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54 **Method and system for picking up and collecting plant matter**

57 The invention relates to a method and system for picking up and collecting plant embryos. To pick up the plant matter, a pick-up unit is used that is mounted to a robotic arm. According to the invention, two separate imaging steps are performed at two different positions of the pick-up unit. The first imaging step is performed to identify an isolated piece of plant matter. The second imaging step is performed when the pick-up unit is at a confirming position and enables a verification of whether a piece of plant matter has been picked up or not. The confirming position is in between the position of the pick-up unit for picking up plant matter and the position for depositing plant matter in suitable receptacles.

Method and system for picking up and collecting plant matter

The invention relates to a method and system for picking up and collecting plant matter, in particular plant embryos.

5 Plant embryos form an important tool in modern contemporary plant breeding leading to hybrid plants. In order to speed up the creation of the required genetically pure lines, the use of doubled haploids (DHs) has become a very valuable tool. In addition, DHs also help greatly to evaluate and monitor difficult traits such as those that are encoded by multiple genes/alleles.

10 The production and the use of DHs in breeding crop plants is well known for many plant species. Thus far, DHs can be obtained from spores of the male (androgenesis) or female (gynogenesis) organs.

Androgenesis is defined as a set of biological processes leading to the development of individuals derived from the nuclei of male spores. Spores from the male organs are called microspores and the in vitro cultures are called microspore cultures. Typical microspore cultures 15 are well established in Brassica since a long time. Spores from the female organs are called megaspores, and the in vitro culture of these spores is commonly named gynogenesis. Gynogenesis is a well established technique for e.g. sugar beet and also cucumber.

Above described techniques result in the formation of plant embryos, through a process called embryogenesis. These embryos develop from one single cell into a plant, when grown under 20 special conditions and provided with appropriate growth media. Depending on the plant species, developing embryos are grown in liquid or on solid growth media. When the embryos have reached the desired growth stage, they might be singulated.

In many situations, it may be desirable to automate a process for picking up and collecting the plant embryos. Typically, the embryos are available in relatively large liquid containing 25 reservoirs. To isolate the embryos, the content of the reservoir is poured into a receptacle, typically having a relatively large surface allowing the embryos to spread over the surface. Then, a user may pick up isolated embryos and place them in respective compartments, such as test tubes, for further analysis or processing. This manual process is very labour intensive, and it is therefore desirable to automate this picking up process.

30 Automated methods for picking up and collecting plant matter such as plant embryos are known from the prior art.

For instance, from US 2005/0114918, a system and method of embryo delivery for manufactured seeds is known in which a robotic arm with a pick-up head comprising micro-tweezers is used. In this system, an imaging system is present for obtaining attributes of the plant 35 embryos. Plant embryos which are determined to be suitable for germination are detected, and are then specifically oriented one at a time by movement of a positioning table to a retrieval position.

In the retrieval position, the embryos are picked up by the pick-up head. It is also mentioned that a robotic housing capable of moving in multiple directions may be used in conjunction with or in the absence of a positioning table.

Another system is known from EP 1 498 025, which discloses an automated system and method for harvesting and multi-stage screening of plant embryos. In this system as well, the embryos may be imaged by a camera, and the image is used to ascertain the embryo's shape and size. Undesirable embryos may be removed. Desirable embryos may be transferred onto a receiving surface, for instance by picking them up using a vacuum tip end.

There is a continuing demand for processing larger quantities of embryos. This requires that the amount of time required for picking up and collecting a plant embryo is reduced. At the same time, for some applications it has to be guaranteed that each compartment, e.g. test tube, is not empty but comprises a single plant embryo.

It is an object to provide a more efficient and more precise method for picking up and collecting plant matter, in particular plant embryos, while still providing sufficient certainty that the plant embryos are deposited in the intended compartments.

This object may be achieved by a method according to the invention, which comprises the steps of capturing a first optical image, being an image of at least one piece of plant matter, such as a plant embryo, arranged in a receptacle. Next, an isolated piece of plant matter is detected in the captured first optical image. Then, a robotic arm having a pick-up unit mounted thereon is controlled to move the pick-up unit to a position in which it is able to pick up the isolated piece of plant matter. A picking up action is performed next for picking up the isolated piece of plant matter using the pick-up unit. As a next step, the robotic arm is controlled to move the pick-up unit to a predefined confirming position, and a second optical image is captured in which a part associated with the picked-up piece of plant matter does not overlap with a part, if any, in the second optical image that is associated with the receptacle.

Thus, the method includes two separate imaging steps. In the first imaging step, the presence of an isolated piece of plant matter is detected, and if an isolated piece of plant matter is found, the position thereof is determined. In the second imaging step, it is checked whether a piece of plant matter was indeed picked up. To be able to properly see the picked-up piece of plant matter, the pick-up unit is moved to a confirming position in which the picked-up piece can be seen separate from other pieces of plant matter that are still arranged in the receptacle.

When a piece of plant matter has been picked up, it can be deposited in a respective compartment, whereas if no piece of plant matter has been picked up, the same intended isolated piece of plant matter or another piece of isolated plant matter can be picked up. As the plant matter is typically arranged in a liquid held in the receptacle, it may be preferable to pick up a different

piece of isolated plant matter as the process of picking up plant matter may have changed the position and/or orientation of the originally intended piece of isolated plant matter.

By checking whether a piece of plant matter has been picked prior to depositing such a piece in a compartment such as a test tube or another receiving surface, it becomes possible to
5 more quickly react to situations in which a piece of plant matter has not been picked up. For instance, the distance that needs to be covered by the robotic arm and more in particular the pick-up unit can be reduced considerably by using the predefined confirming position. As a result, the throughput can be increased considerably.

