# AN ASSESSMENT OF GROWTH FOR EARLY SELECTING FAST-GROWING *MELALEUCA* HYBRIDS ON SEASONAL FLOODING AND SULPHATE ACID SOIL IN SOUTHERN VIETNAM

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**SUMMARY**

This paper presents the first published selection of hybrid *Melaleuca* species which is experimented in Southern Vietnam. Among 126 inter-specific crossing Melaleuca combinations, 27 hybrids with trunk volume with bark exceeding by more than 20% in comparison with either of their best parents have been selected at the just young stage. Additionally, 27 hybrids also perform an aggressive growth response to the harsh condition of seasonal flood and sulphate soil. The general combining ability (GCA) of V43 trees when crossing with others of *M. leucadendra and M. cajuputi* would almost ever give the hybrid offspring of positive heterosis on seasonal flooding and sulphate soil. Whereas the specific combining ability (SCA) of female parent tree Ca65 when crossing with L47 as male parent can create the hybrid combination Ca65L47 with the largest trunk volume at very young stage (3.65 dm3 per tree). There are 7 significant hybrid combinations including Ca65L47, L56Ca72, L42V43, Ca65V32, Ca65L60, L50V43, and L59V66 which are estimated to reach to 30 m3/ha/year of trunk productivity after 5 years old.

**Keywords: Growth, heterosis, hybrid, intercross, *Melaleuca*.**

## I. INTRODUCTION

*Melaleuca* species broadly occur in coastal regions and wetland areas in Australasian and Southeast Asian countries (Blake 1968), of which *M. cajuputi* is a native and multi-used tree in Vietnam. Many species of the genus *Melaleuca* are potentially to adapt to the change of climate which can be appropriate for wood production even in several local harsh conditions (e.g. flooding regions) (Tran et al. 2012).

In Vietnam, *Melaleuca* species have been affirmed as priority trees to constitute the main forest trees collection, especially suitable on seasonal flooding and sulphate acid soil along the coast in the Mekong delta region (MARD 2007).

Inter-specific crossing forest trees planted are most common in the genera *Acacia*, *Eucalyptus*, *Larix*, *Picea*, *Pinus* and *Populus*, of which *Pinus* hybrids used for commercial plantation forestry widely in USA, Korea, and Australia (Dungey 2001). There are several worldwide studies which have been published regarding hybrid forest plants [e.g. early growth of tropical pine hybrid (Shepherd et al. 2003), juvenile growth of hybrid poplars in the boreal conditions (Guillemette and DesRochers 2008; Bilodeau-Gauthier et al. 2011; DesRochers and Tremblay 2009), in Estonia (Tullus et al. 2007), and stability in growth of hybrid poplars in China (Yu and Pulkkinen 2003), genetics of physical wood properties of tropical pine hybrid (Shepherd et al. 2003), of poplar hybrids (Pliura et al. 2007), *Eucalyptus* hybrid in southern China (Wu et al. 2011), wood properties of *Acacia* hybrid in Vietnam (Kim et al. 2011; Kha et al. 2012), genotype - environment interaction of pine hybrid in South Africa (Wright et al. 1991), of hybrid poplars (Yu and Pulkkinen 2003), and genetic diversity of *Eucalyptus* hybrids (Cupertino et al. 2011)], but papers published on *Melaleuca* hybrids is an omission in worldwide English systems.

A series of studies on *Melaleuca* hybrids has been conducted and published in Vietnamese [e.g. morphological and anatomical characteristics of hybrid *Melaleuca* leaves (Hoang and Pham 2009), hybrid

*Melaleuca* fruits and seeds (Hoang 2009), heterosis performance on growth of hybrid *Melaleuca* varieties (Hoang and Nguyen 2010), and selection of hybrid *Melaleuca* varieties experimented in northern Vietnam (Hoang 2011)]. These studies therefore have been taken heed of hybridization among the four *Melaleuca* species (i.e. *M. leucadendra*, *M. cajuputi*, *M. quinquenervia*, and *M. viridiflora*) to improve their qualities and yields. One of these attempts is an earlier finding and selecting good hybrid combinations from experiments which show positive heterosis and offer fast growing rates even at the young stage. This article thus presents the results of growth assessment and early selection of some interspecies crossing *Melaleuca* varieties which have got empirically fast-growth on seasonal flooding and sulphate acid soil in southern Vietnam.

