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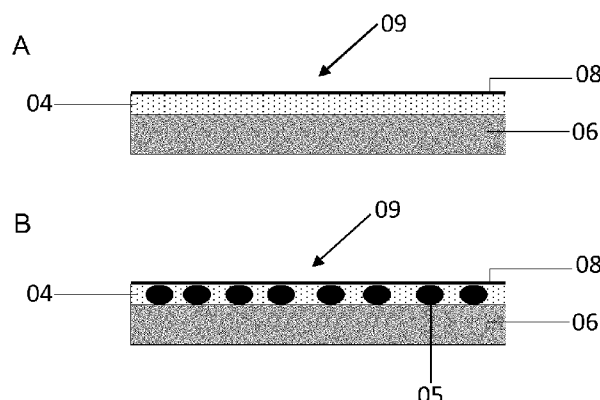
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[Continued on next page]

(54) **Title:** SEEDLING MAT

Figure 1



(57) **Abstract:** The present invention enables/provides an improved seed/seedling mat (10), in particular a rice seedling mat, intended to optimise mat utility. The invention further provides materials with particular characteristics, and the use of such materials in seedling mats (10), as well as component layers made from such materials, and which may be incorporated into seedling mats (10). One such component is a compressed mulch mat, which serves as a seed cover component (02) within an assembled seedling mat (10), and acts to shield seeds (05) from environmental factors (e.g. ambient radiation, temperature, birds and insects) while promoting consistent seedling germination and growth and potentially also providing moisture and nutrition. The invention also employs hot melt adhesive (04) in the preparation of a seed/seedling mat (10), as well as in the preparation of components for such a seedling mat (10). The invention further extends to methods of making such seedling mats (10), and/or component layers, and in particular to methods of making rooting substrate (06) components and/or seed cover (02) components for use within such seedling mats (10).

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SEEDLING MAT

The present invention enables/provides an improved seed/seedling mat, in particular a rice seedling mat, intended to optimise mat utility. The invention further provides materials with particular characteristics, and the use of such materials in seedling mats, as well as component layers made from such materials, and which may be incorporated into seedling mats. One such component is a compressed mulch mat, which serves as a seed cover component within an assembled seedling mat, and acts to shield seeds from environmental factors (e.g. ambient radiation, temperature, birds and insects) while promoting consistent seedling germination and growth and potentially also providing moisture and nutrition. The invention also employs hot melt adhesive in the preparation of a seed/seedling mat, as well as in the preparation of components for such a seedling mat. The invention further extends to methods of making such seed/seedling mats, and/or component layers, and in particular to methods of making rooting substrate components and/or seed cover components for use within such seedling mats.

In agriculture (and general gardening), seedlings are commonly grown initially in a specialised environment such as a nursery, glasshouse or dedicated seed-bed area. In this way certain environmental factors may be more easily controlled so as to improve the likelihood and quality of their early development. Following this, the seedlings are transplanted into a field/garden for longer-term growth.

Seed mats facilitate initial establishment and propagation of seedlings, storage and also convenient seed/seedling transfer for nursery/glasshouse and, subsequently, longer-term cultivation and growth (e.g. in a paddy field).

Mat-type products containing seeds are known in the market. WO01/60144A1 discusses problems associated with raising seedlings and discloses an example that is intended only to provide a light-weight alternative to seed-bed soil and which requires vacuum moulding for its manufacture.

In order to enhance their utility, seed/seedling mats (referred to hereafter as seedling mats) should address various aspects relevant to seed/seedling handling and propagation. For example, it is desirable to simultaneously balance seed(ling) protection and environment, mat integrity (e.g. for ease of handling and transplantation) and growth promotion/control in the mat and after transplantation.

A wide variety of mats containing seeds and different component layers exist in the prior art. Many employ aqueous glues *throughout* their manufacture. It has been found that the use of such adhesives can lead to a high water content in the seedling mat during

production, which is disadvantageous due to (i) the time taken and/or need for specific equipment to dry the mats out, (ii) the space required to store such mats whilst drying and/or (iii) unwanted early seed germination due to the high humidity present in the mats.

The present invention addresses these issues in two ways, (i) through the use of hot melt adhesives and (ii) through the production of a seed cover component in compressed and pre-dried form, which facilitates mat assembly, minimises unwanted initiation of germination of seeds caused by a high water content in assembled prior art mats, and has unexpected beneficial effects on the growth of seeds/seedlings grown in mats incorporating such seed cover components. This has led to an improved seedling mat intended to optimise mat utility. The invention further provides the use of particular materials and materials with particular characteristics in seedling mats and product (component) layers which may be incorporated into seedling mats.

Thus, in a first aspect the invention provides a seedling mat comprising:

a generally planar rooting substrate in which seed root growth is supported and which is self-supporting, coated on one surface with a seed adhesive, for immobilising seeds in or on a top surface region of the rooting substrate;

a seed cover component, which covers the seeds and permits seedling growth therethrough; and

a plurality of seeds, distributed in or on the top surface region of the rooting substrate and adhered thereto by seed adhesive, wherein:

the seed cover component is self-supporting and comprises organic material that has been compressed into a self-supporting layer, the organic material comprising materials selected from the group consisting of coir, rice husk, guar gum, and bagasse.

In a further aspect the invention provides a seed cover component for a seedling mat, said component being self-supporting and comprising organic material that has been compressed into a self-supporting layer, the organic material comprising materials selected from the group consisting of coir, rice husk, guar gum, and bagasse.

In a further aspect the invention provides a rooting substrate component for a seedling mat, said component comprising a generally planar layer of stone wool coated on one surface with hot melt adhesive, said stone wool having generally vertical perforations.

Given that the invention described above relates to seedling mats and components therefore, the skilled man will appreciate that the terms "rooting substrate" and "rooting substrate component" may be used interchangeably in this description, where appropriate.

As used herein with respect to any component, the term "self-supporting" means that the component as formed has a structural integrity such that it can be handled as a discrete

product without disintegrating, and requires no further supporting elements. This differs for example, from a loose layer of mulch or soil which cannot be handled as a discrete layer without some other supporting element. Rooting substrate components and/or seed cover components of the invention are thus robust enough to be held by hand.

5 As stated above, the rooting substrate is self-supporting and is such that it supports seed root growth within the substrate following germination. It should allow development of roots that are preferably strong, healthy and white, and which should hence be likely to become established following transplantation. It should also support the structural integrity of an assembled mat, e.g. by being continuous instead of fragmented.

10 Preferably the rooting substrate comprises mineral wool (which is also known as stone wool). Particular examples are Rockwool® (supplied by Grodan) and stone wool from Cultilene. In this way, mat flexibility facilitates its rolling up and loading into a commercial transplanting machine. The mineral wool/stone wool may be vertically-, horizontally-, or multi-directionally- (i.e. the fibres have no preferential direction, as, for example, in X-Fiber™
15 technology from Cultilene) spun.

The rooting substrate may be unperforated or perforated (e.g. for facilitating root growth into the rooting substrate). Perforations may be generally vertical and may extend partially or completely through the substrate. Partial perforations may, for example, extend about 0.1-1cm into the substrate, more preferably about 0.5-1cm. Perforations may be
20 approximately 0.5-1mm in diameter, and preferably are present at a density of about 1 to 4 (inclusive) perforations/cm² of rooting substrate. Preferably the substrate comprises vertically spun, perforated stone wool. Preferably, perforations extend about 0.5cm into the substrate.

Optionally, the rooting substrate is about 0.5-2.6cm thick, for example about 0.5cm,
25 1cm, 1.5cm, 2cm or 2.6cm thick. Preferably, the rooting substrate is about 1-2.6cm thick, more preferably 1.5-2cm thick, conveniently (about) 1.5cm or 2cm thick.

The rooting substrate component (and thus any subsequently assembled seedling mat) may be of any suitable dimension for growing seeds in a nursery and subsequent transplantation to a field, but is preferably rectangular. Conveniently, the width of the rooting
30 substrate component/seedling mat is in the region of 20-50cm, preferably about 25-40cm, and more preferably about 25-30cm (inclusive), and the length of the rooting substrate component/seedling mat is in the region of 50-100cm, preferably about 50-75cm, and more preferably about 55-60cm (inclusive). In this way, use of a mechanical transplantation machine to transplant the seedling mat may be facilitated. Further, rooting substrate
35 components/seedling mats may be made with a greater length (e.g. in the order of multiples

of the above lengths, for example 2x, 3x, 4x, 5x multiples and the like) and used initially in such a form for storage, transport and/or initial growth of seedlings in a nursery environment, before being subsequently cut to a smaller length to facilitate transplantation. Preferably the width of the rooting substrate component/seedling mat is about 25-30cm and the length of the rooting substrate component/seedling mat is about 55-60cm. In particular embodiments, the rooting substrate component/seedling mat surface area is about 28cm x 58cm.

