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Species-site matching based on growth performance evaluation of mixed native and exotic secondary forest in Musuan Bukidnon

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Key words: Species-site Matching, Growth Performance, Mixed Forest, Native species, Exotic species.

Abstract

Species-site matching is an important consideration in rehabilitation efforts to assure success of a program. This study shows a simple method aiding decision makers in selecting species-site match and species combination (native and exotic) based on growth performance evaluation of trees. A total of 478 individuals composed of 12 species (8 endemic and 4 exotic) were assessed in a 30 year old mixed secondary forest in Bukidnon, Philippines. Data of diameter and height was analyzed using Univariate analysis in Brown-Forsythe's since their is unequal number of samples. Post-Hoc analysis of species performance was compared using Tukey's Honest Signifincant Difference. Results showed significant difference at <0.01 level of significance among the diameter and height of eight native tree species. The same result was found on exotic species at <0.01 level of significance. Tukey's HSD on native species revealed significant difference on the diameter and height of *Pterocarpus* at <0.01 level of significance as compared to *Artocarpus, Shorea*, *Sandoricum* and *Melanolepis*. Tukey's HSD on exotic species showed significant difference on *Gmelina* as compared to *Swietenia* at <0.01 level of significance in both diameter and height. Comparing native and exotic species showed significant difference on the growth of *Pterocarpus* against *Swietenia* at <0.01 and *Tectona* at <0.05 level of significance. *Gmelina* showed significant difference against *Artocarpus* (<0.01), *Shorea* (<0.01) and *Sandoricum* (<0.05). Species-site suitability concludes that *Pterocarpus indicus* and *Gmelina arborea* is the optimum species-mix combination and thus recommended for use in rehabilitation programs in site with similar conditions.

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Introduction

Species-site matching is a critical factor in planning reforestation program thereby considering the species based on restoration objective, climate, soil and other physical characteristics of the site (Wishnie *et al.*, 2007). Evaluation of site suitable species for planting is necessary for rehabilitation especially on degraded lands wherein survival rate and seedling growth is low (Gotoh & Yokota, 2009). Literature already recognized the physical condition of a specific site as the determining factor of the species that could survive in the area (Skovsgaard and Vanclay, 2008; Santos M. *et al.*, 2010). However, there are still some research gaps on the available evaluation on the better type of species.

Either exotic or native type of species would grow better is still a question at any area in humid tropics (Carpenter *et al.*, 2004). Some authors concluded successful use of native species for reforestation although highly affected by the site quality (Pedraza & Linera, 2003; Shono *et al.*, 2006; Schneider *et al.*, 2014). Others conclude exotic species are good option to local tree farmers with its efficient growth rate, available planting material and known silvicultural management techniques (Feyera *et al.*, 2002; Stimm *et al.*, 2008). However, current attempts on combining exotic and endemic trees in the mixed forest had already gained attention to some researchers. It is even known that plantations with exotic trees can facilitate succession of native species (Feyera *et al.*, 2002; Brockerhoff *et al.*, 2008). This conclusion warrants further question therefore on the best combination of native and exotic trees in a mixed forest.

To provide basic knowledge in answering such question, this study was conducted suited in the case of a mixed secondary forest established on the premises of Central Mindanao University in Maramag, Bukidnon, Philippines. The difference of Growth performance of tree species in this mixed forest aging 30 years was evaluated and the relative performance of species either endemic or exotic trees was compared.

This simple method of assessing species-site match based on optimum growth and assessing best combination of native and exotic species will be useful in proposing species-site match and optimum species combination for reforestation programs on nearby areas or areas with similar conditions on the site.

Materials and methods

Study site

The study was conducted in a mixed secondary forest fronting the administration building of College of Forestry and Environmental Science, Central Mindanao University, Musuan, Maramag, Bukidnon (Fig. 1). Geographically, located at 7°51' 35''N latitude and 125°2' 49''E longitude.

