

SEED CARTRIDGE ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application claims priority to U.S. Provisional Application No. 63/540,760
5 filed on September 27, 2023 and entitled “Seed Cartridge Assembly,” which
is incorporated herein by reference in its entirety.

BACKGROUND

[0002] Home gardening and usage of micro gardens in apartment complexes and
10 modular container farms in neighborhoods has grown in recent years throughout the
United States in response to food deserts limiting the availability of fresh produce in
densely populated areas. More consumers desire to have fresh produce and herbs grown
from local sources or at home to provide fresher produce, as well as to limit the
preservatives and chemicals used in large grocery stores. Depending on climate,
15 homeowners and local farmers may be limited to indoor systems for growing fresh
produce and herbs. However, most indoor systems are limited in space and provide
unitary growing conditions for all produce and herbs that often results in suboptimal
conditions for all produce and herbs being produced by the homeowner. Additionally,
homeowners often lack the education and time to properly maintain optimal growth
20 conditions for each individual species and type of plant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The detailed description is described with reference to the accompanying
figures. In the figures, the left-most digit(s) of a reference number identifies the figure
25 in which the reference number first appears. The use of the same reference numbers in
different figures indicates similar or identical components or features.

[0004] FIG. 1 is an example pictorial diagram of an enclosed growing environment or
appliance in an open configuration according to some implementations.

[0005] FIG. 2 is an example pictorial diagram of an enclosed growing environment or
30 appliance in a closed configuration according to some implementations.

[0006] FIG. 3 illustrates example pictorial diagrams of a planting column and seed cartridges that may be utilized with the enclosure growing environment or as standalone system according to some implementations.

5 [0007] FIG. 4 illustrates an example pictorial diagrams of seed cartridge being inserted into a receptacle of the planting column according to some implementations.

[0008] FIG. 5 is an example pictorial view taken from the front of the planting column and a lighting and control column associated with the enclosed growing environment according to some implementations.

10 [0009] FIG. 6 is an example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0010] FIG. 7 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0011] FIG. 8 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

15 [0012] FIG. 9 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0013] FIG. 10 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

20 [0014] FIG. 11 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0015] FIG. 12 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0016] FIG. 13 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

25 [0017] FIG. 14 is an example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

[0018] FIG. 15 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

30 [0019] FIG. 16 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

[0020] FIG. 17 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

[0021] FIG. 18 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

[0022] FIG. 19 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

5 [0023] FIG. 20 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

[0024] FIG. 21 is another example pictorial diagram of a seed cartridge with a lid in an closed position according to some implementations.

10 [0025] FIG. 22 is an example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0026] FIG. 23 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0027] FIG. 24 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

15 [0028] FIG. 25 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0029] FIG. 26 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

20 [0030] FIG. 27 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0031] FIG. 28 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0032] FIG. 29 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

25 [0033] FIG. 30 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0034] FIG. 31 is an example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

30 [0035] FIG. 32 is another example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

[0036] FIG. 33 is another example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

[0037] FIG. 34 is another example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

[0038] FIG. 35 is another example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

5 [0039] FIG. 36 is another example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

[0040] FIG. 37 is another example pictorial diagram of a seed cartridge with a lid in a closed position according to some implementations.

10 [0041] FIG. 38 is an example pictorial diagram of a seed cartridge according to some implementations.

[0042] FIG. 39 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0043] FIG. 40 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

15 [0044] FIG. 41 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0045] FIG. 42 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

20 [0046] FIG. 43 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0047] FIG. 44 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

[0048] FIG. 45 is another example pictorial diagram of a seed cartridge with a lid in an open position according to some implementations.

25 [0049] The figures depict various embodiments for purposes of illustration only. One skilled in the art will readily recognize from the following discussion that alternative embodiments of the structures and methods illustrated herein may be employed without departing from the principles described herein.

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DETAILED DESCRIPTION

[0050] Discussed herein are systems and methods associated with automating, optimizing, and customizing an at home enclosed growing appliance (such as a micro garden) or plant growing apparatus for individual users. For example, the systems,

discussed herein, may be configured to provide an enclosed growing environment for at home and indoor cultivation of vegetation or plants, such as fungi, flowers, fruits, vegetables, produce, mushrooms, herbs, and/or the like. The system may, in some implementations, provide an isolated enclosure that is configured to provide stable and controlled environmental conditions, physically separated from the conditions within the surrounding environment (e.g., a home, office, apartment, warehouse, exterior environment, and the like).

[0051] In some examples, the enclosed growing environment may be configured with a planting column or tower configured to receive one or more seed containers, pods, capsules, etc. via one or more receiving receptacles, slots, ports, or cavities. For example, the planting column may comprise a plurality of receptacles configured to receive individual seed cartridges or pods. The planting receptacles may be arranged in helical conduits/channels, vertical columns/walls and horizontal rows/spirals about the planting column. For instance, in one specific example, the planting column may include twenty columns and five rows of planting receptacles. In some cases, the planting receptacles may be staggered between the columns, such that each column has one planting receptacle for every other row. In these cases, staggering or offsetting the planting receptacles allows the system to be able to monitor each individual plant as well as allowing each individual plant sufficient room to grow.

[0052] In some cases, the planting column (or in some implementation columns) may be rotatable three-hundred and sixty degrees within the enclosure and about a base, or any other limited rotation. For example, a drive motor may be configured to mechanically, electromagnetically, or magnetically rotate the planting column within the enclosure based on one or more control signals from a monitoring and control system. The drive motor can deliver the rotational force from any point of the tower, as well as rotating the hanging support arm of a hanging tower. A magnetically levitating tower could be rotated through air, electromagnetic force, physical touching via an actuator directed on a side of the tower. In some instances, as the planting column rotates, each individual planting receptacle may be assigned a unique identifier, such that the system is able to track each seed cartridge and resulting plant based on a determined location within the planting column. In some examples, the planting column may have any number of partitions extending to or near the outermost walls of the cultivation chamber to rotate separate environments about the central axis of rotation.

