HORTICULTURAL CELL SYSTEM AND METHOD OF MANUFACTURE

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Filed: July 22, 1971

Appl. No.: 165,277

U.S. Cl. 47/34.13, 47/38, 53/28, 53/180

Int. Cl. A01g 9/02

Field of Search 47/34.13, 37, 37.3, 47/38.1, 38, 34.11, 1.2; 53/28, 177, 178, 180

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A cell system for use in horticulture comprises a belt of sheet material such as plastic, folded in half longitudinally and having its two layers sealed along lines transverse to and spaced apart along the belt. The sheet forms a series of spaced web portions in which the layers are contiguous, and an alternating series of cells each suitable for receiving the root system of a mature plant. Cover means for the mouths of the cells may comprise a cover strip separate from the belt, or edge portions of the belt may be folded over the mouths. The seals in the web portions may be discontinuous and localized to allow water and nutrient to flow between the cells; or unsealed edge portions of the webs may form a liquid conduit between cells.

7 Claims, 20 Drawing Figures
HORTICULTURAL CELL SYSTEM AND METHOD OF MANUFACTURE

BRIEF DESCRIPTION OF THE INVENTION

This invention relates to a cell system for planting, germinating and growing plants including vegetables, fruits, and flowers. It has as one object the provision of improved means by which plants may be germinated and grown economically and profitably, with reduced quantities of water, nutrients and control chemicals. It is another object to provide an improved method of manufacturing a cell system for horticultural use. It is another object to reduce pollution by eliminating the discharge of nutrients such as phosphates and nitrates into the ground-water system. Still a further object is to enable any surface, such as desert, rocky soil, or other non-arable land, to be used for agriculture. Further objects and advantages of the invention will appear as the following description proceeds.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective of a strip of seed germination packages which is useful in combination with the improved growth cell system;

FIG. 2 is a view of an individual germination package, partially opened;

FIG. 3 is a fragmentary view showing a seedling growing in a modified germination package;

FIG. 4 is a fragmentary view in perspective of one form of the improved cell system, and illustrating its method of manufacture;

FIG. 5 is a view of the cell system of FIG. 4, showing an illustrative plant in one of the cells, with cover-forming means in place;

FIG. 6 is a view of the same cell system, but showing seedlings implanted therein by means of the germination packages of FIG. 3;

FIG. 7 is a fragmentary view of a modified cell system having discontinuous lines of seams forming a quilted pattern;

FIG. 8 is a view of a further modification having discontinuous seals and perforated cell walls;

FIG. 9 is a view of another cell system having discontinuous seals;

FIG. 9A is a fragmentary view of the cell system of FIG. 9, shown in conjunction with tube means for insuring continued fluid communication;

FIG. 10 is a fragmentary view of an individual cell of the system, showing modified cover-forming flap means;

FIG. 11 is a fragmentary view of an individual cell, showing another form of flap means;

FIG. 12 is a fragmentary view in perspective of another form of the cell system which includes a belt of cells and separate cover-forming means;

FIG. 13 illustrates a modification in which the area of the cell mouths is reduced in relation to the volume of the cells, to provide cover-forming means;

FIG. 14 illustrates a modification involving the formation of the bottoms of the cells;

FIG. 15 is a fragmentary view of a modified system incorporating double-walled cells;

FIG. 16 is a fragmentary view showing a modified bag or tent cover means which is formed integrally with an individual cell of the system;

FIG. 17 illustrates another embodiment employing a bag or tent cover means separate from the cells proper;

FIG. 18 is a fragmentary view in elevation of a modified cell system particularly suited for hydroponic gardening; and

FIG. 19 is an end view in cross-section of the cell system of FIG. 18.

