Locally Produced Cocopeat Growing Media for Container Plant Production

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Abstract

In our pursuit of finding a local alternative to using topsoil for plant production in containers, we concluded that coconut husk can be easily processed into an ideal growing medium. On Yap, Federated States of Micronesia, coconuts are abundant. The coconut kernel is used for food, fodder, and other purposes, but the spongy pericarp (husk) is a byproduct. Over the years, we standardized a method to make a suitable growing medium (cocopeat). This product is not only useful for growing plants but also can be used for soil remediation and other agricultural purposes. This article describes the process we use to create the medium, along with a description of its properties and uses.

Introduction

For small-scale growers in Yap, field-based plant cultivation for gardening, reforestation, and land restoration has always been a challenge due to the inherent properties of native soils. Depleted nutrients and pH-dependent accumulation of soluble aluminum pose serious challenges for field-based agriculture in degraded volcanic red soils. Two upland soil types are prevalent on Yap Proper: upland soils underlain by volcanic material (oxisols in the U.S. Department of Agriculture [USDA] classification) (figure 1) and upland soils underlain by schist (a metamorphic rock) (alfisols in the USDA classification) (figure 2) (Smith 1983). These soils have unique properties and, therefore, need special management practices if used for plant cultivation. The volcanic, red soils are the most degraded and the least fertile soils in Yap. Nutrient contents and the ability to hold nutrients are very low in these soils due to their low cation exchange capacity. These physical, chemical, and biological limitations of degraded soils create challenges for both natural forest regeneration and plant cultivation (figure 3). For example, schist-derived soils are made up of a particular type of

Figure 1. In Yap, soils such as this Gagil series underlain with volcanic material are highly degraded and low in fertility. (Photo by Murukesan V. Krishnapillai)

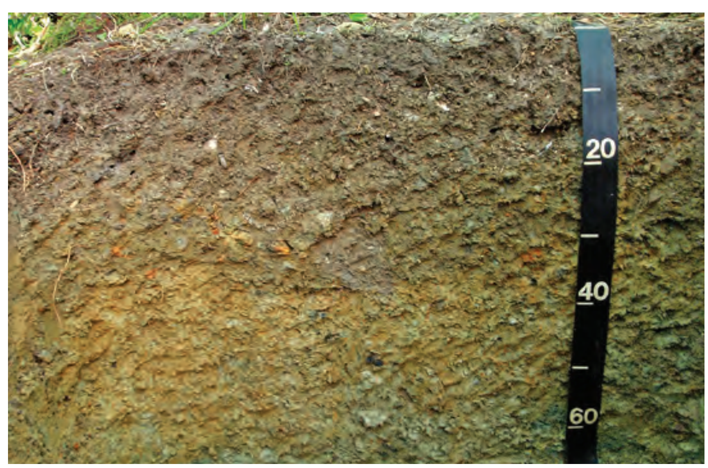

Figure 2. Upland soils over schist, such as this in the Weloy series, are prevalent on Yap proper and are challenging for reforestation and plant cultivation. (Photo by Robert Gavenda, retired, USDA Natural Resources Conservation Service)

Figure 3. Degraded soils often result in nutrient-stressed, slow-growing plants as seen on this site with planted *Calophyllum inophyllum* L. (Photo by J.B. Friday)

shrink/swell clay particles and become sticky when wet and hard when dry. When wet, water movement slows in these soils, thereby making it challenging to grow plants. Because of these inherent soil challenges, plant production in containers has been promoted in Yap as a climate change adaptation strategy for displaced atoll communities residing in marginalized environments.

Growing media or substrates for container production are composed of solid materials that can be used individually or in mixtures. Media directly affect root system development and function. A good-quality growing medium provides sufficient anchorage or support to the plant, serves as a reservoir for nutrients and water, allows oxygen diffusion to the roots, and permits gaseous exchange between the roots and the atmosphere (Abad et al. 2002; Argo 1998a, 1998b; Gruda et al. 2013). Topsoil is commonly used as a component of growing media in many tropical nurseries. Using topsoil, however, can be problematic and hinder successful production of seedlings for field establishment. Problems associated with using topsoil in nurseries include shortages and sustainability of quality topsoil, compaction, introduction of weed seeds or pathogens, poor drainage, and insufficient nutrients. In addition, containers filled with soil are heavy and bulky for handling and transportation. Thus, other suitable growing media are needed for plant production.