As described herein, the rooting substrate is coated on one surface (which in an assembled seedling mat of the invention in use, corresponds to the upper surface of the rooting substrate) with a seed adhesive, which is preferably a hot melt adhesive. In one embodiment, the rooting substrate component of the invention additionally comprises a separation layer placed on top of the hot melt adhesive layer. In a further embodiment, seeds may be applied to the rooting substrate component prior to the addition of a separation layer, which in such an embodiment is placed on top of the seeds and adhesive layer. By fixing seeds the seed adhesive increases the practicality of mat (or seeded rooting substrate component) transport.

The use of a hot melt adhesive reduces the overall water content within a seedling mat, thus facilitating its manufacture (since the time and space required to dry the seed mat is reduced) and improves its quality (by, for example, minimising unwanted early germination of the seeds caused by the higher humidity present in mats produced using aqueous based adhesives as *inter alia* seed adhesives).

Furthermore, the use of such an adhesive to coat the surface of the rooting substrate, and to which seeds are adhered in an assembled seedling mat, facilitates the preparation of such a mat in component form. It thus permits the rooting substrate component to be, for example, manufactured at a different locus to the rest of the seedling mat, and assembled with the remaining components at, for example, the nursery.

By hot-melt adhesive is meant a thermoplastic adhesive, which is applied in molten form at a temperature exceeding 100°C and which solidifies on cooling. Preferably the operating temperature of the hot melt adhesive will be in the range of 150°C-200°C inclusive, more preferably 155°C-190°C inclusive, more preferably 160°C-185°C inclusive, and most preferably 160°C-175°C inclusive. Examples of hot-melt adhesives suitable for use in the present invention include ethylene-vinyl acetate based adhesives, ethylene-acrylate based adhesives, polyolefin based adhesives, polyamide and polyester based adhesives, polyurethane based adhesives, styrene block copolymer adhesives (also known as styrene copolymer adhesives and rubber-based adhesives). Hot-melt adhesives which are pressure-sensitive adhesives are particularly useful in the invention, since they facilitate manufacture

of a component part of the seedling mat lacking seeds. For example, the rooting substrate may be coated on one surface with such an adhesive, which maintains a degree of tack even when solidified and does not bond until pressure is applied. This is particularly advantageous as seeds may subsequently be applied when the adhesive is at a temperature which minimises or even avoids potential heat damage to the seeds, e.g. at room temperature. The degree of tack is sufficient to hold seeds in place during transport in embodiments where seeds are sown on top of the rooting substrate component.

Styrene copolymer and rubber-based hot-melt adhesives are thus particularly preferred, as they provide such pressure sensitivity. Examples include blends of thermoplastic rubber, resins, and plasticiser, which have a softening point in the region of 75°C to 90°C, an operating temperature of 160°C-175°C and typical viscosity of 14-20 poise at 160°C and 9-14 poise at 175°C, such as H1125/6™, H1155™(Sealock); blends of styrene based block copolymers and synthetic resins, which have a softening point in the region of 88°C-98°C, an operating temperature of 160°C-170°C, and a viscosity at 170°C of 6500±1700 cPs, such as D74™ (Powerbond Adhesives Ltd). Thus in one embodiment, the hot melt adhesive employed will be a blend of thermoplastic rubber, resins, and plasticiser, which have a softening point in the region of 75°C to 90°C, an operating temperature of 160°C-175°C and typical viscosity of 14-20 poise at 160°C and 9-14 poise at 175°C, and in a further embodiment the hot melt adhesive will be blends of styrene based block copolymers and synthetic resins, which have a softening point in the region of 88°C-98°C, an operating temperature of 160°C-170°C, and a viscosity at 170°C of between 48 and 82 poise.

The use of a hot melt adhesive, and in particular a pressure sensitive hot melt adhesive, facilitates the production - in component form - of rooting substrate components comprising optionally perforated stone wool coated on one surface with said hot melt adhesive, for example, as described herein in the Examples.

As mentioned above, when produced in component form, the adhesive coated rooting substrates may additionally comprise a separation layer, to facilitate packing, storage and/or transport. Such a separation layer is removed prior to use/assembly into an intact seedling mat. Suitable separation layers include silicon paper, waxed paper, rice paper, potato starch paper and PVOH film.

In order to make a rooting substrate component of the invention, mineral wool rooting substrate is cut to the desired dimensions and optionally perforated using any suitable method, in particular using a perforator as described herein. Hot melt adhesive is applied using any suitable application means, for example, on a small scale a hot melt glue gun and suitable nozzle may be employed, or on a large scale using an ITW Dynatec DDS Delta Fx™

Fiberized spray applicator or similar (e.g. Nordson AltaBlue™ TT series melter with AltaSpray™ gun and Signature Nozzles). A suitable separation layer (e.g. silicon paper, waxed paper or as described hereinbefore) may then be laid atop the adhesive coated rooting substrate. The separation layer serves to prevent rooting substrate components from adhering to each other/packaging materials when stored and/or transported. Rooting substrate components may then be packaged for storage and/or shipping, or alternatively used immediately. Optionally the rooting substrate component may be placed in a rooting barrier as described *infra*, and that may additionally form part of the packaging. In embodiments where pre-seeded rooting substrate components are produced, the seeds may be applied as described *infra* with respect to seedling mats, prior to the application of a separation layer.

In a seedling mat or pre-seeded rooting substrate component of the invention, seeds are sown on top of the rooting substrate and adhered thereto by the seed adhesive. Such seeds are preferably un-germinated. In certain embodiments such seeds are rice seeds. Seeds from any suitable inbred or hybrid rice varieties may be used (e.g. IR64, NK3325, Koshihikari, TR-10 and ADT-34). Prior to incorporation into a mat, seeds may be pre-treated, e.g. with an insecticide, fungicide, herbicide, nematicide, molluscicide, safener, plant growth regulator, micronutrients and/or fertiliser. In one embodiment, seeds are pre-treated with thiamethoxam (Cruiser®, Syngenta). Preferably about 100-150g of seeds are used for a mat measuring approximately 58cm by 28cm. Conveniently for inbred seeds about 150g are used for such a mat and for hybrid seeds about 100g are used for such a mat. Accordingly, (rice) seed density is conveniently in the region of 1-20 seeds/cm² (inclusive), preferably between 1-15 seeds/cm² (inclusive) and more preferably between 1-10 seeds/cm² (inclusive). The skilled man will appreciate that seed density will depend upon the thousand grain weight for any given variety. For example, for rice seeds of the IR64 variety, a preferred seeding density would be in the range of 1-5 seeds/cm² (inclusive), and for rice seeds of the NK3325 variety a preferred seeding density would be in the range of 1-7 seeds/cm² (inclusive).

As stated previously, in an assembled seedling mat, of the invention the seed cover component acts as mulch mat serving to shield seeds from environmental factors (e.g. ambient radiation, temperature, birds and insects) while promoting consistent seedling germination and growth and potentially also providing moisture and nutrition. The production of a seed cover component in compressed and pre-dried form facilitates mat assembly, minimises unwanted initiation of germination of seeds caused by a high water content in assembled prior art mats, and has unexpected beneficial effects on the growth of seeds/seedlings grown in mats incorporating such seed cover components.

The seed cover component must be capable, during use, of allowing seedlings to growth through it, in order to be suitable for use in a seedling mat. As stated above, the seed cover component comprises organic material selected from the materials consisting of coir, rice husk, guar gum and bagasse. It is further distinguished from materials used in the prior art in that preferably, it does not comprise soil, wood pulp, straw and/or cotton.

Coir may be sieved, to give a standard particle size (e.g. $\leq 2.8\text{mm}$), and/or pre-washed, buffered (e.g. to pH6.0) and dried before use. Rice husk and bagasse may be milled (ground) or unmilled (unground).

Preferably the seed cover component comprises coir, coir and guar gum, coir and bagasse, or coir and rice husk.

Where the seed cover component comprises coir and guar gum a preferred weight ratio of coir to dried guar gum is 10:1.

Where the seed cover component comprises coir and bagasse, it may be in any weight ratio of coir to bagasse of from about 1:1 to 9:1. Preferred weight ratios (coir to bagasse) include: 1:1; 3:2; 7:3; 4:1, and 9:1. Particularly preferred is 3:2. The use of milled bagasse is also particularly preferred.

Where the seed cover component comprises coir and rice husk a preferred weight ratio of coir to rice husk is in the region of from about 10:1 to about 1:1, preferably from about 5:1 to about 1:1 and more preferably from about 4:1 to about 2:1.