## II. MATERIALS AND RESEARCH METHODS

### 2.1. Research materials and experimental site

Experimentally evaluating hybrid varieties consist of 140 formulae with 126 hybrid combinations (named Q40V70, Ca61L42… and L25L18) and 14 controls (named L59 (ĐC) … Leu.sx). Long-leaved *Melaleuca* in mass production refers to as Leu.sx and *M. cajuputi* in production as Ca.sx. The results of sexual crossing of every couple among 4 natural *Melaleuca* species, of which *M. leucadendra* refers to as L, *M. cajuputi* as Ca, *M. viridiflora* as V, and *M. quinquenervia* as Q, then artificial breeding and growing on seasonal flooding and sulphate soil in An Giang Province that was inherited from the previous research of the Forest Science Institute of Vietnam (Cuong 2006). So, this study was conducted from 2006 to 2009.

The experimental site is located at Tri Ton District An Giang Province, $10^0$ 07' N latitude and $104^0$ 55' E longitude. It is a plane terrain of about 2 – 3 m high above sea-level. The site has an average annual precipitation of 1416 mm, annual evaporation of 1285.6 mm and annual mean temperature of 27.3 $^0$C. Experimental area is 3.0 ha on sulphate acid soil and seasonal flooding period from 3 to 6 months annually, and flooding water of 0.8 - 1.0 m depth, in which the deepest spot can be 1.5 m. The soil is strong acidity (pH: 3.1 - 3.6) and high active aluminum content (4.4 - 15.4 milliequivalents/100g soil).

### 2.2. Research method

Experiments have been designed as guideline of Graudal (1993), William and Matheson (1994). All experimental formulas were set in random blocks. Each plot consists of 20 trees with 1.0 x 1.5 m and triple repetition. The planting land was prepared by hand and digging planting holes. Each hole was 40 x 40 x 40 cm in dimensions and fertilized with 0.5 kg microbial manure plus 0.2 kg NPK, acting as base manure.

Growth norms were monitored and measured according to conventional forest surveying method including diameter at stump ($D_0$), diameter at breast height ($D_{1.3}$) with vernier caliper, full height ($H_{full}$ ) with measuring rod.

The trunk volume with bark (V) was calculated with equation (1) (Kha 2006) as following:

$$V = \frac{\pi \times D_{1.3}^2}{4} \times H_{full} \times f \qquad (1)$$

*Where*: V - trunk volume with bark, $D_{1.3}$ - diameter at breast height, $H_{full}$ - full height of tree, and f - form coefficient (assuming as 0.5)

The pure heterosis value (Hp) was calculated in percentage with equation (2) (Kha 2006) as following:

$$Hp = \frac{\overline{X}_{F1} - \overline{X}_{BP}}{\overline{X}_{BP}} \times 100 \qquad (2)$$

*Where*: $H_P$ - pure heterosis, $\overline{X}_{F1}$ - average value of certain character in hybrid $F_1$, and $\overline{X}_{BP}$ - average value of the same character in either of the best parents.

The productivity was calculated with equation (3) (Kha 2006) as following:

$$P_r = \left( \frac{V \times N \times SR}{n} \right) \quad (3)$$

*Where*: $P_r$ – productivity, V - trunk volume with bark, N - density of planting trees, SR - survival ratio (%), and n - as harvesting age of tree.

Data were treated with Data Plus and Genstat programs, which are widely used in forest tree breeding study. Also, they were to be applied with biological statistics common in forestry on Excel program.

## III. RESEARCH RESULTS AND DISCUSSION

### 3.1. The growth rate of Melaleuca hybrids

As shown in Table 1, most of hybrid combinations at the age of 3 years have an average growth rate exceeding that of the controls with the same conditions. For example, V43L42 and L42V43 combinations have growth rates being 1.60 and 1.63 m per year in height and 1.79 and 1.88cm per year in diameter respectively, while the best offspring of *M. leucadendra* in mass production (Leu.sx) is 1.24 m per year in height and 1.42 cm per year in diameter, so that the hybrid variety L42V43 exceeds by 1.31 times in height and 1.32 times in diameter comparing with Leu.sx.