The elevation of the area ranges from 300-360 meters above sea level. The general climate of the area falls under Type III based on the Modified Corona classification of PAGASA characterized as having a seasonal variability that is not very well pronounced, with a dry season from November to April and wet during the remaining months of the year.

Data collection

Tree species were identified and recorded by qualified technical persons. Diameter at breast height was measured in centimeter using tree caliper and height was measured in meters using laser range finder. A total of twelve (12) tree species were recorded (Table 1) from the site of which eight (8) are identified endemic and four (4) are exotics. Considerably, Mahogany an exotic species has the largest number of individuals (225 recorded) and Alim and Thailand shower are the least recorded individuals both endemic and exotic respectively. A total of 478 tree individuals were found on the sampling plot.

Experimental lay-out

The study was carried out using Univariate in Completely Randomized Design (CRD) with unequal number of observation. Tree species both native and exotic were randomly distributed on the sampling plot. Using strip-line method, a 20m x 300m plot (shown in Figure 1) was established traversing the whole forest area starting from the upper elevation to the lower part of the site. Tree species serves as treatment and Height and diameter were the variable to be measured.

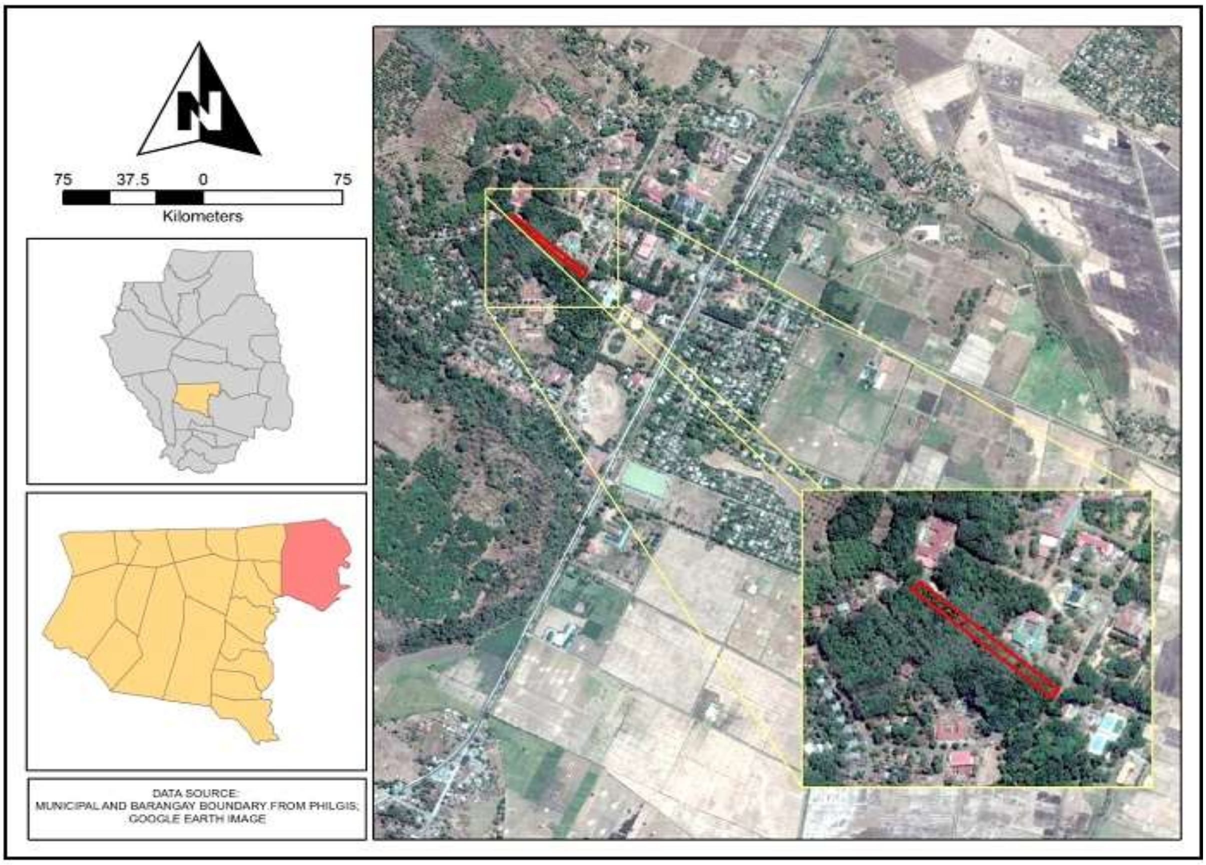

Table 1. Recorded species of trees from the 20x300 meter sampling plot.

Statistical analysis

The data gathered was tabulated statistically and analyzed through analysis of variance (ANOVA) and run in SPSS ver. 16.0 following Completely Randomized Design at 5% level of significance. Significant differences among treatment means were compared using Tukey's W-procedure. CRD analysis was set to Brown-Forsy thes since there is unequal number of samples (tree individual per species) recorded from the site.

Results and discussion

Performance of native species

Analysis of variance showed highly significant difference among the diameter and height of eight native tree species (Table 2*)*. *Pterocarpus* has the highest diameter mean and largest diameter range dispersion ranging from 10 to 95 cm minimum and maximum range respectively (Fig. 2). Following *Pterocarpus* is *Vitex* with a mean diameter of 36 cm for 9 individual samples.