Cocopeat as a Growing Medium

A wide selection of growing media is available in the market. The choice of which medium to use depends on a grower's financial and technical capabilities (Gruda et al. 2013). In tropical regions, most growers use substrates that are locally available because they are inexpensive and reliable. To cope with soil challenges in Yap and to cultivate plants in containers, cocopeat planting medium has been successfully produced. Coconut coir pith (also known as cocopeat or cocopith) is one of the renewable resources widely available in the tropics. Coconut palms (*Cocos nucifera* L.) are abundant in the Pacific Islands (figure 4), where they are extremely important for daily subsistence and also have significant economic and cultural values. Coconut plays a central role in islanders' diets and is thus vital for food security, health promotion, and sustainable livelihoods. As a versatile, raw material that supports both household and wider societal needs—from housing, to transport, to cultural production—coconut is a valuable resource woven into the very fabric of Pacific society and daily life.

On Yap, the inner kernels of coconuts (endosperm) are largely exploited for pig feed and, to a limited extent, coconut oil. The spongy mesocarp (husk) is left as a byproduct. Coconut husk is made up of natural fibers called coir along with parenchymatous, spongy material called coirpith that binds the fibers in the husk (figure 5). Being made up of sclerified tissue, coconut fiber does not retain much water. In a growing medium, however, fibers create aeration through porosity in the coir and provide structure to prevent compaction. These characteristics are important for a healthy root zone. The coirpith acts like micro sponges where the moisture is stored. The fiber and pith (cocopith) together make a great growing medium with an excellent air-to-water ratio.

Figure 4. Coconut palms are abundant in many tropical islands and provide a good source of food, animal feed, oil, and other products. (Photo by J.B. Friday)

Figure 5. The coconut consists mainly of an inner endosperm and outer mesocarp (husk). (Photo by Murukesan V. Krishnapillai))

Raw cocopith has a high carbon (C) to nitrogen (N) ratio (112:1) and high lignin content and can result in immobilization of plant nutrients. This inhibitory effect can be eliminated, however, by using partially decomposed coir pith. Decomposition of coconut husks reduces the C:N ratio to about 30:1, which is ideal for use as an organic growing substrate. Cocopith has many desirable characteristics (table 1), making it

Table 1. Chemical and physical properties of partially decomposed cocopith.

Property	Partially decomposed cocopith
Lignin (%)	28.5
Cellulose (%)	25.8
Organic carbon (%)	29.0
Nitrogen (%)	0.26
Phosphorus (%)	0.01
Potassium (%)	0.76
C:N ratio	30:1
Calcium (%)	0.47
Magnesium (%)	0.41
Copper (ppm)	4.20
Iron (ppm)	0.08
Manganese (ppm)	17.0
Zinc (ppm)	9.8
pH	5.6 – 6.0
EC (millimhos/cm)	0.3 – 0.6
CEC (meq/100 g)	40 - 100

Sources: Alexander and Bragg 2014, Awang et al. 2009, Cahyo et al. 2019, Carlile et al. 2015, Coir Board 2016, Gruda 2019, Holman et al. 2005, Kalaivani and Jawaharlal 2019, Londra et al. 2018, Noguera et al. 2000, Paramanandham et al. 2013, Prasad 1997, Robbins and Evans 2011, Sengupta and Basu 2016.

an ideal medium for various horticultural uses. These characteristics include high moisture retention capacity, high potassium content, low bulk density (0.18 g/cm^3) and particle density (0.8 g/cm^3) and high cation exchange capacity enabling it to retain high amounts of exchangeable potassium (K), sodium (Na), calcium (Ca), and magnesium (Mg). These characteristics also make cocopith ideal for use as a mulch and soil amendment, especially for dry and sandy areas with low water retention.

Cocopith resembles *Sphagnum* peat moss, the most common potting medium used in horticulture, but offers many advantages as a growing medium (table 2). With the demands of commercial horticulture and resulting reduction in *Sphagnum* peat availability due to despoiling of ecologically important peat bog areas, cocopeat has become internationally recognized as an ideal soil amendment and component of soilless container media for the horticultural industry.

While various commercial products are available, the local abundance of coconuts on Yap allows for on-site processing of coconut husks into a suitable growing medium. An average coconut tree produces 150 to 180 coconuts per year, ensuring a continuous supply of husks. One coconut yields approximately 100 g (0.22 lb) of cocopeat, thus making it an affordable and sustainable product.

Cocopith Preparation Method

Both fresh and partly decomposed coconut husks are suitable for preparing quality growing media (figure 6). Coconut husks begin to decompose in about 2 to 3 months under humid, tropical conditions.

Figure 6. Coconut husks will decompose in 2 to 3 months in tropical conditions, making them an ideal source of growing medium for plant production. (Photo by Murukesan V. Krishnapillai)

Table 2. Comparison between cocopith and *Sphagnum* peat.