Crossing the same male parent tree with different female parent trees, the height growth rate of their hybrid offspring being fast or slow mostly depends on that of female parent trees. For example, in 3 years old of such combinations including V43L42, V69L42, and Ca61L42 height growth rate is 1.60, 1.66, and 1.44 m per year, respectively, which corresponds with that of their female parents including V43, V69, and Ca61 having height growth rate of 1.52, 1.62, and 1.41m per year, respectively (Table 1). So, this may demonstrate that the height growth rate of the hybrids is mostly caused by maternal effects and certain couple of parents.

Additionally, the results also show that growth rate of the hybrids depends on individual development stage. For example, the combinations V69L59 and V43L42 in 12 months old have slow height growth rate which are ranked at 54$^{th}$ and 91$^{st}$, respectively of all monitored combinations, but in three years old they reach progressing at 3$^{rd}$ and 44$^{th}$ in this rank, while the combinations Ca61L42, Ca65L20, and V43 rank at 2$^{nd}$, 3$^{rd}$, and 14$^{th}$ in the first year, yet descending to 98$^{th}$, 46$^{th}$ and 92$^{nd}$ ranking respectively, in the third year (Table 1).

Therefore, although the trend of growth of the inter-specific crossing *Melaleuca* combinations is more and more exceeding that of control formulae which are the pure progenies of either of their parents, the extent of superiority of certain hybrid combination varies with ages. The fact is that any assessment of growth for certain hybrid combination in comparison with their parents is perhaps to be suitable certain time or/and certain stage of life.

**Table 1. Growth of *Melaleuca* hybrid combinations and their parents on seasonal flooding and sulphate soil in Southern Vietnam**

| Rank | One year old | | | Three years old | | | | |
|---|---|---|---|---|---|---|---|---|
| | Combinations | Norms | | Combinations | Norms | | | |
| | | $\overline{D}_0$ (cm) | $\overline{H}_{full}$ (m) | | $\overline{D}_{1.3}$ (cm) | $\overline{H}_{full}$ (m) | $\overline{V}(dm^3)$ | SR(%) |
| 1 | Q40V70 | 1.83 | 2.99 | Q40(ĐC) | 4.45 | 4.46 | 3.87 | 90.0 |
| 2 | Ca61L42 | 1.68 | 2.84 | L56Ca72 | 4.19 | 4.38 | 3.18 | 93.3 |
| 3 | Ca65L20 | 1.35 | 2.81 | V69L18 | 4.21 | 4.33 | 3.32 | 93.3 |
| 4 | L56Ca72 | 1.49 | 2.73 | L25L17 | 4.00 | 4.27 | 3.03 | 76.7 |
| 5 | L25L17 | 1.33 | 2.70 | L47(ĐC) | 4.07 | 4.27 | 3.10 | 76.7 |
| 6 | V43L18 | 1.54 | 2.67 | V43L18 | 4.03 | 4.27 | 2.89 | 93.3 |
| 7 | L47V66 | 1.40 | 2.65 | Ca65L60 | 4.14 | 4.26 | 3.14 | 90.0 |
| 8 | L42V36 | 1.52 | 2.61 | V43L39 | 3.81 | 4.26 | 2.72 | 91.7 |
| 9 | L42V43 | 1.58 | 2.59 | L59V66 | 4.10 | 4.25 | 3.12 | 83.3 |
| 10 | L59Ca72 | 1.42 | 2.58 | V69L42 | 4.16 | 4.25 | 3.12 | 80.0 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 50 | Q40L44 | 1.37 | 2.24 | L59V76 | 3.91 | 4.00 | 2.73 | 81.7 |
| 51 | L42V67 | 1.35 | 2.24 | L48(ĐC) | 4.09 | 3.99 | 2.86 | 76.7 |
| 52 | L25L2 | 1.44 | 2.23 | Ca61V43 | 3.92 | 3.98 | 2.62 | 81.7 |
| 53 | L50V32 | 1.22 | 2.23 | L59Ca62 | 3.71 | 3.97 | 2.36 | 83.3 |
| 54 | V69L18 | 1.47 | 2.22 | Ca65L53 | 4.21 | 3.97 | 3.04 | 86.7 |
| 55 | Ca61V43 | 1.30 | 2.22 | Ca65V76 | 4.02 | 3.97 | 2.66 | 91.7 |
| .. | .. | .. | .. | .. | .. | .. | .. | .. |
| 100 | L59(ĐC) | 1.18 | 1.98 | L7L18 | 3.84 | 3.77 | 2.39 | 68.3 |
| 101 | L6L9 | 1.28 | 1.98 | Ca65L50 | 3.93 | 3.76 | 2.54 | 81.7 |
| 102 | V69L25 | 1.24 | 1.97 | L59Ca72 | 3.33 | 3.76 | 1.88 | 78.3 |
| 103 | L48V75 | 1.24 | 1.96 | Ca61L42 | 3.59 | 3.75 | 2.25 | 85.0 |
| 104 | L52V66 | 1.06 | 1.95 | L42Ca61 | 3.87 | 3.75 | 2.50 | 73.3 |
| 105 | L42Ca61 | 1.15 | 1.92 | L56(ĐC) | 3.68 | 3.74 | 2.21 | 78.3 |
| .. | … | .. | .. | .. | .. | .. | .. | .. |
| 135 | L48V74 | 0.92 | 1.65 | L52Ca62 | 3.29 | 3.52 | 1.76 | 88.3 |
| 136 | V69L20 | 0.93 | 1.64 | L47Ca72 | 3.16 | 3.52 | 1.50 | 83.3 |
| 137 | L47Ca62 | 1.03 | 1.63 | L50V69 | 3.62 | 3.46 | 1.92 | 90.0 |
| 138 | Q40V43 | 0.99 | 1.62 | L42V67 | 3.46 | 3.43 | 1.79 | 86.7 |
| 139 | L25L18 | 1.02 | 1.54 | L50(ĐC) | 3.44 | 3.35 | 1.70 | 71.7 |
| 140 | V43Ca62 | 0.82 | 1.45 | Leu.SX | 3.19 | 3.29 | 1.47 | 71.7 |
| | Fpr | < 0.001 | < 0.001 | Fpr | 0.316 | 0.694 | 0.571 | |
| | Lsd | 0.745 | 0.338 | Lsd | 0.788 | 0.649 | 1.345 | |

