parents in appearance and performance. The period from propagation to fruiting is long, sometimes up to 6-7 years. An indigenous practice to accelerate germination and seedling growth is to remove the seed coat and cut off ¼ to ½ the seed. Research verifies that both seedcoat removal and seed cutting accelerate but do not increase germination; however seed cutting may negatively affect seedling growth and survival (Roshetko et al., 2008).

Farmers and researchers have recommended domestication efforts with petai should focus on shorten the juvenile (non-productive) period of the tree and increasing yields by developing vegetative propagation practices to graft high-yielding material on rootstocks of local varieties or compatible species (Narendra et al., 2013). This paper reports results from a study to identify viable vegetative propagation methods for *Parkia speciosa* using interspecific and intraspecific rootstock species. The market demand for petai seed as a food commodity generally exceed supplies, a justification of the indigenous seed cutting propagation practice mentioned above is to retain more seed for household consumption (Roshetko et al., 2008). In recognition of possible competition for seed supplies, the study tested interspecific and intraspecific rootstock suitability for petai scions in vegetative propagation.

## 2. Materials and Methods

The study on interspecific and intraspecific rootstock suitability for petai was conduct in ICRAF project nursery in Tappanjeng Village, Bantaeng District, South Sulawesi Province. Lamtoro (*Leucaena leucocephala*), sengon (*Paraserianthes falcataria*), kedawung (*Parkia timoriana*) (Notes 1 and 2) and flamboyant (*Delonix regia*) were tested as compatible rootstocks for petai scions. Petai rootstocks were included as a scientific control. All five species are members of the Leguminosae family. Petai, lamtoro, sengon and kedawung are in the same sub-family—Mimosoideae, with kedawung being in the same genus as petai. Flamboyant is a member of the Caesalpinioideae subfamily. It was hypothesized that as the species are closely related, they would be compatible rootstocks for petai. Additionally, lamtoro, sengon and flamboyant are common components of local landscapes, produce large quantities of seed that readily germinate and produce vigorous seedlings that could serve as rootstocks.

Seed of the five species were collected from local populations, as those are the genetic resources available to rural communities. Before sowing, seeds were pre-treated according to common recommendations for each species. The seed of kedawung, flamboyant and petai were scarified by nicking the seedcoat (Purnomosidhi et al., 2013) and soaked in water for 12 hours. The seed of lamtoro and sengon did not undergo pre-treatment before sowing as recently collected seed of these species germinate readily. Seeds of all species were sown in nursery polybags measuring 11 × 21 cm. Four grams of NPK fertilizer was applied to each polybag on a monthly basis to assure good stem growth until seedling achieved a root collar diameter of 0.5 cm. Seedlings were ready for grafting after 6 to 8 months in the nursery.

Two vegetative propagation methods were used in the study, budwood grafting and top grafting. These methods were chosen because they match the characteristics of petai scions collected from 7- to 10-year-old trees. Additionally, experience indicated that farmers can quickly master these vegetative propagation methods. The materials required for grafting are razor blades, plastic bags and plastic ties, which are readily available in rural communities. The budwood grafting and top grafting methods used in the study followed the guidelines from Prastowo et al. (2006) and Purnomosidhi et al. (2002). The petai trees from which the scions were collected have demonstrated plentiful production of quality pods. All grafting was conducted by the same nursery technician who has over 20 years of experience in nursery management and vegetative propagation.

*2.1 Research Design*

Due to variations in seed availability, the study was conducted in two stages. In Stage 1 lamtoro, flamboyant and petai rootstocks were grafted with petai scion using the budwood and top graft methods. In Stage 2 lamtoro, sengon, kedawung and petai rootstocks were grafted with petai scions. In both stages, the two grafting methods were applied to twenty seedlings of each species. Root collar diameter of the seedlings were 0.5 cm, a diameter width common for vegetative propagation by budwood and top grafting. Seedlings of each species were uniform in collar diameter, height and health. Seedlings were allocated between the two grafting methods randomly. After grafting operations all seedlings were placed under paranet (55% shading) to reduce desiccation and high temperatures from direct sunlight. Survival and health of seedlings were evaluated weekly through the end of the study period.

