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Note

Survival and growth of *Acacia mangium* Willd. bare-root seedlings after storage and transfer from aeroponic culture to the field

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Abstract – Aeroponic culture has been shown to be a promising nursery technique to raise *A. mangium* and to improve growth rates as well as the level of controlled infection with rhizobia and mycorrhizal fungi. This work was designed to determine whether aeroponically grown bare-root seedlings can be stored out of aeroponic troughs, and/or planted to the field without acclimatization in Polybags. After field planting, no significant differences in terms of survival and growth rates were expressed between bare-root seedlings that had been stored in plastic bags for six days or directly transferred to the field, or acclimatized in Polybags. Storage in dark conditions for more than four days significantly affected the survival rates of the seedlings. Aeroponic culture appears to be the method of choice to obtain high quality seedlings, which are much easier to plant and transport compared to those obtained under classical nursery techniques using soil or solid substrate.

***Acacia* / aeroponic culture / bare-root / nursery / field planting**

Résumé – Survie et croissance de plants en racines nues d'*Acacia mangium* Willd. après stockage et transfert de culture aéroponique au champ. La culture aéroponique est une technique de pépinière prometteuse pour la production de plants d'*Acacia mangium* notamment pour l'amélioration de la croissance des plants ainsi que pour le contrôle des infections par les rhizobia et les champignons mycorhiziens. Afin de déterminer si les plants produits en culture aéroponique peuvent être stockés et/ou plantés directement sans période d'acclimatation en Polybags, un dispositif expérimental a été mis en place. Après plantation au champ, aucune différence significative n'a pu être constatée en termes de survie et de croissance des plants stockés dans des sachets plastiques pendant 6 jours ou transférés au champ directement ou après une période d'acclimatation en Polybags. Le stockage à l'obscurité pendant plus de 4 jours réduit significativement la survie des plants. La culture aéroponique semble être une méthode de choix pour la production de plants de qualité facile à transporter et à planter par rapport aux techniques classiques de pépinières utilisant un substrat solide ou du sol.

***Acacia* / culture aéroponique / racines nues / pépinière / plantation au champ**

1. INTRODUCTION

Acacia mangium originates from Queensland in Australia, Papua New Guinea, Irian Jaya, the Sula, Ceram and Aru islands [6]. It has been introduced in other parts of Southeast Asia where it is a renowned species for pulpwood plantations due to its fast growth [2]. The ability of *A. mangium* to thrive well on infertile soils has partially been attributed to its symbiotic association with nitrogen fixing bacteria and mycorrhizal fungi [5]. Aeroponic culture, a soil-less method, has been shown to be a promising way for growing and for controlled inoculation of *A. mangium* seedlings. Indeed, the growth and the number of nitrogen-fixing nodules obtained in aeroponic culture has been shown to be 2 to 4 times higher than those reached on a solid substratum [8]. Seedlings that had been inoculated with arbuscular mycorrhizal fungi in pots and raised in aeroponics have shown significantly higher rates of mycorrhization and phosphorus content than seedlings grown in soil [7]. Nevertheless, little information is available on growing *A. mangium* in the field from bare-root seedlings. Bare-root seedlings are known to be easy and quick to plant as well as convenient to transport to distant planting sites. Successful trials and pilot plantings using bare-root *A. mangium* seedlings have been reported in the Philippines, these seedlings having also developed a better root system [10]. However, a direct planting of aeroponically grown seedlings of *A. mangium* without any acclimatization period in Polybags containing solid substrate has so far not been tested. Due to their fast-growth, lush foliage

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and soft roots *A. mangium* seedlings grown in aeroponic troughs are particularly sensitive to dehydration. The root system is also particularly well developed reaching up to 1 m long, leading to entanglement at the time of transplanting. At the present time *Acacia mangium* seedlings are grown on a solid substratum in locally established nurseries because seedling transport to the field is rather inefficient as a single truck can transport only a few hundred seedlings at one time. Seedling dispatch to the field meets the same problems and represents a main part of the manpower in plantings. Aeroponically-raised bare-root seedlings can be efficiently packed and easily transported in boxes that would allow transport in large number over large distance. The setting up of appropriate transport and storage conditions that do not affect the quality of aeroponically-raised seedlings are a pivotal matter for the development of industrial plantations. In this study we compared the effect of direct planting, pot acclimatization, and storage conditions on the survival rates and early development of *A. mangium* seedlings raised in aeroponic culture.

2. MATERIALS AND METHODS

2.1. Seed germination and the aeroponic system

Seeds of *A. mangium* (Seedlot No. 19297, Australian Tree Seed Centre, CSIRO, Australia) were germinated for seven days on moist tissue paper at room temperature. The seedlings were then carefully transferred into sponge plugs, previously soaked in water, and grown for another week in the greenhouse at 30 ± 2 °C. Fourteen-day-old seedlings were then transferred into an aeroponic trough with their root system suspended in air [7]. Nutrient mist was supplied to the roots for 40 s at intervals of 30 s. Plants were maintained in the greenhouse under tropical environmental conditions with temperatures ranging from 27 to 32 °C, relative humidity ranging from 80 to 85% and high illuminance (daylight with a maximum of 800 to 1000 $\mu E \cdot m^{-2} \cdot s^{-1}$). After 8 weeks, the roots were inoculated with 0.5 mL per plant of a 4-day-old culture of *Bradyrhizobium* sp. strain AUST13C [3, 4]. The plants were then grown in the aeroponic troughs for another 5 weeks before field planting.