The planting column may also be coupled to a water reservoir that is configured to provide water to the seed cartridge on, for example, an individualized basis. In some examples, a gasket may be positioned between rings that have connected lid flaps that close over the planting receptacles or ports. The top, side, and even the bottom sides of the lid flaps may have a unique identifier for a vision system or wireless communication system such as radio frequency identification (RFID) to recognize planting locations, as discussed herein.

[0053] In some examples, a seed cartridge may be specifically designed to be coupled, mated and/or otherwise be received within a cavity defined by one of the receptacles of the planting column. The seed cartridges may be a self-contained apparatus having an exterior structure of one or more surfaces or walls that contain one or more seeds suspended in one or more layers of substrate or growing medium. For example, in some cases, the substrate or medium for growing plants that may be formed of one or more layers of materials or combination of materials. In some cases, the growing medium may be customizable per cartridge type and/or plant associated therewith. For instance, each cartridge may include a growing medium of one or more layers that is customized or designed to provide the optimal growing medium for the intended plants.

[0054] In this manner, unlike conventional growing appliances, each individual plant may be grown in a medium or material that is suited for the plant's own growing conditions. As an illustrated example, some plants, such as peppers, require a rockier growth medium with better drainage while other plants, such as cauliflower, may require more moist conditions. In this example, the more moisture intensive plants, e.g., the cauliflower, may have looser and/or absorbent material above the seeds to more effectively retain the moisture within the growing media. By customizing each seed cartridge with a growing medium that provides customized nutrients and water retention, the growing appliance may produce a wider variety of healthier, larger, and more robust plants in less time and with less maintenance by the owner when compared with conventional indoor growing systems. The filter material, cartridge material, seed capsule, and/or internal media may be customized based on the desired moisture permeability depending on plant preference. In some cases, the seed cartridge may also include coatings (such as water-soluble coatings) that include growth promoters,

nutrients, and the like that may provide increased oxygenations or other nutrients to the seeds as the seed cartridges are watered by the system.

- [0055] In some examples, the substrate or medium may include a first or bottom layer of fertilizer (such as slow release fertilizer prills with water soluble coatings).
- 5 There may be a second layer over the fertilizer that is composed of an open cell polyurethane foam (e.g., a compostable polyurethane foam). In some case, the second layer may be included to hold the seed in a static position, and/or separate the seeds from the fertilizer prills, wick water upwards to seeds, and/or drain water downwards, so the cartridge does not become oversaturated and generate undesirable
- 10 anaerobic/aerobic microbial growth. Additionally, the second layer may prevent root burn and/or damage from the higher concentrations of nitrates in the fertilizer prills. In some instances, the second layer may be a single solid media to prevent the seeds from becoming translocated throughout the substrate during transport and, thereby, not growing out top of the cartridge as desired. As an alternative example, the second layer
- 15 may be a PLA, PHA, PBSA fiber growing media or silkworm cocoon. In some instances, the media of the second layer is dark colored or black so as to not reflect light and thereby prevent algae growth.

- [0056] In some cases, the one or more of the layers, such as the second layer, may include one or more of starch, paper pulp, bagasse pulp, palm fiber, bamboo fiber or
- 20 pulp, corn starch (such as high amylose corn starch), polyhydroxyalkanoate (PHA), Polyhydroxybutyrate (PHB), uncoated cellulose-based films, biodegradable fungi-based materials, agra wool, grow foam, biodegradable, home compostable, and/or industrial compostable plastics (such as Polycaprolactone (PCL), Polylactic Acid (PLA)), polyurethane (PUR), polystyrene (PS), lignin, polyvinylchloride (PVC),
- 25 polyethylene (PE), Polyvinyl alcohol (PVA), polybutylene succinate (PBS), ASC, Nylon 11 (NY11), polyethylene succinate (PES), acrylonitrile butadiene styrene (ABS), rubber, silicone, polyethylene-vinyl acetate (PEVA), polyethylene (PE), Nitrile rubber (NBR) (such as in a form of foam), Polychloroprene (such as in a form of foam), Polyimide (such as in a form of foam), expanded polypropylene (EPP), polypropylene
- 30 paper (PPP), Polystyrene (PS) (such as in a form of foam), expanded polystyrene (EPS), extruded polystyrene foam (XPS), polystyrene paper (PSP), phenolic, melamine, hemp (such as in the form of fiber, sponge, and the like), among others.

[0057] In some cases, the seeds may be positioned as a third layer, above the second layer and/or within the material of any of the layers discussed herein. The seeds may be suspended in a foam, a sponge, a capsule, a coating, or other solid and compostable media plug. In some cases, the plug may be thermally and/or mechanically formed inserts having a size to match the size of the seeds. A fourth layer may be positioned above the seed layer and/or third layer. The fourth layer may include a loose growing media placed over the seeds. The growing media may be loose for the seedlings to grow through as the foliage cannot pass through a solid or tightly packed media. In some cases, the loose growing media may include polymer based mesh, paper fiber, and/or silkworm cocoons.

[0058] The loose material may be configured to become saturated and retain moisture at a desired rate for the particular plant to ensure good germination rates of the one or more seeds. Additionally, the loose material may block light from entering into the layer that contains the seeds to further optimize growth conditions. Furthermore the loose material may contain beneficial microbes to further optimize plant health. In some examples, either the first layer, second layer, third layer, and/or the fourth layer (and/or an additional one or more layers) may be formed from the materials listed above to provide optimal growth conditions for an associated plant.

