Research Note: Creating an Optimum Potting Mixture for Resource-Constrained Growers

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[Editor's note: For the purpose of this ECHO Asia Note, this article has been condensed and shortened. If you are interested in obtaining a more complete version of this study, please contact echoasia@echonet. org (http://echoasia@echonet.org). Hannah Gray was a student volunteer from Kalamazoo College who conducted her Senior Independent Project at the ECHO Asia Seed Bank from June-August 2012. This ECHO Asia Note is the culmination of that research on potting mixtures for usage at the ECHO Asia Seed Bank. Brock Mashburn, current ECHO Asia Intern, will be continuing Hannah's work in an effort to refine the results and usable conclusions.]

Introduction

In a tropical setting, growing seedlings can be a difficult task. A major factor of concern for nursery production is water-logging (Zhu, 2007). During the rainy season, oversaturated soils can effectively suffocate root systems of a seedling by restricting flow of oxygen and other important minerals (Forcella, 2000). Nursery plants potted in dense soils are more prone to the negative effects of water-logging. Traditionally, the incorporation of materials such as perlite and vermiculite into potting mixtures helps to combat soil compaction and facilitate drainage. However, both perlite and vermiculite can be restrictively expensive for growers, especially resource constrained growers, like many of those with whom you work.

Nursery research from recent years has focused on finding viable, sustainable, low-cost alternative materials for potting mixes, often utilizing waste products of other industries such as: wood shavings, municipal compost, rice hull, and coconut coir (Arenas, 2002; Meerow, 1994; Ahmad et al., 2012). Rice hulls and coconut coir, which are plentiful in Asia, have the potential to effectively minimize risk for water-logging while replacing an expensive input such as perlite or vermiculite. Coir material has a high water-holding capacity within its fibers and good drainage through the pore space it creates in a substrate. Rice hull is an abundant byproduct of the rice milling industry and ubiquitous in tropical settings. Like coir, it creates pore space in mixtures needed for appropriate drainage and does not degrade quickly over time. Together, these two materials are promising low-cost alternatives to peat in nursery potting mixtures.

The purpose of this research was to investigate optimal potting mixtures, utilizing low-cost inputs available in Northern Thailand and in similar settings in Asia. In order to quantify success of a potting mixture, plant health and growth were evaluated by measures of chlorosis/necrosis, seedling length, and biomass, taken in the field and supported with measures of seed health and vigor in the lab through germination trials. This research was done to determine whether mixtures made from local materials can produce plants of a similar, or even better, quality than a commercial mixture.

Experimental Design

We tested seven potting mixtures from the materials of interest across four seed varieties: 'Chiang Dao' lablab bean (*Lablab purpurpeus*), moringa (*Moringa oleifera*), pumpkin (*Cucurbita moschata*), and tomato (*Solanum lycopersicum*). These seed species were selected for importance to farmers in ECHO's network, as well as to provide variety.

Seed bank staff and ECHO Asia advisors determined the potting mix components and ratios based on previous experience, availability to farmers, and potential for being a viable commercial mix alternative (Table 1). Efficacy of potting mixture was measured by evaluating seedling emergence, growth, and percent chlorosis/necrosis (estimate of the amount of yellowing/browning on a scale from 0 [none] to 100 [complete]) over the 36-day growing period. To complement the emergence data from the potting mixture test, germination trials were conducted with eight replications of each of the four varieties over a 20-day period. This established a baseline of seed vigor based on germination to compare to potting mixture emergence results.

Name	Components	Ratio
Commercial	Commercial Potting Mix[1] - inoculated mushroom compost	1
UHDP	Soil, compost[2], manure[3]	5:1:1
Marcia	Rice hull, shredded coconut coir, compost	1:1:1
Modified Marcia	Rice hull, shredded coconut coir	1:1
Heavy	Rice hull, soil, compost	1:1:1
Light	Right hull, chunked coconut coir, shredded coconut coir	1:1:1
Biochar	Burn rice hull[4], rice hull, shredded coconut coir	1:1:1

(/resources/760e99b5-4295-48a9-9ae5-0b5c8bf3c7a2)Table 1. Potting mixtures and their component ratios used in the experiment.

