The Oklahoma Cooperative Extension Service

WE ARE OKLAHOMA

The Cooperative Extension Service is the largest, most successful informal educational organization in the world. It is a nationwide system funded and guided by a partnership of federal, state, and local governments that delivers information to help people help themselves through the land-grant university system.

Extension carries out programs in the broad categories of agriculture, natural resources and environment; family and consumer sciences; 4-H and other youth; and community resource development. Extension staff members live and work among the people they serve to help stimulate and educate Americans to plan ahead and cope with their problems.

Some characteristics of the Cooperative Extension system are:

- The federal, state, and local governments cooperatively share in its financial support and program direction.
- It is administered by the land-grant university as designated by the state legislature through an Extension director.
- Extension programs are nonpolitical, objective, and research-based information.
- It provides practical, problem-oriented education for people of all ages. It is designated to take the knowledge of the university to those persons who do not or cannot participate in the formal classroom instruction of the university.
- It utilizes research from university, government, and other sources to help people make their own decisions.
- More than a million volunteers help multiply the impact of the Extension professional staff.
- It dispenses no funds to the public.
- It is not a regulatory agency, but it does inform people of regulations and of their options in meeting them.
- Local programs are developed and carried out in full recognition of national problems and goals.
- The Extension staff educates people through personal contacts, meetings, demonstrations, and the mass media.
- Extension has the built-in flexibility to adjust its programs and subject matter to meet new needs. Activities shift from year to year as citizen groups and Extension workers close to the problems advise changes.

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EXTENSION

Soilless Growing Mediums

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Oklahoma Cooperative Extension Fact Sheets are also available on our website at: **extension.okstate.edu**

History

The term "hydroponics" was first introduced by American scientist Dr. William Gericke in 1937 to describe all methods of growing plants in liquid media for commercial purposes. Before 1937, scientist were using soilless cultivation as a tool for plant nutrition studies. In 1860, two scientists, Knop and Sachs, prepared the first standardized nutrient solution by adding various inorganic salts to water, then using them for plant growth. Later, scientists started using an aggregate medium to provide support and aeration to the root system. Quartz sand and gravel were the most popular aggregate mediums used in soilless cultivation at that time. In the late 1960s, Scandinavian and Dutch greenhouse growers tested rockwool plates as a soil substitute, which resulted in revolutionary expansion of rockwool-grown crops in many countries. Today, many alternative porous materials are used as growing media in hydroponics, including organic medias like coconut coir, peat, pine bark and inorganic mediums such as mineral wool, growstone, perlite and sand. For more information about hydroponics see OSU Extension fact sheet HLA-6442, *Hydroponics*.

Aquaponics couples hydroponics with aquaculture, using nutrient-rich water to feed the hydroponically grown plants. Nitrifying bacteria convert the ammonia into nitrates. For more information about aquaponics see OSU Extension fact sheet HLA-6721, *Aquaponics*. The three main live components of aquaponics are plants, fish (or other aquatic creatures) and bacteria. Producers also choose growing media that will provide plant nutrition, support the plants and provide surface area for the growth of bacteria. Clay pebbles, lava rocks and expanded shale are among the most widely used growing media in aquaponics.

Characteristics of Growing Mediums

Selection of a growing medium depends on the type of plant, the pH of irrigation water, cost, shelf life of the product, the type of system that is being used and a grower's personal preference (Table 1). A grower should look for specific qualities in choosing media. Soilless media must provide oxygen, water, nutrients and support the plant roots just as soil does.

Table 1. Comparison between the cost, lifespan and pH level of various hydroponics mediums.

