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Creating an Optimum Potting Mixture for Resource-Constrained Growers in Thailand

Hannah Gray and Abram Bicksler
ECHO Asia Regional Impact Center
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Potting soil mixture being used to pot up plants

[Editor's note: 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 article from ECHO Asia Note 19 is the culmination of her research on potting mixtures for usage at the ECHO Asia Seed Bank.]

Introduction

In a tropical setting, growing seedlings can be difficult. A major factor of concern for nursery production is water logging (Zhu *et al.* 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 *et al.* 2000). Nursery plants potted in dense soils are more prone to the negative effects of water logging. 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 within our network.

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

We evaluated several 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 height, and plant 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.

Methods

We tested seven potting mixtures across four crop species: lablab bean (*Lablab purpurpeus*), moringa (*Moringa oleifera*), pumpkin (*Cucurbita moschata*), and tomato (*Solanum lycopersicum*). These seed species were selected for crop variation and because of their importance to farmers in ECHO's network.

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

Table 1. Potting mixtures and their component ratios used in the experiment.

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	Rice hull, chunked coconut coir, shredded coconut coir	1:1:1
Biochar	Charred rice hull[4], rice hull, shredded coconut coir	1:1:1

[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 et al. 2005).

[3]Manure was obtained from free-range cattle dung.

[4]Charred rice hull has the potential to improve plant productivity in much the same way that wood-based biochar has been shown to do (Graber et al. 2010). 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).

Results

Emergence

Species, potting mix, and the interaction between species and potting mix had no significant effect on overall emergence rate. However, the mean number of days to 50% emergence did vary significantly based on species.

Figure 1. Seedlings

Seedling Growth

The significance of species, potting mix type, and their combined interaction upon seedling length changed 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 plant species. By 30 days after planting, species and potting mix treatments continued to exert significant effects on seedling height 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 height. 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 yielded significantly taller seedlings compared to all other mixes. Moringa seedlings were only significantly taller in UHDP mix when compared to those grown in heavy mix. Pumpkin seedlings grown in commercial mix were not significantly taller than those grown in UHDP mix, although they were significantly taller than seedlings grown in all other mixes. Pumpkin seedlings grown in UHDP mix were only significantly taller than those grown in biochar and heavy mixes. Tomato seedlings grown in UHDP mix and in commercial mix grew equally well, and significantly better than all other mix treatments. However, seedling height alone is not always indicative of plant health, as etiolation (elongation of plant stems) can be a sign of stressors, including lack of light.

Figure 2. Measuring seedling growth

Seedling Health

After 36 days of growth, harvested seedlings displayed significant differences between species and between potting mix types for all dependent variables: seedling height, necrosis, chlorosis, fresh weight, and dry matter 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 taller than all other seedlings

Figure 3. Visual evaluation of chlorosis/necrosis

except lablabs grown in commercial mix. Tomatoes ranged greatly in final seedling height. Single potting mix types also displayed varied seedling height by species. In the UHDP potting mix, mean lablab seedling heights were significantly taller than the other three species, which were not significantly different from each other. Modified mix supported lablab plants of intermediate height, while it produced the lowest level of tomato seedling growth.