It is preferable if the confirming position lies on or close to a path from the receptacle to
10 the compartment, wherein the compartment is preferably part of a tray comprising a plurality of compartments. More in particular, it is preferable if the confirming position is close to the receptacle provided that the imaging of the picked up piece of plant matter is not disturbed by either the receptacle or the other pieces of plant matter contained therein. A situation in which a piece of plant matter that is still in the receptacle is misinterpreted as being a picked-up piece of
15 plant matter should be avoided.

The receptacle may be visible in the second optical image, for example only partially. In this case the method may further comprise detecting the further isolated piece of plant matter from the second optical image. This means that the second imaging step for confirming that a current piece of plant matter has been picked up is simultaneously the first imaging step for the detecting
20 the presence of a further isolated piece of plant matter. This is advantageous for reasons of efficiency, and has the further advantage that while the pick-up unit is in the predetermined confirming position, an unobstructed view of the receptacle can be obtained. However, the detecting of the further isolated piece of plant matter may also be done using the already obtained first optical image. Use of several images is also an option, as is the use of a continuous image
25 feed.

The method may comprise capturing a new first optical image for detection of a piece of plant matter to be picked up next when the pick up unit does not obstruct a view of the receptacle in the new first optical image. For instance, the new first optical image may captured when the pick-up unit is at or moving towards the position for depositing a picked-up piece of plant matter.

The two imaging steps may be performed by two different cameras. However,
30 advantageously, a same optical camera may be used for obtaining the first and second optical images. This camera is preferably positioned in such a way that it has a good view of both the receptacle and of the predefined confirming position. However, it may be possible for the camera to move from a first to a second imaging position. Also, the optical camera may perform a
35 zooming function prior to recording the second optical image, as more precision may be desired.

The detecting of an isolated piece of plant matter or the detecting of a further isolated piece of plant matter may comprise finding an isolated piece of plant matter in the first or second optical image, comparing at least one of a size, colour, and shape to predetermined criteria, and determining that the isolated piece of plant matter should be picked up if the at least one of a size, an orientation, colour, and shape meets the predetermined criteria. By comparing with predetermined criteria, plant matter that is unsuitable for further processing, for instance due to abnormal growth or because the plant matter relates to a different type of plant, can be excluded.

The method may comprise controlling the robotic arm to rotate the pick-up unit during and/or after a movement to the predefined confirming position, to allow a better view of the picked-up piece of plant matter, if present. During the picking up of the plant matter, the pick-up unit will likely be located substantially between the camera and the receptacle, therefore potentially obscuring a view of the picked-up piece of plant matter. By controlling the robotic arm to rotate the pick-up unit, detection of the picked-up piece of plant matter, if present, may be improved. Preferably the pick-up unit is rotated to provide an unobstructed view of the picked-up piece of plant matter, if present.

The method may comprise a step of detecting an orientation of the isolated piece of plant matter or the further isolated piece of plant matter in the first and/or second optical image, and orienting the pick-up unit accordingly prior to performing the picking up action. This allows the pick-up unit to more reliably picking up the plant matter with less of a chance of damage. For instance, it may be advantageous to pick-up plant matter by a less fragile part such as, for example, the (primary) root, the hypocotyl or the stem.

If no isolated piece of plant matter is detected in the first and/or second optical image, a blowing unit may be moved along a pre-set trajectory while directing a pressurized gaseous medium, such as air, toward the receptacle. This may break up clusters of plant matter in which several pieces of plant matter are clustered close together, and may make it possible to isolate further pieces of plant matter. The skilled person will be able to assess a necessitated blowing strength as well as possible trajectories.

After the step of moving the blowing unit along a pre-set trajectory, the blowing unit may be moved to a position wherein a new first or second optical image can be obtained having a substantially unobstructed view of the receptacle; and detecting whether there are any isolated pieces of plant matter in the receptacle using the first and/or second optical image. In this manner it may be assessed whether the blowing unit moving along a pre-set trajectory managed to isolate further pieces of plant matter. If no isolated pieces are detected in the last step, the blowing unit may be moved along a different pre-set trajectory while directing the pressurized gaseous medium toward the receptacle. After this, it may again be assessed, by obtaining a new first or second optical image, if the movement of the blowing unit while directing a pressurized gaseous medium

toward the receptacle was successful in isolating further pieces of plant matter. This process may be repeated a number of times, for instance three times with three different trajectories. If after a pre-set number of repetitions it is still the case that no isolated pieces of plant matter may be detected, a warning signal may be transmitted to an operator. This may for instance be at least one
5 of an auditory signal and a visual signal. The operator may thus be prompted to provide a further receptacle containing plant matter. The skilled person will be able to automate this step as well if desired.

In the above, the step of directing pressurized gaseous medium toward the receptacle may involve blowing the pressurized gaseous medium downward at a substantially straight angle with
10 respect to a plan defined by the bottom of the receptacle. This may be most efficient at breaking up clusters of plant matter.

Once there are no longer any free compartments in the tray, the tray may be replaced. While this may be done manually, it is preferably performed using a gripping unit for replacing the tray. Advantageously, the blowing unit and/or the gripping unit may be mounted to the same
15 robotic arm as the pick-up unit. Moreover, the movement of the blowing unit and/or gripping unit can be controlled by controlling the robotic arm. Additionally or alternatively, the blowing unit and/or gripping unit are integrated in the pick-up unit.