### 3.2. The heterosis performance in growth of hybrid Melaleuca

Heterosis is dominant performance of the hybrids in comparison with their parents, expressing in one certain observable character of agricultural and forestry crops, naturally at different levels (Zobel and Talbert 1984; Chahal and Gosal 2010). Table 2 shows that the pure growth heterosis values of some reciprocal crossing combinations depend on individual development stage. For example, two such reciprocal crossing combinations L42V43 and V43L42, in the first year, both perform their heterosis as negative values (-5.0 % and -25,6 % in base diameter and -2.9 % and -19.7 % in tree height, respectively).

However, in the third year, just as these two combinations change into heterosis of positive values (14.4 % and 8.9 % in diameter and 5.8% and 4.7 % in tree height, respectively). In some other reciprocal crossing combinations in this experiment have similar results. This demonstrates that the growth heterosis can perform at one stage, but not at other stages of life. In other words, it could perform as positive or negative values according to ages.

Furthermore, most hybrid combinations which have got heterosis of both diameter and height perform positive heterosis in trunk volume. For instance, hybrid combinations L42Ca61 and Ca61L42 in 3 years old have their heterosis values accounting for 9.9 % and 2.0 % in height and 0.9 % of equal diameters, and also perform their heterosis in trunk volume of 21.5 % and 8.9 %, respectively. Similarly, the other hybrid combinations Ca61V43 and V43Ca61 have their heterosis values of 5.9 % and 4.5% in diameter and 1.2 % and 8.1 % in height, and also perform their heterosis in trunk volume of 14.2 % and 19.6 %, respectively (Table 2).