In other cases, the coating, lining, or seed encapsulation material may include, but are not limited to, hydrous aluminium phyllosilicate minerals (Clay), polyvinyl alcohol (PVOH), Calcium Stearate, polysaccharide-based material derived from seaweed or other organic sources, water-dispersible paraffin wax, oxidized polyethylene, microcrystalline wax, mineral oil, natural petroleum wax, synthetic petroleum wax, wood rosin, carnauba wax, candelilla wax, beeswax, shellac, a triglyceride, linseed oil, corn oil, canola oil, hemp oil, coconut oil, polyacrylamide, poly(acrylic acid), poly(methacrylic acid), polyvinylpyrrolidone, a quaternary ammonium polymer, polyvinyl acetate, ethylene vinyl alcohol, alginate, a polysaccharide, a protein, a pH-adjusted protein, wood pulp, non-wood pulp, non-woven fiber, natural foam, synthetic foam, a derivative of any of the foregoing, or a mixture of any of the foregoing. Examples of suitable proteins include, but are not limited to, soy, whey, casein, caseinate, and pullulan. Each of these proteins may or may not be pH-adjusted and still be suitable for the substrate layer according to the disclosure.

[0001] In some examples, the seed cartridge may include an attached and openable lid or top surface, a bottom surface parallel to the top surface, and a side wall or surface. For example, the lid or top surface may be hinged, retractable, swivelable, slidable, or otherwise movable from a closed position to an open position. In some examples, the hinge may include a bow-tie, butterfly, straight, flat living hinge or a strap hinge. The openable lid may include a friction locking mechanism or snap feature that can resist a specific amount of force to keep the lid closed during shipping, transportation, and/or handling.

[0059] In these examples, the lid or top surface may remain closed during transport and handling to maintain the substrate, seeds, and/or other medium within the cartridge. The top surface may then transition to an open position in which the lid or top surface remains attached to the cartridge but provides an opening from which the seeds may sprout and grow. In this manner, markings, such as a plant type identifier (words, machine readable codes, colors, materials, combinations thereof, and the like), visible on top of the lid remain visible to a vision system of the growing appliance while the opening is free for seedling to emerge. Accordingly, the vision system may utilize the markings on the lid to at least assist in categorizing, classifying, segmenting, defining an area, region or location associated with the plant based at least in part on image data of the plant and the lid. In some cases, the appliance may also utilize the identifier to access grow conditions, settings, and/or parameters customizable for the associated plant at one or more life stages.

[0060] In some examples, the markings may include a hidden (such as an infrared marking) and/or visible portion(s). For example, the visible portion may be used by a user to identify the plant and the hidden portion may be usable by the vision system of the appliance or via a manufacturer. In some cases, the hidden and visible portions may be along the same surface of the lid. However, in other examples, the hidden portion and the visible portion may be along different surfaces (e.g., a top, side, and bottom surface) of the lid. For instance, the visible portion may be along a top surface visible when the lid is in the closed position and the hidden portion may be visible when the lid is in the open position. In one example, the hidden portion may include an infrared or other machine readable but human unreadable spectrum on both the top surface and the bottom surface of the lid. For instance, the hidden portion may include a barcode, QR code, or other machine readable content.

[0061] In some examples, the markings (e.g., the hidden portion and/or visible portion) may include data such as location of origin of the cartridge and/or the seeds, substrate, and the like associated therewith, fertilizer and/or substrate formulas, type of seeds (e.g., types of resulting plants species and any subspecies), combination of seeds, number of seeds, media or substrate related data (e.g., manufacture, supplier, layers, layer make up, amount(s), and the like), compostability data (e.g., one or more metric associated with a rate, amount, and the like that the cartridge may compost), safety data (e.g., allergies and the like), certifications, lot number, dates (e.g., dates of manufacturing, production, seed and/or substrate packing, expiration, shipping, and the like), among others.

[0062] In some cases, the markings may include a word such as plant type (e.g., basil) and the words may have specific characteristic such as font height, width, type weight, color, and the like that may be utilized by pattern recognition and computer vision techniques to identify and access the data associated with the markings (e.g., the font and the like). In this manner, as there are many types of basil and limited surface space on the cartridge, the enclosed growing environment may utilize sensors to capture data (e.g., image data) of the word “basil” and then access cloud based services and/or stored data (such as subspecies) to determine additional information related to the particular subspecies of basil and the other cartridge related data discussed above. In some cases, in addition to the font and word, the cartridge may include a graphic, QR code, barcode icon, pattern, and the like that may be detected using pattern recognition and computer vision techniques together with cloud based services and/or datastores supplement the data printed on the cartridge itself.

[0063] In some cases, the markings (e.g., the hidden portion and/or visible portion) may be machine readable (such as via a barcode, quick response (QR) code, RFID, near-field communication (NFC), or the like). In other cases, the markings may be configured to be readable using infrared (IR) or ultraviolet (UV) illumination, such that the information is invisible to a user under normal visible light conditions. In this example, the enclosed growing environment may be equipped with IR sensors and/or illuminators to extract the data associated with the markings. The system may even project the plant name in readable text, icons, etc. in combination with the plant pod type recognition and lighting system displaying onto, or nearby the plant. Further, augmented reality compatibility, or the glass door of the system itself may present the

plant pod type in readable text, icons, etc. as the tower rotates relative to the observer's position.

[0064] RFID and/or NFC wireless communication technology may be applied to the lid of the seed cartridge for machine readability via external readers or sensors located on the appliance, NFC readers on mobile devices, or to utilize ambient electromagnetic radiation to power and communicate with other wireless devices. One example of this functionality is to allow a user to interact with the seed cartridges using a mobile application on a user electronic device to identify the plant type, manufacturing details, unique identification, origin of assembly, verification of authenticity, or any other type of information that can be stored into the memory of the wireless technology.

