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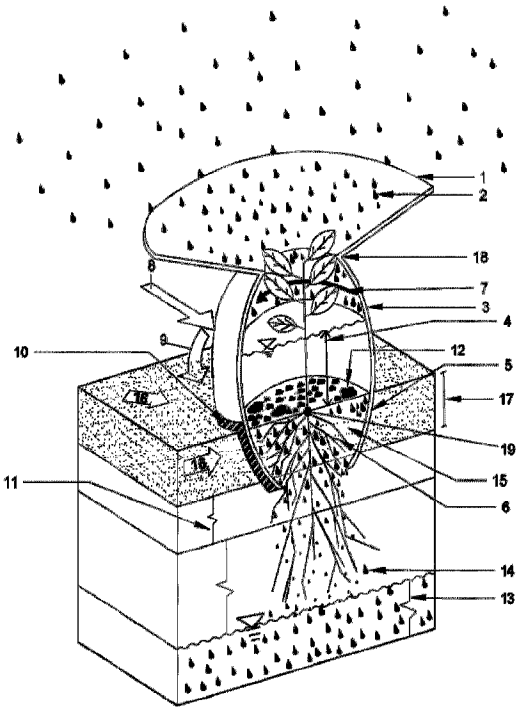
(54) **Titre : PROTECTEUR DE PLANTE DE COMPARTIMENT DE TERRE CUITE NANO-REVETU POUR AMELIORER LA SURVIE DES PLANTES ET REDUIRE LES EFFETS NEGATIFS DES CONTRAINTES ENVIRONNEMENTALES**
(54) **Title: NANO-COATED EARTHENWARE COMPARTMENT PLANT PROTECTOR TO ENHANCE PLANT SURVIVAL AND REDUCE THE NEGATIVE EFFECTS OF THE ENVIRONMENTAL STRESSES**



(57) **Abrégé/Abstract:**
The present apparatus is a biocompatible spindle-shaped, opened upwardly and downwardly, earthenware compartment which is made of clay. It protects the seedling's shoot and root systems simultaneously in stressful environmental conditions. It consists of a

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(57) **Abrégé(suite)/Abstract(continued):**
rainfall collector opening (1), an upper part (3) to shade and protect seedlings shoots, and create a water storage in combination with the lower part. A Nano sealed lower part (5) to protect the root system from alkaline saline soil surrounding the seedling by creating a barrier between them. It increases water application efficiency, because a water head created in the compartment by each irrigation (4), in turn, causes a water pressure to vertically downward the water through the root zone to lower layers, resulting to stimulate the root to follow down the moisture to lower layers to reach the underground water sooner. It prevents the degraded surrounding soil (16), from entering into planting holes.

The present apparatus is a biocompatible spindle-shaped, opened upwardly and downwardly, earthenware compartment which is made of clay. It protects the seedling's shoot and root systems simultaneously in stressful environmental conditions. It consists of a rainfall collector opening (1), an upper part (3) to shade and protect seedlings shoots, and create a water storage in combination with the lower part. A Nano sealed lower part (5) to protect the root system from alkaline saline soil surrounding the seedling by creating a barrier between them. It increases water application efficiency, because a water head created in the compartment by each irrigation (4), in turn, causes a water pressure to vertically downward the water through the root zone to lower layers, resulting to stimulate the root to follow down the moisture to lower layers to reach the underground water sooner. It prevents the degraded surrounding soil (16), from entering into planting holes.

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Nano-Coated Earthenware Compartment Plant Protector to Enhance Plant Survival and Reduce the Negative Effects of Environmental Stresses

Field of Invention

This invention can be used in the field of agriculture, planting seedlings, planting seeds, landscaping, and desertification, to protect planted seedlings or seeds against environmental stresses.

Background

Large areas of land in the world have transformed into desert lands typically because of climate changes or drought, in recent years. One of the methods conventionally used to combat desertification is to plant trees in desert lands. However, different environmental stresses have impeded seedling planting. So, many of the planted seedlings die out annually due to environmental stresses. Of these environmental stresses are the high water losses due to evaporation from planting holes after irrigation, blowing of hot, dry winds to aerial parts of the seedlings, invasion of salinity into seedlings root zone and entering of degraded and alkaline surface soil into planting holes, etc. which individually or collectively can hurt and dry out the seedlings. High water evaporation losses from planting holes can reduce the available water storage for the plant. Blowing hot, dry winds containing fine particles of salt upraised from the degraded surface of the soil can burn and dry out aerial parts of the plants resulting in the plants losing their leaves eventually. The saline and degraded surface soil that exist around plants can enter into the planting holes and can reduce the water storage capacity of the planting holes. The salt that has entered into the holes can be solvated by irrigation water and then that salt reaches into the root zone which can result in salinity stresses to the planted seedling. Different inventions have been patented regarding seedlings' protection including the following.

US3226881A, discloses an apparatus which can readily be used for the protection of outdoor plants during the cold months of the year. The apparatus installed over the plants and can protect aerial parts of seedling (shoot system) against environmental stresses. One of the purposes of the invention was to protect seedlings against cold. Another benefit was its ease of installation, transportation, and storage. It had a gate, which could easily be adjusted to ventilate the air inside the box; the side on the above could be removed for more air circulation.

US5669177, discloses seedling protection with a temperature controller

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apparatus. The holes are made in the box for air circulation. Holes have caps, which can be removed to allow air to easily enter the box. The box is installed over the seedling and can protect the aerial parts of the seedlings against environmental stresses.

US6067747, discloses an apparatus entitled "Plant greenhouse forest protector and growth enhancer". The box is installed over the seedling to protect its aerial parts. The cone-like box has slots from bottom to top. It has slots through which water and air can easily enter the cone.

US2753662, discloses a plant protector apparatus. Its most important purpose was to protect the aerial parts of seedlings. It is easily installed and transported. The cylinder-like box is connected to the ground by brackets protecting aerial parts of the seedlings. The cap installed above the box can be opened and closed, so it doesn't prevent rainfall and sunlight's entering the enclosure.

WO2012081980 is known under the trademark 'WATERBOXX™' Groasis. The waterboxx™ consists of a box made of polyethylene or biodegradable material that stores water in its container. Also, due to its special shape, the body of the waterboxx™ can be placed around the seedlings so that the body of the waterboxx™ can prevent hot winds from directly hitting the aerial parts of a seedling. In addition, its shape is designed to be able to collect precipitation and direct collected rains into its chamber. Moreover, the water in the waterboxx™ reservoir is supplied to the root zone soil through a nylon or PLA wick, in a way that the plant root should use the little amount of moisture transferred by the wick capillary tubes.

