The potential of introducing new variety of *Acacia* hybrids in agroforestry systems

S Sunarti* and A Nirsatmanto

Center for Forest Biotechnology and Tree Improvement Research and Development, Sleman, DI Yogyakarta, Indonesia

*Corresponding author’s e-mail address: nartinrz@biotifor.or.id

**Abstract.** The increases of multiple economic uses and ecological functions are among the essential targets in developing agroforestry systems. In this case, selecting the appropriate species with the range of characters adapted to agroforestry systems would become important. Breeding practices could be applied to produce high productive trees with such desired characters. Some *Acacias* species have been commonly planted under agroforestry systems in several locations, particularly in Java Island, due to producing good quality of wood for home industries and the ability to grow in multi-species associations. *Acacia* hybrids are new variety resulted from breeding through a crossing between two *Acacias*: *Acacia mangium* and *A. auriculiformis*. The main target of breeding for this variety is to produce a higher quality of wood combining the good properties from each both of parents in a shorter rotation. Although the breeding process mainly imposed the selection for better growth, tolerance pest and disease, and wood properties as primary economic production, the variety also performs other potential characters suitable for agroforestry systems such as light branching for stimulating the growth of crops, abundant flowers for increasing food for honey bee, produce tannin from bark residu, and high quality of wood pellet from the sawdust.

**Keywords:** breeding, hybridization, multiple economic, ecological function, community based forest

1. **Introduction**

Agroforestry system is all practices that involve a close relationship between the trees, animals and or pasture in which both of ecological and economic association [1]. The trees are woody perennial as multipurpose trees (MPTs) or as single-purpose trees. The most important is how to find the ideal tree for the successful agroforestry system or usually called the idiotype [2]. The ideal trees is a tree with the performance predictable, leading to the greater quantities and higher qualities of crop yields in defined environmental condition [3], capable of positive interaction with crops and provide any services for farmers [4].

*Acacia* hybrid is offsping that resulted from crossing between *Acacia mangium* and *A. auriculiformis*, naturally or artificialy [5][6]. Firstly found in Ulu Kukut, Malaysia on 1972 at the *Acacia* plantation that showed an outstanding performance among the others [5]. Due to its performance, the *Acacia* hybrid now being developed in many countries such as Malaysia, Vietnam, Thailand and Indonesia [7][8][9]. Comparing to the both of parents, *Acacia* hybrid vigour is faster grow, straighter
stem, lighter branching, better wood properties and more tolerance to pest/disease and more adaptive to many sites conditions [10][11][12].

Some of *Acacia* spp has already planted on agroforestry system such as *A. senegal* in Sudan [13], *A. mangium* and *A. auriculiformis* in Orrisa, India [14], *A. nilotica* in Chhattisgarh, India [15], *A. crassicarpa* in Pekanbaru, Riau, Indonesia [16] and *A. decuren* in Dieng, Indonesia [17]. The *Acacia* spp were combined with grass as fodder, rice, maize and sorghum as food source with the *Acacia* trees as windbreak. Although *A. mangium* and *A. auriculiformis* had been planted at agroforestry system, but *Acacia* hybrid vigor were not planted yet for agroforestry system, whereas superior to the both parents species. This paper will discuss some of the advantages of *Acacia* hybrid when planted in agroforestry systems.

2. Materials and Methods

2.1. Breeding strategy of *Acacia* hybrid

Center for Forest Biotechnology and Tree Improvement (CFBTI) has already set up the breeding strategy for *Acacia* hybrid as laid out on Figure 1. This method has been carried out since 2002s.
Figure 1. Flow chart of breeding strategy of *Acacia* hybrid (*A. mangium* × *A. auriculiformis*) [18].

2.2. Morphological characteristics of *Acacia* hybrid as an idiotype

The phenotypic characters of *Acacia* hybrid was identified in order to describe as an idiotype for agroforestry system. Some important phenotypic characters for agroforestry system are growth, stem straightness, type of branching and crown, abundance of flowers, root system and wood properties.
3. Results and Discussion

3.1. Breeding strategy

The progenies of crossing between *A. mangium* x *A. auriculiformis* are not always perform better than their both parents [19], although the first generation of *Acacia* hybrids were reported better than the parent trees which is known as hybrid vigour or heterosis [8]. Therefore the breeding strategy is needed to get as many *Acacia* hybrid vigor offspring as possible.