1. *ECHO Asia staff purchased "Excellence Soil Brand Dr. Pornchai" commercial potting mix, a dark loamy material made with the addition of Trichoderma mushroom culture and the polysaccharide chitosan, which acts as a biopesticide protection for seed, from the Kamtieng Plant Market in Chiang Mai.*
2. *Compost, made from commonly found farm materials such as vegetative matter, soil, and animal manure, is dense in nutrients and can be made on site (Menalled, 2005).*
3. *Manure was obtained from free-range cattle dung.*
4. *Burnt rice hull has the potential to improve plant productivity in much the same way that woodbased biochar has been shown to do (Graber, et al., 2010). However, upon further research, we realize that our charred rice hulls were not formally treated as biochar, because they were not mixed with compost and allowed to sit for several months (See ECHO Asia Note # 9 Biochar: An Organic House for Soil Microbes (http://goo.gl/cP9C4L).*

Results

1. Emergence

There were no significant effects of species, potting mix, or the interaction

between species and potting mix on overall emergence rate. However, the mean number of days to 50% emergence did vary significantly based on species.

2. Seedling Growth

The significance of species, potting mix type, and their combined interaction upon seedling length changed distinctively over the course of the seedlings' growth (Figure 4). At 10 and 20 days after planting, there was no significant interaction between potting mixture type and species. By 30 days after planting, species and potting mix treatments continued to exert significant effects on seedling length as independent factors, and the interaction between these two effects became moderately significant. Differences among potting mix types at 30 days of growth were more distinct, with commercial and UHDP mixes exhibiting the greatest seedling length. The interaction between species and potting mix type was significant at 30 days, with each individual species exhibiting a unique response to potting mix type, as opposed to generalized responses to potting mix at previous time intervals. While UHDP and commercial mix were among the top two performing mixes for each species, they varied by species as to the level of superiority over other mixes. For lablab seedlings, UHDP mix stood alone as yielding significantly longer seedlings compared to all other mixes. Moringa seedlings were only significantly longer in UHDP mix when compared to those grown in heavy mix. Pumpkin seedlings grown in commercial mix were not significantly longer than those grown in UHDP mix, although they were significantly longer than seedlings grown in all other mixes. Pumpkin seedlings grown in UHDP mix were only significantly longer than those grown in biochar and heavy mixes. Tomato seedlings grown in UHDP and commercial mixes grew equally well and significantly better than all other mix treatments. However, examining seedling length alone is not always indicative of plant health, as etiolation (elongation of plant stems) can often be a sign of other stressors, including lack of light.

3. Seedling Health

After 36 days of growth, harvested seedlings displayed significant differences between species and potting mix types for all dependent variables: seedling height, necrosis, chlorosis, wet mass, and dry mass. In addition, significant interactions occurred between seed species and potting mix type for all post-harvest dependent variables.

Seedling length at time of harvest varied significantly by the interaction of species and potting mix type. Lablabs grown in UHDP mix grew significantly longer than all other seedlings except lablabs grown in commercial mix. Tomatoes ranged greatly in final seedling length. Single potting mix types also displayed varied seedling length by species. In the UHDP potting mix, mean lablab seedlings were significantly longer than the other three species, which were not significantly different from each other. Modified mix supported lablabs of intermediate length for its species, while it produced the lowest level of tomato seedling growth.

Chlorosis and necrosis were used as measures of health before harvest. Seedlings varied significantly in chlorosis and necrosis levels by species and potting mix and by the interaction of those two effects (Figure 5). For tomato and pumpkin, levels of necrosis and chlorosis appeared more varied than for moringa and lablab seedlings (Figure 5). Furthermore, on average, lablab and moringa plants never reached levels of necrosis higher than 10% or levels of chlorosis higher than 25%. Pumpkin and tomato plants in certain potting mixes reached necrosis levels higher than 20% and levels of chlorosis higher than 40%.

Seedling dry biomass varied significantly by species, potting mixture, and the interaction of species and potting mixture (Figure 6). Primary productivity of each species' seedlings, as measured by dry biomass, varied noticeably for lablab and pumpkin specimens by potting mixture treatment (Figure 6). For moringa and tomato, the differences between potting mixture treatments were less dramatic (Figure 6). Grown in UHDP mix, lablab and pumpkin achieved the highest level of dry biomass at 4.6 ± 0.5 g and 4.6 ± 0.4 g. Conversely, moringa and tomato seedlings grown in UHDP mix gained much less dry biomass over the 36-day growing period (0.7 ± 0.4 g and 1.1 ± 0.4, respectively).