Summary

The purpose of the present invention is to: 1) create a protection apparatus around a plant seedling in order to protect aerial parts (shoot system) from the impacts of environmental stresses such as blowing hot and cold winds; 2) prevent the invasion of accumulated salts from surrounding soil into the seedlings root collar and root zone by separating the soil of the root zone from the surrounding soil; 3) Improving the water consumption of seedlings by increasing water application efficiency; 4) By elimination of horizontal water infiltration and by helping vertical infiltration of irrigation water in the root zone, improved water consumption by seedlings may be achieved; 5) prevent degraded and alkaline surface soil from entering into planting holes. Entrance of surrounding degraded and alkaline surface soil into planting holes reduces their water storage capacity; and/or 6) encouraging downward irrigation water vertically towards

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lower layers by separating the soil of the root zone and the surrounding soil. This results in stimulating the root system to follow the moisture downward to the lower layers thereby reaching the underground water in a shorter time than usual.

The present apparatus is biocompatible because it is made of clay and/or earthenware. Therefore extensive use of this apparatus does not harm the environment. Also it is resistant to environmental stresses such as fast winds, high temperatures, successive wetting and drying due to frequent irrigation, and hits by animals in the desert.

In illustrative embodiments of the present invention, there is provided an apparatus for protecting a plant seedling, the apparatus comprising: a) an upper earthenware portion defining a first upper opening and defining a first lower opening, the first upper opening being smaller than the first lower opening and the upper portion being unsealed such that the upper earthenware portion is permeable to water; and b) a lower earthenware portion defining a second upper opening and defining a second lower opening, the second upper opening operable to engage with the first lower opening, the lower earthenware portion being sealed such that the lower earthenware portion is impermeable to water, wherein the upper earthenware portion and the lower earthenware portion are operable to sealably engage such that the second upper opening engages with the first lower opening.

In illustrative embodiments of the present invention, there is provided an apparatus described herein wherein the upper earthenware portion and the lower earthenware portion are each part of a single, inseparable earthenware apparatus.

In illustrative embodiments of the present invention, there is provided an apparatus described herein wherein the upper earthenware portion and the lower earthenware portion are separable parts.

In illustrative embodiments of the present invention, there is provided an apparatus described herein wherein the upper earthenware portion is conical in shape.

In illustrative embodiments of the present invention, there is provided an apparatus described herein wherein the apparatus further comprises a rainfall collector, which rainfall collector is operable to engage with the first upper opening defined by the upper earthenware portion and is shaped such that rain falling on the rainfall collector is biased towards and through the first upper opening.

In illustrative embodiments of the present invention, there is provided an apparatus described herein wherein the rainfall collector is inseparable from the upper earthenware portion.

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In illustrative embodiments of the present invention, there is provided an apparatus described herein wherein the rainfall collector is separable from the upper earthenware portion.

In illustrative embodiments of the present invention, there is provided an apparatus described herein further comprising a handle.

In illustrative embodiments of the present invention, there is provided an apparatus described herein further comprising mycorrhizal fungi.

In illustrative embodiments of the present invention, there is provided a method for protecting a plant seedling, the method comprising: a) placing a lower portion of an earthenware compartment in soil, the lower portion being impermeable to water and the lower portion having a lower opening; b) placing roots of the seedling in the soil and in the lower portion of the earthenware compartment; and c) placing the stem of a seedling in an upper portion of the earthenware compartment, the upper portion being permeable to water and the upper portion defining an upper hole, wherein the upper portion and the lower portion of the earthenware compartment are operable to fill with water such that a vertical column of water is formed inside the earthenware compartment and the upper hole operates to allow water into the earthenware compartment and the lower hole operates to allow water to exit the earthenware compartment.

In illustrative embodiments of the present invention, there is provided a method described herein further comprising directing precipitation towards the plant seedling by attaching a rainfall collector to the upper portion of the earthenware compartment.

In illustrative embodiments of the present invention, there is provided a method described herein further comprising adding mulch to the earthenware compartment such that the mulch is on the soil and within the compartment.

In illustrative embodiments of the present invention, there is provided a method described herein further comprising applying mycorrhizal fungi to the roots of the seedling prior to placing the roots in the soil.

In illustrative embodiments of the present invention, there is provided a method for protecting a plant seedling, the method comprising placing a plant seedling inside an apparatus described herein and placing the apparatus and the plant seedling into soil such that the lower portion of the earthenware compartment is in the soil and the upper portion of the earthenware compartment is not in the soil.

Brief Description of the Drawings

Figure 1 illustrates an embodiment of the present invention using a cross-

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sectional view of the embodiment during operation

Figure 2A is side view of an embodiment of the present invention.

Figure 2B is a cross-sectional view of an embodiment of the present invention during operation.

Figure 2C is a top view of an embodiment of the present invention.

Figure 3 is an illustration of a prior art.

Detailed Description

The present invention provides an apparatus that is a spindle-shaped earthenware compartment defining a first opening at or near the top and a second opening at or near the bottom, which is made of clay and heated to reach its optimum hardness. The earthenware compartment comprises up to six main portions including a rainfall collector (1); a lower portion (5); an upper portion (3); a nano-seal coating (10); mulching materials (12); and mycorrhizal fungi. Individually or together with other portions, each portion may reduce environmental stress and increase the survival potential of seedlings in stressful weather and soil conditions.

The present invention can protect the areal parts of seedlings from environmental stresses but also can protect the root system (6) by preventing accumulated salinity (16) around the planted seedlings from invading into the root collar (19) and root zone (15) of seedlings, by separating the soil of the root zone (15) and the surrounding soil (17). Other advantages of the present invention include: improving water consumption by seedlings by increasing water application efficiency, preventing degraded and saline surface soil entering into the planting holes, which reduces water storage capacity in the planting holes, and encouraging the irrigation water (4) vertically downward toward the lower layers (11) and (14) by separating the soil of the root zone (15) and surrounding soil (17), which results in encouraging the root system (6) to move vertically downward toward the lower layers (11) and (14) to reach the underground water (13) in a shorter time than usual.

The present earthenware compartment is different from some aspects of previous, known devices. In particular, the present invention provides differences in: a) the way water is supplied to the root zone; b) provides a more protective shelter for seedling using an earthenware compartment; and c) the nature of the lower portion of the earthenware compartment.

In the conventional operation of planting seedlings, first a hole in the shape of a cube is dug (See Fig. 3), and a seedling is planted in the hole. Then, the hole is filled

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with irrigation water (23) to moisturize the soil of the root zone (24). However, in deserts with mainly clay soil, which is generally dry and has great moisture suction, the soil can heavily suck in the moisture. Therefore, a considerable portion of the available water filled in the hole can be horizontally sucked in by the hole walls (22). This sucked in moisture can reach the soil surface through capillary ascent to the soil surface (21) and leave salt (20) after evaporation (25), which can increase the cumulative salinity around the seedling after successive irrigation operations, especially when brackish water is applied, devastating the seedling. The water surface inside the hole is in contact with the surrounding open-air thus a portion of water is lost through evaporation (25). The total mentioned losses (21), (22), and (25), in turn, reduce water application efficiency of previous, known devices.