[0065] In some examples, the enclosed growing appliance and/or a cloud service associated therewith may utilize the markings on the seed cartridge together with other data (such as one or more growing policies) received from a cloud-based management system to customize conditions for the individual seed cartridges inserted within the planting column. As an illustrative example, the seed cartridges may include a marking that causes the enclosed growing appliance to access a cloud-based server and/or datastore that contains the seed cartridge data, such as via blockchain, unique identifiers, hash codes, third party APIs, and the like. In some cases, the seed cartridge data may be made accessible to an owner or user of the enclosed growing environments via mobile application or cloud-hosted portal/website.

[0066] In some cases, the lid may be formed with a particular pattern and/or color scheme that corresponds to the cartridge data and planting location on the tower as discussed above. In this example, the enclosed growing appliance may capture sensor data (e.g., image data, sonar data, lidar data, electromagnetic data, and the like) of the cartridge as the cartridge is inserted and utilize the patterns and/or color together with a cloud-based service/datastore and/or third party system to determine the cartridge data. In some cases, the color and/or pattern may be applied using printing, ink, laser, etching, embossing, and the like. In one specific example, the color or pattern may be used to indicate a location or region associated with the planting column in which to plant or insert the seed cartridge. For example, different regions of the planting column may be configured to provide customized growing conditions for specific types of plants. In this manner, the color or pattern may correspond to a specific region of the

planting column designed to provide the customized growing conditions for the plant species and/or subspecies within the corresponding seed cartridge. In some examples, the pattern and/or color may be replicated on the planting column to reduce complicity with respect to placement of the seed cartridge. In one specific example, illuminators
5 associated with the enclosed growing environment may be activated in response to detection or indication of a planting or insertion event to illuminate the desired region or regions in for instance a corresponding color or pattern.

[0067] In some examples, the lid and a rim of the side surfaces may mate such that the lid snaps, screws, or otherwise locks in place with the side surface when the lid
10 is in the closed position. For example, the lid may include a raised male portion of a mating mechanism that is configured to releasably couple to a female portion of the mating mechanism along the side surface or rim of the opening when the lid is in the closed position. In another example, the lid may include the female portion of the mating mechanism and the side surfaces may include the male portion of the mating
15 mechanism. In one specific example, the lid may screw into the closed position using a threaded assembly with respect to the side surface. In this specific example, the lid may be attached to the side surface via a strap or other attachment device, such that when the lid is in the open position the lid remains attached to the cartridge for use in the vision system of the appliance as discussed above.

20 [0068] In some examples, the side surface may be substantially cone shaped to provide a larger top surface when compared with the bottom surface. However, it should be understood that the exterior surface of the seed cartridge may take various forms and/or shapes, such as substantially rectangular prisms, substantially triangular prisms, substantially pyramidal, and the like. In another example, the thickness of the
25 exterior shape may be increased or decreased for structural integrity as well as increase or decrease the composability rate of the seed cartridge material.

[0069] The seed cartridge may include one or more openings, holes, or slits along the exterior side surface to allow water to be delivered from the planting column to the seeds and/or substrate within the seed cartridges. The slits may be arranged in columns
30 along the side surface and the columns may extend substantially the entire width of the exterior side surface, such that the slits are located along substantially the entire width of the cartridge. In some examples, the size of the slits may vary in size or length (as measured from the top surface to the bottom surface of the cartridge) with respect to

- each other. For instance, lower slits may be both longer relative to higher slits as well as closer together (e.g., the distance between the slits is reduced). In some cases, the columns of slits may also become closer to each other (e.g., the horizontal or width wise gaps between the slits may be reduced) as the slits approach the bottom surface (e.g.,
- 5 slits proximate to the bottom surface are closer horizontally and vertically to other slits than slits proximate to the top surface). In some examples, the slits may continue along the bottom surface of the seed cartridge. For example, the lowest slit in each column may partially extend into the bottom surface of the seed cartridge to provide improved drainage during use.
- 10 **[0070]** In this manner, the slits concentrically approach the center of the cartridge as the slits approach the bottom surface of the cartridge. The concentrically designed slits improve upon other traditional seed delivery containers by comparatively directing root growth downwards and increasing the plants and seeds access to water and nutrients contained in the lower sections of the cartridge. Additionally, the
- 15 concentrically designed slits of the seed cartridge provide for easier manufacturing and, in particular, injection molding of the cartridges. In some examples, the slits may be configured with rounded corners and the corners may be equipped with fillets to add structural integrity to the carriage during use and to assist with the flow of the liquid polymer or other material as the material is injected into a mold during manufacturing.
- 20 **[0071]** In some cases, one or more components of the seed cartridge may be compostable. For instance, the top surface may be formed of paper, cardboard, or other compostable material. In some cases, the top surface may be thermal and/or sonic welded, pressure sealed, adhered, or otherwise adhered to the exterior side surface. In one specific example, the entire seed cartridge including the top surface, side surface,
- 25 and bottom surface, seeds, and substrate may be compostable. For instance, the seed cartridge exterior may be formed from polylactic acid (PLA), polybutylene succinate (PBS), polyhydroxyalkanoates (PHA), lignin, a combination thereof, or a derivative of any of these materials as well as other compostable or biodegradable materials and the like.
- 30 **[0072]** In some cases, a removable and/or fixed filter may be positioned between the exterior surface and the substrate within the cartridge to assist with maintaining the substrate, seeds, and/or other medium within the cartridge during use. In some examples, the filter may be a non-woven PLA that is placed inside of the injection mold

prior to injecting the liquid polymer. In another example, the filter may be ultrasonically welded between the exterior surface and the substrate within the cartridge. The non-woven PLA filter provides resistance for root expansion and directs root growth downwards, such that the root mass is largely contained within the cartridge to reduce excessive root formation out of the slits and, thereby, in the drainage tube or other areas of the growing system of the enclosed growing environment. The filter may be cone shaped or a combined cone and circle shape making a cup shape. Alternatively, the filter may be a longer cone component that is sealed at the narrow end to close the filter before being placed inside the injection mold. However, it should be understood that other types of material may be used as a filter and that the filter is not exclusive to the material selection of PLA or to a non-woven material. In a thermoformed molding process, a sheet of the rigid compostable polymer could be cut to include perforations, and then the sheet is sandwich ultrasonically welded to a non-woven filter material sheet. Then the combined sandwich sheet can be used in a vacuum thermoformed mold to create much larger quantities of the seed pod cups.