**Table 2. Growth heterosis in some *Melaleuca* hybrid combinations on seasonal flooding and sulphate acid soil in southern Vietnam**

| Combinations | One year old | | | | Three years old | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $D_0$(cm) | | $H_{full}$(m) | | $D_{1.3}$(cm) | | $H_{full}$(m) | | V($dm^3$) | | SR(%) | |
| | $\overline{X}$ | $H_d$% | $\overline{X}$ | $H_h$% | $\overline{X}$ | $H_d$% | $\overline{X}$ | $H_h$ % | $\overline{X}$ | $H_v$ % | $\overline{X}$ | $H_{SR}$% |
| Q40V43 | 3.63 | -23.6 | 1.86 | -26.5 | 3.23 | -27.5 | 3.57 | -19.9 | 1.63 | -57.9 | 76.7 | -14.8 |
| V43Q40 | 3.70 | -22.1 | 2.08 | -17.7 | 3.74 | -16.1 | 4.08 | -8.5 | 2.65 | -31.6 | 76.7 | -14.8 |
| L48V69 | 3.95 | 1.3 | 2.26 | 7.6 | 3.91 | -13.4 | 4.19 | 1.4 | 2.78 | -18.2 | 90.0 | 17.4 |
| V69L48 | 4.29 | 9.9 | 2.35 | 12.2 | 4.46 | -1.2 | 3.94 | -4.7 | 3.40 | 0.1 | 88.3 | 15.2 |
| L42V43 | 4.51 | -5.0 | 2.45 | -2.9 | 4.24 | 14.4 | 4.16 | 5.8 | 3.27 | 42.2 | 78.3 | -7.8 |
| V43L42 | 3.53 | -25.6 | 2.03 | -19.7 | 4.03 | 8.9 | 4.11 | 4.7 | 2.77 | 20.3 | 93.3 | 9.8 |
| L59V43 | 4.42 | -6.9 | 2.37 | -6.3 | 3.82 | -2.0 | 3.95 | 0.5 | 2.52 | 0.4 | 91.7 | 7.8 |
| V43L59 | 4.84 | 1.9 | 2.08 | -17.6 | 3.99 | 2.3 | 4.04 | 2.8 | 2.83 | 12.6 | 85.0 | 0.0 |
| Ca61V43 | 4.10 | -13.7 | 2.22 | -12.1 | 3.92 | 5.9 | 3.98 | 1.2 | 2.63 | 14.2 | 81.7 | -3.9 |
| V43Ca61 | 4.32 | -9.1 | 2.37 | -6.2 | 3.87 | 4.5 | 4.25 | 8.1 | 2.75 | 19.6 | 88.3 | 3.9 |
| L42Ca61 | 3.61 | -20.6 | 1.93 | -23.5 | 3.87 | 9.9 | 3.75 | 0.9 | 2.51 | 21.5 | 73.3 | -13.7 |
| Ca61L42 | 5.27 | 16.0 | 2.85 | 13.0 | 3.59 | 2.0 | 3.75 | 0.9 | 2.25 | 8.9 | 85.0 | 0.0 |
| V69L42 | 4.12 | 6.3 | 2.17 | 2.0 | 4.17 | -7.7 | 4.25 | 2.7 | 3.12 | -8.1 | 80.0 | -5.9 |
| L42V69 | 3.15 | -18.7 | 1.74 | -18.1 | 3.71 | -17.8 | 3.73 | -9.9 | 2.23 | -34.4 | 81.7 | -3.9 |
| Q40L42 | 3.25 | -22.9 | 1.69 | -30.3 | 3.81 | -14.4 | 3.67 | -17.8 | 2.28 | -41.2 | 88.3 | -1.9 |
| L42Q40 | 4.19 | -0.5 | 2.29 | -5.6 | 3.77 | -15.3 | 3.90 | -12.6 | 2.48 | -36.0 | 70.0 | -22.2 |

Some other hybrid combinations in this experiment give similar results. Therefore, most of hybrid varieties can have volume heterosis when they have simultaneously heterosis both in diameter and height. In other words, a hybrid variety will be able to gain high productivity if it has got growth heterosis.

In the first year, there are 4 combinations (L48V69, V69L48, Ca61L42, and V69L42) performing their positive heterosis in both diameter and height. However, in the third year, positive heterosis combinations of both norms ascend to 7 (increasing by 1.75 times) (Table 2). This demonstrates that the general heterosis trend of hybrid trees is more and more superior to their parents. This is similar to hybrid *Eucalyptus* and *Acacia* plantations which indicated that the role of variety played (occupied) 15% of productivity in the first year, then this value does increase to 50% in the third year, and to 60 % in the sixth year (Chahal and Gosal 2010).