Optionally, the organic material may be combined with an adhesive prior to compression. Suitable adhesives for use in the preparation of seed cover components include aqueous based adhesives, such as for example, VAE (vinyl acetate ethylene), polyvinyl acetate (PVA), polyvinyl alcohol (PVOH) and acrylic adhesives. PVOH adhesives, such as for example, E3443C™ (Sealock) and VAE adhesives, such as for example E1215C™ (also Sealock) are preferred, with PVOH being particularly preferred.

It is particularly preferred to include such an adhesive in seed cover components comprising coir, coir and bagasse, or coir and rice husk. In such embodiments the weight ratio of organic material to adhesive is in the region of from about 5:1 to 5:2. Conveniently, the ratio is from about 4:1 to about 3:1.

Optionally the organic material may be combined with one or more additional agent selected from an agrochemical, biological treatment and/or nutrient (such as herbicides, insecticides, fungicides, molluscicides, nematocides, safeners, plant growth regulators, micronutrients and/or fertilisers). In particular the organic material may be combined with a fertiliser.

The organic material is optionally mixed with adhesive(s) and/or additional agent(s) as described herein, and then compressed using any suitable press, at a pressure in the region of 100-250 kgf/cm², preferably 120-220 kgf/cm². Where adhesive is incorporated the seed cover component may be dried prior to storage/packaging/transport and/or subsequent use within a seedling mat as described herein. To facilitate packing, storage and/or transport, a separation layer may be overlaid a seed cover component. Suitable separation layers include those made from, for example, silicon paper, waxed paper, rice paper, potato starch paper and PVOH film.

A seed cover component may be of any suitable dimension for subsequent use in a seedling mat, but is preferably square or rectangular. Conveniently, the width of the seed cover component is in the region of 20-50cm, preferably about 25-40cm, and more preferably about 25-30cm (inclusive), and the length of the seed cover component is in the region of 20-100cm, preferably about 20-75cm, and more preferably about 25-60cm (inclusive). Seed cover components may be made with a greater length and/or width (e.g. in the order of multiples of the above lengths, for example 2x, 3x, 4x, 5x multiples and the like) and used initially in such a form for storage and/or transport before being subsequently cut to a smaller size to facilitate their use in seedling mats. Preferably the width of the seed component is about 25-30cm and the length of the mat is either about 25-30cm, or about 55-60cm. In certain embodiments, the seed cover component surface area is about 27cm by 28cm or 28cm x 58cm.

The depth of a seed cover component is less than 10mm, preferably less than 5mm, and more preferably less than 3mm. In one embodiment the depth of the seed cover component is in the region of 2-3mm. The skilled man will appreciate that the depth quoted applies to the seed cover component as manufactured and/or immediately after assembly into a seedling mat as described hereinafter. In an assembled seedling mat in use i.e. when water has been applied, and/or seeds are germinating/have germinated and seedlings are growing, such processes may cause the depth to expand beyond the figures quoted above.

Seed cover components as described herein, are then laid atop the seeded rooting substrate.

If appropriate/desirable, the mat may comprise seed cover adhesive for attaching the seed cover component as described herein, to the layers below. Suitable seed cover adhesives include hot melt adhesives as discussed *supra* with respect to seed adhesives. This may be applied over the seeds. In an alternative, physical forces alone may otherwise be convenient for retaining the seed cover component. In a further alternative, the seed adhesive may also function as the mulch adhesive.

Preferably, seedling mats of the invention further comprise a root barrier structure in which the rooting substrate is accommodated, which barrier structure is configured to inhibit lateral and/or downward root growth beyond the periphery of the rooting substrate. The root barrier structure should support the mat structure and make the mat easier to handle. The root barrier structure may be disposed peripherally of side and/or base regions of the rooting substrate. In this way seedling roots are discouraged from growing through into soil in the nursery and/or from becoming entangled with roots of seedlings in adjacent mats. Preferably the root barrier structure extends peripherally around all the sides and encloses the underside of the rooting substrate.

Preferably the root barrier structure has a structural rigidity which helps support and constrain the rooting substrate, seed cover component and/or top cover (discussed below). In this way handling of the mat both *in situ* and during transport is facilitated, e.g. by preventing the seed cover component and/or top cover from falling off.

The root barrier structure may be considered to be discrete or integral with respect to other mat components, e.g. depending on the nature of fit and how easily the root barrier structure may be separated. For example, during/after manufacture the seedling mat may be formed/placed in, for example, a plastic tray, which could act as a root barrier structure during nursery growth and facilitate handling. Mats may then simply be removed from the plastic trays for subsequent transplantation.

The root barrier structure may be provided with a plurality of channels which face the adjacent rooting substrate. In this regard, channels may encourage roots to grow in particular directions. For example, the barrier structure may be provided with a plurality of generally parallel channels extending over the upper surface of the base region thereof. In this way, subsequent root damage when a seedling is mechanically plucked from the mat and transplanted to the field may be reduced. The channels may in general run parallel to a mat edge, for example the shorter edge of a rectangular mat. The channels may be conveniently found integrally in the barrier structure.

In one embodiment, the root barrier structure is a tray having a base region and upstanding sidewalls. The tray is preferably formed of plastics material or (structural) cardboard.

Cardboard gives a degree of flexibility which can help when mats are used with automated transplantation apparatus. Moreover, after a period of seedling growth, degradation of the cardboard may further facilitate subsequent rolling and handling of the mat for transplantation. Accordingly, the cardboard is conveniently relatively thin. The root barrier structure may also act to mitigate changes in mat humidity during storage.

Optionally, the seedling mat further comprises a top cover overlaid the seed cover component. In this way the seed cover component may be protected, e.g. from pests, incidental moisture and generally while the assembled mats are being handled etc. In one embodiment, the top cover is water-soluble and/or perforated. A top cover may comprise
5 paper or (polymeric) film, such as rice paper, potato starch paper, polyvinyl alcohol (PVOH) film or glue film. A liquid chemical coating may also be used.

Conveniently, top cover PVOH film may be 10-300 microns thick (inclusive). Preferably the thickness will lie in the range of about 30 microns to 45 microns, inclusive.

Top cover adhesive may be used between the seed cover component and top cover.

10 The chemical nature and content of the adhesive(s) used for seed cover components and/or top cover layers may be the same as or different to each other, and need to be carefully controlled in order to promote seed/seedling health while still functioning as desired. Conveniently, the adhesive(s) used for a seed cover component (where a separate adhesive is employed in addition to the seed adhesive) and/or top covers comprise(s) aqueous-based
15 adhesive(s), such as for example VAE (vinyl acetate ethylene), polyvinyl acetate (PVA), polyvinyl alcohol (PVOH) and acrylic glues. In further embodiments the adhesive(s) used for seed cover components and/or top cover may be hot melt adhesives as described hereinbefore. In making the mat, adhesive(s) may be applied by any suitable method including, for example, spray, roll, foam and slurry.

20 An adhesive (such as an aqueous adhesive, e.g. PVOH glue, or a hot melt adhesive) could also be used as a top cover.

Conveniently, one or more seedling mat component(s) (including the rooting substrate, root barrier structure, adhesive(s), seeds, seed cover component and/or top cover), may be pre-treated with, or comprise, one or more plant protection chemical,
25 agrochemical, biological treatment and/or nutrient (such as herbicides, insecticides, fungicides, molluscicides, nematocides, safeners, plant growth regulators, micronutrients and/or fertilisers).

To make an embodiment of a seedling mat of the invention, a rooting substrate component is cut (if necessary) to the required size. If an integrated root barrier structure is
30 not being used the substrate may be placed in, for example, a plastic tray. Alternatively, a rooting barrier is not employed. Seed adhesive, preferably hot melt adhesive, is then applied (e.g. by spray) to the rooting substrate component and pre-treated (rice) seeds are dispersed on the substrate. Optionally, a mulch adhesive is sprayed on/over the seeds. The seed cover component is then applied over the seeds. Top cover adhesive may then be sprayed

on the upper surface of the seed cover component and a top cover applied if desired. The mats are then left to dry before storage or use.

Thus, in a further aspect the invention provides a method for the preparation of a seedling mat as defined herein comprising the steps of:

5 (a) coating on one surface with a seed adhesive, a generally planar rooting substrate in which seed root growth is supported and which is self-supporting, wherein the seed adhesive is preferably a hot melt adhesive;

(b) sowing seeds onto the adhesive-coated surface of the rooting substrate component;

10 (c) applying a seed cover component over the top of the sown seeds, wherein the seed cover component is self-supporting and comprises organic material that has been compressed into a self-supporting layer, the organic material comprising materials selected from the group consisting of coir, rice husk, guar gum, and bagasse.

Once assembled, dried mats can be stored or used to grow (rice) seedlings in a nursery/glasshouse more immediately. Mats with established seedlings can subsequently be transplanted to a (paddy) field. Commercial machinery is ordinarily used for seedling transplantation, a process which results in a small 'plug' of mat also being transplanted.