There are differences in terms of water supply to the root zone provided by the present invention. The supply of water to the root zone from some devices may be done through a wick. In these wick devices, the plant root should use the small amount of moisture transferred by the wick capillary tubes to the root zone. However, in dry areas with hot winds where the rate of evapotranspiration is high and accordingly the water required for seedlings is more than usual; the moisture in the soil around the wet wick may not be enough to meet the volume of water required for plant evapotranspiration and growth. Therefore, in desert areas with hot winds, the use of such wick devices may lead to drought stress and eventually destroy the plant.

Further, the small amount of moisture in the wet wick, supplies moisture near the topsoil and cannot encourage water vertically downward to lower layers of the soil, therefore this method can cause roots to collect around the wet wick and slow down the root movement toward deeper layers of the soil. Due to the shallow roots it can be expected that high-speed winds in deserts may cause plants cultivated with this method to fall down. However, using the earthenware compartment of the present invention, the seedling is located inside the compartment and the compartment is filled with irrigation water (4). The seedling placed inside the compartment is immersed in irrigation water (4) and the water penetrates through the root zone (15) soil inside the compartment toward the deeper layers (11) and (14) of the soil below. This in turn can stimulate the root to move downward, following the water to the deeper soil layers (11) and (14), which can lead to the better establishment of seedlings in the soil.

The conical shape of the upper portion (3) of the earthenware compartment protects the aerial part of the seedling. Due to the conical shape of the upper portion (3) of the earthenware compartment (slightly smaller diameter of the upper opening (18)

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than lower opening below), the upper portion (3) of the compartment extends around the aerial parts of the seedling, and creates an enclosed shelter and shade for the seedling which can help to reduce transpiration in the seedling. Air entering into the large earthenware compartment from the upper opening (18) of the earthenware compartment has space (7) to rotate around the seedling, which can help with proper ventilation and transpiration of the seedlings.

Ways of protecting the root collar (19) and root zone (15) are provided by the present invention. Successive irrigation operations, especially in heavy textured soil, hot weather conditions, or irrigation with brackish water, can cause salt accumulation around the root collar (19) and root zone (15) of the seedlings. During exposure to salinity, seedlings can experience drought stress, reduction in leaf expansion, iron limitations, etc. Since, the nano-seal coating (10) of the lower portion (5) of the earthenware compartment surrounds the root collar (19) and root zone (15), to the depth of root establishment, and the nano-seal coating (10) of the lower portion (5) separates the soil inside the root zone (15) and the outside, surrounding soil (17), the salinity (16) in surrounding soil (17) cannot invade the root collar (19) and root zone (15). Therefore, using the earthenware compartment can reduce the negative effects of salinization on seedlings.

Water weight pressure, caused by a water column from irrigation water (4) is created in the earthenware compartment after each irrigation operation. With each irrigation, the earthenware compartment fills with irrigation water (4), which creates a column of water inside its empty volume space. The pressure from the elevation of the irrigation water (4) water column can help the vertically downward penetration of water into the lower layers (11) and (14) of the soil. The movement of water vertically downward to the lower layers (11) and (14) can leach the soil of the root zone (15) and push the available salts from the root zone (15) to the lower layers (11) and (14) of the soil. This approach to irrigation using the present invention motivates the root system (6) to follow the moisture vertically downward to the deeper layers (11) and (14). In turn, the seedling is better able to be established and the roots reach the underground water (13) sooner than usual.

Rainfall Collector

The rainfall collector (1) is made of clay and installed on the uppermost portion of the earthenware compartment. It is intended to collect precipitation (2) guiding the precipitation into the upper portion (3) and lower portion (5), and eventually to the root

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system (6) via the upper portion (3) and lower portion (5) of the earthenware compartment. The rainfall collector (1) can be separated from the upper portion (3), for the ease of installation. The rainfall collector (1) can be installed on the upper portion (3) after the earthenware compartment is installed properly. Note that in hot, dry weather, which precipitation (2) contributes a very small share to fulfilling plant water requirements, and irrigation planning is mainly based on irrigation operations, the use of the rainfall collector (1) can be skipped to save related costs. Irrigation water (4) can easily enter through the rainfall collector (1) to the earthenware compartment.

Earthenware Compartment

The earthenware compartment is comprised of lower portion (5) and upper portion (3) and is made of clay earthenware heated at high-temperature to reach its optimum hardness. The earthenware compartment dimensions can be varied to have enough volume for all ornamental, medicinal, fruitful, non-fruitful, and any other planted seedlings or seeds. For the ease of transportation and installation, the earthenware compartment may be two separate portions, namely the lower portion (5) and the upper portion (3). Alternatively, both the lower portion (5) and the upper portion (3) can be connected and have an integrated design. When an integrated design is used, first the planting hole should be dug, then the seedling root should be impregnated with mycorrhizal fungi, if needed, before planting. Then, an integrated earthenware compartment should be put into the soil (around the seedling) so that the lower portion (5) of the earthenware compartment implants into the soil and surrounds the seedling in such a way that the wall of the lower portion (5) of the compartment can create a sealed barrier between the root zone (15) soil and the outside, surrounding soil (17). Next, mulching materials (12) should be spread over the surface of the soil inside the compartment.

Lower Portion (5) of Earthenware Compartment

The lower portion (5) is the first portion to be installed in soil. After digging a planting hole, with dimensions equal to the dimensions of the lower portion (5) of the compartment, it should be installed in the depth equal to the height of the lower portion (5). The body of the lower portion (5) together with the nano-seal coating (10) creates a sealed barrier between the root zone (15) soil and the outside, surrounding soil (17). Then, a seedling should be planted in the soil inside the lower portion (5). Before planting the seedling, some mycorrhizal fungi can be impregnated with the roots (if

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needed) and the soil should be compacted, enough to make sure that the seedling is established well. Then, to avoid capillary action and reduce evaporation losses inside the earthenware compartment, mulching materials (12) if needed should be spread over the soil surface inside the lower portion (5). The mulching materials (12) can be made of composted plants leaves or sugarcane cake filters, etc. It is required that the covering mulch materials (12) be fully composted before using in the compartment to prevent poverty of nitrogen in the root zone (15) soil.