Summary In this study, we attempted to examine to what extent variation in potting mixture composition and species influenced emergence and vigor of seedlings grown in a tropical nursery setting. Previous studies indicated that rice hull and coconut coir are appropriate additions or substitutions to traditional potting mixes with innocuous effects (Ahmed, 2012). Addition of rice hull and coconut coir to potting mixtures is thought to minimize risk of pathogens and growth of weeds as well as increase porosity and prevent water-logging due to their status as a soilless material and their physical properties. Burnt rice hull has been indicated as an enhanced form of soilless material and correlated with increased fertility of potting substrate (Graber et al., 2010).

Although our results cannot support nor discredit these claims, they do suggest that nutritional qualities of soil-

(/resources/03832fd4-5bed-4b86-bc10-1c65cb6cff82) Figure 1. Seedlings.

(/resources/9ec98bb7-8f65-43d4-831f-c5a157196b5a)Figure 2. Measuing seedling growth.

(/resources/7c1c45ff-5592-42fe-8d36-dd364a1743a3)Figure 3. Evaluating chlorosis/necrosis.

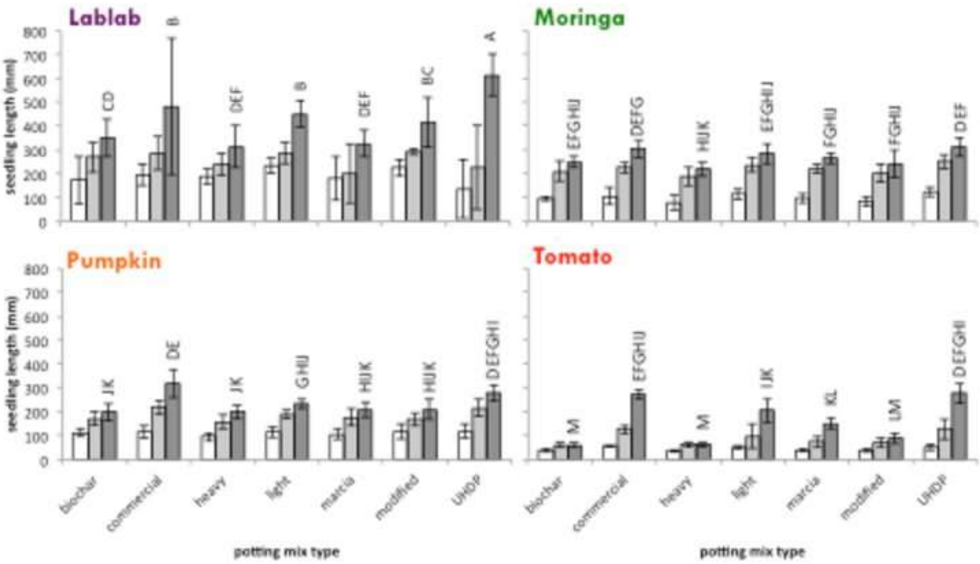

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Figure 4. The effect of potting mixture, species and date [10 (white), 20 (light grey), and 30 (dark grey) days after planting] on seedling length (mm). Different letters above bars denote the significant effect of species on overall germination rate, $F = 5.99$, $p = 0.0041$. Error bars represent ±1 SE of the mean.