Grow media	*Cost*	*Lifespan*	*pH*
Mineral wool	Medium	Renewable	Basic
Coconut fiber	Low/Medium	Short	Neutral
Expanded clay	High	Reusable	Neutral
Perlite	Low	Reusable	Neutral
Vermiculite	Medium	Reusable	Basic
Oasis cubes	Low	Short	Neutral
Sand	Low	Reusable	Neutral
Peat	Medium	Short	Acidic
Grow stones	Medium	Reusable	Basic
Rice hulls	Low	Short	Neutral/ Acidic
Pine bark	Low	Short	Acidic
Pumice	High	Reusable	Neutral
Sawdust	Low	Short	Acidic
Polyurethane foam	Low	Short	Neutral
Gravel	Low	Reusable	Basic
Expanded shale	Low/Medium	Reusable	Neutral
Lava rock	Low	Reusable	Neutral

An ideal growing medium should have all or some of the following characteristics:

- **Good aeration and drainage.** While the medium must have good water retention, it also must provide good drainage. Excessively fine materials should be avoided to prevent excessive water retention and lack of aeration within the medium.
- **Durability.** The medium must be durable over time. Soft aggregates that disintegrate easily should be avoided.
- **Porosity.** The medium must stay damp from the nutrient flow long enough for plants to absorb all their required nutrients between cycles.
- **Sterile.** A clean and sterile growing medium will minimize the spread of both diseases and pests. A clean medium does not introduce additional nutrients to the roots. Some media can be reused by pasteurizing at 180 F for 30 minutes or using a 10% bleach soak for 20 minutes followed by multiple rinses of tap water.

- **Chemical properties.** Neutral pH and good cation-exchange capacity (the ability to hold nutrients).
- **Functionality.** Lightweight, easy to handle, reusable and durable.

Overview of the Most Popular Hydroponic Growing Mediums

Mineral wool

Mineral wool (such as Rockwool) is a sterile, porous, non-degradable medium composed primarily of granite and/or limestone, which is superheated and melted, then spun into small threads and formed into blocks, sheets, cubes, slabs or flocking. It readily absorbs water and has decent drainage properties, which is why it is used widely as a starting medium for seeds, rooting medium for cuttings and for large biomass crops like tomatoes.

Figure 1. Mineral wool.

Advantages

- It has a large water retention capacity and is 18% to 25% air, which gives the root system ample oxygen as long as the medium is not completely submersed.
- It is available in multiple sizes and shapes for various hydroponic applications. Everything from 1-inch cubes to huge slabs can be found.
- Mineral wool slabs can be reused by steam sterilizing the slabs between crops. Structurally, it does not break down for three to four years.

Disadvantages

- It has a high pH, and nutrient solutions must be adjusted to accommodate for that factor. The initial pH of the commercial material is rather high (7.0 to 8.0), therefore, continuous pH adjustment to a more favorable range (5.5 to 6.0) is required, or the medium must be conditioned by soaking in a low-pH solution before use.
- Mineral wool does not biodegrade, which makes it an environmental nuisance when disposed of. Lately there has been a decline in the use of mineral wool.
- It has a restricted root environment and a low buffering capacity for water and nutrients. The water flow to plant roots may be hindered, even when the water content is apparently high.
- Many people find mineral wool dust irritating to the skin.

Coconut Coir

Coconut coir is also known by trade names like Ultrapeat®, Cocopeat® and Coco-tek®. It is a completely organic medium made from shredded coconut husks. Different sources and

Figure 2. Coconut coir.

production procedures result in a large variability of end products in the market. The most popular is the compressed briquette form, which requires soaking in water before use. During soaking, the coir rehydrates and expands up to six times the size of the original briquette.

Advantages

Coconut coir is slightly acidic and holds moisture very well, yet still allows for good root aeration.

- There are claims that coir dust enhances rooting due to the presence of root-promoting substances.
- Coir can be used either as a stand-alone medium or as an ingredient in a mix for the cultivation of vegetables and cut flowers. It can also serve as a rooting medium for cuttings under mist and in high humidity chambers.
- It is biodegradable, organic and non-toxic, which makes its disposal easier and environmentally friendly.
- Since it is compactable, it can be bought compressed then expanded at home, which saves money on shipping.

Disadvantages

- If the husks are soaked in salt water during manufacturing and not rinsed with fresh water, then there could be a problem with high salinity.
- Coconut coir is rich in sodium and chlorine and may damage the plants, which is why it must be washed. Usually, calcium and magnesium need to be added to both facilitate sodium removal and provide nutrients.

Expanded Clay Aggregate

Expanded clay pellets are made by heating dry, heavy clay and expanding it to form round porous balls. It is commonly known as lightweight expanded clay aggregate (LECA), grow rocks or Hydroton®. They are heavy enough to provide secure support for the plants, but are still lightweight. Their spherical shape and porosity help to ensure a good oxygen/water balance so as not to overly dry or drown the roots.