Upper Portion (3) of Earthenware Compartment

The diameter of the upper opening (18) of the upper portion (3) is smaller than the diameter of the upper opening of the lower portion (3). For the ease of transportation and proper establishment of the seedling in the soil inside the compartment, the upper portion (3) can be separated from the lower portion (5). After the installation of the lower portion (5) in the planting hole and planting the seedling into the root zone (15) soil inside the lower portion (5), as explained above, the upper portion (3) should be installed over the lower portion (5), and the seam between two portions must be fully sealed. The combination of the upper portion (3) and the lower portion (3) creates a box which can store the irrigation water (4), and encourage water vertically downward through the root zone (15) soil inside the lower portion (15) to the lower layers (11) and (14) under the root zone (15). As explained above, because the nano-seal coating (10) of the lower portion (5) separates the surrounding soil (17) from root zone soil (15), the irrigation water (4) has no way to spread horizontally to the surrounding soil (17) from the root zone (15). Therefore, the water application efficiency considerably increases and vertically downward infiltration of the irrigation water (4) can stimulate the root system (6) to follow the moisture to the lower layers (11) and (14), which can help the root to reach the underground water (13) in a shorter time than usual. Fig. 2 shows the combination of the upper portion (3) and the lower portion (5) to create a water storage box. Fig. 2 also shows how the wall of the lower portion (5), can protect the root system (6) against the invasion of accumulated salts (16) in the root zone (15) especially in saline soils. The height of the upper portion (3) is intended to cover up the aerial parts of the seedling and to create a head of water pressure to encourage stored irrigation water (4) vertically downward to the lower soil layers (11) and (14) under the root zone (15). To reduce evaporation from the stored water inside the compartment, the upper portion (3) of the compartment has a conical shape. Note that irrigation water (4) and sunlight enter the compartment through the upper opening

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(18) of the upper portion (3) of the compartment. Successful maintenance and transplantation of seedlings from the nursery to environmental stressful conditions such as desert areas usually requires some preparations such as going through the habituation period and using seedlings of one to several years old to withstand environmental stresses. Also, the establishment of seedlings in areas of environmental stress can result in more damage or loss of seedlings, including the negative effects of wind scorch on leaves. The following explains how the earthenware compartment deals with such conditions to reduce the cost of plant survival.

Reducing the habituation period

For the plants to be ready for cultivation in a stressful condition such as the desert, they should be kept outdoors for some time before being transplanted from the nursery to the desert in order to adapt to environmental conditions outside the nursery or greenhouse. This process is called habituation, which will require associated time and expense. The earthenware compartment can balance the temperature to some extent by creating a microclimate around the seedlings. The earthenware compartment also prevents hot winds (8) and (9) from directly hitting the seedling shoots, which in turn can prevent damage to the seedling. Therefore, if the earthenware compartment is used, it is possible to reduce time and cost for habituation, by adapting seedlings in the earthenware compartment in the deserts where they are to be planted.

Application of seedlings of one or several years old to improve planting and seedling survival chances in environmental stressful conditions

Seedlings less than one-year-old usually have less tolerance to environmental stresses in the desert, such as soil salinity and drought stress, than plants more than one to several years old. Therefore, if these very young seedlings, before passing some months in the nursery to strengthen their root and root systems, are planted in a stressful condition such as desert, the possibility of their damage and loss increases significantly. Therefore, for planting seedlings in unsuitable conditions, experts recommend that seedlings be kept in the nursery for one to several years to increase their root volume, stem diameter, height, and other shoot and root system so that seedlings achieve more resistance when exposed to stressful conditions. This, in turn, can increase expenses associated with seedlings' maintenance time in the nursery. The earthenware compartment creates a microclimate around the aerial parts of the seedlings (using the upper portion (3) of the earthenware compartment), and protecting

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the root zone (15) from the invasion of soil salinity (16) and alkalinity (using the lower portion (5) of the earthenware compartment together with the nano-seal coating (10)) which can provide more protected conditions to increase the chance of survival of seedlings less than one-year-old. In stressful conditions, therefore, seedlings maintenance costs can be considerably reduced.

Wind scorch

Burning of leaves often occurs in long time periods of dry, windy weather or bright sunshine, like what happens in the desert, when the roots are unable to supply water to the plant shoot system as quickly as it is lost by transpiration from the leaves. The earthenware compartment prevents hot or cold, dry winds (8) and (9) directly hitting seedling leaves by creating more suitable climatic conditions around the seedlings. Therefore, using the earthenware compartment can reduce scorch damage to seedlings substantially.

Leaf necrosis

Usually in deserts, with *Saline-sodic soil* with clay texture, the soil sodicity can cause degradation of structure on the soil surface, which is called soil dispersion. By soil dispersion, the soil structure disintegrates into very fine particles due to the presence of a high level of sodium on the topsoil. Therefore, as soon as the local winds blow, these very fine particles, impregnated with sodium and salt, rise from the soil surface and settle on the leaf surface of seedlings. Then, with the first morning dew, these salts dissolve into water and enter the leaves or accumulate on the surface of the leaves, which can increase necrosis in the leaves of seedlings. The upper portion (3) of the earthenware compartment protects the seedling's leaves from the direct strike of such particles raised with winds (8) and (9). Therefore, these particles can only strike the exterior body of the earthenware compartment's upper portion (3). In such a way, the earthenware compartment can reduce the negative effects of necrosis on leaves.

Application of nano-seal coating (10)

While using the earthenware compartment, the whole amount of irrigation water (4) is stored inside, and encouraged vertically downward through the root zone (15) soil inside the lower portion (5) of the compartment to the lower layers (11) and (14) below the root zone (15). The lower portion (5) of the earthenware compartment separates the surrounding soil (17) from root zone (15) soil inside, and the outside body of the lower

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portion (5) is coated with a nano-seal coating (10) so no moisture can pass through. The conical shape of the upper portion (3) of the earthenware compartment reduces evaporation losses such that almost all of the irrigation water (4) infiltrates vertically downward to the root zone (15) soil and is available for the root system (6). Therefore the efficiency of applied irrigation water can be increased noticeably.

Application of mulching materials (12)

In heavy-textured soils, because the very fine pores between the soil particles are interconnected and create capillary channels, the water rises in these channels to the surface due to the capillary ascent (21) and evaporates (25), leaving salt (20) on the soil surface. Successive irrigation operations, especially in hot weather conditions, in turn increases the evaporation rate, gradually leads to an increase of accumulated salts (20) surrounding the plants. This process is called salinization, which can increase accumulated salts (2) to toxic levels for seedlings. Salt in soils can increase the osmotic potential of the soil so that seedlings cannot take up water from it. When soils become salty, the soil has more concentration of solute than the root does, so the root of the seedling cannot get water from the soil. The evaporation rate plays an important role in this process. Experts usually recommend some methods to reduce the connection between the capillary pipes in the soil profile and connections between the soil surface and open air. Mixing the soil inside the earthenware compartment with mulching materials (12) can reduce the capillary action considerably. Spreading mulching materials (12) over the surface soil inside the earthenware compartment in combination with the conical shape of the upper portion (3) of the compartment can noticeably reduce the evaporation loss rate from the soil surface inside the compartment. Therefore, the application of mulching materials (12) in the earthenware compartment helps in the reduction in salts accumulation around the seedling.