Characteristics	Cocopith	Sphagnum peat
pH	5.5 – 6.5	3.9 – 4.3
Water holding capacity	6 to 11 times its dry weight; coirpith is composed of spongy parenchyma cells and will hold up to 80 percent water once the excess drains away.	4 to 8 times its dry weight
Rewetting time	Very rapid because cocopith's sponge-like parenchyma structure has the ability to absorb large quantities of water very quickly	Considerably slower than cocopith; becomes hydrophobic once dried.
Longevity	Approximately 3 to 5 years owing to high lignin content which inhibits bacterial and fungal breakdown and thus allows cocopith to decompose much more slowly than traditional peat moss.	6 months to 1 year depending upon the quality of product.
Air-filled porosity	Quality cocopith can retain high (~96 percent) air porosity while also holding large quantities of water without becoming waterlogged.	Sphagnum peat has 71-95 percent air porosity. Over time, however, air porosity can decrease due to breakdown, thereby decreasing oxygen to the roots.
Shrinkage	Due to its high lignin and cellulose structure, cocopith does not shrink	Sphagnum peat can shrink away from sides of the container if allowed to get too dry resulting in water draining down the sides.
Cation Exchange Capacity (CEC)	Coirpith has a high CEC ratio of 40 to 100 meq per 100 g, thus nutrients are not leached away but are held to release to the plant as required.	Sphagnum peat has a CEC of 55 to 200 meq per 100 g
Sustainability	Coconut husks are always available as a waste product wherever coconut palms are present.	Peat bogs take at least 25 years to renew.

Sources: Holman et al. 2005, Londra et al. 2018, Prabhu and Thomas 2002, Rezanezhad et al. 2016, Shanmugasundaram et al. 2014, Wellock et al. 2011, WSU 2018, Xiong et al. 2017.

Though fresh husks result in a long-lasting product, coarse fibers need to be screened out before using. Soft, partially decomposed husks are ideal for shredding into a usable medium (figure 7). A commercially available chipper-shredder of at least 10 horsepower is recommended to shred the coconut husks (figure 8). We use a Troy-Bilt Model CS 4325 Chipper Shredder (Troy-Bilt LLC, Valley City, OH). Before feeding into the chipper-shredder, husks must be chopped into small (1- to 2-in [2- to 5-cm]) pieces

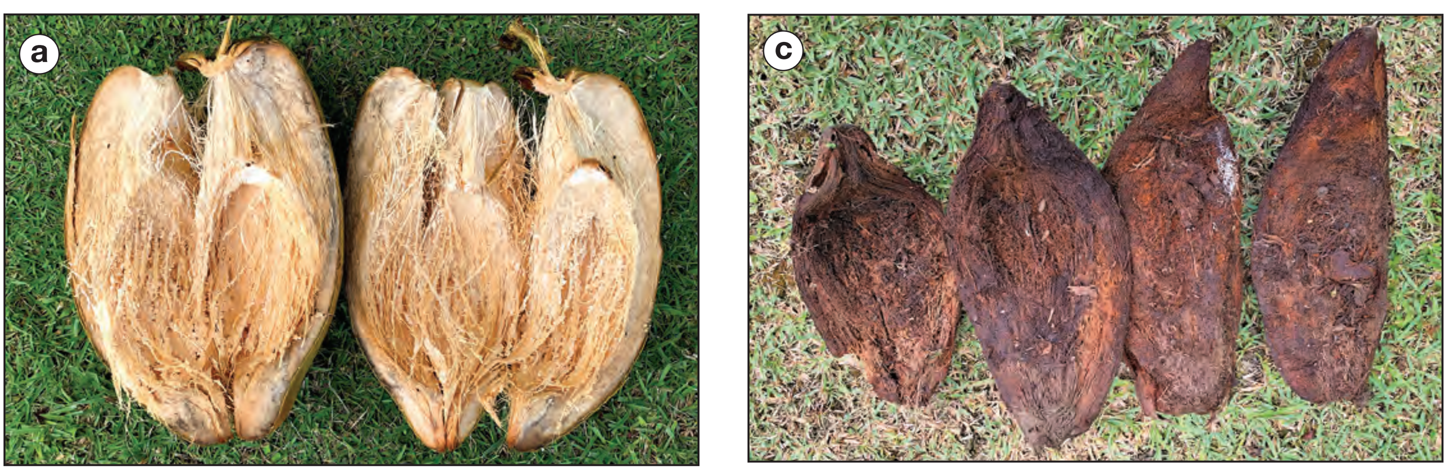

Figure 7. (a) Fresh, (b) partially decomposed, and (c) fully decomposed coconut husks can all be shredded to create a suitable substrate for forest and agriculture plants. (Photos by Murukesan V. Krishnapillai)

(figure 9). By chopping the husks before shredding, the final mix usually consists of 10 to 20 percent short fibers and 80 to 90 percent parenchymatous pith ranging in size from fine dust to granules (up to 5 mm [0.2 in])(figure 10). If using fresh husks, a mesh screen may be used to separate coarse fibers from the shredded mix (figure 11).