Referring first to FIGS. 1 and 2, seedlings 16 are germinated in a strip 10 of connected packages 11, which are formed in a known manner by folding a sheet of polyethylene or other thermoplastic material in half lengthwise, and forming a series of heat-sealed seams 12 across the width of the folded strip at spaced intervals. A line 14 of perforations is formed near the bottom of the strip 10, to permit a narrow strip 18 of material to be easily torn from the bottom of each package 11 when the seedlings are ready for transplanting. A suitable quantity of plant growth material, for example soil, a suitable fertilizer and water, is inserted with one or more seeds in each package 11, and the strip is then heat-sealed along a seam 13 to close the mouths of the packages. The seeds are germinated in the sealed packages by placing them in sunlight or in a suitable greenhouse under appropriate temperature and light conditions. When the seedlings 16 have reached a suitable size, the individual packages 11 are torn from the strip 10, the strip 18 is removed by tearing along the perforation line 14, and the plug of plant growth material 15 and seedling 16 are transplanted to the growth cell system which will be described hereinafter.

A modified germination package 11, shown in FIG. 3 has a die-cut bottom edge 20, in which a series of slots 22 are cut. This permits the roots of the growing seedling 16 to protrude as shown from the germination package into the soil after transplanting, so that the package need not be removed from the seedling during the transplanting process. The package is cut across the top in this case to form an open mouth 24 through which the plant stem protrudes.

FIG. 4 illustrates a method of forming an improved plant growth cell system in accordance with the invention. A sheet of material 24, which is preferably of a thermoplastic such as polyethylene, but may be made of paper or other suitable sheet material, is drawn in the direction shown by the arrow through opposed folding shoes 26 to double the sheet along a bottom fold line 28, with the free edges 30 of the sheet extending in parallelism. The sheet 24 is drawn forwardly in intermittent steps, and is stopped at intervals during which two pairs of reciprocable gripping shoes 37 and 41 are moved to grip the sheet between them. The portion of the sheet between the two pairs of shoes is then pushed forwardly by movement of the shoes 37, to separate the layers of material into the form of a cell 34 which has a generally oval cross-section. This action tends to open the fold 28, flattening the bottom of the cell. Two pairs of reciprocable heat-sealing shoes 38 and 39, which may be carried by the shoes 37 and 41, then act on the ends of the cell to form heat seals 40 between the layers of the sheet 24. These seals extend transversely to the length of the sheet 24, and, in the construction shown in FIG. 4, extend only partially across the width of the folded material, leaving portions of the sheet adjacent to the free edges 30 unsealed, for purposes which will be explained hereinafter. If the sheet 24 is formed of a material that is not sealable by heat, the seals 40 may be made by cement, by staples, or by other known means.
After a cell 34 is thus formed, the shoes 37, 38, 39 and 41 are withdrawn from the sheet 24, which is then advanced to form a succeeding cell in the series. In this manner a belt generally designated 44 is formed, which comprises a series of cells 34 spaced apart by intervening web portions 46, in which the layers of sheet material are contiguous.

After the belt 44 is formed, the cells 34 are filled with suitable plant life support material, such as earth, fertilizer, and the like. Referring to FIG. 5, each cell is adapted to receive and support the root system of an individual plant 48, and one such plant is illustrated. A seed may be germinated within the cell, or transplanted as a seedling thereto, either from a conventional flat or from the germination packages of FIGS. 1–3. The free edges 30 are, as previously explained, left free of heat seals 40 to provide closure-forming flaps 50, which are folded over the soil at the mouth 33 of the cell, and may be pinned in place, to limit the rate of moisture evaporation from the cell. The unsealed portions of the edges 30 which extend across the intervening webs 46 serve as a liquid communication means between the cells, by means of which liquid nutrients and water can be added from time to time by pouring into one end of the belt 44, from whence they will flow successively into all of the cells.

A preferred method of transplanting seedlings to the cells is shown in FIG. 6. This method utilizes the germination packages 11' illustrated in FIG. 3 and previously described. The maturing seedlings 16' are planted within the packages 11', from which their roots penetrate into the soil in the cell proper.