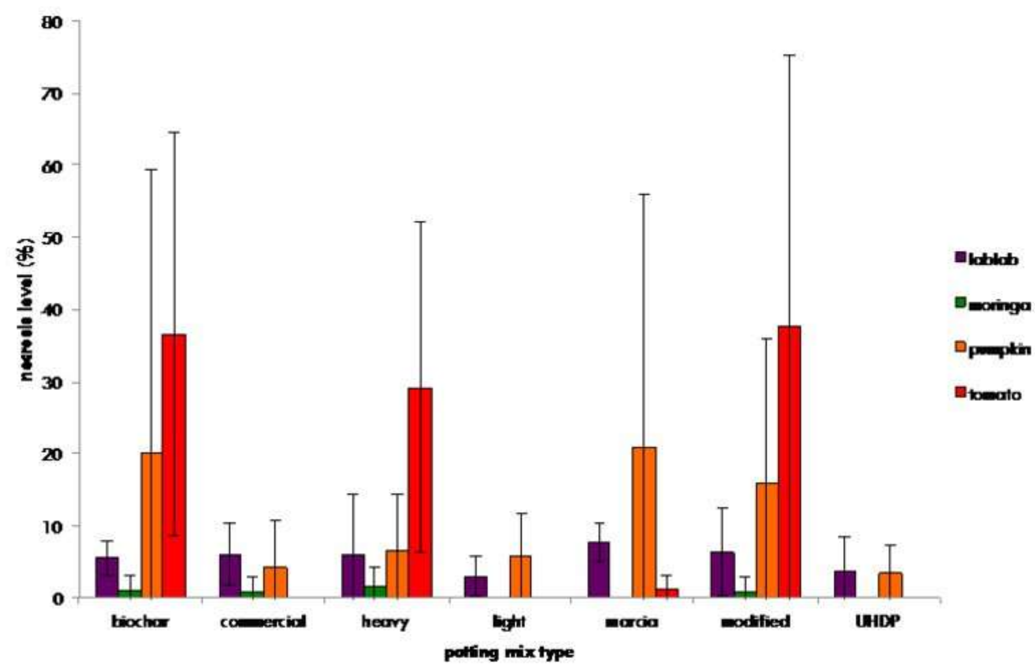

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Figure 5. The effect of seed species and potting mix on necrosis levels (%) at time of harvest, 36 days after planting. Error bars represent ±1 SE of the mean.

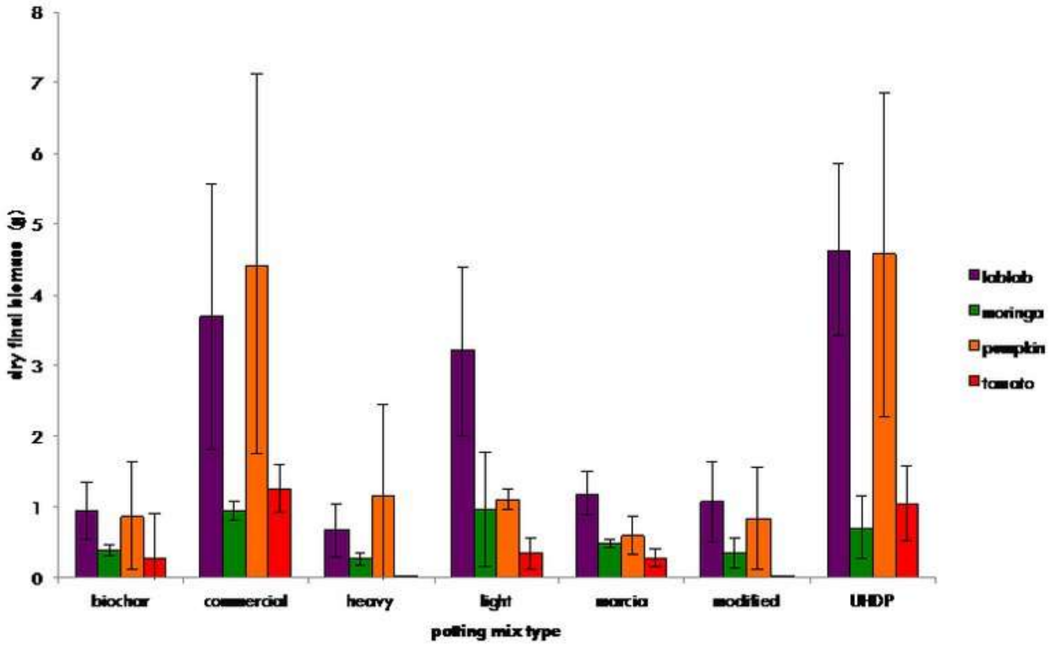

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Figure 6. The effect of seed species and potting mix on dry biomass (g) at time of harvest, 36 days after planting. Error bars represent ±1 SE of the mean.