Tukey's Honest Significant Difference test was used to compare means of species. Results obtained shows there is a significant difference in the growth of diameter of *Pterocarpus* as compared to *Artocarpus, Shorea*, *Sandoricum* and *Melanolepis* at *<0.01* level of significance. No other species showed a significant difference.

The same results was found on height wherein Tukey's HSD reveals significant difference on the growth of *Pterocarpus* as compared to *Melanolepis*, *Artocarpus* and *Sandoricum* at *<0.01* level of significance. Also, there is a significant difference in the height of *Shorea* as compared to *Artocarpus* (*<0.01* level of significance), *Melanolepis* and *Sandoricum* (both at <*0.05* level of significance). Observably, *Pterocarpus* has the highest mean among native tree species (Fig. 3) with 50% *Pterocarpus* individuals varies along a height of 15-28 meters.

Performance of exotic species

Results of Analysis of Variance confirmed highly significant difference among the diameter and height of four exotic trees (Table 3). Obviously, *Gmelina* has the highest diameter dispersion among exotic trees (Fig. 4) of which 50% of individuals' ranges on a diameter from 23 to 45 cm and a minimum and maximum diameter range of 10 to 70 cm.

Tukey's HSD reveals significant difference on the diameter *Senna* as compared to *Swietenia* (*at <0.01 level of significance*) and *Tectona* (*at <0.05 level of significance). Gmelina* also showed significant difference against *Swietenia* at <*0.01* level of significance having mean diameter difference of 12.5 cm.

Table 1. Recorded species of trees from the 20x300 meter sampling plot.

No.	Common Name	Scientific Name	Individuals
		Native Species	
1	Alim	*Melanolepis multiglandulosa* (Reinw. ex Blume) Rchb. & Zoll	5
2	Banaba	*Lagerstroemia speciosa* (L.) Pers.	10
3	Ipil	*Intsiabijuga*(Colebr.) O. Ktze.	6
4	Marang Banguhan	*Artocarpus odoratissimus* Blanco	24
5	Molave	*Vitex parviflora*Juss.	9
6	Narra	*Pterocarpus indicus* (Pers.) Rojo forma echinatus	35
7	Santol	*Sandoricum koetjape*(Burm. f.) Merr.	13
8	White Lauan	*Shorea contorta*S. Vidal.	49
		Exotic Species	
9	Teak	*Tectona grandis* Linn.	10
10	Mahogany	*Swietenia macrophylla*King.	225
11	Thailand Shower	*Senna siamea*H.S.Irwin & Barneby (Lam.)	5
12	Yemane	*Gmelina arborea* Roxb.	87
Total			478

The diameter of the remaining two exotic species did not show significant difference against each other.