FIG. 7 shows a modification in which the seals between the layers of a belt 52 of cells 58 are discontinuous, being formed as lines of localized spot-seals 54 in the web portions 56. Again in this embodiment, a portion of the layers near the edges 60 are left free of seals 54, and serve to provide cover-forming flaps like those in FIG. 6 for the mouths of the cells. The seals 54 form a quilted pattern which permits liquid flow through the webs 56 between cells, but holds the layers of the sheet in close contiguity against the hydrostatic pressure of a water supply contained within the web portions, and prevents the belt from bursting.

FIG. 8 illustrates a belt 62 having discontinuous lines of spot-seals 64 defining the webs 65 and the cells 68. Again, the seal lines may terminate somewhat short of the upper edges 66 of the sheet to allow ample free material for the formation of flaps that will fully cover the mouths of the cells. The dimensions of the belts and cells in all embodiments are chosen to accommodate the particular size of plants for which they are intended; that is, the cell volume should be appropriate to maintain and nurture the root system of the mature plant, and the cells should be spaced apart by the intervening webs sufficiently far to avoid undue interference between the leaf systems of adjacent plants. The belt of cells may be inserted in a suitable trench in the earth, and this is the normal mode of use; however, it may also be rested on the surface.

The cells 68 in FIG. 8 are provided with a number of surface perforations 70. These perforations may serve both the purposes of drainage and aeration, and their diameters should be selected according to the purpose intended. The uppermost perforations should preferably be spaced a sufficient distance from the mouths of the cells, usually one or two inches, so that water entering the mouths will percolate through the cells, and not simply run out of perforations placed too close to the mouths. The bottom 68 of each cell is provided with a drainage hole 69.

FIG. 9 shows a belt 72 in which the web portions 74 are formed with discontinuous lines of horizontal linear seals 76, which serve to provide fluid flow communication through the webs 74 between adjacent cells 78. The bottom of each cell is again provided with a drainage hole 82. The layers of material between adjacent seals 76 assume a generally cylindrical form when the belt is filled with water. Because of the flexibility of the material, these internal passages may tend to collapse if the belt is planted in the earth. As shown in FIG. 9A, a series of short plastic tubes 84 may be inserted between pairs of seals 76 for preventing the possibility of such a collapse.

FIG. 10 shows a modified belt 86, in which the flaps 92, formed by unsheared portions of the sheet material adjacent to the edges 88, are formed with rows of perforations 90 to provide aeration and to permit free entry of rain water.

A belt 100 shown in FIG. 11 has fringed flaps 97 which are die-cut or slit, as at 96, to cover the mouths of the cells 102. These flaps can be fitted snugly around a plant stem regardless of its size or location in the mouth of the cell, and yet will allow air and water to pass freely through the slits between the fringes.

In the embodiments thus far described, cover means for the cells are formed by the layers of the belt themselves. Alternatively separate cover means may be used. In one such construction that is illustrated in FIG. 12, a belt 106 of cells 108 has separate cover-forming means comprising a strip 110 which includes a series of lids 112 interconnected by web portions 114. The lids 112 are conformably received over the mouths of the cells 108, and each has an opening 116 for a plant stem. In this case, the lines of heat seals 117 which separate the cells 108 from the intervening webs 118 may be either continuous or discontinuous as previously described, but preferably extend to the upper edges of the belt so that the mouths of the cells will be stiff to facilitate attachment of the lids. The cover strip 110 may be formed in a manner similar to the belt 106, by folding and suitably sealing a single strip of sheet material.

While the belts and cover means may be made of various sheet materials, including papers, a heat-sealable plastic is usually preferable. However, sunlight eventually deteriorates most plastics, even though ultraviolet inhibitors may be added. The one-piece constructions of FIGS. 1–11 must be replaced in their entirety when any portion deteriorates, and this will ordinarily be the cover flaps because of their direct exposure to sunlight. In the two-piece construction of FIG. 11, the belt 106 may be constructed of a heavy-gauge plastic sheet which is relatively permanent, while the cover strip 110 may be made of relatively thin material and treated as a disposable item.