It is a further object of the invention to provide a more efficient and/or precise system for picking up plant matter, such as plant embryos and for collecting the picked-up plant matter in a
20 tray having at least one compartment. This object may be achieved by a system according to the invention, which comprises a surface whereupon a receptacle containing at least one piece of plant matter may be provided. The system further comprises a robotic arm provided with a pick-up unit configured to pick-up a piece of plant matter, wherein the robotic arm is able to move the pick-up
unit for picking up a piece of plant matter from the receptacle, to move the pick-up unit to a
25 predefined confirming position for confirming the picking up of a piece of plant matter, and to move the pick-up unit for depositing a picked-up piece of plant matter into a respective compartment of the tray.

The system of the present invention also comprises a camera system comprising an optical camera, said system being configured for capturing a first optical image being an image of at least
30 one piece of plant matter arranged in a receptacle, and for capturing a second optical image in which a part associated with the picked-up piece of plant matter does not overlap with a part, if any, that is associated with the receptacle. The camera system preferably comprises a single camera for capturing the first and second optical images.

The system comprises a controller configured for detecting an isolated piece of plant
35 matter in the first optical image, controlling the robotic arm to move the pick-up unit to a position in which the unit can pick-up the detected isolated piece of plant matter, controlling the pick-up

unit to pick-up the detected isolated piece plant matter, controlling the robotic arm to move the pick-up unit to a predefined confirming position, confirming the presence of a picked-up piece of plant matter in the second optical image, controlling the robotic arm and the pick-up unit to deposit the picked up piece of plant matter in a respective compartment if the picked up piece of plant matter is visible in the second optical image, or controlling the robotic arm to move the pick-up unit to a position in which it is able to pick up a further isolated piece of plant matter if no picked up piece of plant matter is visible in the second optical image.

The system described above is suitable and/or configured for performing the method of the invention.

The system may comprise a first light source configured for emitting light through the surface from a side of the surface opposite to a side of the surface where the receptacle is or is to be placed, wherein the receptacle is provided between the camera system and the light source, said light source preferably emitting red light. This may increase the visibility of the isolated pieces of plant matter, for instance by increasing the contrast of the image. The light source may emit red light, as this has been shown to advantageously increase the visibility of the plant matter, which tends to be green.

The system may further comprise a second light source, wherein the pick-up unit, when at the predefined confirming position, is located between the camera system and a second light source that is configured for emitting light to the pick-up unit, said light source preferably emitting red light. This allows the contrast of a picked-up piece of plant matter to be improved.

The first light source can be the second light source. In other words, a single light source is used for emitting light to the receptacle and the pick-up unit.

The surface may comprise a first transparent region on which the receptacle is to be placed and a second transparent region, spaced apart from the first transparent region, wherein the first light source is configured for emitting light through the first transparent region, and wherein the second light source is configured for emitting light through the second transparent region. The first transparent region is substantially the same size as the receptacle and the receptacle is provided thereon. The receptacle is then placed on the first transparent region through which the receptacle itself is illuminated. Because the first transparent region has substantially the same size as the receptacle, little to no light is transmitted to the camera system without having passed through the receptacle. This may be advantageous as an unimpeded light source outside the receptacle may negatively affect the first image. The second transparent region may be much smaller, which is suitable for illuminating the picked-up piece of plant matter, if present, when the pick-up unit is in the predetermined confirming position.

The pick-up unit may comprise a pair of tweezers suitable for picking up an isolated piece of plant matter, wherein the tweezers are part of the pick-up unit. Tweezers suitable for picking up

pieces of plant matter are known from the art and will be familiar to the skilled person. The tweezers may for instance be pneumatically actuated tweezers, although alternatives will be known to the skilled person.

5 The pick-up unit may be moved in a plurality of directions by the robotic arm. This allows for very precise movement of the pick-up unit, which makes it possible to pick up very small pieces of plant matter. This also allows for the positioning of the pick-up unit in such a way that a potentially picked up piece of plant matter may be properly and efficiently detected. This may also help the depositing of the piece of plant matter in the compartment of the tray.

10 The pick-up unit can be pivotally mounted to an end of the robotic arm to allow rotation of the pick-up unit relative to the end of the robotic arm.

The system may further comprise a blowing unit suitable for directing a pressurized gaseous medium at the receptacle. As described above, in the absence of isolated pieces of plant matter, this may be employed to isolate pieces of plant matter from clusters of pieces of plant matter. The blowing unit is preferably controlled by the controller.

15 The system may further comprise a gripping unit suitable for gripping the tray, as the tray may need to be periodically replaced when all compartments contain a piece of plant matter. To make the process as efficient as possible, it is desirable to also automate this replacement of the tray. The gripping unit is preferably controlled by the controller.

20 The blowing unit and/or the gripping unit may be mounted to the same robotic arm as the pick-up unit, and the movement of the blowing unit and/or gripping unit may be controlled by controlling the robotic arm, to make the system as compact as possible. This is desirable as, when taking a first optical image of the receptacle, an unobstructed view is advantageous. The blowing unit and/or the gripping unit may be incorporated in the pick-up unit.

25 The present invention also provides a pick-up unit that is configured as the pick-up unit defined above.

The invention will now be explained in more detail at the hand of the figures, in which: Figure 1 shows a top view illustrating a receptacle and tray to be used in the invention; Figure 2 is a side view illustrating a receptacle, tray, and robotic arm to be used in the invention;

30 Figure 3 is a block diagram of a system according to the invention;

Figure 4 is a flow chart illustrating a method in accordance with the invention;

Figure 5 is a side view of an embodiment of the pick-up unit according to the invention;

and

Figure 6A-6E present different views of the embodiment shown in figure 5.

