

Additional researches

# "Embracing Nature"

Symasya

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# Research on the material

Design opportunity of the material and feasibility for growing plants



# Paper

### Can we use paper for growing plants?

From the research made, it appears that paper pulp itself has never been used as a soil for growing plants in agriculture. However existing researches and case studies have confirmend that it is possible and feasible, on a technological point of view, and it has also benefits for plants and soil.

Paper pulp is an organic material, since it is a raw material for paper manufacture that contains vegetable, mineral, or man-made fibres. So, since it is organic, plants can grow in it. Despite it has never been used as soil itself, there are plenty of case studies suggesting that paper sludges coming from paper wastes, moixtured, can be used as compost and as a revitalising material for fields in agriculture.

From an article of the Agriculture Research Service of the U.S. department of agriculture (Avant, S., 2019), it is shown how the ARS helped the U.S. military to solve the problem of revegetating damaged training grounds through the usage of classified paper that has been pulverized, so unrecyclable. The research showed how placing this paper waste on the damaged fields helped soil restoration and increased the growth of grass again. A research from the International Journal of Agronomy (2010) written by Adrien N'Dayegamiye has showed the opportunities of using paper sludge in agriculture. The research includes a initial deinking process for making the paper completely organic. Fine debris are initially separated from the mixture in a sedimentation basin to produce the primary sludge, followed by extraction in a second basin where the water soluble fibers are digested by the microorganisms to produce the secondary sludge. Mineral fertilizers (N, P, and K) are generally added in the second basin to stimulate microorganism growth and activity.

This paper sludges are used as compost and also for revitalising soil. The benefits for soil and plants are plenty: for example paper sludges are known as lignin-rich organic material that resist against mineralization and therefore contribute to increase the soil organic matter content. Secondly applications of paper sludges and vegetable residues with high Nitrogen contents and C:N ratios of 12–25 have shown a net Nitrogen mineralization and this contributed to better wheat and corn nutrition and yields. (N'Dayegamiye, A, Drapeau, A. and Nduwamungu, C, 2010)

According to the source althou-

gh paper sludges and their combosts are largely available, their use in agriculture is still low due to the high cost associated to their acquisition and their applibation to the soils. However, the use of these organic materials may sustain crop yields and soil productivity in intensive cropping systems. The utilization of paper sludges as source of both plant nutrients and organic matter to mprove soil structure is of high interest to maintain soil productivity particularly in low carbon input rotation systems (N'Dayegamiye, A, Drapeau, A. and Nduwamungu, C, 2010).

From these data we can understand that creating a soil with paper pulp is not just possible, but has huge opportunities of development and benefits for plants and the environment.





# First test

#### Germination in paper pulp



During the phase of the research a first experiment to test the feasibility of the material as a growin soil has been conducted. The aim of this first prototypation was to test the phase of germination of plants in paper pulp and to test if a plant can actually grow in a shallow soil. This test was first made preparing the material. For making the material as more similar to our product, so using the soft paper pulp, we have blended toilet paper (100% celulose)



per pulp. We have planted seeds (in this case, using vegetables seeds because easier to find on the market). The test has been watered through a spray daily. After one week seeds started to inflate and after two weeks those were completely germinated. The test was successful because it proved that paper pulp can be esaily used as a soil, since in this case no nutrients were added. Secondly the depth ended up to be sufficient for the phase of aermination of the plants.

### Soil ingredients Most common ingredients for soil

The primary ingredient in most potting soils is **sphagnum peat moss**. It is well-draining and well-aerated, but it's very low in available nutrients and it has an acidic pH, typically ranging between 3.5 and 4.5. Limestone is added to peat-based potting mixes to help balance the pH.

An alternative to peat moss is a by-product of the coconut industry, **coir**, which looks and acts a lot like sphagnum peat moss in both commercial and DIY potting soil blends. It has more nutrients than peat moss and lasts even longer. Coir fiber's pH is close to neutral, so it does not need to add limestone to balance. It is also more sustainable than sphagnum peat moss.

**Perlite** is a mined, volcanic rock. When it's heated, it expands, making perlite particles look like small, white balls of Styrofoam. It is a lightweight, sterile addition to potting mixes. It holds three to four times its weight in water, increases pore space, and improves drainage. Vermiculite is a mined mineral that is conditioned by heating until it expands into light particles. It's used to increase the porosity of potting soil mixes. In potting soil, vermiculite also adds calcium and magnesium, and increases the mix's water-holding capacity.

**Coarse sand** improves drainage and adds weight to potting mixes. Mixes formulated for cacti and other succulents tend to have a higher percentage of coarse sand in their composition to ensure ample drainage.

Pulverized **calcitic limestone** is added to peat-based potting soils to neutralize their pH.

**Fertilizers** are usually added to peat-based potting soils because these mixes don't naturally contain enough nutrients to support optimum plant growth. The main nutrients fundamental for the growth of the plants are N (nitrogen), P (phosohorus), K (potassium), better if in a ratius of N-P-K I-2-1. (Welliser, J., 2019.)