Various aspects and embodiments of the present invention will now be illustrated in more detail in the Figures and by way of example. It will be appreciated that modification of detail may be made without departing from the scope of the invention.

BRIEF DESCRIPTION OF THE FIGURES

25 **Figure 1** schematically represents two embodiments of a rooting substrate component from a side-on, cross-section perspective.

The drawing shows a generally planar, rectilinear rooting substrate (09). The rooting substrate component in part A includes a generally planar rooting substrate (06) formed of vertically spun stone wool having a thickness of 0.5-2.6cm, preferably 1.5-2.0cm. Covering one surface of the rooting substrate (06) is a layer of hot melt adhesive (04), which serves to function as a seed adhesive (see also part B, or Figure 2). Atop the exposed surface of hot melt adhesive (04) is a separation layer (08) of silicon paper.

35 The rooting substrate component (09) in part B includes a generally planar rooting substrate (6) formed of vertically spun stone wool having a thickness of 0.5-2.6cm, preferably 1.5-2.0cm. Covering one surface of the rooting substrate (06) is a layer of hot melt adhesive (04), which serves to function as a seed adhesive for fixing seeds (05) to the rooting

substrate Atop the exposed surface of hot melt adhesive (04) and seeds (05) is a separation layer (08) of silicon paper.

Figure 2 schematically indicates a basic seedling mat structure from a side-on, cross-section perspective.

The drawing shows a generally planar, rectilinear seedling mat (10). The mat includes a generally planar rooting substrate (06) formed of vertically spun stone wool having a thickness of 0.5-2.6cm, preferably 1.5-2.0cm. The rooting substrate (06) is accommodated in a root barrier tray (07). The tray has a flat base portion and upstanding side walls. The side walls of the root barrier tray enclose the rooting substrate (06). Rice seeds (05) are dispersed over a top surface of the rooting substrate. Seed adhesive (04) on the top surface of the rooting substrate (06) fixes the seeds (05) to the rooting substrate. The rooting substrate upper surface region is formed with a plurality of vertical perforations (not shown). These extend to a depth of 0.5-1cm, preferably 1cm, and provide paths for downward root growth.

Above the seeds is seed cover component (02), which is adhered to the components below by virtue of the seed adhesive (04) and/or physical forces. Atop the seed cover component (02) is a protective top cover (01) (optional) of rice paper.

EXAMPLES

EXAMPLE 1 Use of hot melt adhesive as seed adhesive in seedling mats

The suitability of 3 different types of hot melt adhesive as seed adhesive for seedling mats was investigated and compared to the use of PVOH E3433C™ (an aqueous adhesive obtained from Sealock, Scott Close, Walworth Industrial Estate, Andover, Hampshire, SP10 5NU, UK) as Control seed adhesive.

Vertically-spun stone wool 58cm by 28cm with a thickness of 1.5cm was obtained from Grodan (Rockwool B.V., Industrieweg 15, 6045 JG Roermond, P.O. Box 1160, 6040 KD Roermond, The Netherlands (Rockwool®)) and was perforated to a depth of approximately 0.5-1.0cm using a handheld perforator (fashioned in bronze by Perforation Machinery Ltd. Bradford, UK: 1353 bronze pins arranged on a bronze cylinder, each pin 13mm in height, 8mm spacing between pins, each pin 1.02 in diameter) by pressing the perforator down onto the stone wool and making two passes over the entire surface.

Following perforation, each stone wool mat was placed into a black plastic tray (approximate dimensions 30x60x3.0cm), with one tray per treatment.

For treatments A to L inclusive, hot melt adhesive was applied to the upper (perforated) surface using a ITW Dynatec DDS Delta Fx™ Fiberized spray applicator using the parameters described in Table 1 below.

Using a conveyor belt, rooting substrate was passed under an ITW Dynatec DDS Delta Fx™ Fiberized spray applicator at rates suitable to achieve an application rate of either 5g/m² or 20g/m² of hot melt adhesive. Hot melt adhesive was applied to the perforated surface. Rooting substrate components were prepared with three different hot melt adhesives, Sealock H1125/26™, Sealock H1155™, and Power Bond D74™, using this methodology.

For the control, PVOH E3443C™ glue was applied evenly across the upper (perforated) surface of the stone wool using a handheld Graco Easymax battery operated sprayer with a 310 nozzle, for 10 seconds at a rate of 5.33g glue per second.

Table 1 Seed Adhesive application parameters. For treatments A to L inclusive, hot melt adhesive was applied evenly over the upper surface (perforated surface) of the stone wool rooting substrate. * H1125/6™ and H1155™ were obtained from Sealock (supra) and D74™ from Powerbond Adhesives Ltd, 253 Scotia Road, Tunstall, Stoke on Trent, Staffordshire, ST6 6AB, United Kingdom).

Treatment No	Seed adhesive	Application rate (g/m ²)	Air flow details
A	H1125/6™	5	High
B		20	High
C		5	Low
D		20	Low
E	H1155™	20	Low
F		20	High
G		5	High
H		5	Low
I	*Power Bond D74™	5	Low
J		5	High
K		20	High
L		20	Low
Control	PVOH E3443C	n/a	n/a

For each treatment, 150g of IR64 rice seeds were sprinkled uniformly on top of the seed adhesive to provide a seed density of approximately 4 seeds/cm². This was followed by the application of a layer of PVOH E3443C™ glue as mulch adhesive (even application for 2 seconds at a rate of 5.33g/second) before applying 25g of sieved coir. A further layer of mulch adhesive (PVOH E3443C™ glue, even application for 2 seconds at a rate of 5.33g/second), was applied over the first layer of coir, and a second layer of 25g sieved coir was applied atop this. A final layer of PVOH E3443C™ glue was applied over the second layer of coir (4 second application, 5.33g/second), as a top cover.

It can be seen that treatments A to L inclusive comprised 42.67g aqueous glue in comparison to the control, comprised 85.33g aqueous glue. The use of hot melt adhesive as seed adhesive thus halves the water content of the assembled seedling mat.

The seedling mats were transported to the glasshouse and placed into a bay set at the following conditions: 28 °C day time temperature, 18 °C night time temperature, 14 hour photoperiod, 70 % relative humidity). All mats were watered immediately by overhead watering and also by flooding the trays with tap water until the surface of the water was just below the top of the stone wool layer. After twenty minutes the water was drained from the trays. Subsequently, all mats were watered every other day using this method.

The seedling mats were grown in the glasshouse for a total of 12 days. Seedlings had reached growth stage 3.4 and were visually assessed for the criteria described in Table 2 below.

Table 2 Assessment of suitability of various hot melt adhesives as seed adhesive in seedling mats. Seedlings were grown to the 3.4 leaf stage on test mats with various hot melt adhesives used as seed adhesive. The following seedling measurements were taken when the seedlings had reached the 3.4 leaf stage: I: Average seedling height (cm); II: Uniformity of greening (%); III: Average leaf colour chart* (unit); IV: Uniformity of growth (%); V: Rootlift (%); VI: Root growth (%); VII: Root whiteness (%). For all test mats, including control, no stickiness of rootmat and tray was observed, and all mats were sufficiently robust to be rollable.

Treatment	Seed Adhesive	I	II	III	IV	V	VI	VII
A	Sealock H1125/6™	5.6	90	2.0	80	15	95	85
B		8.1	90	2.0	90	15	95	85
C		9.4	80	2.0	95	5	95	85
D		9.6	83	2.0	93	10	95	85
E	Sealock H1155™	8.6	95	2.0	90	10	95	85
F		8.8	90	2.0	90	15	95	85
G		8.7	85	2.0	85	15	95	85
H		6.5	90	2.0	85	10	95	85
I	Power Bond D74™	9.0	95	2.0	95	10	95	85
J		9.7	87	2.0	95	10	95	85
K		9.0	83	2.0	90	5	95	85
L		6.5	85	2.0	85	10	95	85
Control	PVOH E3433C	8.6	83	2.0	85	30	90	85

* Leaf colour chart was obtained from the International Rice Research Institute, and is a tool typically employed to monitor leaf colour for Nitrogen application.

Seedling mats produced with all three hot melt adhesives and with the control aqueous adhesive as seed adhesive performed equally well in supporting healthy seedling and root growth. Seedlings grown on mats where the seed adhesive was a hot melt adhesive appeared to exhibit lower root lift than the control. Root lift is where roots do not penetrate into the (stone wool) substrate but instead grow more on its surface, which lifts the rice seed and so leads to uneven growth.

EXAMPLE 2 Large scale preparation of rooting substrate components

Vertically-spun stone wool of the dimensions 58cm by 28cm, and with a thickness of 1.5cm was obtained from Grodan, *supra*. The substrate was perforated to a depth of approximately 0.5-1.0cm using a handheld perforator (as before) by pressing the perforator down onto the stone wool and making two passes over the entire surface.