## 3. Results

In the Stage 1 trail, all seedlings from each species x grafting combination remained alive in the first week following grafting operations. In the second week all the lamtoro and flamboyant seedlings and 70% of the petai seedlings suffered morality. An examination of the dead seedlings indicated that the scions and the cambium of the rootstocks were desiccated in all cases. After four weeks 25% of the petai survived and were ready for outplanting (Table 1).

Table 1. Seedling survival by species x grafting method combination for the Stage 1 trial

| Species | Grafting Method | Seedling Survival—Post Grafting Period | | | |
|---|---|---|---|---|---|
| | | Week 1 | Week 2 | Week 3 | Week 4 |
| **Lamtoro** | Budwood | 100% | 0% | 0% | 0% |
| | Top | 100% | 0% | 0% | 0% |
| **Flamboyant** | Budwood | 100% | 0% | 0% | 0% |
| | Top | 100% | 0% | 0% | 0% |
| **Petai** | Budwood | 100% | 30% | 25% | 25% |
| | Top | 100% | 30% | 25% | 25% |

In Stage 2 survival of all species x grafting combination was again 100% one week after grafting. As in Stage 1, thereafter seedling mortality increased greatly. During the second week all lamtoro and sengon seedlings died, as did approximately one-third of the petai-kedawung and petai-petai grafted seedlings. Again, examination revealed that the scions and cambium of the rootstocks were brown and desiccated. No signs of disease or insect damage was identified on the dead seedlings in either stage. After one month, 40% of the petai-kedawung grafts and 50% of the petai-petai grafts were alive and ready for outplanting.

Table 2. Seedling survival by species x grafting method combination for the Stage 2 trial

| Species | Grafting Method | Seedling Survival—Post Grafting Period | | | |
|---|---|---|---|---|---|
| | | Week 1 | Week 2 | Week 3 | Week 4 |
| **Lamtoro** | Budwood | 100% | 0% | 0% | 0% |
| | Top | 100% | 0% | 0% | 0% |
| **Sengon** | Budwood | 100% | 0% | 0% | 0% |
| | Top | 100% | 0% | 0% | 0% |
| **Kedawung** | Budwood | 100% | 60% | 40% | 40% |
| | Top | 100% | 70% | 40% | 40% |
| **Petai** | Budwood | 100% | 70% | 50% | 50% |
| | Top | 100% | 70% | 50% | 50% |

## 4. Discussion

Budwood and top grafting are vegetative propagation methods that attach the scion of a desire plant to the stem of another plant, which retains its roots either in a nursery or in situ in the soil. Under nursery conditions the stem plant is referred to as the rootstock. In successful grafts, the tissues of the two plants heal together to grow as a single plant (Hartmann et al., 1997; Mudge et al., 2009). In smallholder agroforestry, budwood and top grafting are commonly used to multiple superior individuals with desired characteristics, shorten the juvenile (non-production) period of the plant, and utilize superior rootstocks for general or specific conditions (Prastowo et al., 2006; Purnomosidhi et al., 2002).

Petai is a priority tree species in Southeast Asia widely cultivated by smallholder farmers primarily for its seed, a recognized component of regional cuisine. In Indonesia, besides Sulawesi, petai is cultivated by smallholder farmers in Java, Sumatra, West Kalimantan and Nusa Tenggara (Stoney, 1992; Djogo, 1992; Ostama & Sumantri, 1999; Roshetko et al., 2002; Manurung et al., 2008). The species also provides a number of secondary products and is often grown as a shade tree for commodity crops and in multi-species tree gardens. Commercial demand for the seed commodity often exceeds supply. Even as a minor component of a farming system petai can be a notable source of income. In Nanggung, West Java petai was only 2.2% of on-farm trees (Manurung et al., 2005) yet delivered 10% of non-timber product income, 3% of farm income and 1% of total household income (Budidarsono et al., 2006). Farmers and researchers recommended efforts to develop grafting methods for high-yielding petai material on rootstocks of local varieties or compatible species (Narendra et al., 2013). This study tested interspecific and intraspecific species options as suitable rootstock for petai to address the three grafting objectives stated in the previous paragraph. Results found that all five vegetative combinations remain viable one week after grafting. However, the petai scions grafted to flamboyant, lamtoro, and sengon rootstocks all suffered 100% mortality by the second week after grafting in both stages of the study. Only the petai scions grafted to kedawung and petai rootstocks remained alive one month after grafting. The suitable of these combinations are inferred by Wiradinata and Bamroongrugsa (1994).