A separate cover strip may alternatively consist of nothing more than a strip of plastic, either solid, perforated, or fringed, which is flattened over the mouths of the cells and pinned to secure it in place.

A one-piece cell system shown in FIG. 13 comprises a belt 120 of cells 122 which have mouths 124 of smaller cross-sectional area than the interiors of the cells; thus the cell walls themselves provide cover means that partially enclose the soil surface to limit the
rate of moisture evaporation. The cells 122 are formed by seal lines 128 which are vertical, and by inclined seal lines 130, each pair of which slopes toward one another to define the reduced mouths 124. The seals 130 may terminate short of the free edges 132 of the sheet to define a liquid passage between the cells. The mouths 124 may be made just large enough to accommodate the stem of a mature plant. This configuration appears to promote unusually rapid germination and growth, perhaps because it tends to retain the sun's heat within the soil in the cell.

Another modification is shown in FIG. 14, in which a belt 134 is formed with a doubled gusset fold 142, which opens into an oval bottom 140 as each cell 136 is formed. This method of folding produces a more-nearly cylindrical cell bottom when filled with soil.

FIG. 15 shows a doublewall cell construction that is particularly useful in hot climates since it tends to insulate the roots of the plants. The belt 150 includes outer cells 152 and inner cells 154, the latter are formed separately from the belt, and may have their bottoms heat-sealed to the bottom of the outer cells if desired. The space between the cells is filled with particulate granular material such as pea-sized gravel, sand, polystyrene foam crumbs, vermiculite, or the like. The walls of the inner cells are perforated as at 156 to permit air and moisture to flow between the inner and outer cells. The inner cells 154 contain the soil and plant roots, and either cell may be provided with cover-forming means of the kinds previously described.

FIG. 16 illustrates a belt 160 of cells 162, each of which is fully enclosed by a conical bag or tent element 164, comprising pre-cut extensions of the sheet material laterally beyond the edges 163 about the cell mouth. In this case, the seals 167 extend not only fully across the width of the sheet to the edges 163, but also along the edges of the extensions forming the tent 164, so that the cell is sealed to entirely close a plant 165. This makes it possible to maintain a control of artificial atmosphere within the cell structure to promote photosynthesis. Any desirable gas mixture may be introduced, such as a combination of carbon dioxide and air. The material used for the tent structure may be clear, or tinted to a purple or wine color to transmit preferred frequencies of light to promote plant growth.

In FIG. 17, a bag or tent 170 is provided for each cell 168; the tent is formed separately from the belt 166, and comprises a cone-shaped structure whose mouth 172 is shaped to fit snugly over the mouth 174 of the cell. This cover is not hermetically sealed, but has the virtue of being separately disposable when it deteriorates.

An embodiment shown in FIGS. 18 and 19 is particularly suitable for hydroponic gardening, and comprises a belt 180 formed by folding a sheet of plastic or other suitable material along a fold line 183, the layers being contiguous and having their edges 185 extending in parallelism. The layers are interconnected in a quilted pattern by a number of lines of spot-seals 181. In addition, localized groups of discontinuous seals 182 form cells at spaced intervals, in which hydrophilic foam 186 is placed. When the belt 180 is filled with water, the foam in each cell swells and firmly embraces the stalk of a plant 184 to hold it upright, while the roots 188 of the plant grow downwardly between the layers of the belt, finding their own favored path among the spot-seals 181. The cell system is filled with suitable liquid plant nutrients, as commonly used in hydroponic gardening. The upper parts of the belt 180, extending above the cells formed by the seals 182, provide cover-forming means which limit the rate of liquid evaporation.