Figure 3. Expanded clay aggregate.

Advantages

- They are lightweight, porous and provide beneficial drainage, aeration, water retention and even trace elements to the system.

Disadvantages

- A notable disadvantage is their jagged texture. The sharp edges of lava rocks have the potential to cut your hands as well as damage the root system of plants.

References

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Advantages

- Expanded clay pellets release almost no nutrients into the water stream and are neutral with a pH of about 7.0.
- They have high pore space, which results in better flow of solution. They rarely become clogged or blocked, so water drains very effectively, which makes it a great option for ebb and flow systems as well as aquaponic media bed systems.
- After use, the pellets can be washed and sterilized for reuse.
- They are very stable and can last for many years.

Disadvantages

- The clay pellets do not have good water-holding capacity as compared to many other substrates. They drain and dry very fast, which may cause roots to dry out.
- They are fairly expensive.
- They often bind tightly around roots in Dutch bucket systems and can be hard to separate.
- Because clay pellets float for the first few months until they're saturated, the pebbles can get sucked into filters or drain lines and cause blockages.

Perlite

Perlite is a natural volcanic mineral that expands when subjected to very high heat, and becomes very lightweight, porous and absorbent. It is produced in various grades, the most common being 0 to 2 mm and 1.5 to 3 mm in diameter. Perlite can be used by itself or mixed with other types of growing media.

Advantages

- It has one of the best oxygen retention levels of all growing mediums.
- It is very porous and has a strong capillary action. It can hold three to four times its weight of water.
- Its sterility makes it highly suitable for starting seeds. There is little risk of root rot or damping off.
- It is comparatively inexpensive and is reusable. After use, it can be steam pasteurized.
- Its stability is not greatly affected by acids or microorganisms.

Disadvantages

- Since it is very lightweight, it easily washes away. This drawback makes perlite an inappropriate medium in the flood-and-flush type of hydroponic systems.
- When used alone in hydroponic systems like drip systems, it does not retain water very well.
- Perlite dust can create respiratory problems and eye irritation, necessitating precautions such as wearing goggles and a mask to reduce dust exposure when working with it. When dry, fans can blow it around the greenhouse.

Figure 4. Perlite.

- Perlite is prone to algae growth that can lead to irrigation and fungus gnat problems.

Vermiculite

It is a micaceous mineral that is heated at temperatures near 2,000 F until it expands into pebbles. It is considered an excellent rooting medium. It is often used in combination with other types of media like coconut coir or peat moss to start seedlings. It is produced in various grades, the most common being 0 to 2 mm, 2 to 4 mm and 4 to 8 mm in diameter.

Figure 5. Vermiculite.

Advantages

- It has a relatively high cation exchange capacity and holds nutrients for later use.
- It is very porous, has a strong capillary action and has excellent water-holding capacity.

Disadvantages

- When used alone, it can retain too much moisture, which can result in waterlogged conditions, inviting bacterial and fungal growth.
- It cannot be steam sterilized as it disintegrates during heating.
- It is comparatively expensive and can contain a small amount of asbestos.

Oasis cubes

Oasis cubes are a brand of medium manufactured from water-absorbent phenolic foam, also known as floral foam. It is a grow medium designed for both seeds and cuttings and is mostly used for plant propagation. Oasis cubes are most used for rapid germination of crops such as lettuce and cole crops (cabbage, collards and kale), onions and alliums, herbs and sometimes tomato and eggplant seedings.

Advantages

- It has a neutral pH and a great water-retention capacity.
- It is pretty versatile and can be transplanted into many different types of hydroponic systems and grow mediums.

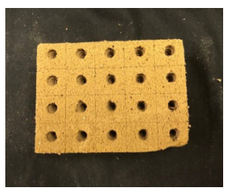

Figure 6. Oasis foam cubes.

- It is inexpensive and no pre-soaking is required.
- It comes in several different sizes.

Disadvantages

- It does not have any buffering capacity, cation exchange capacity or initial nutrient charge.
- Beyond seed germination and propagation, it is of limited value.
- The foam can break off and clog pump filters.