[0073] FIGS. 1 and 2 are an example pictorial diagram of an enclosed growing enclosure 100. The enclosure 100 may be configured as a plant growing apparatus that provides a climate-controlled interior that houses at least one plant housing assembly or planting column 104. However, unlike conventional home garden systems that provide uniform lighting and temperature, the enclosure 100 may provide active monitoring and adaptive environmental conditions based on the health, stage of growth, type or species of plants, and the like via one or more systems either internal to the enclosure 100, co-located within a physical environment or a remote cloud-based systems.

[0074] In some specific implementations, the enclosure 100 may be configured to monitor individual plants within the growing environment and to provide tailored growing conditions, such as custom lighting (e.g., length of exposure, focal length, temperature, specific wavelengths, intensity, amount, and the like). For example, the enclosure 100 may include one or more illuminators (or light sources) associated with or positioned with respect to one or more lighting and control columns 106.

[0075] In some implementations, the lighting and control column (or panel) 106 may be configured within the enclosure 100 or along a specific region of the enclosure 100. The lighting and control column 106 may be equipped with various sensors for

monitoring the individual plants in addition to the one or more illuminators. For example, the lighting and control column 106 may be equipped with one or more sensors, such as image devices (e.g., red-green-blue image devices, infrared image devices, monochrome image devices, lidar devices, dot matrix devices, stereo cameras, thermal imaging devices, hyperspectral imaging devices, and the like), humidity sensors, temperature sensors, air pressure sensors, air quality/particulate sensors, gas sensors, oxygen sensors, carbon dioxide (CO₂) sensors, spectral sensors, and the like to generate sensor data associated with the interior of the enclosure 100.

[0076] In other implementations, the sensors such as image devices mentioned above may be coupled to a suspended cable system to allow one set of sensors to be used to monitor multiple planting columns 104 in a larger environmentally controlled enclosure, such as a shipping container. In effect, this reduces the need for multiple sensor devices which will reduce the cost of implementation.

[0077] As discussed above, the lighting and control column 106 may also be equipped with one or more illuminators (such as visible lights, infrared illuminators, ultraviolet lights, fiber optic solar lighting, and the like). The illuminators may be adjustable to provide specific spectrums, amounts of light, and intensities of light to each individual planting receptacle based on the corresponding plant's health, life stage, size, and type or species.

[0078] In some implementations, a field of view or a region of interest associated with each of the sensors and/or illuminators may be adjustable such that a single sensor and/or illuminator may, respectively, capture data and provide light to multiple planting locations or receptacles while maintaining individual per plant spectrum, amount, and intensity characteristics. For example, the individual growing conditions (e.g., health, size, stage of life, species, and the like) may be detected or determined per plant.

[0079] For instance, the enclosure 100 may include a planting column or tower 104 within the enclosure 100. The planting column 104 may comprise a plurality of receptacles, generally indicated by 108, configured to receive individual seed cartridges, as discussed above. The planting receptacles 108 may be arranged both in vertical columns and horizontal rows about the planting column 104. In some cases, the planting receptacles 108 may be staggered between the columns, such that each column has one planting receptacle for every other row. In these cases, staggering the planting

receptacles 108 allows the enclosure 100 to be able to monitor each individual plant as well as allowing each individual plant sufficient room to grow.

[0080] In some cases, the planting column 104 may be rotatable three-hundred and sixty degrees within the enclosure 100 and about a base, or any other limited rotation. For example, a drive motor may be configured to mechanically or magnetically rotate the planting column 104 within the enclosure 100 based on one or more control signals or setting data, such as, in some examples, from a cloud based system (or, in other examples, via internal control system of the enclosure 100). In some instances, as the planting column 104 rotates, each individual planting receptacle 108 may be assigned a unique identifier, such that the enclosure 100 is able to track each seed cartage and emerging plant based on a determined location within the planting column 104. The planting column 104 could then rotate a planting receptacle 108 toward the door 110 for user access.

[0081] In these instances, the lighting and control column 104 may capture sensor data usable to determine the assigned location of a plant upon insertion or planting within a specific planting receptacle 108. For example, a planting receptacle 108 may have a visible marking or invisible marking (e.g., an infrared spectrum mark) that the lighting and control column 106 may capture data usable to determine an insertion of a planting pod into a receptacle 108 and the corresponding receptacle identifier and/or location on the planting column 104. In other cases, the captured sensor data may be usable to determine that a receptacle 108 has been filled as the planting column 108 rotates. In some cases, markings for location determination may also be placed at various positions about the interior surfaces of the enclosure 100 and/or the top and bottom of the planting column 104 to assist with initialization or location determination upon restart or reboot of the enclosure 100 as well as in response to an upgrade or replacement lighting and control column being installed or calibrated.

[0082] In some implementations, in addition to the sensors and/or illuminators of the lighting and control column 106, sensors, illuminators, and the like may be positioned above the planting column 104, such that the sensors have an aerial view of the planting column 104. In one example, the sensors may include one or more image capture devices positioned over or on top of the growing chamber facing downwards with a field of view of a front region of the planting column or tower 104, such as would be visible to a user opening the door 110 of the enclosure 100. In another example, the

overhead sensors may include multiple sensor types or instances positioned about the top surface of the enclosure 100, such as in each corner, corresponding to each side wall, and the like. In this example, the combination of sensors may provide a top down view of the enclosure 100 as well as a 360 degree view of the planting column 108 including the front view.