35 In figure 1, a top view is shown of a receptacle 1 and tray 3 to be used in the invention, whereas figure 2 shows a corresponding side view. In figure 1, the robotic arm and the pick-up unit

affixed thereon have been omitted to offer a clear view. Receptacle 1 contains clusters 7 of plant matter as well as isolated pieces 6 of plant matter, floating in a suitable liquid. In what follows, it will be assumed that the pieces of plant matter are plant embryos, but the invention is also suitable for the picking up of other types of pieces of plant matter.

5 Tray 3 may comprise a plurality of compartments 4, depicted as test tubes in figure 2. Each compartment 4 is suitable for receiving a respective picked-up piece of plant matter. While tray 3 is displayed as a grid, compartments 4 may also be distributed in a different manner, and the displayed number of compartments 4 should not be taken as limitative.

 Receptacle 1 is provided on a support surface 5 such as a table, see figure 2. Surface 5 is
10 provided with a first transparent region 2, located underneath receptacle 1, and a second transparent region 2'. Transparent regions 2 and 2' are indicated with dashed lines to make clear that they let through at least a part of the light emitted by a light source 9 that is arranged underneath surface 5. Here, light source 9 is abstracted as a light bulb but may be embodied as any type of light source, preferably one emitting red light, or as a combination of light sources. Light
15 source 9, which preferably emits red light, allows for efficient detection of isolated embryos. Red is preferred since embryos and other plant matter tends to be green, and enhanced contrast may make it easier to detect isolated pieces.

 While both receptacle 1 and transparent regions 2, 2' are depicted as having a rectangular shape, other shapes are of course also possible. Furthermore, the size of receptacle 1 and the size of
20 transparent region 2 are preferably substantially equal. This may be advantageous as an unimpeded light source outside receptacle 1 may negatively affect capturing images of receptacle 1, thus making the detection of isolated embryos more difficult.

 Tray 3 is depicted as resting on a different surface 8. However, surface 5 and surface 8 may be part of a single surface. Furthermore, while surfaces 5 and 8 are depicted as being
25 rectangular, other shapes are also possible.

 An embodiment of a system according to the invention comprises a stationary frame relative to which surfaces 5 and 8 may have a fixed position. The system may further comprise a robotic arm 13 having a pick-up unit 14 mounted on an end thereof. Pick-up unit 14 may be provided with means for picking up a plant embryo, such as for instance tweezers 15. By means of
30 robotic arm 13, pick-up unit 14 is able to translate and rotate to position itself relative to a piece of plant matter to be picked up. An example of a pick-up unit is illustrated in figure 5.

 Robotic arm 13 and pick-up unit 14 are configured such that a plant embryo may be picked up from receptacle 1 from a position detected using an image made by an optical camera 12. Furthermore, robotic arm 13 may be controlled to position pick-up unit 14 such that the presence
35 of a picked-up plant embryo may be checked above transparent region 2' in a second image made

by camera 12. Robotic arm 13 may also be controlled to position pick-up unit 14 such that the plant embryo may be deposited in one of the compartments or test tubes 4 in tray 3 on surface 8.

Figure 3 illustrates a block diagram of an embodiment of a system in accordance with the present invention. This system may comprise the components illustrated in figures 1 and 2. Camera system 12 may comprise multiple cameras. Preferably, a single camera is used for capturing a first and second optical image. The camera(s) is/are preferably mounted to the stationary frame.

Robotic arm 13 and pick-up unit 14 are controlled by a controller 11, which may also control camera system 12 if needed. Based on the first and/or second optical image, controller 11 controls robotic arm 13 to move pick-up unit 14 to a desired position above first transparent region 2, which may be a position to pick-up an isolated embryo 6 of which the position and preferably also orientation have been determined in the first optical image. Controller 11 may also control robotic arm 13 to move pick-up unit 14 to a predetermined confirming position above second transparent region 2', or to a position above a compartment 4 in tray 3 in which a picked-up embryo may be deposited. Other positions may also be possible, such as for instance a position in which a gripping unit 17 may grip tray 3, a position to which tray 3 may be moved, and a position in which a new tray may be gripped by gripping unit 17. Gripping unit 17 may be incorporated in pick-up unit 14.

The position and orientation of pick-up unit 14 may be controlled by controller 11 indirectly by controlling robotic arm 13. Pick-up unit 14 may also be controlled directly by controller 11. For instance, a rotation of pick-up unit 14 may be controlled by controlling robotic arm 13 or by directly controlling pick-up unit 14. Robotic arms with pick-up units as well as methods to move these precisely are known from the prior art, and therefore the skilled person will be aware of several ways to control such a robotic arm and pick-up unit.

Pick-up unit 14 comprises tweezers 15 suitable for picking up a plant embryo or other piece of plant matter. Tweezers 15 may be controlled by controller 11. For instance, tweezers 15 may be pneumatically actuated tweezers, and controller 11 may control the opening and closing of tweezers 15 by means of controlling one or more pneumatic cylinders. Controller 11 may also control a blower 16 which is part of a blowing unit, and which is preferably also part of pick-up unit 14. Pressurized gaseous medium such as air may be expelled by blower 16, for instance, from in between tweezers 15, in which case a small amount of gaseous medium may be expelled, if needed, to help with the depositing of the piece of plant matter into a compartment 4 in tray 3. Furthermore, the pneumatic actuation of tweezers 15 and the source of gaseous medium may be part of a single system. However, these latter options are not necessary. The skilled person will be able to assess in which circumstances this configuration would be useful.