Root improvement using Mycorrhizal Fungi

Plants may increase their resistance in response to stressful environmental conditions such as drought and salinity and nutrient deficiencies in the soil by strengthening their root system (6). In this regard, mycorrhizal fungi can play an important role in improving plant nutrition and growth. The presence of mycorrhizal fungi and coexistence with the root of many plants in unsuitable soils shows that these fungi can increase the tolerance of plants to environmental stresses by strengthening the root system (6) and shoot system of plants against various stressful conditions such

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as drought, salinity, temperature, and some diseases. The application of mycorrhiza fungi brings about the following benefits. More enduring and healthier plants, increased efficiency and biomass, optimization of water application, ensuring availability of minerals to the plant, and increased survival chances of seedlings. For this reason, it is considered that the root zone (15) soil inside the earthenware compartment may be impregnated with a mycorrhizal fungus if needed.

Protecting the aerial part and root system (6) of the seedling simultaneously

The earthenware compartment, can protect the areal parts of seedlings from environmental stresses, and can protect the root system (6) at the same time by preventing accumulated salinity around the seedling from entering into the root collar (19) and root zone (15) of the seedling, by separating the root zone (15) soil and the surrounding soil (17).

Stimulating root system (6) to move vertically downward to the deeper soil layers (11) and (14)

The pressure caused by the elevation of the water column of irrigation water (4) in the earthenware compartment can help the vertical penetration of irrigation water (4) into the soil and encourage the water vertically downward to the lower layers (11) and (14) of the soil, leaching the soil of the root zone (15) and pushing the available salts from the root zone (15) into the lower layers (11) and (14) of the soil. Stimulating the root system (6) to follow the moisture downward to the deeper layers (11) and (14) can help the seedling become better established and the root to reach the underground water (13) sooner than usual.

Increasing water application efficiency

The lower portion (5) of the earthenware compartment disconnects the surrounding soil (17) from root zone (15) soil by creating a sealed wall between them so that the irrigation water (4) has no way to spread horizontally outside the root zone (15). Therefore the water application efficiency will be increased.

Decreasing the evapotranspiration from inside the earthenware compartment

The conical shape of the upper portion (3) of the earthenware compartment (slightly smaller diameter of the upper opening (18) than the lower opening), extends around the aerial parts of the seedling and creates an enclosed shelter and shade for

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the seedling, which can help to reduce transpiration. Mixing the soil inside the earthenware compartment with mulching materials (12) can reduce the capillary action considerably. Spreading mulching materials (12) over the surface soil inside the earthenware compartment in combination with the conical shape of the upper portion (3) of the compartment can noticeably reduce the evaporation losses rate from the soil surface.

Nano-seal coating (10) of the lower portion (5) of the compartment

The body of the earthenware compartment is porous because it is made of clay and/or earthenware. After each irrigation, the water can wet the exterior body of the compartment, and, in the absence of a nano-seal coating (10), salts existing in the soil around the compartment could dissolve in the moisture and gradually pass through a non-sealed porous body of the lower portion (5) of the compartment to the root zone (15). Sealing the body of the lower portion (5) of the compartment with the nano-seal coating (10) prevents the salinity (16) passing from the outside, surrounding soil (17) to inside the compartment and the root zone (15).

Biocompatibility of the material and inexpensive production

A benefit of the present invention is its biocompatible nature. The compartment is made of clay-based earthenware. Therefore, extensive use of it does not harm the environment. Also, it is resistant to environmental damage such as fast winds, high temperatures, successive wetting and drying due to frequent irrigation, and hits by animals in the desert. It is also commercially competitive due to its low price. Additionally, it does not seem to be worthwhile to steal, hence, reducing guarding costs.

Creating a microclimate inside the earthenware compartment

One of the characteristics of the earthenware clay compartment is that it can balance the weather inside the earthenware compartment. The body of the earthenware compartment is porous because it is made of clay. After each irrigation, the water can exit to the exterior body of the upper portion (3) of the compartment and as the winds (8) and (9) blow on the body of the compartment, the compartment can balance the weather inside itself and create a microclimate inside the compartment.

Enough sheltered space for better ventilation

The interior space (7) of the earthenware compartment is large enough for

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ventilation. Fresh air entering from the upper opening (18) of the earthenware compartment has enough space (7) to rotate around the seedling, which can help to provide proper ventilation and transpiration of the seedlings.

Upper opening (18) of the compartment for receiving sunlight and irrigation water (4)

Sunlight and irrigation water (4) can easily enter the compartment from the upper opening (18).

Decreasing irrigation costs in winter due to the existence of rainfall collector (1)

A clay rainfall collector (1) may be installed on the uppermost portion of the earthenware compartment. In winters, the rainfall collector (1) can collect precipitation (2) above itself and guide the precipitation (2) into the earthenware compartment and eventually to the root zone (15). In such a way, the irrigation operation periods and the related costs can be reduced in rainy seasons.

The role of mycorrhizal fungi in the compartment

The presence of mycorrhizal fungi and coexistence with the roots of many plants in unsuitable soils shows that these fungi can increase the tolerance of plants to environmental stresses by strengthening the root system (6) and shoot system of plants against various stressful conditions such as drought, salinity, temperature, and some diseases.

Encouraging irrigation water (4) vertically downward to the lower layers (11) and (14)

The special shape of the compartment can help encourage irrigation water (4) vertically downward to the lower layers (11) and (14), by separating the root zone (15) soil and the surrounding soil (17), thereby stimulating the root system (6) to follow the moisture toward the lower layers (11) and (14) to reach the underground water (13), in a shorter time than usual.

Reducing the habituation period

The earthenware compartment can moderate the temperature to some extent by creating a small microclimate around the seedling. It also prevents hot winds (8) and (9) from directly hitting the shoots of the seedlings, which in turn can prevent damage to a

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seedling. If the earthenware compartment is used, it is possible to save extra time and reduce the cost of a habituation period by adapting seedlings inside the earthenware compartment, in the place where seedlings are to be planted.

Reducing the irrigation period and related costs

When the seedling is planted in stressful environments like dry land deserts, the irrigation frequency should be increased to reduce the negative effects of environmental stresses to the newly planted seedling, which considerably increases the costs of transferring proper water to deserts and replanting damaged seedlings. It is possible to reduce the cost of replanting and extensive irrigation using the earthenware compartments to create a microclimate around the seedlings and protect them (shoot and root system (6) simultaneously) from environmental damage.