After shredding, we thoroughly mix 3 parts shredded cocopith with 1 part commercial composted chicken manure (figure 12). In Yap, this gives an excellent growing medium for both forest seedling production and vegetable production. Unlike commercially available cocopeat bales or briquettes, cocopith extracted from freshly sourced husks does not contain excessive salt levels, does not require rehydration, and contains sufficient coarse fibers to maintain adequate aeration. When using cocopeat made from fresh husks, however, there is a likelihood of nitrogen drawdown. Therefore, adding slow-release or organic fertilizers in addition to the composted chicken manure is advised.

Figure 8. Coconut husks can be shredded using a commercially available chipper-shredder. (Photo by Diane L. Haase)

Uses for Cocopeat

Cocopeat can be mixed with soil and other media components to make suitable mixes for plant propagation. It is widely used in agriculture, horticulture, and restoration for the production of flowers, vegetables, trees, shrubs, and forbs (Alzrog et al. 2013, Ayesha et al. 2011, Bagci et al. 2011, Barrett et al. 2016, Cahyo et al. 2019, Erwan et al. 2013, Gohil et al. 2018, Ilahi and Ahmad 2017, Khan et al. 2019, Kumarasinghe et al. 2015, Rose and Haase 2000, Rubio et al. 2011, Soltani and Naderi 2016, Sutari et al. 2018, Tariq et al. 2012, Udayana et al. 2017, Xiong et al. 2017). Cocopeat media can be used in various container types as well as vertical gardening structures (figure 13).

Figure 9. To ensure uniformity and optimum fiber size, composted coconut husks should be (a and b) chopped into (c) small pieces before shredding. (Photos on left and in middle by Diane L. Haase, photo on right by J.B. Friday)

Figure 10. After shredding, both (a) fresh and (b) composted husks can be used in a growing mix for plant production. (Photos by Diane L. Haase)

Figure 11. A mesh screen is often needed to separate coarse fibers from shredded fresh husks (Photo by Diane L. Haase)

Figure 12. Shredded coconut husks can be mixed with chicken manure to create an excellent medium for growing forest seedlings or agricultural plants. (Photo by Diane L. Haase)

Because it is relatively resistant to harmful microbial and fungal growth, it is an ideal medium for germinating seeds (Hyder et al. 2009). Increasingly, cocopeat is used for roof, patio, and kitchen gardening. Cocopeat and coir fibers are also used to make pots for growing plants. These pots can be arranged on screens in vertical gardening and can even be hung on balconies. The versatility and quality of cocopeat supports various community programs on Yap (figure 14).

In addition to growing plants, cocopeat has many other uses. It is an excellent bedding for the growth of earthworms for vermiculture (Patil et al. 2017). Cocopeat is also used as bedding in animal farms, poultry sheds, and pet houses to absorb animal waste. It can be used as an oil absorbent on slippery floors.