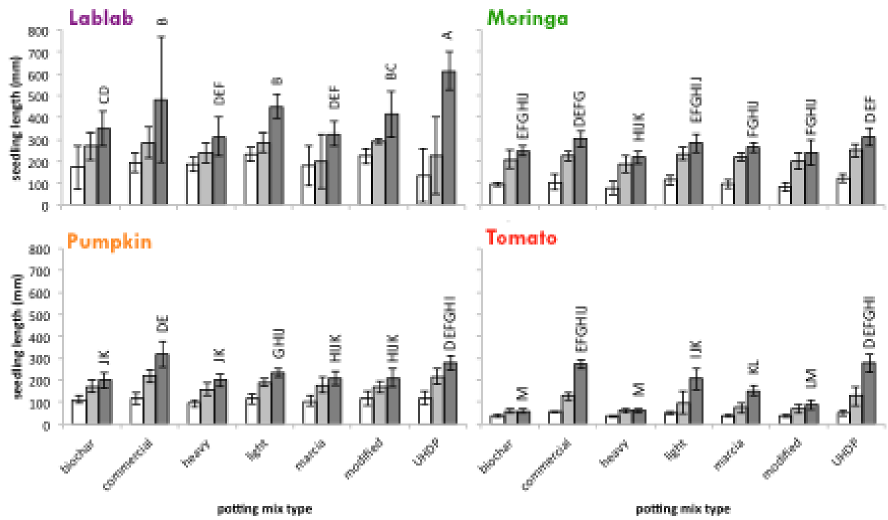

Figure 4. The effect of potting mixture, species and date [10 (white), 20 (light grey), and 30 (dark grey) days after planting] on seedling length (mm). Different letters above bars denote the significant effect of species on overall germination rate, F = 5.99, p = 0.0041. Error bars represent ±1 SE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

Chlorosis and necrosis were used as measures of health before harvest. Seedlings varied significantly in chlorosis and necrosis levels by species, by potting mix and by the interaction of those two factors (Figure 5). For tomato abd pumpkin, levels of necrosis and chlorosis varied more than for moringa and lablab seedlings (Figure 5). 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 biomass dry matter 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 biomass dry matter, 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 biomass dry matter at 4.6 ± 0.5 g and 4.6 ± 0.4 g, respectively. 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).

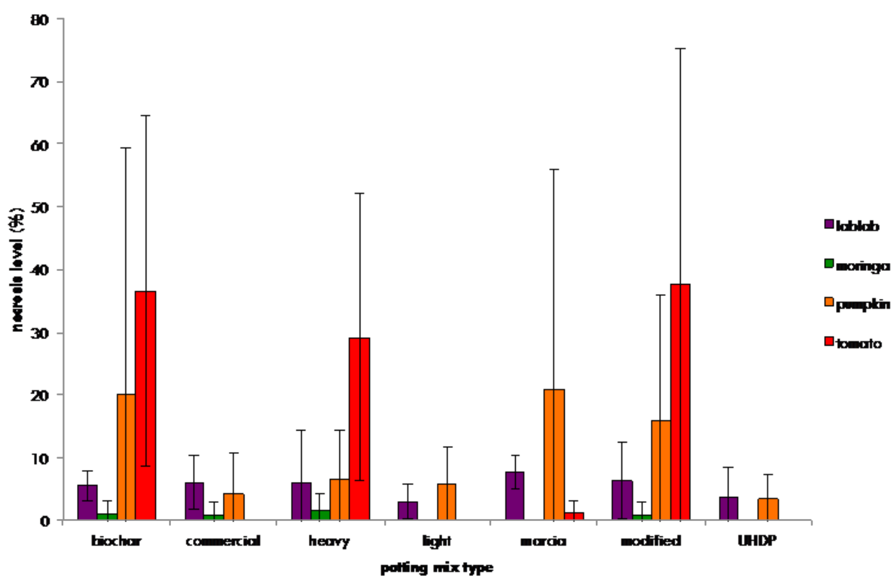

Figure 5. The effect of seed species and potting mix on necrosis levels (%) at time of harvest, 36 days after planting. Error bars represent ±1 SE of the mean.