While the word "gripping unit" suggests active gripping, and while controller 11 may control gripping unit 17 to grip tray 3, this need not be the case. Gripping unit 17 may also be

embodied as a passive gripping unit, such as a hook or other gripping organ, which may cooperate with gravity in order to grip tray 3. In this latter case, controller 11 controlling robotic arm 13 and/or pick-up unit 14 may be sufficient to achieve gripping of tray 3.

5 Camera system 12 comprising at least one camera is used for capturing a first optical image which shows receptacle 1 and a second optical image for detecting a picked-up embryo. For instance, a single camera 12 may be affixed at a certain distance above surface 5. Camera 12 is preferably positioned such that it can capture an image on which both receptacle 1 and second transparent region 2' are visible without needing to be moved. However, while this is an efficient arrangement, the skilled person will be able to envisage alternate arrangements, for instance in 10 which a single camera changes focus and/or position or in which several cameras are used.

Advantageously, it may be that in the second optical image, which allows the system to determine whether an embryo was indeed picked up, receptacle 1 is visible as well. If this is the case, and if the second optical image shows that no embryo was picked up, the location of a further isolated embryo may be detected from the second optical image as well, which allows pick-up unit 15 14 to pick-up a further embryo without either having to rely on the first optical image again (since the pick-up action may have changed the location of embryos) or requiring the capturing of a further first optical image. In other embodiments, when receptacle 1 is also captured in the second optical image, a single optical image may be used for both detecting isolated embryos 6 and for confirming the presence of a picked-up embryo held by tweezers 15.

20 Figure 4 is a flowchart illustrating a method in accordance with the invention. More in particular, the method depicted in figure 4 can be used with the system depicted in figure 3.

In step S1, a receptacle and tray are provided. Both of these may be replaced while performing the method. The receptacle may be replaced once no more isolated embryos can be seen or blown loose from clusters, and the tray once there is an embryo in every compartment. 25 While in the presently illustrated embodiment the replacement of the tray, by using a gripping unit which is attached to the pick-up unit, is automated and the replacement of the receptacle is not, replacing the tray may also be done manually and the process of replacing the receptacle may be automated as well. The skilled person will be able to determine, depending on circumstances and cost, which if any of these two processes to automate.

30 In step S2, a first optical image of the receptacle is captured. Preferably, the entire receptacle may be seen in this first optical image. To achieve this, the first optical image is preferably captured when the pick-up unit is away from the area between the camera capturing the first optical image and the receptacle itself.

In step S3, it is determined whether at least one isolated embryo may be seen in the first 35 optical image. The skilled person will be familiar with algorithms which are able to do this, as detecting the presence of isolated embryos is known from the state of the art. To improve the

accuracy of detection, the receptacle is preferably lighted from below as shown in figure 1, preferably by a light source which emits red light, for increased contrast.

The image of the isolated embryo may be compared with predetermined criteria, comprising features such as size, shape, colour. If the image of the embryo does not meet these
5 criteria, the embryo may be discarded and a next isolated embryo is selected.

If at least one isolated embryo is detected in step S3, the pick-up unit is moved, in step S4, towards the receptacle, where it may be positioned above the location of the selected embryo. Once the pick-up unit is thus positioned, a pick-up action may be performed (S5), wherein for example tweezers close around the embryo and grab the embryo by its stem. To make this possible, it is
10 advantageous to detect not just the presence and position of isolated embryos in the first optical image in step S3, but to also detect the orientation of a selected embryo. In step S4, the motion of the pick-up unit may not just serve to position it substantially above a selected embryo to be picked up, but may also comprise an element of rotation (of either the pick-up unit as a whole or just an element, e.g. the tweezers) to make it possible to pick-up the embryo in step S5.

Once the pick-up action has been performed, the pick-up unit may be moved, in step S6, to the predetermined confirming position above second transparent region 2' to confirm whether indeed an embryo was picked up in step S5. Advantageously, the pick-up unit is not just moved laterally for this step, but it rotated too, in such a way that a camera may get an unobstructed view of the position in which the embryo, if present, would be located. Generally, a rotation of the
15 tweezers bringing the tweezers in an essentially horizontal plane should allow this. Next, a second optical image is captured in step S7. The light source improves accuracy, as the embryo, if present, will obstruct part of the light going from the light source to the camera. Therefore, the presence of an embryo may for instance be detected by determining if the shadow of an embryo is present in the second optical image captured in step S7.

The camera capturing the second optical image may be the same camera that captures the first optical image. In fact, the second optical image, which is taken as the pick-up unit is in the predetermined confirming position and hence is likely to not be obstructing the view of the receptacle from the camera, may also be used as the first optical image in a subsequent step S2. If necessary, however, a refocusing of the camera may take place between the capturing of the first
20 optical image and the second optical image, in which case the second optical image will likely not be suited to be used as a subsequent first optical image. Separate cameras may also be used.

If a successful pick-up is confirmed in step S8, the pick-up unit may move towards the tray and deposit the embryo in a compartment of the tray. Various ways of achieving the depositing step will be familiar to the skilled person. If tweezers are used, simply opening the tweezers may
25 be sufficient. Since the embryos may still have some medium attached to them and may therefore

be sticky, a small blast of pressurized air may also be applied to deposit the embryo if necessary. After depositing the embryo in step S9, the method may be repeated by returning to step S2.