Tukey's HSD revealed only a significant difference on the height of *Gmelina* as compared to *Swietenia* at <*0.01* level of significance with a mean difference of 8 cm. Other exotic species do not significantly differ from each other. Mean height of the exotic species and height distribution of individuals is presented in Fig 5.

Native vs. Exotic Species Performance

Diameter and height growth of native and exotic species were compared using Analysis of Variance to determine if whether what type of species performed best on the area.

Results revealed no significant difference (Table 4) on height and diameter in both types of species. Thus, it is not conclusive that given site condition, either one of the types of species will grow better.

Table 3. Results of Analysis of variance on Diameter and Height of Exotic species.

	ANOVA					
		Sum of Squares	Df	Mean Square	F	Sig.
Tree Diameter	Treatment	12256.278	3	4085.426	16.986	.000
	Error	77687.106	323	240.517		
	Total	89943.384	326			
Tree Height	Treatment	4049.518	3	1349.839	13.883	.000
	Error	31404.713	323	97.228		
	Total	35454.231	326			

Table 4. Results of Analysis of variance between native and exotic type of species.

		ANOVA				
		Sum of Squares	D f	Mean Square	F	Sig.
Tree Diameter	Treatment	390.100	1	390.100	1.281	.258
	Error	144922.071	476	304.458		
	Total	145312.171	477			
Tree Height	Treatment	81.531	1	81.531	.776	.379
	Error	50020.346	476	105.085		
	Total	50101.877	477			

All the species were analyzed at the same time using Tukey's HSD to reveal if there are endemic trees grow better than exotic trees or vice versa. Table 5 shows the result of Analysis of variance and revealed it was only *Pterocarpus* among the native species grow significantly against slow performing exotic species in terms of diameter. On the other hand, *Senna* and *Gmelina* performed better as compared to some native species. *Pterocarpus* was consistent on height showing a significant difference as compared to *Swietenia* only. Among exotics, only *Gmelina* showed significant difference against *Artocarpus* and *Sandoricum*.

Table 5. Results of Tukeys HSD on the Diameter between native and exotic species.

Multiple Comparisons						
Tree Diameter Tukey's HSD						
(I) Tree Species	(J) Tree Species	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Pterocarpus[N]	*Swietenia*[E]	20.2751*	2.8981	.000	10.755	29.795
	Tectona[E]	19.2929*	5.7190	.038	.507	38.079
Gmelina[E]	*Artocarpus*[N]	17.4368*	3.6774	.000	5.357	29.516
	Shorea[N]	11.7905*	2.8488	.002	2.433	21.148
Tree Height Tukey's HSD						
Pterocarpus[N]	*Swietenia*[E]	8.6790*	1.7516	.000	2.925	14.433
Gmelina[E]	*Artocarpus*[N]	9.9464*	2.2226	.001	2.646	17.247
	Sandoricum[N]	10.3454*	2.8664	.018	.930	19.761

*. The mean difference is significant at the 0.05 level.
[N]. Native Species
[E]. Exotic Species

These results imply that growth performance among the species does not depend enormously on type (native or exotic). Defining growth performance at species type (native or exotic) level is not well-established since differences among growth performance vary from specific species character and its success depends on plantation site quality (Pedraza and Linera, 2003). Evidently, the notion that exotic trees grow better than endemic trees was also disproved based on the results that native species outcompetes some exotic species even when planted in mixed forest.