Sand

Sand is inarguably the oldest hydroponic medium and is very common. It is commonly mixed with other substrates like vermiculite, perlite and coconut coir. When using sand as a growing medium, growers often prefer coarse sand, as it helps to increase aeration to the roots by increasing the size of the air pockets between the grains of sand.

Advantages

- It is comparatively inexpensive and is readily available in most locations.
- The finer sand particles allow lateral movement of water through capillary action, which makes the solution applied at each plant evenly distributed throughout the root zone.
- When mixed with vermiculite, perlite and/or coconut coir, it helps aerate the mix for roots.
- Sand is very durable because it is neither chemically nor biologically affected.
- It can be easily steam-sterilized for reuse.

Disadvantages

- It has very low water- and nutrient-holding capacity and can exacerbate deficiencies quickly.
- Salt buildup may occur in the sand during the growing period. This can be corrected by flushing the medium periodically with pure water.
- It is very heavy.

Peat

Peat consists of partially decomposed marsh plants, including sedges, grasses and mosses. Sphagnum peat moss, hypnum peat moss, and reed and sedge peat moss are three types of peat in horticultural classification. Sphagnum peat moss is the most desirable and popular type, as it has higher moisture-holding capacity and does not break down as rapidly as other types of peat.

Advantages

- Peat moss has a high moisture-holding capacity and can hold up to 10 times its dry weight of water.
- Most peat mosses are acidic with pH of 3.8 to 4.5, which can be an advantage for some acid-loving plants.
- Even though peat moss retains water incredibly well, it can drain freely. Excess water quickly moves through the material to drain out.
- Disposal of used peat moss does not pose any environmental problem.

Disadvantages

- It is generally considered as a substrate conducive to numerous soil-borne diseases. Although peat can be sterilized, it does not alleviate the problem, as sterilization leaves a biological vacuum that can be easily filled by pathogenic fungi.
- In some cases, its acidic property may be a disadvantage for some crops, so lime or dolomite is usually added to increase the pH.
- It is not sustainable. Peat moss extraction from bogs is a destructive process that removes layers that took centuries to develop.

Growstones

Growstones are made from recycled glass. They are light weight, unevenly shaped, porous and reusable. They have good wicking ability and can wick water up to 4 inches above the water line. It is important to have good drainage to prevent stems from rotting.

Figure 7. Growstones.

Advantages

- Since growstone is inert, it does not supply plants with any additional inputs or elements that could interfere with the nutrient solution in the system.
- It is highly porous and provides a lot of aeration to the roots.
- Because it is made from glass, it is non-toxic and guaranteed to be free of contaminants like pathogens.
- Growstones can be reused or further recycled.

Disadvantages

- Sometimes growstones can cause root damage because they tend to grip the plant roots too much. This also makes it difficult to move the plants from one medium or grow area to another.
- Growstones come coated with a fine dust of silica, which needs to be carefully washed off. This is best done outdoors or in a well-ventilated space as the dust can clog drains and is dangerous to inhale.

Rice hulls

Rice hulls are a byproduct of the rice industry. Even though it is an organic plant material, it breaks down very slowly like coconut coir, making it suitable as a growing medium for hydroponics. It is often used as part of a mix of growing media such as 30% to 40% rice hulls and pine bark mix. Rice hulls are referred to as either fresh, aged, composted, parboiled or carbonized. Parboiled hulls have been shown to be superior to other hulls as a medium amendment.

Advantages

- The overall pH of parboiled and composted rice hulls range from 5.7 to 6.5, which is right in the optimal pH range for most hydroponically-grown plants.
- They are comparable to perlite in water-holding capacity per weight but have a greater air-porosity ratio and can hold more oxygen in the root zone.
- They drain well and retain little water in general.

Disadvantages

- Fresh and composted rice hulls often have high amounts of manganese. If pH is not maintained properly, manganese toxicity is a potential problem.

- Rice hulls work well when mixed with peat or coir, but not as well when used as a standalone medium.
- It has a low cation-exchange capacity.

Pine bark

Composted and aged pine bark was one of the first growing media used in hydroponics. It was generally considered a waste product, but has found uses as a ground mulch, as well as substrate for hydroponically grown crops.