If the embryo is not detected in the second optical image in step S8, the pick-up unit is moved back to the receptacle in order to pick up a subsequent embryo in step S4. It may also be possible that the subsequent embryo is the same embryo which was not at first successfully picked up. The location of the embryo to be picked up may be detected from the second optical image. Alternately, the method may be repeated from step S2, and start with the capturing of a new first optical image, preferably before the pick-up unit is moved back, so as to obtain an unobstructed view of the receptacle.

Going back to step S3, if an isolated piece of plant matter such as a plant embryo is not detected in the first optical image, this may be because all embryos in the receptacle are clumped together in at least one cluster of embryos. To be able to deal with this, the system according to the invention may comprise a blowing unit, and in step S4' this blowing unit is moved along a first predefined trajectory while blowing a pressurized gaseous medium, e.g. air, downward toward the receptacle. This may break up at least one of the clusters to the extent that isolated embryos are again present in the receptacle. To see if the blowing unit moving along the predetermined trajectory had this desired result, a further first optical image of the receptacle may be captured, preferably after the blowing unit is moved to a position in which it does not impede the camera's view of the receptacle, and the presence of isolated embryos may be detected in this captured image. If an isolated embryo is detected, the process continues from step S4. If it is not, the blowing unit may be moved along a predetermined trajectory which is preferably different from the first predetermined trajectory, repeating step S4'. If after a certain number of repetitions of this process, for instance 3 repetitions, no isolated embryos are detected in the receptacle, the system may be configured to send a signal to a user, who may then replace the receptacle.

Figure 5 and figures 6A-6E show various views and cross sections of an embodiment of a pick-up unit according to the invention. In these figures, like reference numbers refer to like elements.

Figure 5 is a front view of pick-up unit 14 that shows gripping unit 17 most clearly. The gripping unit comprises a cylinder 171 which may move a piston 172 through actuation of piston rods 172'. Piston 172 is connected to a primary gripping element 175. Supporting elements 174 are also provided that are attached to secondary gripping elements 173. By actuating cylinder 171, piston 172 and primary gripping element 175 may be moved against secondary gripping elements 173, as seen in figure 6B, gripping an edge of a tray that is arranged in the space between elements 173, 175. In the shown embodiment, cylinder 171 is a pneumatic cylinder, controlled through air supply 176. Other means of actuating the gripping unit are of course also possible.

Figure 6A shows a top view of pick-up unit 14. Figure 6B shows a cross section through line A in figure 6A whereas figure 6C shows a cross section through line B. Figure 6B shows a cross section through cylinder 171, piston 172, primary gripping element 172 and secondary gripping elements 173. An opening is visible between the primary and secondary gripping elements 173, 175 where the edge of a tray may be gripped.

Figure 6C is a cross section of pick-up unit 14, specifically. More in particular, this figure shows air passages 168 through pick-up unit 15 that may be used either for the blowing function described above or, if needed, to deposit an embryo that is stuck to tweezers 15. Air may be supplied through air supply opening 167 and may then be blown through passages 168.

Figure 6D is the same view as shown in Figure 5. On it, a line C is indicated wherein figure 6E is a cross-section through this line. Air supply opening 167 for the pick-up unit is also indicated here, as are the elements comprising air passages 168. In this figure tweezers 15 which are used to pick up the embryo may also be seen.

Figure 6E is a cross section in which the operation of tweezers 15 may be seen in more detail. Tweezers 15 in this embodiment are pneumatically actuated by means of a double-acting cylinder 150, though alternatives are also possible. Air supply channels 151 and 152 may be used to close and open tweezers 15, respectively, by supplying a suitable pressurized gaseous medium.

A setting screw 155 is shown that allows the positioning of supporting blocks 153, 154. The space between blocks 153, 154 determines the maximum angle or stroke of tweezers 15.

The embodiment described above is included only for illustrative purposes. The skilled person will be able to envisage equivalents for many of the above-mentioned features, and the scope of the claims is not limited to the specific features mentioned above.

CONCLUSIES

1. Werkwijze voor het oppakken en verzamelen van plantmateriaal, in het bijzonder plantembryo's, omvattende de volgende stappen:

5 het verkrijgen van een eerste optische afbeelding, zijnde een afbeelding van ten minste een stukje plantmateriaal, zoals een plantembryo, gerangschikt in een vergaarbak;

het detecteren van een geïsoleerd stukje plantmateriaal in de verkregen eerste optische afbeelding;

10 het aansturen van een robotarm met een hierop gemonteerde oppakeenheid, om de oppakeenheid te bewegen naar een positie waarin het in staat is het geïsoleerde stukje plantmateriaal op te pakken;

het uitvoeren van een oppakactie voor het oppakken van het geïsoleerde stukje plantmateriaal met gebruik van de oppakeenheid;

15 het aansturen van de robotarm om de oppakeenheid te bewegen naar een vooraf bepaalde bevestigingspositie;

het verkrijgen van een tweede optische afbeelding waarop een deel dat geassocieerd is met het opgepakte stukje plantmateriaal niet overlapt met enig deel dat geassocieerd is met de vergaarbak;

20 het aansturen van de robotarm om de oppakeenheid te bewegen voor het afleggen van het opgepakte stukje plantmateriaal in een respectievelijk compartiment in een tray omvattende ten minste één compartiment, wanneer het opgepakte stukje plantmateriaal zichtbaar is in de tweede optische afbeelding, of het aansturen van de robotarm om de oppakeenheid te bewegen naar een positie waarin het in staat is een verder geïsoleerd stukje plantmateriaal op te pakken, wanneer geen opgepakt stukje plantmateriaal zichtbaar is in de tweede optische afbeelding.