[0083] In some cases, the overhead or side mounted sensors may be used to track and/or monitor the planting, pruning, harvesting, cleaning, and assembly of the seed pods, growth rings, and any other component, life stage, maintenance, or consumable associated with the enclosure 100. The sensor data (e.g., image data and the like) may also be used to assist or guide the user experience of farming with the enclosure 100. This experience may include an onboard touch glass interface (such as incorporated into the door 110 of the enclosure 100), mobile application (accessible via a remote mobile device), audible commands, or any other type of machine to human interface.

[0084] In some cases, as discussed above, the lids of the seed cartridges may include markings in a visible or invisible spectrum (e.g., infrared spectrum) that the sensors may read upon insertion of a pod into a planting receptacle. The marking may indicate a type or species of plant associated with the planting pod as well as other information, such as an age of the pod and the like. In other cases, the planting receptacles of the planting column 104 may include an electrical or magnetic coupling such that the planting system is able to detect an insertion and determine the information associated with the cartridge upon insertion and during use via the markings on the lid.

[0085] FIGS. 3 and 4 are examples 300 and 400 pictorial diagrams of an interior of the enclosed growing enclosure 100 with one or more seed cartridges in various stages of germination. As discussed above, the planting column 104 may comprise a plurality of receptacles 108 configured to receive individual seed cartridges. The planting receptacles 108 may be arranged both in vertical columns and horizontal rows about the planting column 104. In some cases, the planting column 104 may be rotatable three-hundred and sixty degrees within the enclosure and about a base, or any other limited rotation. In some instances, as the planting column 104 rotates, each individual planting receptacle 108 may be assigned a unique identifier to track each plant based on a determined location (e.g., determined receptacle 108) within the planting column 104. In these instances, the enclosure 100 may determine the assigned location of a plant upon insertion of an open seed cartridge 402 within a specific planting receptacle,

such as illustrated with respect to FIG. 4. For example, the lid 404 of the seed cartridge 402 may have a visible marking or invisible marking (e.g., an infrared spectrum mark) that the enclosure 100 may read upon insertion of a seed cartridge 402 into the receptacle 108. In some cases, markings may be used by the enclosure for location or
5 region determination, segmentation or plant classification. The markings may also be useable to determine growing conditions, settings, characteristics, and the like, usable for the emerging plant at various life cycles.

[0086] FIG. 5 is an example pictorial view 500 taken from the front of the planting column and a lighting and control column 104 associated with the enclosure
10 100. In the illustrated example, the planting column 104 includes a plurality of planting receptacles, generally indicated as planting receptacles 108(A)-(H). Each planting receptacle 108 may be configured to receive a seed cartridge and arranged such that each receptacle 108 provides space or room above the receptacle 108 for a plant to mature.

[0087] In the current example, the lighting and control column 104 may be arranged vertically and include one or more sensors, such as sensors 502(A) and 502(B), as well as one or more illuminators, such as illuminator 504. In this example, the sensor 502(A) may be a spectral sensor and the sensor 502(B) may be an image sensor. Each of the sensors 502 may have a corresponding field of view of the planting
20 column 104 as illustrated. Similarly, the illuminator 504 may also have a field of illumination. In this example, the field of illumination may be configured to provide directed illumination to a single plant associated with a specific planting receptacle (currently illustrated as planting receptacle 108(B)). In this example, the characteristics of the light being emitted by the illuminator 504 and the position of the field of
25 illumination may be adjustable based on the current target (e.g., a seed cartage of the planting receptacle 108(B)). For instance, the intensity, wavelength, and type of illumination may vary as the field of illumination is adjusted from the seed cartridge of the planting receptacle 108(B), as each plant may have a different settings at a different maturity level or life stage and accordingly requiring different lighting for optimal
30 growth.

[0088] FIGS. 6-45 illustrate various examples 600-4500 of embodiments of a seed cartridge, such as seed cartridge 402, having a lid 602 or top surface that remains attached after insertion or planting and a base 604. In these examples 600-4500, the

seed cartridge 402 may include a plurality of openings, holes, or slits, generally indicated by 606, along the exterior side and bottom surfaces, as shown. The slits 606 may be configured to allow water or fluid (including nutrients) to be delivered and/or drained from the planting column to the seeds and/or substrate within the seed
5 cartridges 402. The slits 606 may be arranged in columns, such as example columns, along the side surface and the columns may extend substantially the entire width of the exterior side surface, such that the slits 606 are located along substantially the entire width of the cartridge 402.

[0089] In some examples, the size of the slits 606 may vary in size or length (as
10 measured from the top surface to the bottom surface of the base 604 of the cartridge 402) with respect to each other. For instance, lower slits 606(A) may be both longer relative to higher slits 606(B) as well as closer together (e.g., the distance between the slits is reduced). In some cases, the columns of slits 606 may also become closer to each other (e.g., the horizontal or width wise gaps between the slits within each column
15 may be reduced) as the slits 606 approach a bottom surface (e.g., slits proximate to the bottom surface are closer horizontally and vertically to other slits 606 of other columns than slits of other columns proximate to the top surface or lid). In some examples, the slits 606 may continue along the bottom surface of the seed cartridge 402. For example, the lowest slit in each column may partially extend into the bottom surface of the base
20 604 of the seed cartridge 402 to provide improved drainage during use, generally indicated by 606(C).

[0090] In this manner, the slits 606 concentrically approach a center of the base
604 of the cartridge 402 as the slits 606 approach the bottom surface of the base 604 of the cartridge 402. In some cases, the bottom surface of the base 604 may be spherical
25 shape, a substantially rounded bottom surface, or the like.