# Research on plants

Selection of plants based on the dimension of roots and feasibility

# Succulents

Absorbation of electromagnetic radiations





Blue Pearl Graptoveria



Moon Silver Pachyphytum



Chocolate Soldier Calanchoe Tomentosc



Hen and Chicks Sempervivum



Blue Giant Graptosedum Hybrid



Golden Glow Sedum Hybrid



Zebra Cactus Haworthia



"Living Stone" Plant Lithops

# Features



#### Sources

- Daniels, E. (2018)
- Andrychowicz, A. How to make your own
- succulent soi
- Getbusygardening.com
- Succulentbox How to stimulate root growth
- in succulen



Filmy fern Hymenophyllaceae



Fern Asplenium ruta-muraric

### Ferns

Air purification and absorbation of elecrtomagnetic radiations



Silver lace fern Pteris ensiformis



Rabbit foot fern Humata tyermannii



Maidenhair Fern Adiantum



Fern Pteris Cretica

# Features



#### Sources:

- Schwartz, M. (2018)
- Yatskievych, G. et Al. (2020)
- Wallington, J.(2016)





Bryophyte Bryophytc

Takakia lepidozioide

# Moss

Acoustic isolation, control temperature, air purification, absorbe moisture







Polytrichum commune

Funaria hygrometric

Dicranum Scoparium









Hookeria Lucens

Bartramia halleriar

Bryopsida

# Features



#### Sources

- Rahoumi, T. (2016)
- Mosslovers 'Does moss have roots? Are
- rhizoids roots'
- Mountainmoss 'Watering your moss gar 'den'



Tall Fescue Festuca arundinacea



Bermudagrass Cynodon dactylon

# Grass

Air cleaning, traps dust, reduces heating, reduced stress and improve wellness



Zoysia



Buffalograss Bouteloua dactyloides



Centipede Grass Eremochloa ophiuroide:



Carpet Grass Axonopus

# Features



#### Sources:

- Stma.org 'Eight benefits of natural grass
- Harris, T. 'How Grass Works
- This old house 'How to Grow Grass Fast



Thymus Thymus praecox



Coriander Coriandrum sativum

# Herbs

Culinary and medical use. Smells and essences





Blue Boy Rosemary Rosmarinus officinalis



Golden Rain Rosemary Rosmarinus officinalis



Mint Mentha piperita

# Features

#### Sources:

- Mountain Valley Growers
- 'Ground cover thymes'
- Epic gardening (2019
- Grant, B. L. and Badgett, B. (2020)

- Balcony Garden Web 'How To Grow Cilantro In A Pot | Growing

- Coriander In Containers
- MasterClass (2020)
- · Iannotti, M. (2021

# Flowers

Smells and ornamental. In some cases culinary use.





Creeping Jenny ysimachia nummularic aurea



Frog foot hyla nodiflora



Alyssum Lobularia maritima



Johnny-jump-ups Viola cornuta



Creeping Jenny Lysimachia nummularia



Chia Salvia hispanica



Daisy Bellis perennis



Forget-me-nots Myosotis

# Features

#### Sources:

- Richerds, J. (2018) - Floral Encounters 'Alyssum Se eds (Lobularia maritima)'



# Combination of plants

Different combinations for different needs, home conditions and users skills.

# Symbiotic plants

#### Moss + Succulents

Drier soil



More humid soil



#### Moss + Ferns

Drier soil



More humid soil



# Low maintenance

#### Moss + Succulents

Drier soi



More humid soil



#### Grass + Herbs

Less water



More wate



# Low maintenance

#### Herbs + Succulents

owator



More water



#### Moss + Grass

Drier soil



More humid soil



# Shaded houses

Grass + Herbs



Succulents + Ferns



Moss + Grass



Moss + Ferns





#### Flowers + Herbs



#### Flowers + Grass



#### Moss + Succulents



#### Succulents + Ferns





Flowers + Herbs + Grass

Moss + Succulents + Ferns





# Humid houses

#### Grass + Ferns

Less water



More water



#### Moss + Grass





More humid soi



# Humid houses

#### Moss + Ferns



#### Moss + Ferns



#### Moss + Ferns + Grass



# Humid houses

# Air purification

#### Moss + Ferns + Grass

Grass + Ferns

Funaria grometrica





More wate



# Air purification

#### Succulents + Ferns



#### Succulents + Ferns



#### Moss + Ferns



#### Moss + Ferns



# Air purification

#### Succulents + Grass



#### Succulents + Grass



#### Moss + Succulents

Drier soil



More humid soi



# Air purification

#### Moss + Grass

Drier soi



More humid soil



... Many other combinations possible



# Research on lights

Colors and frequencies suitables for growing plants and the available technologies



### Light Role of light in plants growth

A crucial component in the growth of a plant besides water and oxygen, is sunlight. Light is a crucial component of the plant's nourishment, since by receiving it, a plant is able to convert sunlight into edible food that it can use. This process is called photosynthesis.