The grafting process connects the transport tissues, phloem and xylem, of the scions and rootstocks. The phloem transports food generated by photosynthesis in the leaves throughout the plant, while xylem transports water and nutrients from the roots to the leaves and throughout the plant. The cambium is a layer of actively dividing cells that connect the phloem and xylem. The cambium's role in maintaining and restoring the transport function of the phloem and xylem is essential (Kramer & Kozlowski, 1960; Lacointe & Minchin, 2008). The authors, with over 20 years of grafting experienced, identify the key factors of grafting success under smallholder farmer conditions as the thickness of the cambium on the rootstock, microclimatic conditions (temperature and humidity) under which the grafted plants are maintained, and the interaction between these two factors. Petai has a thin cambium. Other commodity species with thin cambium that are cultivated by smallholder farmers include rambutan (*Nephelium lappaceum*) and clove (*Syzygium aromaticum*). To maximize success when grafting rambutan and clove, farmers and nurserymen in Lampung irrigate the rootstock plants in the nursery or in situ before grafting operations and keep scions fresh by minimizing the time between scion harvesting and grafting (authors' experience).

During Stage 1 of the study, immediately after the grafting operations temperatures were unexpectedly high and humidity unusually low. This likely contributed to the low survival rate of the intraspecific grafting combination (petai-petai), 25% after one month. All intraspecific species combinations (petai-lamtoro and petai-flamboyant) experienced 100% mortality two weeks after grafting. In Stage 2 efforts were made to reduce the time between scion harvest and grafting. That effort combined with more favourable post-grafting conditions (lower temperatures and high humidity) resulted in higher survival of successful grafting combinations. Recent grafts are recognized as being sensitive to environmental conditions (Leakey et al. 2005). One month after grafting survival of the petai-petai interspecific combination was 50% and for the petai-kedawung intraspecific species combination was 40%. Similar to Stage 1 results, the petai-lamtoro and petai-sengon intraspecific species combinations experienced 100% mortality after two weeks. Inspections of grafts during the study revealed that the bark and cambium of lamtoro, sengon and flamboyant seedling were thin, discoloured and desiccated very quickly.

**5. Conclusions and Recommendations**

From the study it is concluded that the petai and kedawung are viable rootstocks for petai scions with the budwood and top grafting methods, but lamtoro, sengon and flamboyant rootstocks are incompatible. A factor that may favour kedawung is that it is in the same genius, *Parkia*, as petai. The results with lamtoro and sengon are surprising and disappointing. Both species are in the Mimosoideae subfamily with petai. Additionally, their seed is abundant and germinates easily, providing a potential ready source of rootstocks. By comparison, kedawung is less common and its seed crops are less profuse. The incompatibility of flamboyant is less surprising as it is a member of a different subfamily, Caesalpinioideae.

Petai has a thin cambium and is vulnerable to high temperature, low humidity and desiccation. To manage the species sensitivity, it is recommended that scions be collected between dawn and sunrise when the temperature is low and conditions remain humidity. The scions should be wrapped in a moist cloth or paper and stored in humid container for transport. Petai scions should be grafted immediately, during the same morning under shaded nursery conditions. It is further recommended that one week before grafting operations rootstock receive 4-5 grams of NPK fertilizer of a type commonly used in nurseries and are adequately watering during that period. This pre-grafting treatment is intended to nourish the rootstock, improve cambium condition and facilitate exfoliation of older bark. To reduce stress on the grafted petai plants it is recommended to use heavier shading in the nursery; 75% paranet or natural shade should be appropriate, as these are common shade levels in smallholder nurseries.

The stacking technique is the grafting of rootstock directly to the scion without remove the scion from its mother plant. Once the graft has begun to heal and the graft plant is healthy, it is cut from the mother tree. This technique might be possible with petai. However, it is not feasible to multiple large quantities of plants in this manner. It can be used to produce small numbers of grafted plants from high-yielding individuals or varieties.

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## Notes

Note 1. *Parkia timoriana* is synonymous with *Parkia javanica* and *Parkia roxburghii.*

Note 2. Seed of kedawung is also eaten as human food but is considered an inferior choice to petai (Kessler, 1996).

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