The breeding strategy used is co-improvement method in which the parents tree should be improved and selected (Figure 1). By crossing the improved trees, it is expected that the superior offspring will be obtained in accordance with the Mendell's Law which states that the characters of the progeny is a combination of the properties of the both parents tree [20]. Center for Forest Biotechnology and Tree Improvement had been produced 3 *Acacia* hybrid vigour which one of them has already registered at Variety Plant Protection (PVT) namely Sri Purwo 044 by the co-improvement method [18].

3.2. Idiotype of Acacia hybrid (*A. mangium* x *A. auriculiformis*)

*Acacia* hybrid (*A. mangium* x *A. auriculiformis*) is a new variety of forest plants which is categorized as fast growing species that used for raw material of any wood timber industries such as pulp and paper industry [6][9]. The first generation of *Acacia* hybrid usually have a good performance which called as hybrid vigour or heterosis, although hybrid breakdown with the opposite performance of hybrid vigour were sometimes occurred [6][19]. The *Acacia* hybrid vigour or heterosis usually showed better growth, stem form and branching, and better wood properties than the both parent species (Figure 2A) while the hybrid breakdown was worse [11][6][19][21]. While morphologicael characters mostly intermediate between the parents tree such as bark type, leaf (phyllodia), flowers and fruits (pods) (Figure 3).

![Figure 2](image-url). The comparation of branching type between *A. mangium* and *Acacia* hybrid (*A. mangium* x *A. auriculiformis*) (A) on 1- year old in Wonogiri, Central Java and the brancing on *Acacia* hybrid (B).
Figure 3. Mophological characters of *Acacia* hybrid (*A. mangium* × *A. auriculiformis*): base of branching (A), bark of young tree (B), bark of mature tree (C), phyllodia (C), spike of flowers (D) and young pods (E).

Generally, the tree phenotypic characteristics varies in type and colour bark, branching type, crown shape and stem circularity and mostly have intermediate characteristics between the parents, although some of them were very similar to the female or male tree [9]. The variation of tree phenotypic characters on *Acacia* hybrid seems has many advantages for being applied on agroforestry system. The tree can be functioned adjusted according to its phenotypic characters. For instance, the tree which harvested for sawntimber wood, the tree phenotypic characteristic should be straight stem, light branching and good wood basic density (Figure 4D and 4E). While for wood energy, fodder and wind breaking, the tree with heavy branching with fully leaves are very recommended (Figure 4C). All the trees which have any tree phenotypic characteristics, have ability to fixed the soil fertility by uptaking the nitrogen from the soil [21], make it suitable for fixing marginal lands with any tree functions.
3.3. Advantages of Acacia hybrid for Agroforestry system
The Acacia hybrids tree is a woody perennial which could be categorized as multipurpose tree based on its characteristics. The tree may provide more than one significant contribution to the production and other service functions whether in small scale or macro scale. The small scale is in the individual farm which trees grown around the house, the yard or as boundary land with the neighbors and the macro scale is the wide farming on agroforestry system such as in cropland, mixed intercropping and contour strip in farmland.
Figure 5. Young tree (1 year-old) (A) and mature tree (5 years-old) of *Acacia* hybrid (*A. mangium* × *A. auriculiformis*) (B) in Wonogiri, Central Java.

Figure 6. The development of terrace wood of *Acacia* hybrid (*A. mangium* × *A. auriculiformis*), cross section of 1-year old (A) and 5 years-old (B) log from Wonogiri, Central Java.