Light behaves like a waves and the visible part of light is just a fraction of all the spectrum of frequencies. An important thing to know when growing plants is that light has different properties depending on its wavelength. For example, a source of light with a wavelength of around 650 nm will be detected as having a red colour and will have a different impact on the plant growth compared to a blue light.

Thanks to the recent developments in LED (light emitting diode) grow light technology, specific light wavelengths can now be isolated in order to control the different physical properties that a plant displays as it develops throughout its life cycle. These properties include, but are not limited to, height, weight, color, and texture, as well as the chemical composure of the plant itself. As a plant grows, you can use LED grow lights to manipulate these physical properties depending on the plant characteristics that you desire.

# Colours

### The Effects of colours on plants



#### Ultraviolet (20nm to 380 nm)

Being exposed to UV light for a long period has harmful effects. Likewise, exposure to this type of light will damage plants. In fact, plants raised without exposure to UV light exhibited enhanced growth.

#### Violet (380 nm to 445 nm)

When a plant receives visible violet light, the colour, taste, and aroma of the plant are enhan-

ced. Additionally, the plant's antioxidants are able to perform their functions more efficiently, which prevents the cells in the plant from being damaged.

#### Blue (450 nm to 495 nm)

Blue light has one of the largest effects on the development of a plant. Multiple studies have shown that exposing a plant to this colour influences the formation of chlorophyll, which enables the plant to intake more energy from the sun. It also controls a plant's cellular respiration and lessens water loss through evaporation during hot and dry conditions.

Blue light also has an effect on photosynthesis, and more exposure to this light can increase a plant's growth and maturity rates. This process is called photomorphogenesis.

#### Green (495 nm to 570 nm)

Plants have a green colour. This is due to the fact that they absorb all of the colours in the light spectrum (blue, red, violet, etc) but reflect the green one. As such, only the green light is bounced back to our eyes.

Even with the relatively low amount absorbed compared to the other colours, a study found that green light enhances the production of chlorophyll which helps with photosynthesis while giving the plants a greener color. Overall, adding the green colour to your plants does not have much effect in their life process compared to other light colours such as blue. Employing this type of light would be as a pigment for proper viewing of your plants in the grow room or grow box, but not necessary for the growth of the plant itself.

#### Yellow (570 nm to 590 nm)

This frequency has no particula impact on the growing process. Plants exhibit less growth compared to blue and red light, that are more useful on that point of view.

#### Red (620 nm to nm 750)

Red is the second fundamental colour for plants. It is responsible for making plants flower and produce fruit. It's also essential to a plant's early life for seed germination, root growth, and bulb development. When combined with blue light it yields more leaves and crops, depending on what is being grown.

From, Baessler, L. (2020) and Thie<sup>.</sup> e, C. (2019)





### Technology Sources of lights

#### Fluorescent Lights

The standard fluorescent bulb, makes a decent grow light for houseplants, starting seeds, supplementing the natural light of a window, and other situations where lighting needs are modest. They are fairly weak in light intensity, however, and must be placed within a few inches of the foliage to have much of an effect. Compact fluorescent bulbs (CFLs) are an option for small spaces.

#### HID Lights

Before the advent of LED grow lights, HID were the main option for large indoor plantings. They are extremely powerful, but are expensive to purchase, consume electricity inefficiently, require special light fixtures, and give off a lot of heat. All that said, they are very effective and are still widely used. It is especially indicated to grow large plants like tomatoes or lemon bushes, because the light penetrates farther into the foliage than with other bulbs.

There are two types of HID bulbs. High-pressure sodium (HPS) bulbs are best for flowering (low spectrum), while MH (metal halide) bulbs are required to support vegetative growth (high spectrum); the two types are often used in conjunction. Unfortunately, each type requires its own fixture.









#### LED Lights

LEDs use half the electricity and last five times longer, while in the past this technology was more expensive, it is getting more and more affordable and available. LED grow bulbs are capable of much greater light intensity than fluorescent bulbs and are available in fullspectrum form or in different colours. Fluorescent bulbs are often used when growing just a handful of plants; LEDs are preferable for larger quantities since you can achieve higher light intensity per square foot. They produce very little heat compared to other bulbs, so it is the best option because it does not dry the plants and it is safer when put into paper, like in our product.

An important advantage of LED technology is that there are plenty of small powerful options with different shapes (LED stripes, modules) that just need electric connection and no other special fixture, making it easy to assemble and put into a product; secondly LEDs can be incorporated with timer and sensors, that can be controlled remotely, on the market there are already available modules with these components, making it very easy and cheap to produce product with wireless LED.

From Barth, B. (2018) and Levinson, S. (2020).





Project realized for the course of Innovation Studio during the Master in **Product Service System Design** at **Politecnico di Milano** 

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