Hybrid varieties having high productivity are based on heterosis. However, it is not all hybridizations between any couple or two lines of parents resulting in offspring of heterosis, because it depends on the combining ability of the couple of parents involved. For example, among 8 inter-specific combinations which V43 acting as either male parent or female parent, there are 5 combinations having positive heterosis in diameter, corresponding with 62.5 %, and 6 combinations having positive heterosis both in height and in volume, corresponding with 75 %. This demonstrates that V43 has got a general combining ability (GCA), where by when crossing with the one of *M. leucadendra* or *M. cajuputi*, most of hybrids would perform heterosis in growth (except with Q40).

Therefore, the important characters (e.g. height growth or/and diameter growth) are to be adjusted more by additive alleles rather than by non-additive alleles or they perform in specific combination. Thus, if one certain male parent or female parent has got good general combining ability (GCA), it will then be able to create more favors for more trees to involve in the pollination. In this case, estimating value for breeding of female parent tree will be greater, especially in the seed orchards, because of it is generally very expensive to carry out an experiment of a huge number of trees only to find out few of outstanding specific combinations.

By control pollination, however, to choose individual trees of good specific combining ability (SCA) is very worth. For example, the female parent Ca65 was crossed with each of a series male parent trees as *M. leucadendra* or *M. viridiflora* that most of hybrid offspring perform negative heterosis in volume, but only one combination as Ca65L47 does perform positive heterosis in volume (20.46 %). This combination occupies 4.76 % of all combinations of the female parent tree Ca65. This demonstrates that, female parent tree Ca65 has got outstanding SCA when crossing with male parent tree L47. Growth in volume of their hybrid offspring (Ca65L47) ranks at $2^{nd}$ in 3 years old.

Furthermore, it is necessary to mention that the hybrid trees could perform heterosis under one certain environmental condition, but not in the others [e.g. in the third year, the hybrid combinations as L42V43 and V43L42 planted in An Giang perform positive volume heterosis (42.2 % and 20.3%, respectively), while with the same combinations and same ages, yet perform negative heterosis (-7.69% and -23.71 %, respectively) in Ninh Binh Province - northern Vietnam (Hoang 2011)]. Therefore, it could preliminarily remark that the discrepancy of growths between the hybrid varieties is caused by the difference of heredity and the interaction between genotype and environment. In other words, all the characters (or traits) of tree are the addition of hereditary value plus influence of environment where it grows and develops.

In addition, the results also indicate that if the hybrid variety is planted in the suitable conditions of climate and soil, it would increase the plantation productivity with no more any adding expenses. Moreover, by choosing various experimental sites the researcher could choose hybrid varieties which perform the best heritability on certain sites or in large scale. Therefore, to enhance plantation productivity of hybrid varieties, it is necessary to alleviate the confining factors of environment by properly using a series of sylvicultural measures, including determination of soil and climate conditions.

Thus, heterosis is subject to a sophisticated mechanism that can be integrally influenced by many factors such as additive gene effects, dominance, epitasis, gene linkage, maternal effects, and even genotype-environment interaction, but how differently each of them contributing to heterosis is subject to concrete conditions.

### 3.3. Selecting hybrid combinations with volume productivity exceeding 20% of the best parents

Generally, heterosis in biomass productivity is always the most important objective of the forest tree breeder. Productivity depends on survival ratio, growths (diameter, height, and trunk volume) with age and density. For most of tree species, it is impossible to evaluate satisfactorily their growing parameters by the early half of rotation (Kha 2006; Cuong 2006; Keiding 1992; Lantz 2008; Matheson and Williams 1994). However, rotation of forest plantation is always too long, even with some fast-growing species which timber as raw-material is the product being at least 7 - 8 years. So, predicting early performance of hybrids is important to subsequent breeding steps.

The objective of this study is a selection of some hybrid combinations which have trunk volume productivity exceeding 20% than that of the best parents. It is necessary to select out significant hybrid combinations satisfied the above objective at young stage. In the third year of experiment, there are 27 hybrids selected out of 126 inter-specific *Melaleuca* combinations with trunk volume exceeding their best parents from 20.30 % to 83.85 %, corresponding with 21.43 % of all experimented combinations (Table 3). Therefore, the best selected individuals are crossed with one another will cause to change gene frequency and genotype frequency in relation to genes influencing a certainly specific character, such as growth rate of tree.