Using a conveyor belt, rooting substrate was passed under an ITW Dynatec DDS Delta Fx™ Fiberized spray applicator at a rate of 5m/min in order to achieve an application rate of hot melt adhesive of 5-7g/m². Rooting substrate components were produced with three different hot melt adhesives using the conditions described in Table 3 below.

Table 3 Hot melt adhesive application parameters. Hot melt adhesive of the type specified was applied using an ITW Dynatec DDS Delta Fx Fiberized spray applicator with a 1.16cc pump.

Adhesive	Pump speed	Air pressure (psi)	Height of spray head (mm)	Hopper	Temperature °C		Spray head
					Air	Hose	
Sealock 1125/6™	8%	5	240	165	190	175	180
Sealock H1155™	8%	5	240	160	190	175	180
PowerBond D74™	8%	5	240	170	190	175	180

Following adhesive application, a sheet of silicon paper was overlaid the adhesive-coated rooting substrate. Rooting substrate components were subsequently packaged and shipped to a nursery site for assembly into complete seedling mats.

It has been found that the use of a relatively high application temperature in conjunction with a relatively low air pressure provides an open web spray pattern of the hot melt adhesive, which has the advantage of maintaining optimal wicking/water permeation into the rooting substrate in subsequent use.

EXAMPLE 3: Suitability of different types of organic material for the preparation of seed cover components

3.1 Preparation of seed cover components

Seed cover components were prepared with the composition specified in Table 4 below. PVOH E3433™ glue was obtained from Sealock (Scott Close, Walworth Industrial Estate, Andover, Hampshire, SP10 5NU, UK)

Table 4 Composition of seed cover components for a component of dimensions approximately 27cm by 28cm. Coir was pre-washed, buffered to pH 6.0, dried and sieved to a particle size of ≤ 2.8 mm. Bagasse, where milled, was milled to give a particle size of 180-1200 μ M. Rice husk was milled (for 2 minutes using a Robot Coupe floor standing cutter, Model R20).

Treatment No.	Seed cover component composition
1	100g unmilled coir + 32g PVOH E3433 glue
2	50g unmilled coir + 50g milled bagasse + 32g PVOH E3433™ glue
3	100g unmilled coir + 10g dry guar gum + 50g water
4	25g milled bagasse + 25g unmilled coir + 16g PVOH E3433™ glue
5	12.5g milled bagasse + 12.5g unmilled coir + 8g PVOH E3433™ glue
6	50g unmilled bagasse + 16g PVOH E3433™ glue
7	50g milled bagasse + 16g PVOH E3433™ glue
8	25g milled bagasse + 25g unmilled coir + 8g granular fertilizer + 16g PVOH E3433™ glue

The components were mixed and compressed at approximately 120 kgf/cm² for several minutes using an apple press. Compressed seed cover components were removed from the press and allowed to dry at room temperature overnight before subsequent incorporation in a seedling mat.

Dried seed cover components had the properties described in Table 5 below.

Table 5 Properties of dried seed cover components

Treatment No.	Observations
1	Held together well, robust enough to hold by hand
2	Held together well, robust enough to hold by hand, looked better than treatment 1
3	Held together well, robust enough to hold by hand, slightly warped (not flat)
4	Robust enough to hold by hand, but not to roll
5	Thinner than treatment 4 and more fragile
6	Robust enough to hold by hand, but not to roll
7	Robust enough to hold by hand, but not to roll
8	Robust enough to hold by hand, but not to roll

3.2 Assembly of seedling mat

Vertically-spun stone wool of the dimensions 58cm by 28cm, and with a thickness of 1.5cm was obtained from Grodan, (Rockwool B.V., Industrieweg 15, 6045 JG Roermond, P.O. Box 1160, 6040 KD Roermond, The Netherlands (Rockwool®)) and was perforated to a depth of approximately 0.5-1.0cm using a handheld perforator (manufactured by Aircraft Spruce, Aircraft Spruce West, 225 Airport Circle, Corona, CA 92880, USA) by pressing the perforator down onto the stone wool and making one pass over the entire surface.

Following perforation, each stone wool mat was placed into a black plastic tray (approximate dimensions 30x60x3.0cm). Power Bond D74™ hot melt adhesive (Powerbond Adhesives Ltd, 253 Scotia Road, Tunstall, Stoke on Trent, Staffordshire, ST6 6AB, United Kingdom) was applied to the upper (perforated) surface using a Reka TR 60 LCD hand

sprayer (Rheological Ltd., Moor Mead Road, Twickenham, Middlesex, TW1 1JN, UK) and swirl jet nozzle at 3 bar pressure, to give coverage of 5g/m² of seed adhesive.

150g of IR64 rice seeds were sprinkled uniformly on top of the seed adhesive to provide a seed density of approximately 4 seeds/cm².

For each seeded stone wool mat/tray, two seed cover components were laid on top. Each treatment was carried out in single replicates (2 seedling mats/1 tray per treatment). For all treatments the seedling mats were transported to the glasshouse and placed into a bay set at the following conditions: 28 °C day time temperature, 18 °C night time temperature, 14 hour photoperiod, 70 % relative humidity). All mats were watered immediately by overhead watering and also by flooding the trays with tap water until the surface of the water was just below the top of the stone wool layer. After twenty minutes the water was drained from the trays. Subsequently, all mats were watered every other day using this method. The seedling mats were grown in the glasshouse.

3.3 Results

After 18 days the seedlings were visually assessed for the criteria described in Table 6 below.

Table 6. . The following seedling measurements were taken at 15-18 days growth; 0: growth stage; I: Average seedling height (cm); II: Uniformity of greening (%); III: Leaf colour chart (unit); IV: Uniformity of growth (%); V: Rootlift (%); VI: Root growth (%); VII: Root whiteness (%). For all test mats, including control, no stickiness of rootmat and tray was observed, and all mats were sufficiently robust to be rollable.

Treatment No	0	I	II	III	IV	V	VI	VII
1	3.8	11.3	80	<2	82.5	3.5	95	85.5
2	3.2-3.8	10.3	67.5	<2	67.5	2	95	87.5
3	3.4	10.2	90	2.0	70	95	90	89.5
4	3.2-3.4	9.0	80	2.0	80	1	90	85
5	3.2-3.4	8.4	85	2-2.5	90	2	90	85
6	3.0-3.2	8.0	70	<2	85	100	85	85
7	3.2-3.4	9.1	75	2.0	70	nd	90	85
8		12.3	80	2.5-3.5	65	1	90	85

EXAMPLE 4: Investigations into the use of different ratios of coir:bagasse in seed cover components

From Example 3 above, it can be seen that seed cover components comprising coir and bagasse performed well in rice seedling mats. Accordingly the studies were carried out to investigate the effect of varying the coir to bagasse ratio in seed cover components.

The following ratios of sieved coir to milled bagasse were employed: treatment 1: 3:2; treatment 2: 7:3; treatment 4: 4:1; treatment 5: 9:1. For each treatment seed cover

components were made using 50g of organic matter + 16g PVOH E3433C™ adhesive following the method described in 3.1 above.

Seedling mats were assembled, and seedlings grown as described in 3.2 above. The results obtained are summarised in Table 7 below.

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Table 7 The following seedling measurements were taken at 13 days growth; 0: growth stage: I: Average seedling height (cm); II: Uniformity of greening (%); III: Leaf colour chart (unit); IV: Uniformity of growth (%); V: Rootlift (%); VI: Root growth (%); VII: Root whiteness (%).

Treatment	Replicate	0	I	II	III	IV	V	VI	VII
1	a	3.4	9.4	85	<2	85	0	95	85
	b	3.4	9.4	85	<2	85	0	95	85
2	a	3.4	9.6	95	<2	85	0	95	85
	b	3.4	9.4	95	<2	85	0	95	85
3	a	3.4	9.5	90	<2	80	0	95	85
	b	3.4	9.5	90	<2	85	0	95	85
4	a	3.4	8.4	90	<2	75	0	95	85
	b	3.4	8.3	90	<2	70	0	95	85

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EXAMPLE 5: Performance of seed cover components comprising coir and rice husk in comparison to the use of loose coir mulch

The use of efficacy of seed cover components comprising sieved coir and milled rice husk (treatments 1-4, 9-12, and 17-20) in rice seedling mats was compared to the use of layers of loose sieved coir and aqueous adhesive (referred to in the results as loose (i.e. non-compressed) mulch, LM; treatments 5-8, 13-16, 21-25).