Application of the Invention:

The present invention protects plants and seedlings planted within, including protecting seedlings from hot or cold winds (8) and (9) blowing to aerial parts of seedlings (shoot system). At the same time it can protect the lower parts of seedlings (root system (6)) against the invasion of accumulated salts (16) to the seedling root zone (15) resulting from applied water especially in saline heavy textured soils. Further, it can protect planting holes being filled by fine dust entering from the surface of the soil around the planted seedlings into planting holes thereby reducing holes water storing capacity. In the present invention, a seedling refers to a plant in its initial stages of life, including a small seedling, a sprouted seed, or a cutting. The possibility of planting seeds in the earthenware compartment is also contemplated.

The earthenware compartment can be used in an environmental operation aiming at reversing desertification to protect planted seedlings against environmental stresses and to increase irrigation water (4) efficiency. In urban environments and green belts in large cities as well as places where water transmission through pipes is not practically possible, the earthenware compartment can increase water application efficiency, increasing a seedling's survival chances. It can also be used across cities to plant seedlings that are more normally affected by environmental stresses. The application of mycorrhizal fungi applied in earthenware compartments can improve the root system (6) of seedlings to resist dryness and salinity.

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Industrial and Commercial Application

The present invention is a low cost plant protector apparatus against environmental stress. The present invention is biocompatible. It is made from clay-based earthenware; therefore, extensive use of it does not harm the environment. Production of earthenware compartments is easy. Local people of each region can be used in the production processes, which, in addition to creating employment for local people, can reduce the transferring costs of earthenware compartments to planting regions. The materials suitable for use for making the present invention are generally availability meaning that the present invention may be produced almost everywhere. The present invention is easy to use so that people are able to use it without the need for much knowledge or technical skills. Using an earthenware compartment can provide a water transferring cost saving by creating a proper microclimate around the seedlings thereby protecting the shoot and root systems (6) simultaneously from environmental stresses so that the irrigation frequency and related costs can be reduced.

In desert areas with stressful environmental conditions, the number of seedlings lost after planting is usually high, which can significantly lead to an increase in the cost of replantation and re-irrigation. The earthenware compartment can work as a small local greenhouse and create a suitable microclimate around each newly planted seedling. Using the earthenware compartment reduces the number of seedlings lost due to stressful environmental conditions.

The present invention can be used by a variety of organizations, including, National Organizations of Forests, Rangelands Watershed Management, to increase irrigation efficiency and survival chances of seedlings or seeds in desertification projects. Municipalities may use the present invention to increase irrigation efficiency and survival chances of newly planted seedlings as well as seedlings with higher sensitivity to environmental stresses, urban green belts and places exposed to environmental stresses such as highways or areas where water transmission is not practically possible by pipelines. By using earthenware compartments, seedlings with lower tolerance against cold can be planted in cold areas, while seedlings with lower tolerance against heat and dryness can be planted in warm areas by creating a microclimate around the seedlings. National Organizations of Agriculture and horticulture may use the present invention in areas where water transmission is not practically possible by pipelines or ditches, using earthenware compartments can help considerably to increase water application efficiency in gardens and growing medical herbs, etc.

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Claims

1. An apparatus for protecting a plant seedling, the apparatus comprising:

a) an upper earthenware portion defining a first upper opening and defining a first lower opening, the first upper opening being smaller than the first lower opening and the upper earthenware portion being unsealed such that the upper earthenware portion is permeable to water; and

b) a lower earthenware portion defining a second upper opening and defining a second lower opening, the second upper opening operable to engage with the first lower opening, the lower earthenware portion being sealed such that the lower earthenware portion is impermeable to water,

wherein the upper earthenware portion and the lower earthenware portion are operable to sealably engage such that the second upper opening engages with the first lower opening.

2. The apparatus of claim 1 wherein the upper earthenware portion and the lower earthenware portion are each part of a single, inseparable earthenware apparatus.

3. The apparatus of claim 1 wherein the upper earthenware portion and the lower earthenware portion are separable parts.

4. The apparatus of any one of claims 1 to 3 wherein the upper earthenware portion is conical in shape.

5. The apparatus of any one of claims 1 to 4 wherein the apparatus further comprises a rainfall collector, which rainfall collector is operable to engage with the first upper opening defined by the upper earthenware portion and is shaped such that rain falling on the rainfall collector is biased towards and through the first upper opening.

6. The apparatus of claim 5 wherein the rainfall collector is inseparable from the upper earthenware portion.

7. The apparatus of claim 5 wherein the rainfall collector is separable from the upper earthenware portion.

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8. The apparatus of any one of claims 1 to 7 further comprising a handle.

9. The apparatus of any one of claims 1 to 8 further comprising mycorrhizal fungi.

10. A method for protecting a plant seedling, the method comprising:

a) placing a lower portion of an earthenware compartment in soil, the lower portion being impermeable to water and the lower portion having a lower opening;

b) placing roots of the seedling in the soil and in the lower portion of the earthenware compartment; and

c) placing the stem of a seedling in an upper portion of the earthenware compartment, the upper portion being permeable to water and the upper portion defining an upper hole,

wherein the upper portion and the lower portion of the earthenware compartment are operable to fill with water such that a vertical column of water is formed inside the earthenware compartment and the upper hole operates to allow water into the earthenware compartment and the lower hole operates to allow water to exit the earthenware compartment.

11. The method of claim 10 further comprising directing precipitation towards the plant seedling by attaching a rainfall collector to the upper portion of the earthenware compartment.

12. The method of claim 10 or 11 further comprising adding mulch to the earthenware compartment such that the mulch is on the soil and within the compartment.

13. The method of any one of claims 10 to 12 further comprising applying mycorrhizal fungi to the roots of the seedling prior to placing the roots in the soil.

14. A method for protecting a plant seedling, the method comprising placing a plant seedling inside the apparatus according to any one of claims 1 to 9 and placing the apparatus and the plant seedling into soil such that the lower earthenware portion of the apparatus is in the soil and the upper earthenware portion of the apparatus is not in the soil.