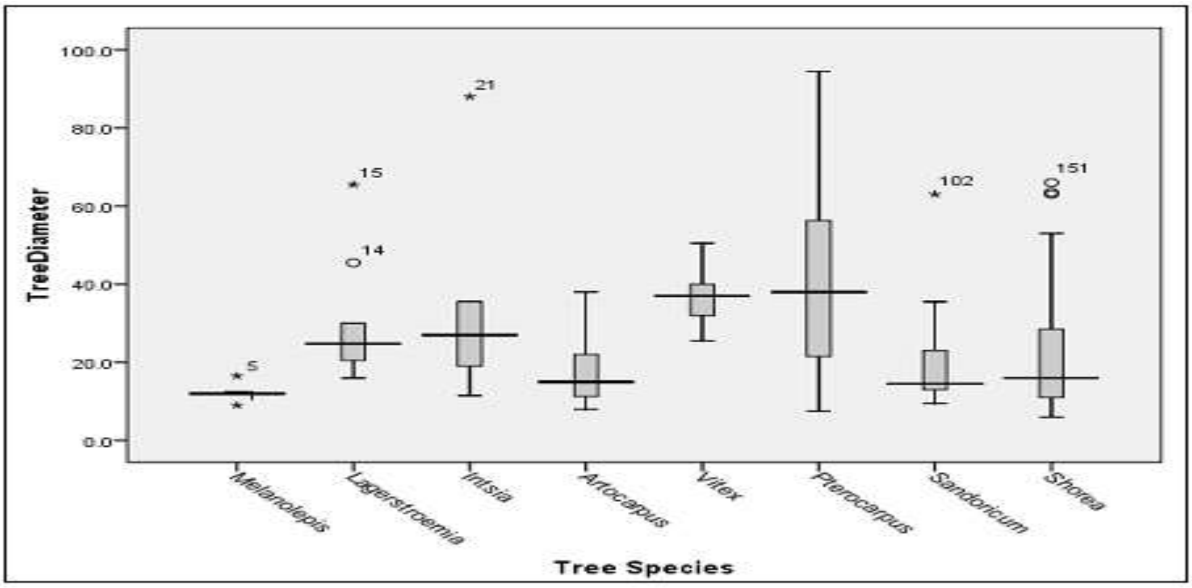

Fig. 2. Diameter dispersion among eight native tree species.