Flap means integral with the belt of cells, as shown in FIGS. 4-11, 13, 16, 18-19, comprise free, unsealed edge portions of both layers of the belt. An alternative within the scope of the invention is to terminate one of the layers at the height of the soil within the cell, and to extend the remaining layer far enough beyond the first layer to form a one-part flap that can be folded over the entire cell mouth and into overlapping relation to the opposite cell wall. In this case, it is necessary to provide a slit or hole in the flap to receive the stem of the plant growing in the cell.

It will be observed that the improved horticultural cell system requires no more soil, plant nutrients, or water than the minimum needed for maturing the plants. It is not necessary to apply excess amounts, as required in conventional farming methods, which are wasted by leaching into unproductive soil surrounding the useful plants. The system eliminates the pollution of the ground-water system which arises from leaching away of phosphates and nitrates in conventional agricultural practices. It will be apparent that the system can be used to carry on horticulture on any surface, including non-arable, desert, or rocky land, since the cells may rest on the soil surface rather than being implanted.

What I claim is:

1. A horticultural cell system comprising, in combination:
   a belt of sheet material folded along a fold line longitudinally into two layers with the edges of the sheet material substantially parallel, said layers being sealed to one another along lines of seals which have extent transverse to the length of said belt and are spaced apart longitudinally of said belt, to form a series of web portions of said belt in which said layers are contiguous, and a series of cells alternately spaced between said web portions; said cells having Approximately oval cross-sections and each being of a size to contain the root system of a preselected mature plant and a corresponding quantity of plant life-support materials; each of said cells having an open mouth formed between the edges of said layers;
   each of said cells being provided with cover-forming means for overlying at least a portion of said mouth to retain moisture in the cell while permitting a plant stem to protrude therefrom; each of said lines of seals extending from said fold line only partially across the width of said belt toward said edges; portions of said layers which lie beyond said lines of seals adjacent to said edges and which form parts of said cells providing said cover-forming means;
   portions of said layers which lie beyond said lines of seals adjacent to said edges and which form parts of said web portions providing fluid-communication troughs between said cells.

2. A horticultural cell system comprising, in combination:
   a belt of sheet material folded along a fold line longitudinally into two layers with the edges of the sheet material substantially parallel, said layers being
sealed to one another along lines of seals which have extent transverse to the length of said belt and are spaced apart longitudinally of said belt, to form a series of web portions of said belt in which said layers are contiguous, and a series of cells alternately spaced between said web portions; said cells having approximately oval cross-sections and each being of a size to contain the root system of a preselected mature plant and a corresponding quantity of plant life-support materials; each of said cells having an open mouth formed between the edges of said layers; each of said intervening web portions being formed with a plurality of said lines of seals by means of spaced-apart localized seals between said layers, forming a quilted pattern and providing liquid communication paths between adjacent cells, while holding said layers in said web portions in contiguity against the pressure of liquid contained within said web portions.

3. A cell system as recited in claim 2, in which portions of said layers forming parts of the walls of said cells are joined by a plurality of spaced-apart localized seals in a quilted pattern, to hold said portions in contiguity against the pressure of liquid contained therein.

4. A cell system as recited in claim 3, in which other portions of said layers forming parts of the walls of said cells, other than said portions having said localized seals, are filled with hydrophilic foam material to support the root systems of selected plants.

5. A horticultural cell system comprising, in combination:
a belt of sheet material folded along a fold line longitudinally into two layers with the edges of the sheet material substantially parallel, said layers being sealed to one another along lines of seals which have extent transverse to the length of said belt and are spaced apart longitudinally of said belt, to form a series of web portions of said belt in which said layers are contiguous, and a series of cells alternately spaced between said web portions; said cells having approximately oval cross-sections and each being of a size to contain the root system of a preselected mature plant and a corresponding quantity of plant life-support materials; each of said cells having an open mouth formed between the edges of said layers; each of said lines of seals being discontinuous and being formed by spaced-apart localized seals, to form fluid communication paths between adjacent ones of said cells through the intervening web portions.