15

5.1 Preparation of seed cover components

Seed cover components were prepared as follows. Coir, pre-washed, buffered to pH 6.0 and dried, was sieved to give a particle size of ≤ 2.8 mm. For each seed cover component (measuring approximately 28cm by 29cm) 40g sieved coir was mixed with 20g of milled rice husk and 16g of PVOH E3433C™ glue. The mixture was compressed at approximately 15psi for several minutes using an apple press. Compressed seed cover components were removed from the press and allowed to dry at room temperature overnight before subsequent incorporation in a seedling mat.

25

5.2 Preparation of rooting substrate components

Vertically-spun stone wool 58cm by 28cm with a thickness of 1.5cm was obtained from Grodan (*supra*; Rockwool®) and was perforated to a depth of approximately 0.5-1.0cm using a handheld perforator (fashioned in bronze by Perforation Machinery Ltd. Bradford, UK: 1353 bronze pins arranged on a bronze cylinder, each pin 13mm in height, 8mm spacing

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between pins, each pin 1.02 in diameter) by pressing the perforator down onto the stone wool and making two passes over the entire surface.

Following perforation, each stone wool mat was placed into a black plastic tray (approximate dimensions 30x60x3.0cm), with one tray per treatment.

5 For treatments 1 to 24 inclusive, hot melt adhesive was applied to the upper (perforated) surface using a ITW Dynatec DDS Delta Fx™ Fiberized spray applicator using the parameters described in Table 8 below.

Table 8 Seed Adhesive application parameters. For treatments 1 to 24 inclusive, hot melt adhesive was applied evenly over the upper surface (perforated surface) of the stone wool rooting substrate.

Treatment No.	Seed adhesive	Application rate (g/m ²)	Air flow details
1	Sealock H1125/6™	5	High
2		20	High
3		5	Low
4		20	Low
5		5	High
6		20	High
7		5	Low
8		20	Low
9	Sealock H1155™	20	Low
10		20	High
11		5	High
12		5	Low
13		20	Low
14		20	High
15		5	High
16		5	Low
17	Power Bond D74™	5	Low
18		5	High
19		20	High
20		20	Low
21		5	Low
22		5	High
23		20	High
24		20	Low

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Using a conveyor belt, rooting substrate was passed under an ITW Dynatec DDS Delta Fx™ Fiberized spray applicator at rates suitable to achieve an application rate of either 5g/m² or 20g/m² of hot melt adhesive. Hot melt adhesive was applied to the perforated surface. Rooting substrate components were prepared with three different hot melt adhesives, Sealock H1125/26™, Sealock H1155™, and Power Bond D74™, using this methodology.

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For treatment 25, PVOH E3433C™ glue was applied evenly across the upper (perforated) surface of the stone wool mat using a handheld Graco Easymax battery operated sprayer with a 310 nozzle, for 8 seconds at a rate of 5.33g glue per second.

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5.3 Assembly of Seedling mat

For each treatment, 150g of IR64 rice seeds were sprinkled uniformly on top of the seed adhesive to provide a seed density of approximately 4 seeds/cm².

For treatments 1-4, 9-12, and 17-20, seed cover components, produced as described in 5.1 above, were laid over the seeded rooting substrates (two seed cover components of dimensions 28 cm x 29cm were used per seeded rooting substrate mat).

For treatments 5-8, 13-16, 21-25 an even layer of PVOH E3443C™ glue (as mulch adhesive) was applied using a Graco Easymax battery operated sprayer with a 310 nozzle, (2 seconds spray at a rate of 5.33g/second) before applying 25g of sieved coir. A further layer of mulch adhesive (PVOH E3433C™ glue, even application for 2 seconds at a rate of 5.33g/second), was applied over the first layer of coir, and a second layer of 25g sieved coir was applied atop this. A final layer of PVOH E3433C™ glue was applied over the second layer of coir (4 second application, 5.33g/second), as a top cover.

Table 9. Seedlings were grown to the 3.4 leaf stage on mats where vertically spun (V) perforated stone wool of 1.5cm depth was used as a rooting substrate and was coated with seed adhesive as specified. IR64 seeds were sown atop the adhesive and covered with either loose mulch (LM – see above) or a seed cover component comprising rice-husk and coir (CM). The following seedling measurements were taken when the seedlings had reached the 3.4 leaf stage: I: Average seedling height (cm); II: Uniformity of greening (%); III: Average leaf colour chart (unit); IV: Uniformity of growth (%); V: Rootlift (%); VI: Root growth (%); VII: Root whiteness (%). For all test mats, including control, no stickiness of rootmat and tray was observed, and all mats were sufficiently robust to be rollable.

Treatment	Seed Adhesive	Seed Covering	I	II	III	IV	V	VI	VII
1	Sealock H1125/6™	CM	10.2	85	2.0	90	0	95	85
2		CM	11.3	80	2.0	90	0	95	85
3		CM	10.2	65	<2	85	0	95	85
4		CM	10.4	70	<2	85	0	95	85
5		LM	5.6	90	2.0	80	15	95	85
6		LM	8.1	90	2.0	90	15	95	85
7		LM	9.4	80	2.0	95	5	95	85
8		LM	9.6	83	2.0	93	10	95	85
9	Sealock H1155™	CM	9.6	60	<2	85	0	95	85
10		CM	9.2	65	<2	85	0	95	85
11		CM	10.4	85	2.0	90	0	95	85
12		CM	8.6	85	2.0	60	0	95	85
13		LM	8.6	95	2.0	90	10	95	85
14		LM	8.8	90	2.0	90	15	95	85
15		LM	8.7	85	2.0	85	15	95	85
16		LM	6.5	90	2.0	85	10	95	85
17	Power Bond D74™	CM	10.8	85	2.0	90	0	95	85
18		CM	9.8	70	<2	85	0	95	85
19		CM	9.4	65	<2	85	0	95	85
20		CM	8.9	70	<2	80	0	95	85
21		LM	9.0	95	2.0	95	10	95	85
22		LM	9.7	87	2.0	95	10	95	85
23		LM	9.0	83	2.0	90	5	95	85
24		LM	6.5	85	2.0	85	10	95	85
25	PVOH E3433C	LM	8.6	83	2.0	85	30	90	85

For all treatments the seedling mats were transported to the glasshouse and placed into a bay set at the following conditions: 28 °C day time temperature, 18 °C night time temperature, 14 hour photoperiod, 70 % relative humidity). All mats were watered immediately by overhead watering and also by flooding the trays with tap water until the surface of the water was just below the top of the stone wool layer. After twenty minutes the water was drained from the trays. Subsequently, all mats were watered every other day using this method.

The seedling mats were grown in the glasshouse for a total of 12 days after which, the seedlings had reached growth stage 3.4. They were then were visually assessed for the criteria described in Table 9 above.

EXAMPLE 6: Performance of seedling mats in a Nursery environment

6.1 Preparation of rooting substrate components comprising hot melt adhesives

Vertically-spun stone wool 58cm by 28cm with a thickness of 1.5cm (Rockwool®, Grodan *supra*) and perforated to a depth of approximately 0.5-1.0cm using a handheld perforator (manufactured by Aircraft Spruce, Aircraft Spruce West, 225 Airport Circle, Corona, CA 92880, USA) by pressing the perforator down onto the stone wool and making one or two passes over the entire surface.

Using a conveyor belt, rooting substrate was passed under an ITW Dynatec DDS Delta Fx™ Fiberized spray applicator at rates suitable to achieve an application rate of either 5g/m² or 20g/m² of hot melt adhesive. Hot melt adhesive was applied to the perforated surface. Rooting substrate components were prepared with three different hot melt adhesives, Sealock H1125/26™, Sealock H1155™, and Power Bond D74™, using this methodology. Following adhesive application, a sheet of silicon paper was overlaid the adhesive-coated rooting substrate. Rooting substrate components were subsequently packaged and shipped to a nursery site for assembly into complete seedling mats.

6.2 Test A

Vertically-spun stone wool of dimensions 58 x 28 x 1.5cm obtained from Grodan (*supra*) was perforated as described previously and either supplied to the nursery in component form (i.e. pre-coated as described above, on the upper perforated surface with either Sealock H1125/6™ or Sealock H1155™ at either 5 g/m² or 20g/m², and overlaid with silicon paper which was removed prior to use), or coated on-site on the upper perforated surface with E3433C™ PVOH adhesive. 150g of ADTT45 rice seeds (treated with thiamethoxam [Cruiser® 350FS, Syngenta] at a rate of 70 g/ 100 kg seed) were sown evenly

over the adhesive-coated rooting substrate, and the seeds were then covered either with seed cover components comprising a 2:1 ratio of sieved coir to milled rice husk (prepared as described in 5.1 above; two seed cover components of dimensions 28 cm x 29cm were used per seeded rooting substrate mat), or with a loose coir mulch layer as follows:

5 10g E3433C™ PVOH adhesive was sprayed over each seeded rooting substrate, and surface of all mats either using a Wagner W450 SE compressed air sprayer (Wagner, UK), or a Graco Easymax battery operated sprayer, before 25g of coir (pre-washed, dried and buffered to pH 6.0, then sieved prior to application) was applied using a Kubota SR-K610IN seeder. A second layer of 10g E3433C PVOH adhesive was sprayed over the coir,
10 and a second layer of 25 g coir (as before) was applied on top using the Kubota seeder. A third layer of 20g E3433C™ PVOH was sprayed over the top of the second layer of coir, and the mats left to air dry. This type of seed covering is referred to in the results as loose (i.e. non-compressed) mulch (LM).