2.2. Experimental design

The experiment involved 180 plants in 6 treatments using 30 plants for each treatment. Plants were randomly assigned to each treatment from a population of 400 aeroponically-grown seedlings. Four of the treatments concerned storage conditions. For these plants, before storage the plants were cut to the height of the last remaining bud at between 20 and 30 cm on the stem. The roots were cut to a length of 25 cm. The plants were packed in 20 L transparent plastic bags at a rate of 5 plants per bag, which were inflated with air and sealed. The bags were stored in darkness for 4 and 6 days (4DD, 6DD) or in the shade for 4 and 6 days (4DS, 6DS). The two other treatments consisted of direct planting of seedlings from the aeroponic trough (NSt) and acclimatization of seedlings in 1.5 L Polybags for 2 weeks before planting (PA). For these treatments, the stalk and the roots were reduced as described above and the Polybags were filled with soil from the planting site. The plants were watered daily with the same nutrient solution as used in aeroponic culture. The roots were cut just before the transfer to the Polybags and the stalks just before the transfer to the field. Within 2 days plants of all treatments were labeled and transplanted into a fully randomized design in the field in 6 rows of 30 plants each with a square spacing of 1 m. The planting site was on reclaimed land, having a moderately deep clay layer and poor drainage. Plant growth rates were calculated from the height measured between the collar and the last living bud before transplanting and at 2 and 7 months after planting out.

2.3. Statistical analysis

A single factor analysis of variance (ANOVA) was performed to determine significant difference of plant height and growth between treatments at $P < 0.05$. Differences of survival among the different treatments were estimated by the $[\text{Khi}]^2$ test at $P < 0.05$. These test procedures were carried out with MINITAB software [9].

3. RESULTS

3.1. Transplanting stress and survival after planting

Transplanting stress was visible after one week. Some plants began to loose leaves and, under sunlight, the grass-green color of the stem turned to a more brownish color. In some cases, the terminal bud died and growth began in the underlying bud. An examination of the transplants revealed that 2 weeks after transplanting, new lateral roots had developed. Two months after transplanting, all the seedlings were growing well without visible symptoms of stress. The healthy appearance of the plants 2 months after transplanting showed that the seedlings were able to overcome the initial transplanting stress. The distribution of surviving plants was uniform over the different treatments ($P < 0.05$). Treatment 6DD significantly affected the survival of the transplanted seedlings (73% against 93–96%). No significant difference in mortality was observed for the other treatments (4–7%).

3.2. Plant growth after transplanting

During the first 2 months, growth rates were moderate comparing to those observed for the following 5 months (Fig. 1). Plants of the treatment 6DD were sensitive to transplanting stress as their growth rates were significantly lower than those of the other treatments except for the treatment 4DD. Storage in dark conditions increased the sensitivity to transplanting stress even after only 4 days. Between the 2nd and the 7th months after transplanting, no significant differences in growth rates have been measured between the treatments.

4. DISCUSSION

In plantations, survival rates are linked to the ability to survive transplanting stress and to out-compete the growth of noxious grasses. Storage in dark conditions slowed down the recovery of growth and increased mortality after planting, thus affecting the plantation success. The comparatively moderate growth rates observed for each treatment after 2 months were probably linked to the fact that the growth recovery was not initiated from the top shoot but from lateral buds that formed a new leader. The growth of topped seedlings has been reported to recover in a short period without adverse effects or subsequent plant deformations [1, 6]. Fast-growing *A. mangium,* which develop a soft stalk and lush foliage were reported to be

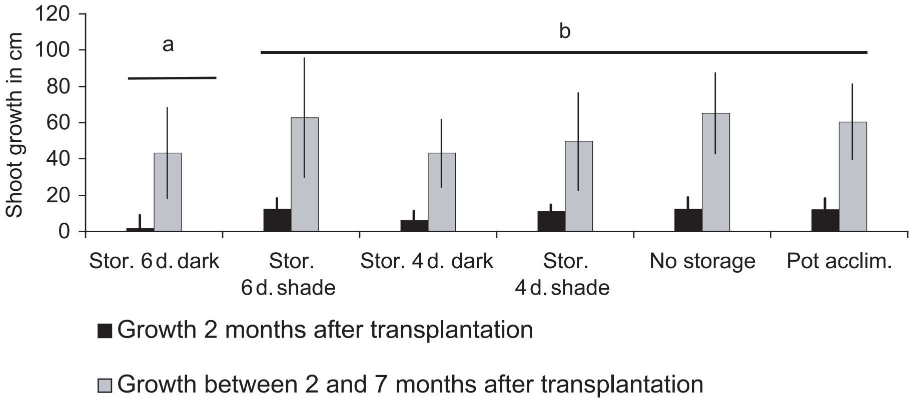

Figure 1. *Acacia mangium* shoot growth in cm (means and standard deviations) 2 months after transplanting and between 2 and 7 months after transplanting according to applied storage conditions. Values under the same bar are not significantly different at $P < 0.05$, for both durations.

fragile for handling and sensitive to desiccation. However, it has been shown that they establish well and with a good subsequent growth [6]. This observation was confirmed by our results with *A. mangium* grown in aeroponic culture. The percentage survival rates after transplanting were comparable with the 97% obtained with the use of containerized seedlings raised under traditional nursery techniques [6]. For fast-growing seedlings a 3 to 4 week hardening procedure has been seen as essential before their transplanting to the field. This procedure consists usually of exposure to full sunlight, and a progressive reduction of nitrogen fertilization and watering with a view to encourage woodiness [6]. The use of bare-root seedlings conditioned in blown-up plastic bags allows the protection of saplings from dehydration and transportation shocks. Field trials in the context of industrial plantings are under progress in collaboration with an industrial pulp company.

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