based substrates might be more important to overall plant growth than the relatively sterile environment and physical properties offered by soilless substrates that we used in the experiment. This is of particular consequence in resource-limited settings where additional fertilizer is economically restrictive. During the rainy season, poor drainage of a substrate can decrease seed germination rates, by increasing the chance of seed rot and hindering water balance in the seedling (Zhu, 2007). In designing our mixes, we were most interested in the role that water status of the substrate plays in the growth of the plants, and therefore did not incorporate fertility status of the substrate into the experiment. The addition of rice hull and coconut coir to mixes was to increase drainage capacity and decrease the negative effects of oversaturation of water in the young plants. The data indicate that in this field study, drainage capacity played a lesser role in successful seedling growth than previously postulated. However, these results are grounded in the particular setting and needs of the ECHO Asia Seed Bank in northern Thailand and are ultimately primarily most applicable to this specific sub-tropical climate during rainy season.

The results from this study suggest that by day 30, nutrient status was a limiting factor to plant growth. Earlier in the study, potting mix type was not a significant determinate of seedling growth. This implies that for plants potted for only a short-time, mixtures of a lower nutrient status might be a viable option for growers with restricted access to resources. Therefore, the planned time spent in a nursery setting is an important factor to consider when selecting a potting mixture.

Although this study did not amend potting mixtures with any fertilizer, future studies should explore the effect of adding a slow-release or liquid fertilizer to the potting mixtures, whether organic or synthetic. Additionally, future studies could add drainage-improving materials (coir, and rice husk) to the UHDP mix to increase porosity. Use of osmocote or other nutritional supplements to potting mixtures is common practice in the nursery industry. While perhaps not ideal for resource-constrained settings, there are low-cost methods of fertilization, such as ground bone or blood meal, and fertilizer from drained fish ponds. Addition of a fertilizer would allow us to explore the effect of physical-chemical variation, without the confounding variable of nutrition differences among mixtures. Financial resources allowing, a secondary study would benefit from measuring nutrient levels in the potting mix samples before, during, and after growth of a seedling. Obtaining a nutrient profile would allow us to better examine variation in nutrient status of different mixes and adjust for variation in soil-based materials from batch to batch. It would also be good to reuse the potting mixes in secondary and tertiary plantings to gauge the fertility of a mix over a longer time frame.

The burnt rice husks were included in the study because of their availability and use in the nursery industry of Thailand; however, research related to biochar suggests that charred material is best utilized after that material has been thoroughly incorporated with nutrient- and microbially-rich substrates, kept moist, and allowed to age for several months. The bio-char material used in this study was not aged in this manner prior to incorporation with potting mixtures. When used appropriately, the use of biochar in a potting mix may have many benefits to plants including: water holding capacity, improved drainage, Cation Exchange Capacity (CEC) for holding nutrients, and improved habitat for microbial organisms, all of which may contribute to an ideal potting mix in resource-constrained settings. Future research should focus on the incorporation of biochar (with and without substrate aging) into soilless mixes for use as a potting soil in nurseries.

The timing of this study was limited to the rainy season in Thailand and would benefit from replication in both the dry and rainy seasons. Mixtures that did poorly under the high moisture, relatively high temperatures of rainy season might fare better in the drier months of hot or cold season. Just as the ECHO Seed Bank grows different plants in the different seasons, methods for cultivation must also vary due to changing climatic patterns. Furthermore, the study would benefit from testing successful mixes in this study (such as UHDP mix) with a different variety of plant species. We attempted to provide a wide spectrum of plant types to establish a baseline of usefulness for each mix that would be broadly applicable. A follow-up study would focus on species that are specifically wellsuited for transplanting or that benefit from a longer grow-out period in the nursery. Tree species, such as moringa and acacia, which often have trouble starting from seed in the field, would benefit from a longterm study of health and growth in potting mixtures.

Grounding this study within the context of the ECHO Asia Regional Seed Bank presented a unique opportunity to explore alternatives appropriate for a specific set of resource-constrained farmers. Innovation at the seed bank is based on techniques applicable for ECHO's partner communities and network partner NGOs. This study successfully demonstrated that a low-cost mix, using materials easily obtained from the local vicinity, could yield as healthy—or healthier—plants than those grown in expensive commercial potting mixes. Any smallholder farmer or backyard gardener can make UHDP mix with little extra cost or labor. In this particular study, we found that UHDP mix was optimal for Northern Thai growers in resource-constrained settings.

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