Following production the mats were laid outside in the nursery. All mats were watered
15 overhead with a fertiliser treatment containing 500 g basal fertiliser /m³ (*supra*) and 20 g ZnSO₄ /m³ at a rate of 1 litre / tray. Following fertiliser application, a single layer of black netting was placed over all the treatments to protect them from birds. The mats were flooded and drained twice per day from day 2 onwards. When the growth stage of the rice plants had reached 3.2 leaf stage, the mats were rolled up and transplanted into a pre-prepared (i.e.
20 levelled and puddled) field using a Kubota transplanter (source: Kubota).

6.3 Test B

This test was performed essentially as described above with respect to Test A. The differences being that mats were additionally prepared using pre-prepared rooting substrates
25 coated the hot-melt adhesive, Power Bond D74™, and following production and once all mats were laid outside in the nursery, they were watered overhead at a rate of of 2 litre / tray.

6.3 Results

Prior to being rolled up and transplanted, the mats from both tests were visually
30 assessed for a number of criteria as described previously. The results are shown below in Table 10.

6.3.1 Summary of results from Test A: Mats produced with seed cover components comprising compressed coir and rice husk produced taller greener seedlings than mats produced using a mulch of loose layers of coir interspersed with layers of aqueous glue. On
35 average the increase in height of the seedlings at the 3.2 leaf stage was 1.5cm. No root lift

was observed in mats produced using seed cover components comprising compressed coir and rice husk. A better transplanting efficiency was obtained from mats produced using seed cover components comprising compressed coir and rice husk in comparison that from mats produced using a mulch of loose layers of coir interspersed with layers of aqueous glue.

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6.3.2 Summary of results from Test B: All mats produced healthy seedlings with good root growth and root whiteness. Mats produced with seed cover components comprising compressed coir and rice husk produced taller greener seedlings than mats produced using a mulch of loose layers of coir interspersed with layers of aqueous glue. No root lift was observed in mats produced using seed cover components comprising compressed coir and rice husk.

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Table 10 Results from Tests A & B: Seedlings were grown to the 3.2 leaf stage on mats where vertically spun (V) perforated stone wool of 1.5cm depth was used as a rooting substrate and was coated with seed adhesive as specified. ADT45 seeds were sown atop the adhesive and covered with either loose mulch (LM – see above) or a seed cover component comprising rice-husk and coir (CM). The following seedling measurements were taken when the seedlings had reached the 3.2 leaf stage: A: Time in days to reach 3.2 leaf stage; B: Seedling height (cm); C: Uniformity of greening (%); D: Average of leaf colour chart* (unit); E: Uniformity of growth (%); F: Root growth (%); G: Root whiteness (%); Root lift (%).

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Test	Seed adhesive	Adhesive coverage (g/m ²)	Seed covering	Seedling measurement at 3.2 leaf stage							
				A	B	C	D	E	F	G	H
3A.1	Sealock H1125/6™	5	LM	15	13	85	2.5	90	90	90	10
3A.2	Sealock H1125/6™	20	LM	15	13	80	2.0	88	90	90	10
3A.3	Sealock H1125/6™	5	CM	14	14	75	2.0	90	90	90	9
3A.4	Sealock H1125/6™	20	CM	14	14	80	2.0	85	90	90	9
3A.5	Sealock H1155™	5	LM	15	13	80	2.0	90	90	90	10
3A.6	Sealock H1155™	20	LM	15	13	80	2.0	90	90	90	10
3A.7	Sealock H1155™	5	CM	14	14	75	2.0	90	90	90	0
3A.8	Sealock H1155™	20	CM	14	14	75	2.0	86	90	90	0
3A.9	PVOH E3433C™	n/a	LM	14	13	85	2.3	90	90	90	10
3A.10	PVOH E3433C™	n/a	CM	13	14	75	2.0	85	90	90	2
3B.1	Sealock H1125/6™	5	LM	nd	nd	nd	nd	nd	nd	nd	nd
3B.2	Sealock H1125/6™	20	LM	13	9.8	87	2.0	95	80	82	3
3B.3	Sealock H1125/6™	5	CM	nd	nd	nd	nd	nd	nd	nd	nd
3B.4	Sealock H1125/6™	20	CM	13	12.0	90	2.5	83	80	85	0
3B.5	Sealock H1155™	5	LM	13	9.7	87	2.0	95	77	85	3
3B.6	Sealock H1155™	20	LM	13	10.0	88	2.2	93	78	83	3
3B.7	Sealock H1155™	5	CM	13	12.0	83	2.5	80	73	82	0
3B.8	Sealock H1155™	20	CM	13	11.8	87	2.5	83	78	85	0
3B.9	Power Bond D74™	5	LM	13	9.8	88	2.2	92	78	83	3
3B.10	Power Bond D74™	20	LM	13	9.8	87	2.2	93	78	85	3
3B.11	Power Bond D74™	5	CM	13	11.8	85	2.3	82	75	83	0
3B.12	Power Bond D74™	20	CM	13	11.8	87	2.5	80	80	83	0
3B.13	PVOH E3433C™	n/a	LM	13	10.2	82	2.0	87	72	82	2
3B.14	PVOH E3433C™	n/a	CM	13	11.7	80	2.0	80	73	82	0

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* Leaf colour chart was obtained from the International Rice Research Institute, and is a tool typically employed to monitor leaf colour for Nitrogen application. nd = not determined.

CLAIMS

1. A seedling mat comprising:

a generally planar rooting substrate in which seed root growth is supported and which is self-supporting, coated on one surface with a seed adhesive, for immobilising seeds in or on a top surface region of the rooting substrate;

a seed cover component, which covers the seeds and permits seedling growth therethrough; and

a plurality of seeds, distributed in or on the top surface region of the rooting substrate and adhered thereto by seed adhesive, wherein:

the seed cover component is self-supporting and comprises organic material that has been compressed into a self-supporting layer, the organic material comprising materials selected from the group consisting of coir, rice husk, guar gum, and bagasse.

2. The seedling mat according to claim 1, wherein the seed adhesive is a hot melt adhesive.

3. The seedling mat according to claim 2, wherein the hot melt adhesive is pressure sensitive.

4. The seedling mat according to claim 3, wherein the hot melt adhesive is selected from the group consisting a blend of styrene based block copolymers and synthetic resins, which have a softening point in the region of 88°C-98°C, an operating temperature of 160°C-170°C, and a viscosity at 170°C of 6500±1700 cPs, a blend of thermoplastic rubber, resins, and plasticiser, which have a softening point in the region of 75°C to 90°C, an operating temperature of 160°C-175°C and typical viscosity of 14-20 poise at 160°C and 9-14 poise at 175°C, and a blend of styrene based block copolymers and synthetic resins, which have a softening point in the region of 88°C-98°C, an operating temperature of 160°C-170°C, and a viscosity at 170°C of between 48 and 82 poise.

5. The seedling mat according to any one of the preceding claims, wherein the seed cover component comprises coir and bagasse.

6. The seedling mat according to claim 5, wherein the coir to bagasse ratio in the seed cover component is from about 60:40 to about 90:10 by weight.
- 5 7. The seedling mat according to claim 6, wherein the coir to bagasse ratio in the seed cover component is about 60:40 by weight.
8. The seedling mat according to any one of claims 5-7, wherein the bagasse in the seed cover component is milled.
- 10 9. The seedling mat according to any one of claims 1-4, wherein the seed cover component comprises coir and rice husk.
10. The seedling mat according to claim 9, wherein the coir to rice husk ratio is about 10:1 to about 1:1 by weight.
- 15 11. The seedling mat according to any one of the preceding claims further comprising seed cover adhesive for attaching the seed cover component to the layer below.
12. The seedling mat according to claim 11 wherein the seed adhesive functions as the seed cover adhesive.
- 20 13. The seedling mat according to any one of the preceding claims, further comprising a top cover which is optionally water-soluble and/or perforated.
- 25 14. The seedling mat according to claim 13, wherein the top cover comprises rice paper, potato starch paper, an aqueous adhesive or PVOH film.
15. The seedling mat according to claim 13 or claim 14, further comprising a top cover adhesive for attaching the top cover.
- 30 16. The seedling mat according to any one of claims 11 to 15 wherein the seed cover adhesive and/or the top cover adhesive used comprise(s) aqueous-based adhesive(s) and/or hot melt adhesive(s).