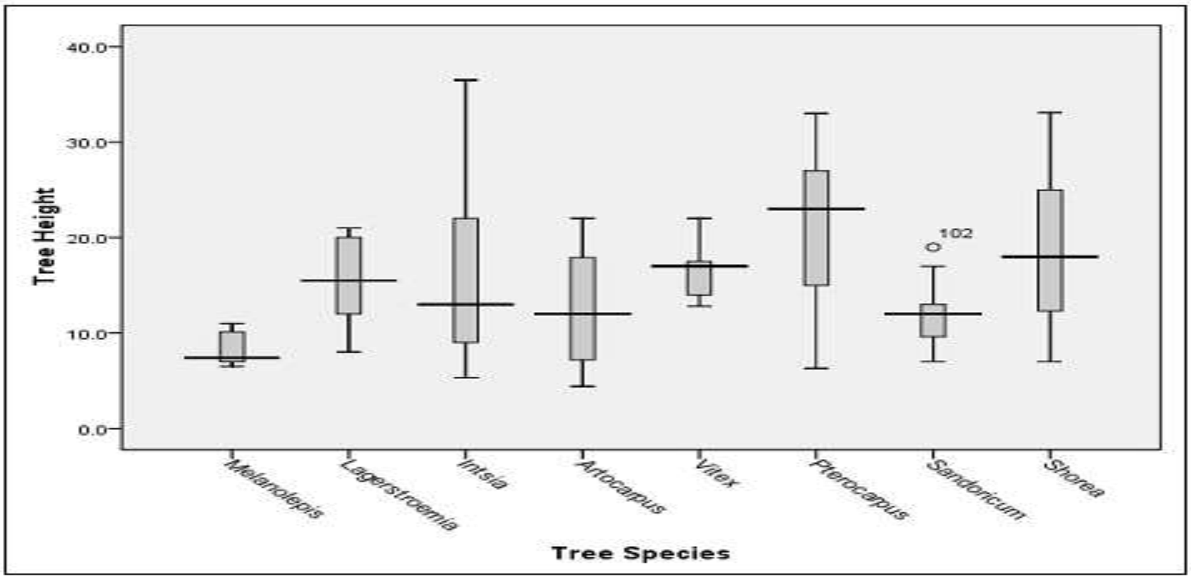

Fig. 3. Height dispersion among eight native tree species.

The same result was acquired by Schneider *et al.*, (2014) as native species grow better than exotic species when planted in open areas in Leyte, Philippines. Some authors reported no significant difference in the growth performance between native and exotic species similar to the results of this study (Mulizane *et al.*, 2005; Martin and Canham, 2010).

Results revealed the good growth performance of *Pterocarpus* (native) and *Gmelina* (exotic), considerably attributed to the high adaptability of the species on the local site conditions. This is supported by several experiments conducted assessing the survivability of *Pterocarpus* and *Gmelina* on different site conditions and concluded the high adaptability of both species on different extremes of the area (Castañeto, 1997; Calvo-Alvarado *et al*., 2007).

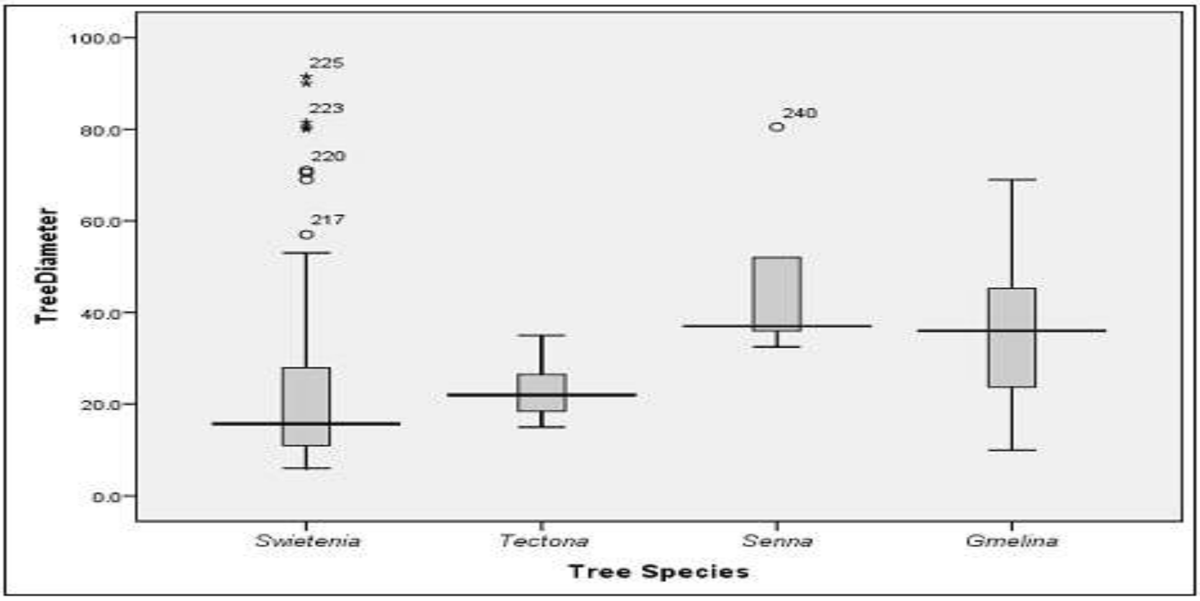

Fig. 4. Diameter dispersion among four exotic tree species.