Conclusion

In this study, we explored the effect of potting mixture composition and species type on emergence and vigor of seedlings grown in a tropical nursery setting. Previous studies indicated that rice hulls and coconut coir are appropriate additions to or substitutions in typical potting mixes, with innocuous effects (Ahmed *et al.* 2012). Addition of rice hulls and coconut coir to potting mixtures is thought to minimize risk of pathogens and growth of weeds. These ingredients can increase porosity and prevent water logging of soil due to their status as a soilless material and their physical properties. Charred rice hulls have been identified as

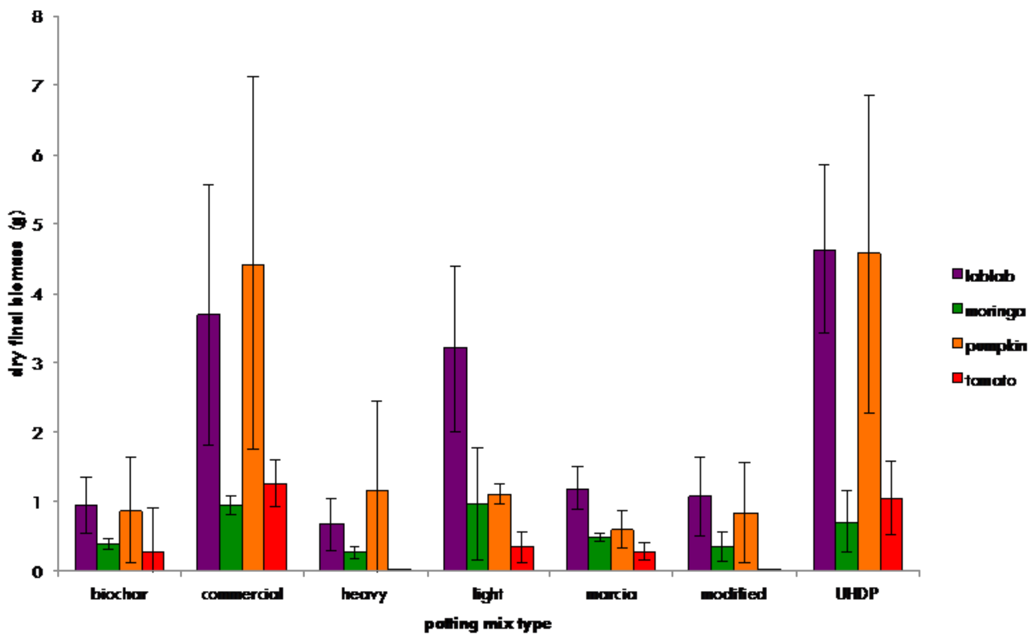

Figure 6. The effect of seed species and potting mix on dry biomass dry matter (g) at time of harvest, 36 days after planting. Error bars represent ±1 SE of the mean.

an enhanced form of soilless material, when correlated with increased fertility of potting substrate (Graber *et al*. 2010).

Our results cannot support nor discredit these claims. However, our results do suggest that nutritional qualities of soil-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 particularly relevant 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 *et al.* 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. We added rice hull and coconut coir to mixes to increase drainage capacity and to decrease negative effects from 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 our study suggest that by day 30, nutrient status was a limiting factor to plant growth. Earlier in the study, potting mix type did not significantly impact 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 fertility sources. Therefore, the planned time spent in a nursery setting is an important factor to consider when selecting a potting mixture.

In our study we 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. Additionally, future studies could add drainage-improving materials (such as coir, or 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. Other lower-cost methods of fertilization, such as ground bone or blood meal, and fertilizer from drained fish ponds could be added instead. Addition of a fertilizer would allow us to explore the effect of physical-chemical variation, without the confounding variable of nutrition differences among mixtures.

A secondary study could measure 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. Potting mixes could also be used in secondary and tertiary plantings, to gauge the fertility of a mix over a longer time frame.

Charred rice hulls 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 microbe-rich substrates, kept moist, and charged for several months. The biochar material used in this study was not charged prior to incorporation with our potting mixtures. When used appropriately, the use of biochar in a potting mix may have many benefits to plants including: better water holding capacity, improved drainage, higher 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. It would benefit from replication in both the dry and rainy seasons. Mixtures that did poorly under the high moisture, relatively high temperatures of the rainy season might fare better in the drier months of a 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.

The study would also 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 could be broadly applicable. A follow-up study would focus on species that are specifically well-suited 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 long-term 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. A 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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