17. The seedling mat according to any one of the preceding claims wherein the rooting substrate comprises mineral/stone wool.
- 5 18. The seedling mat according to claim 17 wherein the mineral/stone wool is vertically spun.
19. The seedling mat according to any one of the preceding claims, wherein the rooting substrate is about 1-2.6 cm thick.
- 10 20. The seedling mat according to any one of the preceding claims, wherein the rooting substrate is provided with generally vertical perforations, preferably extending about 0.5-1cm into the substrate.
- 15 21. The seedling mat according to any one of the preceding claims further comprising a root barrier structure in which the rooting substrate is accommodated, which barrier structure is configured to inhibit lateral and/or downward root growth beyond the periphery of the rooting substrate.
- 20 22. The seedling mat according to claim 21 wherein the root barrier structure is disposed peripherally of side and/or base regions of the rooting substrate.
- 23 23. The seedling mat according to claim 21 or 22 wherein the root barrier structure has a structural rigidity which helps support and constrain the seed cover component and/or top layer.
- 25 24. The seedling mat according to any one of claims 21 to 23 wherein the root barrier structure is provided with a plurality of generally parallel channels extending over the upper surface of the base region thereof.
- 30 25. The seedling mat according to any of claims 21 to 24 wherein the root barrier structure is a tray having a base region and upstanding sidewalls.
- 35 26. The seedling mat according to any one of the preceding claims, wherein the seeds are ungerminated.

27. The seedling mat according to any one of the preceding claims, wherein the seeds are rice seeds.
- 5 28. The seedling mat according to any preceding claim wherein the seed density is in the region of 1-20 seeds/cm² (inclusive).
- 10 29. The seedling mat according to any one of the preceding claims wherein any one or more of the components of the seedling mat is pre-treated with, or comprises, one or more agrochemical, biological treatment and/or nutrient.
30. The seedling mat according to any one of the preceding claims which is rectangular.
- 15 31. A seedling mat substantially as described herein with respect accompanying examples and figures.
32. A seed cover component for a seedling mat, said component being self-supporting and comprising organic material that has been compressed into a self-supporting layer, the organic material comprising materials selected from the group consisting of coir, rice husk, guar gum, and bagasse.
- 20 33. The seed cover component according to claim 32, wherein the organic material comprises coir and bagasse.
- 25 34. The seed cover component according to claim 32 or claim 33, wherein the coir to bagasse ratio is from about 60:40 to about 90:10 by weight.
- 35 35. The seed cover component according to claim 34, wherein the coir to bagasse ratio is about 60:40 by weight.
- 30 36. The seed cover component according to any one of claims 32-35 wherein the bagasse is milled.
- 35 37. The seed cover component according to claim 32, wherein the organic material comprises coir and rice husk.

38. The seed cover component according to claim 32 or claim 37, wherein the coir to rice husk ratio is about 10:1 to about 1:1 by weight.
- 5 39. The seed cover component according to any one of claims 32-38, coated on at least one surface by an adhesive.
40. The seed cover component according to claim 39, wherein the adhesive is a hot melt adhesive.
- 10 41. The seed cover component according to claim 39, wherein the adhesive is an aqueous-based adhesive such as: VAE, PVA, PVOH or an acrylic glue.
42. The seed cover component according to any one of claims 32-41, additionally comprising a separation layer.
- 15 43. The seed cover component according to claim 42, wherein the separation layer is silicon paper, waxed paper, rice paper, potato starch paper, or PVOH film.
44. Use of a seed cover component as defined in any one of claims 32-43 in a seedling mat as defined in any one of claims 1 to 31.
- 20 45. Use of a seedling mat as defined in any one of claims 1 to 31, or a seed cover component as defined in any one of claims 32-43, for the growth of rice seedlings.
- 25 46. A method for the preparation of a seedling mat as defined in any one of claims to 31, comprising the steps of:
- 30 (a) coating on one surface with a seed adhesive, a generally planar rooting substrate in which seed root growth is supported and which is self-supporting, wherein the seed adhesive is a hot melt adhesive;
- (b) sowing seeds onto the adhesive-coated surface of the rooting substrate component;
- (c) applying a seed cover component over the top of the sown seeds, wherein the seed cover component is self-supporting and comprises organic material that has been compressed into a self-supporting layer, the organic material comprising

materials selected from the group consisting of coir, rice husk, guar gum, and bagasse.

Figure 1

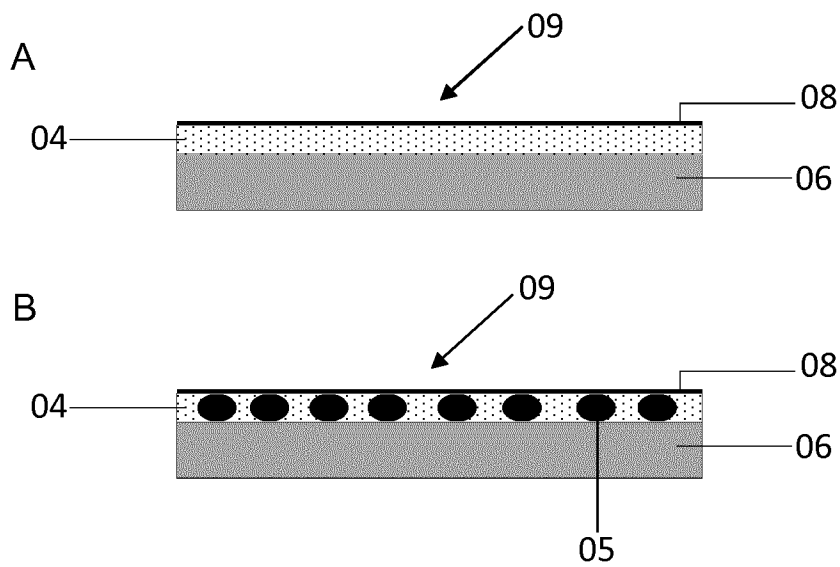
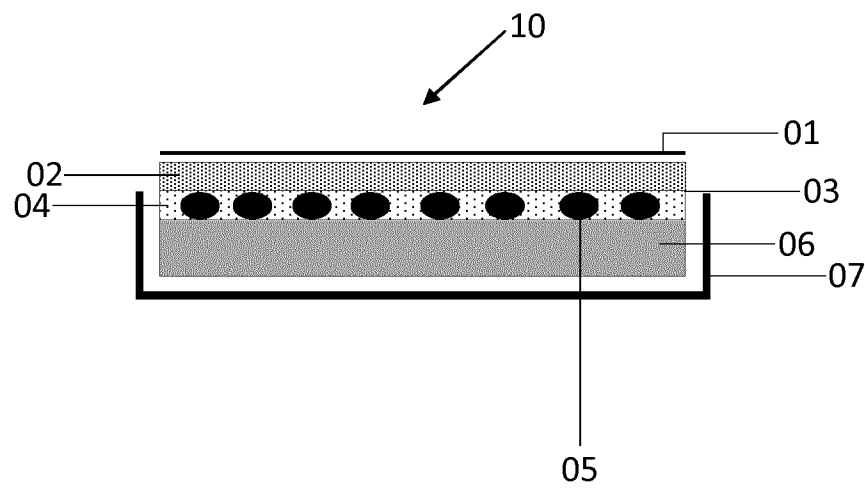


Figure 2



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/051291

A. CLASSIFICATION OF SUBJECT MATTER
 INV. A01C1/04 A01G1/00
 ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

A01C A01G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X,P	US 2014/130408 A1 (FAGIN CHARLES R [US] ET AL) 15 May 2014 (2014-05-15) abstract page 1, paragraphs 14,15,16 page 2, paragraph 16 claims; figures -----	1-5,8,9, 11-13, 15,16, 26-30, 32,33, 36,40, 41,44-46
X	JP H01 98421 A (MARUSAN SEISHI KK) 17 April 1989 (1989-04-17)	32-43,45
Y	abstract	1-30
A	claims; figures ----- -/-	31



Further documents are listed in the continuation of Box C.



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Date of the actual completion of the international search

28 April 2015

Date of mailing of the international search report

08/05/2015

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INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2015/051291

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2001 178211 A (YAMAGUCHI PREFECTURE; MATSUMURA AQUA KK) 3 July 2001 (2001-07-03)	45
Y	abstract	1-30
A	claims; figures -----	31
A	AU 23781 84 A (CHEN C L) 1 August 1985 (1985-08-01) page 4, line 12 - line 27 page 5, line 8 - line 26 claims; figures -----	1-46

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2015/051291

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