Advantages

- Compared to other types of tree bark, pine resists decomposition better and has fewer organic acids that can leach into the nutrient solution.
- A naturally biodegradable material, used bark can be recycled in many ways, including as mulch.
- Because of its fibrous structure with pockets of many sizes, it holds nutrient solution and air well.

Disadvantages

- It absorbs water easily, which may result in water-logged conditions. A layer of rocks at the bottom will aid drainage greatly.
- Pine bark floats and may pose problems with an ebb and flow system. It is more suitable for a drip or a wick system.
- The pH of pine bark is acidic and might be a disadvantage.

Pumice

Pumice is a siliceous material of volcanic origin. It is graded and kiln dried to 80 F, making it sterile and ready to use. It can be mixed with other types of growing media, such as vermiculite or coir to improve aeration and drainage.

Advantages

- It breaks down slowly and is very lightweight.
- Its light-colored appearance makes it an ideal media for summer growing as it does not absorb heat.
- It has a high oxygen-retention level.

Disadvantages

- It has essentially the same properties as perlite but does not absorb water as readily.
- It can be too lightweight for some hydroponics systems, if bought as small pieces.

Sawdust

There are many variables that determine how well sawdust will work, predominantly the kind of wood used and the purity of it. Sawdust from Douglas fir and western hemlock have been found to give best results, while western red cedar is toxic and should never be used. A moderately fine sawdust or one with a good proportion of planer shavings is preferred, because water spreads better laterally through these than in coarse sawdust.

Advantages

- The best thing about sawdust is that it is very cheap or usually free.
- It retains a lot of moisture, so care must be taken while watering.

Disadvantages

- Sawdust might acquire salt levels toxic to plants. Therefore, the sodium chloride content of the samples should be tested before using. If any significant amount of sodium chloride is found (greater than 10 ppm), sawdust should be thoroughly leached with fresh water.
- Growers need to ensure their sawdust is not contaminated with soil and pathogens or chemicals from wood-processing facilities or undesirable tree species.

Polyurethane grow slab/cubes

Polyurethane grow slabs and cubes are an uncommon hydroponics medium used as an alternative to oasis cubes or rockwool for starter cubes. It can be found as poly foam at hobby or fabric stores. It comes in rolls or sheets of different thickness and sizes. Starter cubes can be self-made by just cutting 1- to 2-inch-thick poly foam sheets/rolls.

Advantages

- It is a comparatively cheaper alternative to rockwool or oasis cubes for starting seeds.
- It is easy to find.

Disadvantages

- It may contain harmful chemicals.
- It is not likely to have predetermined holes for seed germination.

Gravel

Gravel has been used with great success, especially in ebb and flow systems. It is a fragmented media from rocks like sandstone, limestone or basalt and has large spaces between each particle. This helps give a plentiful supply of air to the roots, however, the medium does not hold water well, which can cause roots to dry out quickly.

Advantages

- Gravel is usually fairly cheap, works well as a starter medium and is typically easy to find.
- It is durable and reusable as long as it is washed and sterilized between crops.
- It does not break down in structure and can be reused.

Disadvantages

- Its heavy weight makes it difficult to handle.
- Gravel is not suitable for heavy plant roots.

Expanded shale

Expanded shale is created when quarried shale is heated to temperatures above 2,000 F. The process renders the shale chemically and biologically inert. The heated shale loses its water, which causes the shale to expand. It is considered one of the best aquaponics grow media. It is lightweight and works well in aquaponic grow beds. Each stone has a large surface area for supporting the bacteria necessary to convert ammonia into nitrates.

Advantages

- The free draining quality of this medium aids in the necessary oxygenation of roots.
- Expanded shale holds up to 40% of its weight in water, allowing for better water retention around plants.

Disadvantages

- Expanded shale has a slightly polished surface area, but edges can be sharp, which can harm the root system of plants.
- Its heavy weight makes it difficult to handle.

Lava rock

Lava rock is a lower cost alternative to expanded clay or expanded shale. These types of rock form when hot lava rapidly cools down. They contain air pockets inside, which gives an additional surface area for beneficial bacteria.