[0091] The concentrically designed slits 606 improve upon other traditional seed
delivery containers by comparatively directing root growth downwards and increasing the plants and seeds access to water and nutrients contained in the lower sections of the base 604 of the cartridge 402. Additionally, the concentrically designed slits 606 of the
30 base 604 of the seed cartridge 402 provide for easier manufacturing and, in particular, injection molding of the cartridges 402. In some examples, the slits 606 may be configured with rounded corners and the corners may be equipped with fillets to add

structural integrity to the carriage during use and to assist with the flow of the liquid polymer or other material as it is injected into a mold during manufacturing.

[0092] In the examples 600-2100, the lid 602 of the seed cartridge 402 is configured to slide or planarly rotate about an axis joint 608 from the closed position 1402 illustrated with respect to examples 1400-2000 to the open position 610 illustrated with respect to examples 600-1300. In this manner, the lid or top surface 602 may remain closed during transport and handling to maintain the substrate, seeds, and/or other medium within the cartridge and the top surface may then transitioned to an open position 1402 in which the lid or top surface 602 remains attached to the cartridge 402 and visible to the vision system of the enclosure during the life cycle of the emerging vegetation or plant.

[0093] In some implementations, the lid 602 may include markings 1302, such as a plant type identifier (words machine readable codes, colors, combinations thereof, and the like), on top of the lid 606 to remain visible to a vision system of the growing appliance while the opening is free for seedling to emerge. Accordingly, as discussed above, the vision system of the enclosure may utilize the markings on the lid to at least assist in categorizing, classifying, segmenting, defining an area, region or location associated with the plant or vegetation based at least in part on image data of the plant and the lid 602. In some cases, the appliance may also utilize the markings to access grow conditions, settings, and/or parameters customizable for the associated plant or vegetation at one or more life stages.

[0094] In some particular examples, the markings 1302 may include a hidden (such as an infrared marking) and/or visible portion(s). For example, the visible portion may be used by a user to identify the plant and the hidden portion may be usable by the vision system of the appliance or via a manufacturer. In some cases, the hidden and visible portions may be along the same surface of the lid 602. However, in other examples, the hidden portion and the visible portion may be along different surfaces (e.g., a top and bottom surface) of the lid 602. For instance, the visible portion may be along a top surface visible when the lid is in the closed position and the hidden portion may be visible when the lid is in the open position. In one example, the hidden portion may include an infrared or other machine readable but human unreadable spectrum on both the top surface and the bottom surface of the lid. For instance, the hidden portion may include a bar code, QR code, or other machine readable content.

[0095] In some examples, the markings 1302 (e.g., the hidden portion and/or visible portion) may include data such as location of origin of the cartridge and/or the seeds, substrate, and the like associated therewith, fertilizer and/or substrate formulas, type of seeds (e.g., types of resulting plants species and any subspecies), number of
5 seeds, media or substrate related data (e.g., manufacture, supplier, layers, layer make up, amount(s), and the like), compostability data, safety data (e.g., allergies and the like), certifications, lot number, dates (e.g., dates of manufacturing, production, seed and/or substrate packing, expiration, shipping, and the like), among others.

[0096] In some cases, the markings 1302 may include a word such as plant type
10 (e.g., basil) and the words may have specific characteristics such as font height, width, type weight, color, and the like that may be utilized by pattern recognition and computer vision techniques to identify and access the data associated with the markings (e.g., the font and the like). In this manner, as there are many types of basil and limited surface space on the cartridge, the enclosed growing environment may utilize sensor to capture
15 data (e.g., image data) of the word “basil” and then access cloud based services and/or stored data (such as subspecies) to determine additional information related to the particular subspecies of basil and the other cartridge related data discussed above. In some cases, in addition to the font and word, the cartridge 402 may include a graphic, QR code, barcode icon, pattern, and the like that may be detected using pattern
20 recognition and computer vision techniques together with cloud based services and/or datastores supplement the data printed on the base 604 of the cartridge 402 itself.

[0097] In some cases, the markings 1302 (e.g., the hidden portion and/or visible portion) may be machine readable (such as via a barcode, QR code, RFID, NFC, or the like). In other cases, the markings 1302 may be configured to be readable using infrared
25 (IR) or ultraviolet (UV) illumination, such that the information is invisible to a user under normal visible light conditions. In this example, the enclosed growing environment may be equipped with IR sensors and/or illuminators to extract the data associated with the markings 1302.

[0098] In the examples 2200-4500, the lid of the seed cartridge 402 is configured
30 to open and remain attached to the seed cartridge 402 via a hinged connector 2202. In this manner, the lid or top surface 602 may remain closed during transport and handling to maintain the substrate, seeds, and/or other medium within the cartridge and the top surface may then transitioned to an open position 610 in which the lid or top surface

602 remains attached to the base 604 of the cartridge 402 and visible to the vision system of the enclosure during the life cycle of the emerging plant, as discussed above.

[0099] For instance in the examples 2200-4500, the connector 2202 is a bow-tie, butterfly, bi-stable, straight, or strap hinge type connector. While a rotatable slider joint and a strap hinge are shown in examples 600-2100 it should be understood that various other types of connectors may be used to maintain the lid attached to the cartridge 402 after insertion into a receptacle of a grow appliance. For example, the cartridges 402 may include vertical sliding members, living hinges, spring based hinges, and the like. In some cases, such as the examples 2200-4500, the lid 602 may include a locking mechanism 2204 to releasably couple the lid 602 to the base 604 of the cartridge 402.