The trees can produce the wood for sawn timber based on the physical and mechanical properties such as the dried specific gravity and T/R ratio of shrinking of dried kiln condition were 0.6 and 3.9 respectively that suitable for sawn timber [22]. Beside its good wood properties, the wood were also easy being dried by dry kiln using final temperature of 70°C [23] and also more tolerance to termites (*Cryptotermes cynocephalus* Light.) attack [24]. Base on Indonesian National Standard (SNI) on resistance of termites attack, *Acacia* hybrid wood was categorized into grade 1 as very resistance.

years-old in Wonogiri, Central Java which climate type was C with the type of soil was vertisol (Figure 6B) [22]. Beside good growth and wood properties, *Acacia* hybrid also abundance of flowers on the peak flower season with bright colour and nice fragrance which attract the honey bees (Figure 3D).
The trees may also provide service functions such as trees in home garden and live fences or hedges. It is also suitable for windbreak, shelterbelt and hedgerow intercropping. The exercise of matching the site where a tree is planted needed to be done incorporate with climate and soil. Not only the wood is useful, but the waste such as bark and sawdust can also be used for any kind of product. The bark as waste of the sawmill useful for producing tannin extract [25], whereas the dust and sawdust waste can be used as a raw material for making pellets [26]. Further, it is necessary to determine the quality of tannins and pellets produced from this *Acacia* hybrid wood waste.

The growth of *Acacia* hybrid was 17% faster than a second generation of *A. mangium* based on the data of 1 year-old of the *Acacia* hybrid clonal test in Wonogiri, Central Java (Figure 5) [9]. Although fast growing species, *Acacia* hybrid has a good terrace wood of 65.4% on 5 years-old in Wonogiri, Central Java which climate type was C with the type of soil was vertisol (Figure 6B) [22]. Beside good growth and wood properties, *Acacia* hybrid also abundance of flowers on the peak flower season with bright colour and nice fragrance which attract the honey bees (Figure 3D).

The trees may also provide service functions such as trees in home garden and live fences or hedges. It is also suitable for windbreak, shelterbelt and hedgerow intercropping. The exercise of matching the site where a tree is planted needed to be done incorporate with climate and soil type to optimalize the advantages of the tree.

4. Conclusion

*Acacia* hybrid trees are potential for being develop on agroforestry system based on their phenotypic characteristics such as growth, stem form, type of branching and the wood properties. The trees will provide not only wood product but also non-wood product and any service functions. Establishment of demonstration plot may needed to observe more advantages of *Acacia* hybrid for agroforestry system.

References

[1] P.J. Wood, J. Burley. 1991. *A tree for all reason*. English Press. Nairobi. Kenya.
[2] P.K.R. Nair. 1985. *An Introduction to Agroforestry*. Kluwer Academic Publisher. London.
[3] C.M. Donald. 1968. *The Breeding of Crop Idiotypes*. Springer Link.
[4] P.A. Huxley. 1985. The tree/crop interface-or simplifying the biological/environmental study of mixed cropping agroforestry system. Dalam: *Agroforestry System*. Nederland.
[5] Z. Ibrahim. 1993. Reproductive Biology. *Acacia mangium*: Growing and Utilization. Winrock International and the Food and Agriculture Organization of the United Nations. Bangkok, Thailand. pp. 21-30.
[6] L.D. Kha. 2001. *Studies on the Use of Natural Hybrids between Acacia mangium and Acacia auriculiformis in Vietnam*. Agriculture Publising House. Hanoi.
[7] V. Luangviriyasaeng. 2007. Current situation and potential of plantation for pulp industry. *NFT News*. 10 1.
[8] L.D. Kha LD, Harwood CE, Kien ND (2012) Growth and wood basic density of *Acacia* hybrid clones at three location in Vietnam. *New Forest* (43):13–29. https://doi.org/10.1007/s 1056-011-926-y
[9] S. Sunarti. *Strategi breeding hibrid Acacia (Acacia mangium × Acacia auriculiformis)*. Dissertation. Faculty of Forestry. Gadjah Mada University. Yogyakarta. 2013.
[10] R. Yahya, J. Sugiyama, J. Gril. 2010. Some anatomical features of *Acacia* hybrid, *A. mangium* and *A. auriculiformis* grown in Indonesia with regard to pulp yield and strength paper. *J. Trop. For. Sci.* 33(3) 343-351.
[11] U.K. Rokeya, M.A. Hossain, M.R. Ali, S.P. Paul. 2010. Physical and mechanical properties of hybrid *Acacia* (*A. auriculiformis × A. mangium*). *J. Bang. Ac. Sci.* 32(2) 181-187.
[12] K. Kato, S. Yamaguchi, Chigira, Y Ogawa, K. Isoda. 2012. Tube pollination using stored pollen for creating *Acacia auriculiformis* hybrid. *Jour. Trop. For. Sci.* 24(2) 209-216.
[13] A.M. Gafaar, A.A. Salin, O. Lukanen, M.A. Fadl. 2007. The influence of different Acacia senegal agroforestry system on soil water and crop yield in clay soil of the Bule Nile. Region. Agriculture Water Management 87(1) 61-72.