Further than trunk volume, 27 *Melaleuca* hybrids also perform the aggressive growth responses to the locally harsh condition of flood and high sulphate acid soil in the Mekong River Delta of Vietnam where Erwin (2009) assessed that this region is one of the most vulnerable regions in the earth affected by global climate change.

Based on the experiment data, an estimate of approximate trunk volume of hybrids in 5 years old is extrapolated that seven combinations (i.e. Ca65L47, L56Ca72, L42V43, Ca65V32, Ca65L60, L50V43, and L59V66) can reach 33.23, 29.33, 28.28, 28.04, 27.78, 27.41, and 27.35 $dm^3$/tree, respectively. If density of stand in the later 5 years old is assumed 5,500 trees/ha (current experiment), the productivity of those combinations would be 36.55, 32.26, 30.84, 30.55, 30.15 and 30.08 $m^3$/ha/year, respectively.

Based on national strategic objectives of forest tree varieties development for the period of 2010 - 2020 being by the end of rotation, the little–poled timber plantation is to be achieving $30m^3$/ha/year (MARD 2007), the hybrid *Melaleuca* varieties of this study will be able to achieve 7 combinations with their timber productivity above this objective threshold, corresponding with 5.56 % of all combinations of the experiment. These selected hybrid combinations are valuable materials for subsequent breeding steps, taking part in the supply new high-quality varieties to afforestation, especially to production forest under the same environmental conditions.

Several *Melaleuca* species aggressively respond to conditions of high sulphate acid soil [e.g. *M. cajuputi* in natural settings of Mekong Delta of Vietnam (Nguyen et al. 2009), and in experimental settings in Thailand (Tahara et al. 2008a; Tahara et al. 2008b)]. Seven hybrid *Melaleuca* varieties of this study appear aggressive growth in the same natural condition of their parents in Mekong Delta of Vietnam that shows the high potential adaptation of these varieties to seasonal flooding and sulphate acid soil.

**Table 3. Exceeding level (%) in trunk volume of hybrid varieties in comparison with their best parents planted on seasonal flooding and sulphate soil in southern Vietnam (at three years old)**

| Rank | Combinations | $\overline{D}_{1.3}$ (cm) | $\overline{H}_{full}$ (m) | Trunk volume with bark | |
|---|---|---|---|---|---|
| | | | | $\overline{V}(dm^3)$ | Exceeding level (%) |
| 1 | L50V32 | 4.14 | 4.03 | 3.12 | 83.85 |
| 2 | L50Ca61 | 4.03 | 4.13 | 2.94 | 73.07 |
| 3 | Ca65V70 | 4.16 | 4.05 | 3.27 | 59.51 |
| 4 | Ca65L60 | 4.14 | 4.26 | 3.14 | 53.32 |
| 5 | Ca65V32 | 4.26 | 4.09 | 3.05 | 48.63 |
| 6 | Ca65L53 | 4.21 | 3.98 | 3.03 | 47.95 |
| 7 | L56Ca72 | 4.18 | 4.40 | 3.16 | 43.32 |
| 8 | L42V43 | 4.24 | 4.16 | 3.27 | 42.17 |
| 9 | Ca65V71 | 4.05 | 4.03 | 2.91 | 41.95 |
| 10 | Ca65L51 | 4.05 | 4.08 | 2.81 | 37.07 |
| 11 | L50V43 | 4.18 | 4.15 | 3.09 | 34.22 |
| 12 | Ca65L20 | 3.94 | 3.92 | 2.73 | 33.17 |
| 13 | Ca65L54 | 3.94 | 3.87 | 2.73 | 33.02 |
| 14 | Ca65L42 | 3.75 | 4.13 | 2.67 | 30.10 |
| 15 | Ca65V76 | 4.02 | 3.97 | 2.66 | 29.76 |
| 16 | L42V32 | 3.79 | 3.71 | 2.60 | 28.71 |
| 17 | Ca65L52 | 3.92 | 3.88 | 2.64 | 28.63 |
| 18 | V43Ca31 | 4.01 | 4.09 | 2.92 | 26.83 |
| 19 | Ca65L49 | 3.93 | 3.87 | 2.56 | 24.88 |
| 20 | L59V66 | 4.11 | 4.25 | 3.13 | 24.67 |
| 21 | Ca65L50 | 3.93 | 3.78 | 2.52 | 23.07 |
| 22 | Ca65V43 | 3.93 | 4.08 | 2.82 | 22.48 |