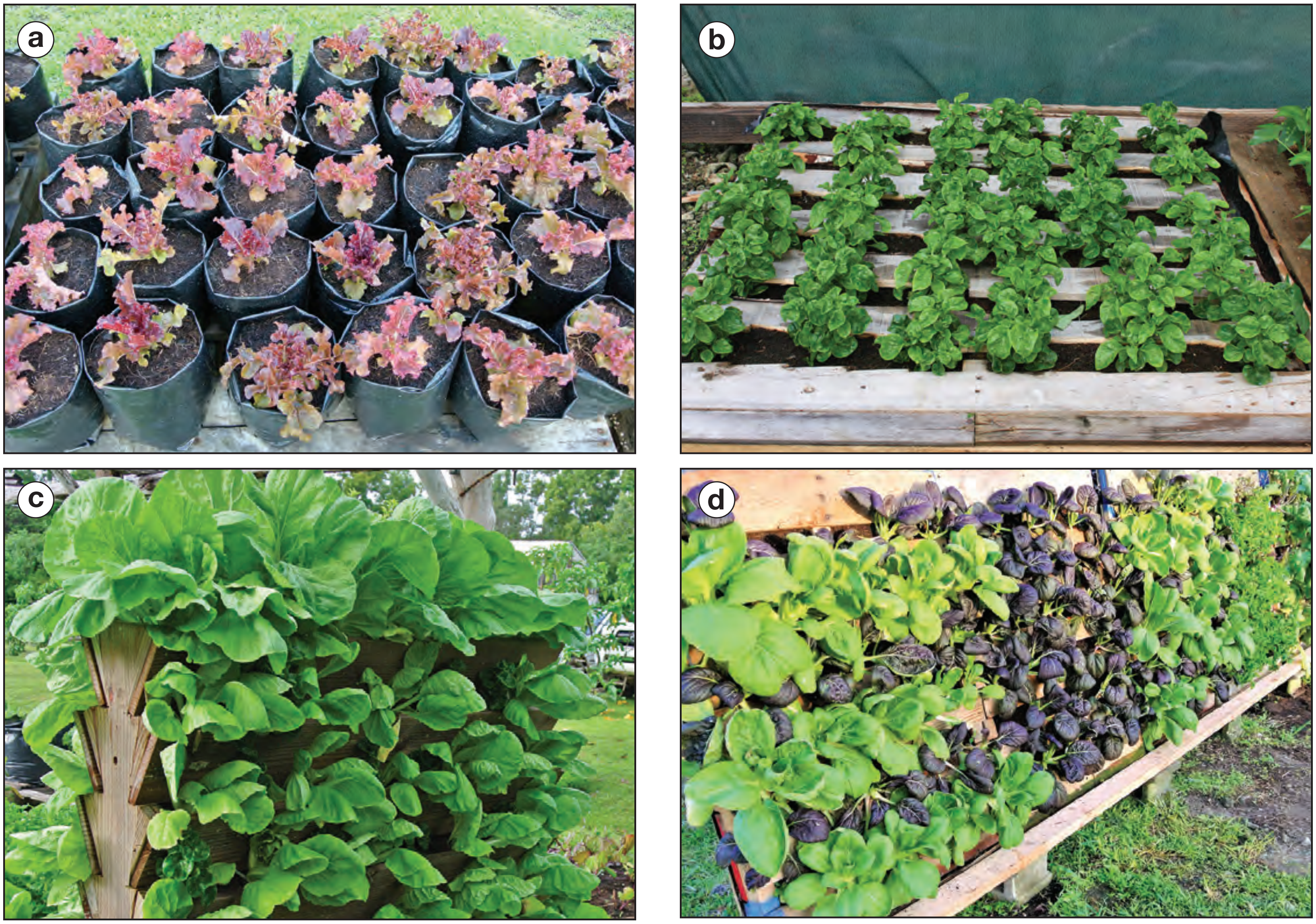

Figure 13. Cocopeat media can be used in a variety of containers including (a) polybags and (b) pallet planters. It can also be used in (c) vertical planters such as a (d) salad wall. (Photos by Murukesan V. Krishnapillai)

Cocopeat can be used as a soil conditioner and is widely used as a mulch for soil remediation (Santiago and Santhamani 2010, Udayana et al. 2017). It helps conserve water, slow evaporation, and reduce nutrient leaching. Bioengineering managers incorporate a mixture of coir and cocopeat into land-stabilization structures used to prevent soil erosion, sediment runoff, and land degradation. The high tensile strength of coir and cocopeat can be used on steep surfaces to inhibit heavy water flow and debris movement.

Conclusions

Growing medium is an important step to successful plant production in containers. In our pursuit of finding a local alternative to soil, we concluded that coconut husk, locally processed into cocopeat, is an ideal medium for growing plants in various container types. The favorable chemical and physical properties of cocopeat are a determining factor in its ability to support quality plant development (Awang et al. 2009, Ilahi and Ahmad 2017, Nazari et al. 2011, Paramanandham et al. 2013, Udayana et al. 2017, Xiong et al. 2017). In addition to reducing exploitation of peatland, there is an increasing emphasis on using alternatives to *Sphagnum* peat-based media for container production. Cocopith is an ideal alternative in many tropical locations, given the abundance of coconut palms and the fact that it is a byproduct that would otherwise be wasted. Use of these organic byproducts for plant production, mulch, soil remediation, disease suppression, and other purposes results in a renewable and environmentally sustainable system. In a world of increasing soil scarcity and climate uncertainty, soilless cultivation has much to contribute towards a truly green industry which minimizes waste while improving productivity and efficiency of plant production.

Figure 14. Production of cocopeat growing medium results in a sustainable resource to support forestry and agriculture projects for Yap's communities. (Photos by Murukesan V. Krishnapillai)

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