[00100] In some cases, the lid 606 may be formed with a particular pattern 2802 (such as the cross hatch of examples 2800 or 3700) and/or color scheme that corresponds to the cartridge data as discussed above. In this example, the enclosed growing appliance may capture sensor data (e.g., image data) of the cartridge as the cartridge is inserted and utilize the patterns and/or color 2802 together with a cloud-based service/datastore and/or third party system to determine the cartridge data. In some cases, the color and/or pattern may be applied using printing, ink, laser, etching, embossing, and the like. In one specific example, the color or pattern 2802 may be used to indicate a location or region associated with the planting column in which to plant or insert the seed cartridge. For example, different regions of the planting column may be configured to provide customized growing conditions for specific types of plants. In this manner, the color or pattern may correspond to a specific region of the planting column designed to provide the customized growing conditions for the plant species and/or subspecies within the corresponding seed cartridge. In some examples, the pattern and/or color may be replicated on the planting column to reduce complicity with respect to placement of the seed cartridge. In one specific example, illuminators associated with the enclosed growing environment may be activated in response to detection or indication of a planting or insertion event to illuminate the desired region or regions in, for instance, a corresponding color or pattern 2802.

[00101] In some examples, the lid 602 and a rim 4002 of the side surfaces may mate such that the lid snaps, screws, or otherwise locks in place with the side surface when the lid is in the closed position. For example, the lid 606 may include a raised male portion 4004 of a mating mechanism that is configured to releasably couple to a

- female portion 4002 of the mating mechanism along the side surface or rim of the opening when the lid 602 is in the closed position. In another example, the lid 602 may include the female portion of the mating mechanism and the side surfaces may include the male portion of the mating mechanism. In one specific example, the lid 602 may
- 5 screw into the closed position using a threaded assembly with respect to the side surface. In this specific example, the lid 602 may be attached to the side surface via a strap or other attachment device, such that when the lid is in the open position the lid 602 remains attached to the base 604 the cartridge 402 for use in the vision system of the appliance as discussed above.
- 10 **[00102]** Although the subject matter has been described in language specific to structural features, it is to be understood that the subject matter defined in the appended claims is not necessarily limited to the specific features described. Rather, the specific features are disclosed as illustrative forms of implementing the claims.

CLAIMS

WHAT IS CLAIMED IS:

1. A seed cartridge for an enclosed growing environment comprising:
 - 5 a base having a bottom surface and a side surface defining a cavity, the side surface and bottom surface including a plurality of openings; and
 - a lid releasably coupled to the base, the lid configured to remain attached to the base when the seed cartilage is in an open configuration, the lid including at least one machine readable marking indicating at least one of:
 - 10 a characteristic of the cartridge;
 - a characteristic of seed contents of the cartridge; or
 - a configuration setting for the enclosed growing environment associated with the contents of the cartridge.
- 15 2. The cartridge of claim 1, wherein:
 - the plurality of openings are arranged in at least a first column and a second column
 - a first opening of the first column positioned closer to the bottom surface of the body than a second opening of the first column; and
 - 20 the first opening having a greater vertical length than the second opening.
3. The cartridge of any of claims 1 or 2, wherein the lid includes a locking mechanism for securing the lid to the base when the seed cartridge is in a close configuration.
- 25 4. The cartridge of any of claims 1-3, wherein the markings are located on a bottom surface of the lid, the bottom surface exposed to the cavity when the seed cartridge is in a closed configuration.
- 30 5. The cartridge of any of claims 1-3, wherein the markings are located on a top exterior surface of the lid.

6. The cartridge of any of claims 1-3, wherein a first portion of the markings are located on a top exterior surface of the lid and a second portion of the markings are located on a bottom surface of the lid, the bottom surface exposed to the cavity when the seed cartridge is in a closed configuration.

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7. The cartridge of any of claims 1-6, wherein the base of the seed cartridge is conical in shape and has a narrower diameter at the bottom surface than at a top opening.

8. The cartridge of any of claims 1-7, wherein the lid includes a raised male portion of a mating mechanism and the base includes a female portion of the mating mechanism.

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9. The cartridge of any of claims 1-8, wherein a butterfly hinge is used to secure the lid to the base when the seed cartridge is in the open conformation.

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10. The cartridge of any of claims 1-8, wherein a horizontal sliding hinge is used to secure the lid to the base when the seed cartridge is in the open conformation.

11. A system comprising:

20 a seed cartridge having a lid releasably coupled to a based, the base including a side surface and a bottom surface defining a cavity and a plurality of openings, the cavity containing seeds and growth medium, wherein the lid including at least one machine readable marking indicating at least one of:

a characteristic of the cartridge;

25 a characteristic of seed contents of the cartridge; and

an enclosed growing environment including:

a planting column having a plurality of receptacles, a first receptacle of the plurality of receptacles configured to receive the seed cartridge; and

at least one configurable illuminator.

30

12. The system of claim 11, wherein the seed cartridge includes at least one marking on an interior surface of the lid.

13. The system of any of claim 12, wherein the enclosed growing environment includes at least one image device to determine configuration data from the at least one marking on the interior surface of the lid and adjust at least one setting of the configurable illuminator based at least in part on the configuration data.

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14. The system of claim 13, wherein adjusting the at least one setting of the configurable illuminator includes adjusting at least one of:

a length of exposure of the seed cartridge to light output by the at least one illuminator with respect to the seed cartridge;

10 a focal length of the light output by the at least one illuminator with respect to the seed cartridge;

a temperature spectrum associated with the light output by the at least one illuminator with respect to the seed cartridge;

15 a wavelengths of the light output by the at least one illuminator with respect to the seed cartridge;

an intensity of the light output by the at least one illuminator with respect to the seed cartridge; or

an amount of the light output by the at least one illuminator with respect to the seed cartridge.

20

15. The system of any of claims 11-14, wherein the seed cartridge further comprises:

25 a first opening of the plurality of openings arranged in the first column having a center that is horizontally aligned with a vertical midpoint between a center of a second opening of the plurality of openings arranged in the second column and a center of a third opening of the plurality of openings arranged in the second column, and wherein:

the third opening being vertically adjacent to the second opening in the second column;

30 the third opening of the second column positioned closer to the bottom surface of the seed cartridge than the second opening of the second column; and

the third opening has a greater vertical length than the second opening.