[14] S. Puri and J. Panwar. 2007. Agroforestry: Systems and Practices. New India Publishing.

[15] S.S. Bargali, K. Bargali, L. Singh, L. Ghosh, L. Lakhera. 2009. Acacia nilotica based traditional agroforestry system: effect on paddy crop and management. Current Science 96(4) 581-587.

[16] A. Pribadi, Purnomo. Agroforestry sorghum (Sorghum spp) pada HTI Acacia crassicarpa sebagai sumber pakan lebah Apis cerana di propinsi Riau untuk mendukung budidaya lebah madu. The Proceeding of National Seminar of Agroforestry: Menuju pangan dan lingkungan yang lebih baik. Malang. Jawa Timur. 2017.

[17] A. Pujiwijanarko. Model agroforestri pengelolaan hutan bersama masyarakat (PHBM) di hutan lindung dataran tinggi Dieng. Thesis. University of Padjajaran. Bandung. 2015.

[18] S. Sunarti, M. Na’iem, E.B. Hardiyanto, S. Indrioko. 2013. Breeding strategy of Acacia hybrid (A. mangium x A. auriculiformis) to increase forest plantation productivity in Indonesia. J. Trop. For. Man. 19(2) 128-137. https://doi.org/10.7226/jtfm.19.2.128.

[19] B.J. Zobel and J. Talbert. 1984. Applied Forest Tree Improvement. New York. John Wiley.

[20] I. Mulyono. 2019. Variasi sifat fisika dan mekanika kayu hibrid akasia (Acacia mangium x Acacia auriculiformis) pada arah radial dari tiga klon yang berbeda. Undergraduate Thesis. Faculty of Forestry. Gadjah Mada University. 2019.

[21] E. Astari. Penyusunan skedul pengeringan dengan metode Terazawa dan penerapannya pada kayu hibrid akasia (Acacia mangium x Acacia auriculiformis) dari KHDTK Wonogiri. Undergraduate Thesis. Faculty of Forestry. Gadjah Mada University). 2019.

[22] F.I. Zohra. Variasi keawetan alami kayu hibrid akasia (Acacia mangium x Acacia auriculiformis) pada arah aksial dan radial pohon terhadap sarangan rayap kayu kering (Cryptotermes cynocephalus Light.). Undergraduate Thesis. Faculty of Forestry Gadjah Mada University. Yogyakarta. 2019.

[23] S. Mutiar, A. Kasim, Emriadi, A. Asben. 2018. Studi awal tanin dari kulit kayu Acacia auriculiformis A. Cunn. ex. Benth. Dari hutan tanaman industri untuk bahan penyamak kulit. Majalah Kulit, Karet, dan Plastik 34(2) 41-48. https://doi.org/10.20543/mkkp.v34i2.3967.

[24] R. Amirta, T. Anwar, Sudrajat, Yuliansyah, W. Suwinarti. 2018. Trial production of fuel pellet from Acacia mangium bark waste biomass. IOP Publishing. https://doi:10.1088/1755-1315/144/1/012040.

Acknowledgement
Gratefully thanks to The Acacia and Eucalyptus Team of Center for Forest Biotechnology and Tree Improvement who have a lot contribution in in establishment and measurement the plot.