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FIG. 1

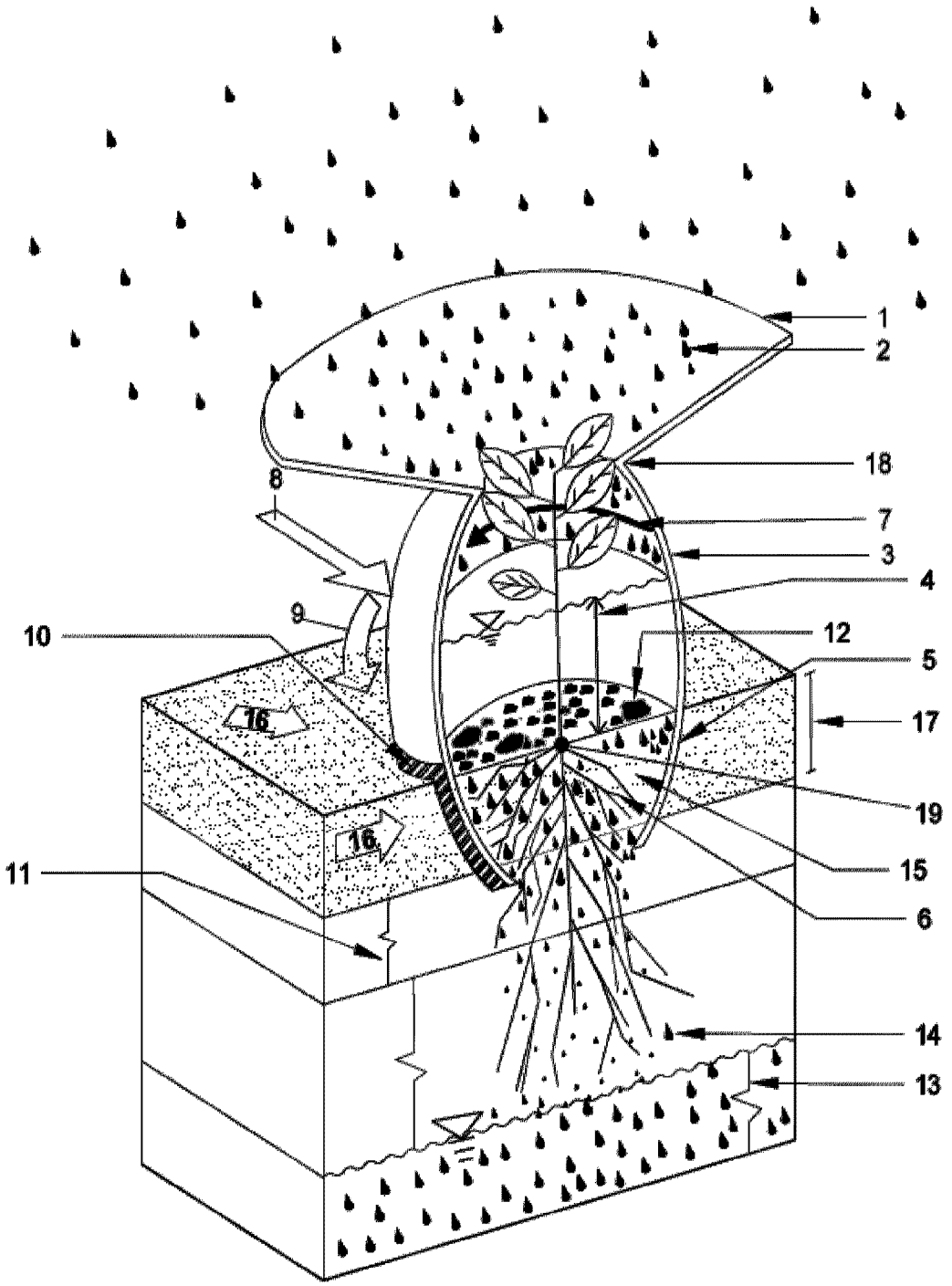

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FIG. 2A

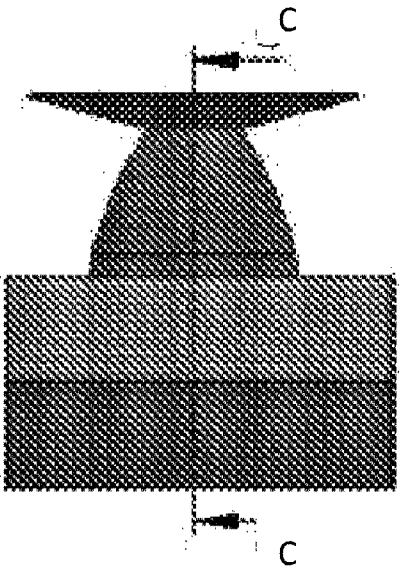

FIG. 2B

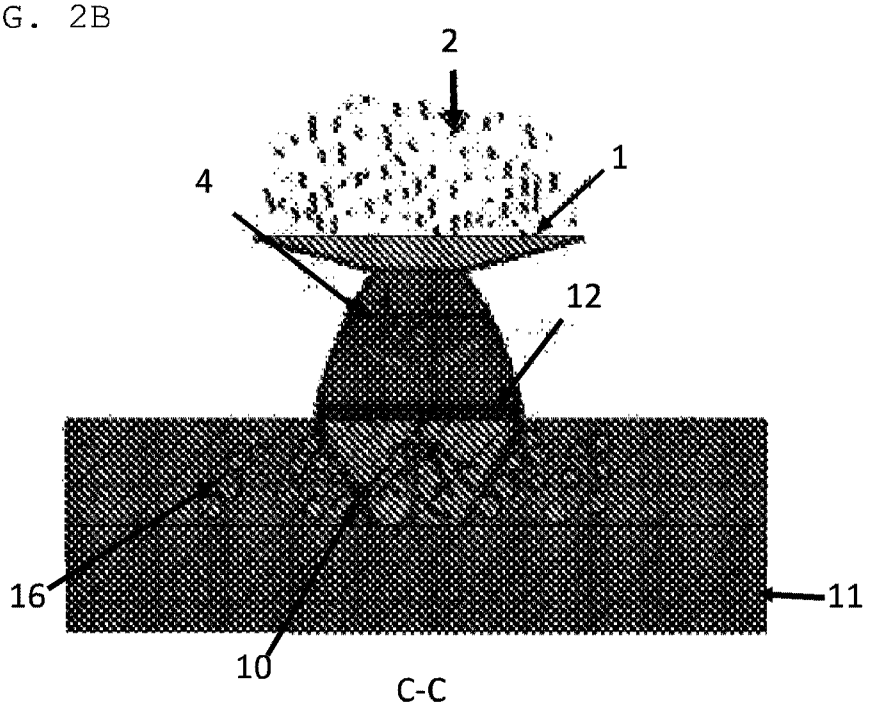

FIG. 2C