Growth performance of *Gmelina* originating from the study area was actually tested by Nicholls and Laureto (1995). Results of the study reported the seeds from the area could grow up to 10.3 cm Diameter at Breast Height, 5.43 meter height and a 90% survival rate at 2.5 years of age. This result indicates the good species-site match and excellent combination of *Pterocarpus* and *Gmelina* assuring success of species mix use on areas with similar site condition.

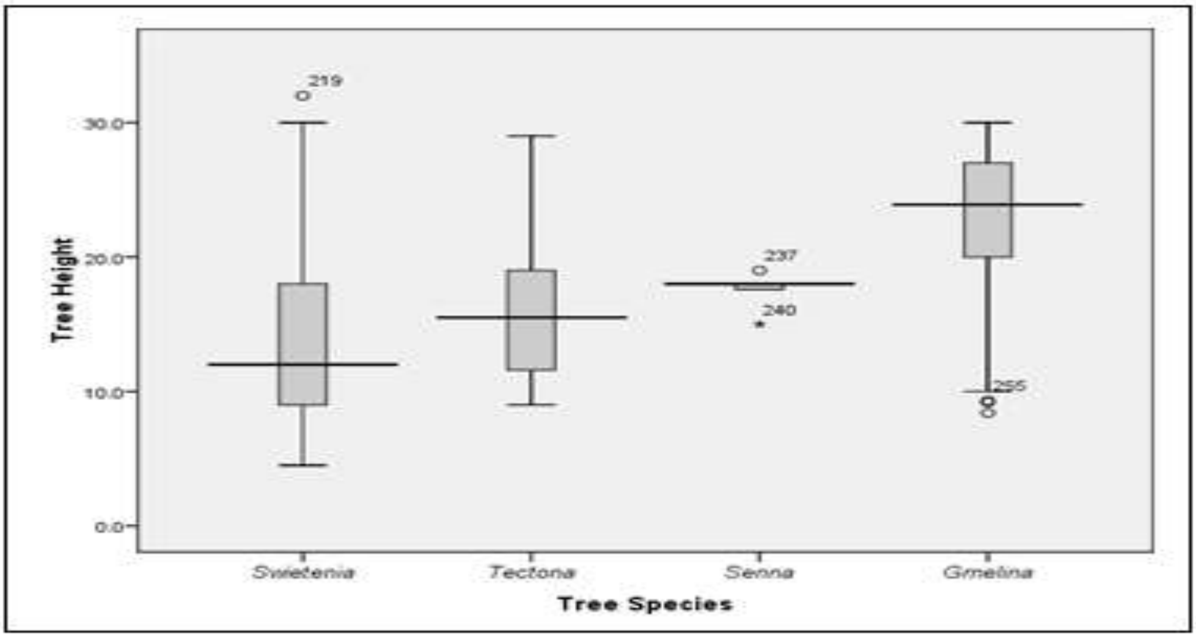

Fig. 5. Height dispersion among four exotic tree species.

Conclusion

Species-site suitability concludes that Narra (*Pterocarpus indicus* (Pers.) Rojo forma echinatus) a native species and Yemane (*Gmelina arborea* Roxb.) an exotic species is the optimum species-mix combination since both performed remarkably on the given site condition and thus recommended for use in reforestation/afforestation programs in site with similar conditions of the area under study. It was also found out that comparing growth performance at the species type (native or exotic) level is not conclusive since growth of trees varies from specific species character level and its matching with the existing site condition. Rehabilitation programs must always anchor the principles of species-site matching and should be guided with growth performance evaluation studies using simple methods such as the study conducted to assure successful implementation of programs in the field.