25

2. Werkwijze volgens conclusie 1, waarbij de vergaarbak zichtbaar is in de tweede optische afbeelding, waarbij de werkwijze verder omvat het detecteren van het verdere geïsoleerd stukje plantmateriaal in de tweede optische afbeelding.

30 3. Werkwijze volgens conclusie 1, omvattende het detecteren van het verdere geïsoleerde stukje plantmateriaal in de eerste optische afbeelding.

35 4. Werkwijze volgens een van de voorgaande conclusies, omvattende het verkrijgen van een nieuwe eerste optische afbeelding voor het detecteren van een volgend op te pakken stukje plantmateriaal wanneer de oppakeenheid het zicht op de vergaarbak in de nieuwe eerste optische afbeelding niet blokkeert.

5. Werkwijze volgens conclusie 4, waarbij de genoemde nieuwe eerste optische afbeelding verkregen wordt wanneer de oppakeenheid zich in de positie voor het afleggen van het opgepakte stukje plantmateriaal bevindt of ernaar aan het bewegen is.

5

6. Werkwijze volgens een van de voorgaande conclusies, omvattende eenzelfde optische camera voor het verkrijgen van de eerste en tweede optische afbeeldingen.

7. Werkwijze volgens conclusie 6, waarbij de optische camera een zoomfunctie uitvoert voordat de tweede optische afbeelding gemaakt wordt.

10

8. Werkwijze volgens een van de voorgaande conclusies, waarbij het genoemde detecteren van een geïsoleerd stukje plantmateriaal of het detecteren van een verder geïsoleerd stukje plantmateriaal omvat:

15 het vinden van een geïsoleerd stukje plantmateriaal in de eerste of tweede optische afbeelding;

het vergelijken van ten minste één van de afmeting, de kleur en de vorm met vooraf bepaalde criteria;

10 het bepalen dat het geïsoleerde stukje plantmateriaal opgepakt moet worden als de genoemde ten minste één van een afmeting, oriëntatie, kleur en vorm overeenkomt met de vooraf bepaalde criteria.

9. Werkwijze volgens een van de voorgaande conclusies, omvattende het aansturen van de robotarm om de oppakeenheid te draaien tijdens en/of na een beweging naar de vooraf bepaalde bevestigingspositie, om zo beter zicht toe te laten van het opgepakte stukje plantmateriaal, als het aanwezig is.

25

10. Werkwijze volgens een van de voorgaande conclusies, verder omvattende een stap van het detecteren van een oriëntatie van het geïsoleerde stukje plantmateriaal of het verdere geïsoleerde stukje plantmateriaal in de eerste en/of tweede optische afbeelding, en het overeenkomstig oriënteren van de oppakeenheid voor het uitvoeren van de oppakactie.

30

11. Werkwijze volgens een van de voorgaande conclusies, omvattende, wanneer geen geïsoleerd stukje plantmateriaal gedetecteerd wordt in de eerste en/of tweede optische afbeelding, het bewegen van een blaaseenheid volgens een vooraf bepaald pad terwijl er een gasachtig medium onder druk, bijvoorbeeld lucht, gericht wordt op de vergaarbak.

35

12. Werkwijze volgens conclusie 11, omvattende, na de stap van het bewegen van de blaaseenheid volgens het vooraf bepaalde pad:

5 het bewegen van de blaaseenheid naar een positie waarin een nieuwe eerste of tweede optische afbeelding kan worden verkregen hebbende een hoofdzakelijk ononderbroken zicht op de vergaarbak; en

het detecteren of er enige geïsoleerde stukjes plantmateriaal in de vergaarbak zijn met gebruik van de eerste en/of tweede optische afbeelding.

10 13. Werkwijze volgens conclusie 12, verder omvattende, wanneer geen geïsoleerde stukjes gedetecteerd worden in de laatste stap, het bewegen van de blaaseenheid langs een ander vooraf bepaald pad terwijl er gasachtig medium onder druk wordt gericht op de vergaarbak.

15 14. Werkwijze volgens een van de conclusies 11-13, omvattende, wanneer geen geïsoleerde stukjes gedetecteerd worden, een stap van het zenden van een waarschuwingssignaal naar een gebruiker.

20 15. Werkwijze volgens een van de conclusies 11-14, waarbij de stap van het richten van gasachtig medium onder druk op de vergaarbak inhoudt: het blazen van het gasachtig medium onder druk naar beneden met een hoofdzakelijk rechte hoek ten opzichte van een vlak gedefinieerd door de bodem van de vergaarbak.

25 16. Werkwijze volgens een van de voorgaande conclusies, omvattende, wanneer er geen vrije compartimenten meer zijn in de tray, het vervangen van de tray.

17. Werkwijze volgens conclusie 16, omvattende het gebruik van een grijpeenheid voor het vervangen van de tray.

30 18. Werkwijze volgens een van de voorgaande conclusies, waarbij de blaaseenheid en/of de grijpeenheid gemonteerd zijn op dezelfde robotarm als de oppakeenheid, en waarbij de beweging van de blaaseenheid en/of grijpeenheid aangestuurd wordt door het aansturen van de robotarm.