| | | | | | |
|---|---|---|---|---|---|
| 23 | L42Q41 | 3.85 | 3.91 | 2.47 | 22.28 |
| 24 | L42Ca61 | 3.87 | 3.75 | 2.51 | 21.52 |
| 25 | L42V35 | 3.77 | 3.88 | 2.44 | 20.79 |
| 26 | Ca65L47 | 4.54 | 4.24 | 3.65 | 20.34 |
| 27 | V43L42 | 4.03 | 4.11 | 2.77 | 20.30 |

## IV. CONCLUSION

The growth rate of the hybrid variety named L42V43 in 3 years old exceeds 1.31 times in height and 1.32 times in diameter than *Melaleuca* in mass production under the same conditions. Additionally, the height growth rate of hybrids is much more influenced by female parent trees.

In the third year experiment, having 27 hybrid combinations are selected out with trunk volumes exceeding at least 20% of the best parents, corresponding with 21.43% of all combinations. Additionally, they also perform the aggressive response to the locally harsh conditions of flood and high sulphate concentration soil.

In the fifth year, estimating 7 hybrid combinations (Ca65L47, L56Ca72, L42V43, Ca65V32, Ca65L60, L50V43, and L59V66) are estimated to reach above the threshold of 30m$^3$/ha/year of productivity, corresponding with 5.56 % of all combinations.

For the general combining ability (GCA), most of hybrids of V43 when crossing with *M. leucadendra* or *M. cajuputi* (either male parent or female parent) would perform positive heterosis in growth on seasonal flooding and sulphate soil.

For the specific combining ability (SCA), the hybrid combination Ca65L47of female parent tree Ca65 when crossing with male parent tree L47 has the largest trunk volume (3.65 dm$^3$ per tree) even at young stage.

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# ĐÁNH GIÁ SINH TRƯỞNG NHẰM CHỌN LỌC SỚM GIỐNG TRÀM LAI SINH TRƯỞNG NHANH TRÊN ĐẤT PHÈN NGẬP NƯỚC THEO MÙA TẠI PHÍA NAM VIỆT NAM

**Hoàng Vũ Thơ**

*Trường Đại học Lâm nghiệp*

## TÓM TẮT

Bài viết này giới thiệu kết quả chọn lọc tổ hợp tràm lai trồng khảo nghiệm ở khu vực phía Nam Việt Nam. Trong số 126 tổ hợp tràm lai khác loài, đã chọn lọc được 27 tổ hợp lai có thể tích thân cây vượt 20% so với bố mẹ tốt nhất ngay ở giai đoạn tuổi nhỏ. Hơn nữa, 27 tổ hợp lai này sinh trưởng tốt trên điều kiện đất phèn bán ngập. Khả năng tổ hợp chung (GCA) của cây V43 khi lai với các bố mẹ khác của *M. leucadendra* và *M. cajuputi*, thì đa số đều cho cây lai có ưu thế lai dương về sinh trưởng trên đất phèn bán ngập theo mùa. Trong khi đó, khả năng tổ hợp riêng (SCA) của cây mẹ Ca65 khi lai với cây bố L47 tạo ra tổ hợp lai Ca65L47 có thể tích thân cây lớn nhất (3,65 dm3/cây) ngay ở giai đoạn tuổi nhỏ. Đến cuối giai đoạn tuổi 5, ước tính có thể thu được 7 kết hợp lai khác gồm Ca65L47, L56Ca72, L42V43, Ca65V32, Ca65L60, L50V43, và L59V66 đạt năng suất vượt ngưỡng 30 $m^3$/ha/năm.

**Từ khóa: Cây lai, lai khác loài, sinh trưởng, tràm, ưu thế lai.**

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