References

Brockerhoff EG, Jactel H, Parrotta JA, Quine CP, Sayer J. 2008. Plantation forests and biodiversity: oxymoron or opportunity?. Biodiversity and Conservation **17,** 925-951.
http://dx.doi.org/10.1007/s10531-008-9380-x

Calvo-Alvarado JC, Arias D, Richter DD. 2007. Early growth performance of native and introduced fast growing tree species in wet to sub-humid climates of the Southern region of Costa Rica. Forest Ecology and Management **242**, 227-235.
http://dx.doi.org/10.1016/j.foreco.2007.01.034

Carpenter FL, Nichols JD, Sandi E. 2004. Early growth of native and exotic trees planted on degraded tropical pasture. Forest Ecology and Management **196,** 367-378.
http://dx.doi.org/10.1016/j.foreco.2004.03.030

Feyera S, Beck, Lüttge U. 2002. Exotic trees as nurse-trees for the regeneration of natural tropical forests. Trees **16**, 245-249.
http://dx.doi.org/10.1007/s00468-002-0161-y

Gotoh T, Yokota Y. 2009. Development of Agroforestry technology for the rehabilitation of tropical forests. Japan International Research Center for Agricultural Sciences (JIRCAS) Working Report, **60**.

Martin PH, Canham CD. 2010. Dispersal and recruitment limitation in native versus exotic tree species: life-history strategies and Janzen-Connell effects. Oikos **119,** 807-824.
http://dx.doi.org/10.1111/j.1600-0706.2009.17941.x

Mulizane M, Katsvanga CAT, Nyakudya IW, Mupangwa JF. 2005. The growth performance of exotic and indigenous tree species in rehabilitating active gold mine tailings dump at Shamva mine in Zimbabwe. Journal of Applied Science and Environmental Management **9,** 57– 59.
http://dx.doi.org/10.4314/jasem.v9i2.17292

Nicholls 1. Laureto ES. 1995. Bukidnon Forests Incorporated 1995 Annual Report to Australian Center for international Agricultural Research Project 9208. Bukidnon Forests Incorporated Internal Report. Malaybalay, Bukidnon, Philippines.

Pedraza RA, Williams-Linera G. 2003. Evaluation of native tree species for the rehabilitation of deforested areas in a Mexican cloud forest. New Forests **26**, 83-99.
http://dx.doi.org/10.1023/A:1024423511760

Santos MF, Betha Lusiana, Meine Van Noordwijk. 2010. "Tree growth prediction in relation to simple set of site quality indicators for six native tree species in the Philippines." International Journal of Forestry Research.
http://dx.doi.org/10.1155/2010/507392

Schneider T, Ashton MS, Montagnini F, Milan, PP. 2014. Growth performance of sixty tree species in smallholder reforestation trials on Leyte, Philippines. New forests **45,** 83-96.
http://dx.doi.org/10.1007/s11056-013-9393-5

Shono K, Davies SJ, Kheng CY. 2006. Regeneration of native plant species in restored forests on degraded lands in Singapore. Forest Ecology and Management **237**, 574-582.
http://dx.doi.org/10.1016/j.foreco.2006.10.003

Skovsgaard JP, Vanclay JK. 2008. Forest site productivity: a review of the evolution of dendrometric concepts for even-aged stands. Forestry **81,** 13-31.
http://dx.doi.org/10.1093/forestry/cpm041

Stimm B, Beck EG, Unter S, Aguirre N, Cueva, E, Mosandl R, Weber M. 2008. Reforestation of abandoned pastures: seed ecology of native species and production of indigenous plant material. In: Beck, E., Bendix, J., Kottke, I., Makeschin, F. & Mosandl, R. (eds.) Gradients in a tropical mountain ecosystem of Ecuador. Ecological Studies **198,** 417-429. Springer, Berlin.
http://dx.doi.org/10.1007/978-3-540-73526-7_40

Wishnie MH, Dent DH, Mariscal E, Deago J, Cedeno N, Ibarra D, Ashton PMS. 2007. Initial performance and reforestation potential of 24 tropical tree species planted across a precipitation gradient in the Republic of Panama. Forest Ecology and Management **243,** 39-49.
http://dx.doi.org/10.1016/j.foreco.2007.02.001