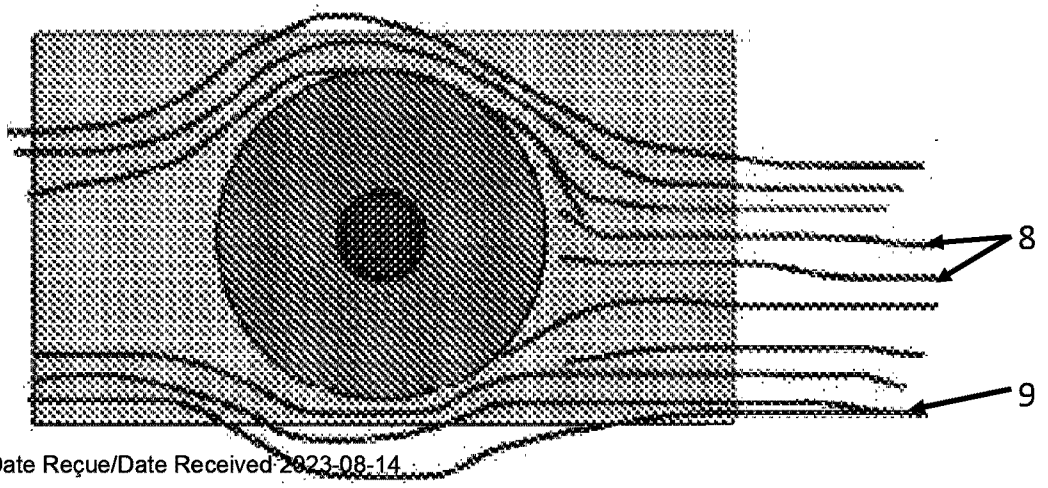

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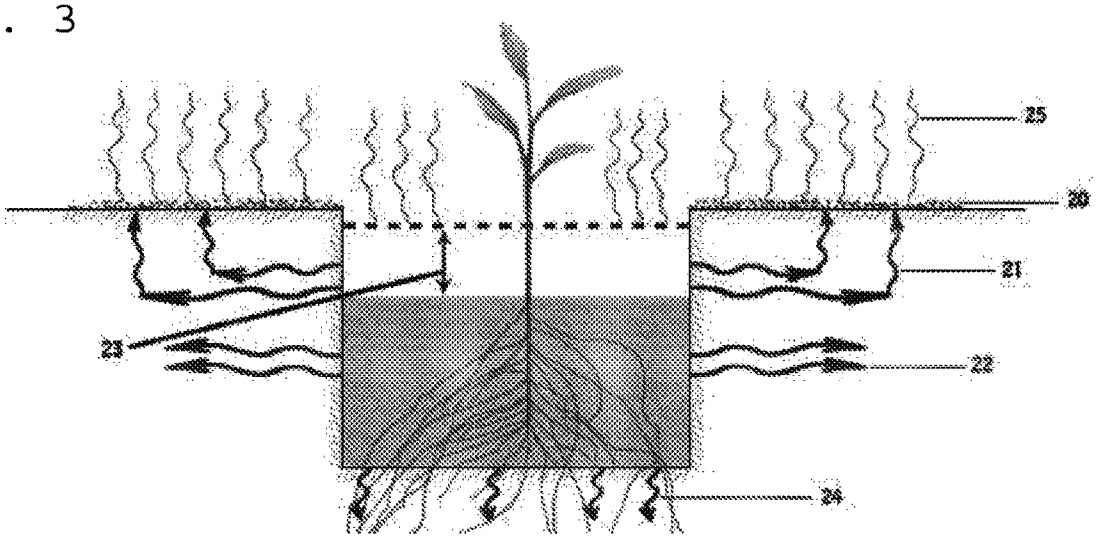
FIG. 3



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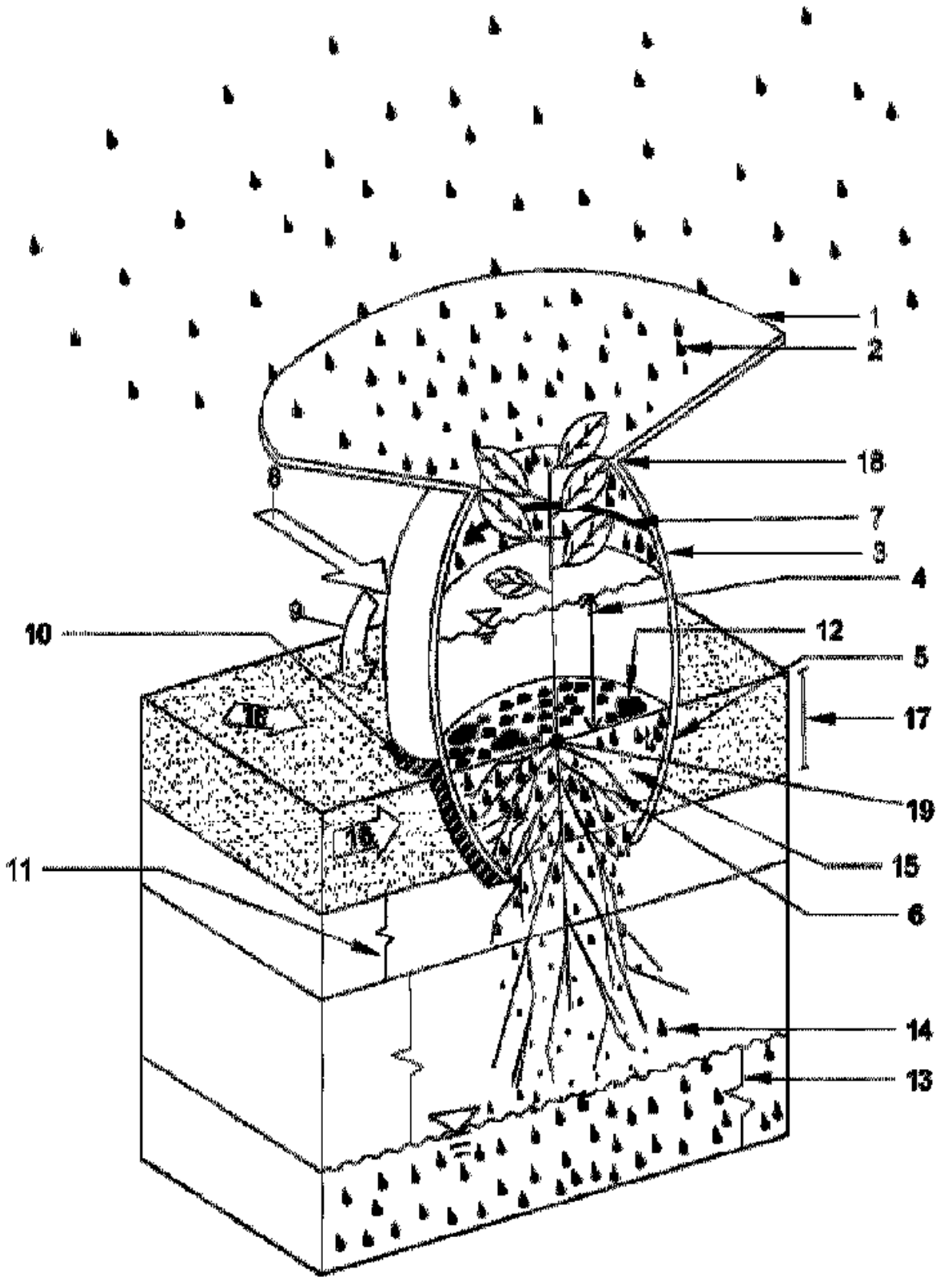
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