19. Systeem voor het oppakken van plantmateriaal en voor het verzamelen van het opgepakte plantmateriaal in een tray hebbende ten minste één compartiment, in het bijzonder plantembryo's, omvattende:

- 5 een oppervlak waarop een vergaarbak omvattende ten minste één stukje plantmateriaal zoals een plantembryo kan worden verschaft;
- een robotarm voorzien van een oppakeenheid ingericht om een stukje plantmateriaal op te pakken, waarbij de robotarm in staat is de oppakeenheid te bewegen voor het oppakken van een stukje plantmateriaal uit de vergaarbak, om de oppakeenheid te bewegen naar een vooraf bepaalde bevestigingspositie voor het bevestigen van het opgepakte stukje plantmateriaal, en
- 10 om de oppakeenheid te bewegen voor het afleggen van een opgepakt stukje plantmateriaal in een tray omvattende ten minste één compartiment dat geschikt is voor het ontvangen van het opgepakte stukje plantmateriaal;
- een camerasysteem omvattende een optische camera, waarbij dit systeem ingericht is voor het verkrijgen van een eerste optische afbeelding, zijnde een afbeelding van ten minste één stukje
- 15 plantmateriaal in een vergaarbak, en voor het verkrijgen van een tweede optische afbeelding waarin een deel dat geassocieerd is met het opgepakte stukje plantmateriaal niet overeenkomt met enig deel dat geassocieerd is met de vergaarbak, en
- een aansturing ingericht voor:
 - het detecteren van een geïsoleerd stukje plantmateriaal in de eerste optische afbeelding;
 - 20 het aansturen van de robotarm om de oppakeenheid te bewegen naar een positie waarin de eenheid een gedetecteerd geïsoleerd stukje plantmateriaal op kan pakken;
 - het aansturen van de oppakeenheid om het gedetecteerde geïsoleerde stukje plantmateriaal op te pakken;
 - het aansturen van de robotarm om de oppakeenheid te bewegen naar een vooraf bepaalde
 - 25 bevestigingspositie;
 - het bevestigen van de aanwezigheid van een opgepakt stukje plantmateriaal in de tweede optische afbeelding;
 - het aansturen van de robotarm en de oppakeenheid om het opgepakte stukje plantmateriaal af te leggen in een respectievelijk compartiment als het opgepakte stukje plantmateriaal zichtbaar
 - 30 is in de tweede optische afbeelding, of het aansturen van de robotarm om de oppakeenheid te bewegen naar een positie waarin het in staat is een verder geïsoleerd stukje plantmateriaal op te pakken als geen opgepakt stukje plantmateriaal zichtbaar is in de tweede optische afbeelding.

20. Systeem volgens conclusie 19, verder omvattende een eerste lichtbron

35 ingericht voor het uitzenden van licht via het oppervlak vanuit een zijde van het oppervlak welke tegenovergelegen is aan de zijde van het oppervlak waarop de vergaarbak geplaatst of te plaatsen

is, waarbij de vergaarbak verschaft is tussen het camerasysteem en de lichtbron, en waarbij de lichtbron bij voorkeur rood licht uitzendt.

5 21. Systeem volgens conclusie 19 of 20, verder omvattende een tweede lichtbron, waarbij de oppakeenheid, wanneer deze zich in de vooraf bepaalde bevestigingspositie bevindt, geplaatst is tussen het camerasysteem en een tweede lichtbron welke ingericht is voor het uitzenden van licht naar de oppakeenheid, waarbij deze lichtbron bij voorkeur rood licht uitzendt.

10 22. Systeem volgens conclusie 20 of 21, waarbij de eerste lichtbron de tweede lichtbron is.

15 23. Systeem volgens een van de conclusies 20-22, waarbij het oppervlak een eerste transparant gebied omvat waarop de vergaarbak te plaatsen is en een tweede transparant gebied, apart geplaatst van het eerste transparante gebied, waarbij de eerste lichtbron ingericht is voor het uitzenden van licht door het eerste transparante gebied en waarbij de tweede lichtbron ingericht is voor het uitzenden van licht door het tweede transparante gebied,

 waarbij de lichtbron uitgevoerd is als een lichtgevend oppervlak bedekt door een masker met twee ramen, waarbij een van de ramen hoofdzakelijk dezelfde afmeting heeft als de vergaarbak en de vergaarbak hierop verschaft is.

20

24. Systeem volgens een van de voorgaande conclusies, waarbij de oppakeenheid een pincet omvat geschikt voor het oppakken van een geïsoleerd stukje plantmateriaal, waarbij het pincet deel uitmaakt van de oppakeenheid.

25 25. Systeem volgens conclusie 24 waarbij het pincet een pneumatisch geactueerd pincet is.

30 26. Systeem volgens een van de conclusies 19-25, verder omvattende een blaaseenheid geschikt voor het richten van een gasachtig medium onder druk op de vergaarbak, waarbij de blaaseenheid bij voorkeur aangestuurd wordt door de aansturing.

35 27. Systeem volgens een van de conclusies 19-26, verder omvattende een grijpeenheid geschikt voor het grijpen van de tray, waarbij de grijpeenheid bij voorkeur aangestuurd wordt door de aansturing.

28. Systeem volgens conclusie 26 of 27, waarbij de blaaseenheid en/of de grijpeenheid gemonteerd zijn aan dezelfde robotarm als de oppakeenheid, en waarbij de beweging van de blaaseenheid en/of grijpeenheid aangestuurd wordt door het aansturen van de robotarm, en/of waarbij de blaaseenheid en/of de grijpeenheid deel uitmaken van de oppakeenheid.

5

29. Oppakeenheid ingericht zoals de oppakeenheid volgens een van de conclusies 19-28.

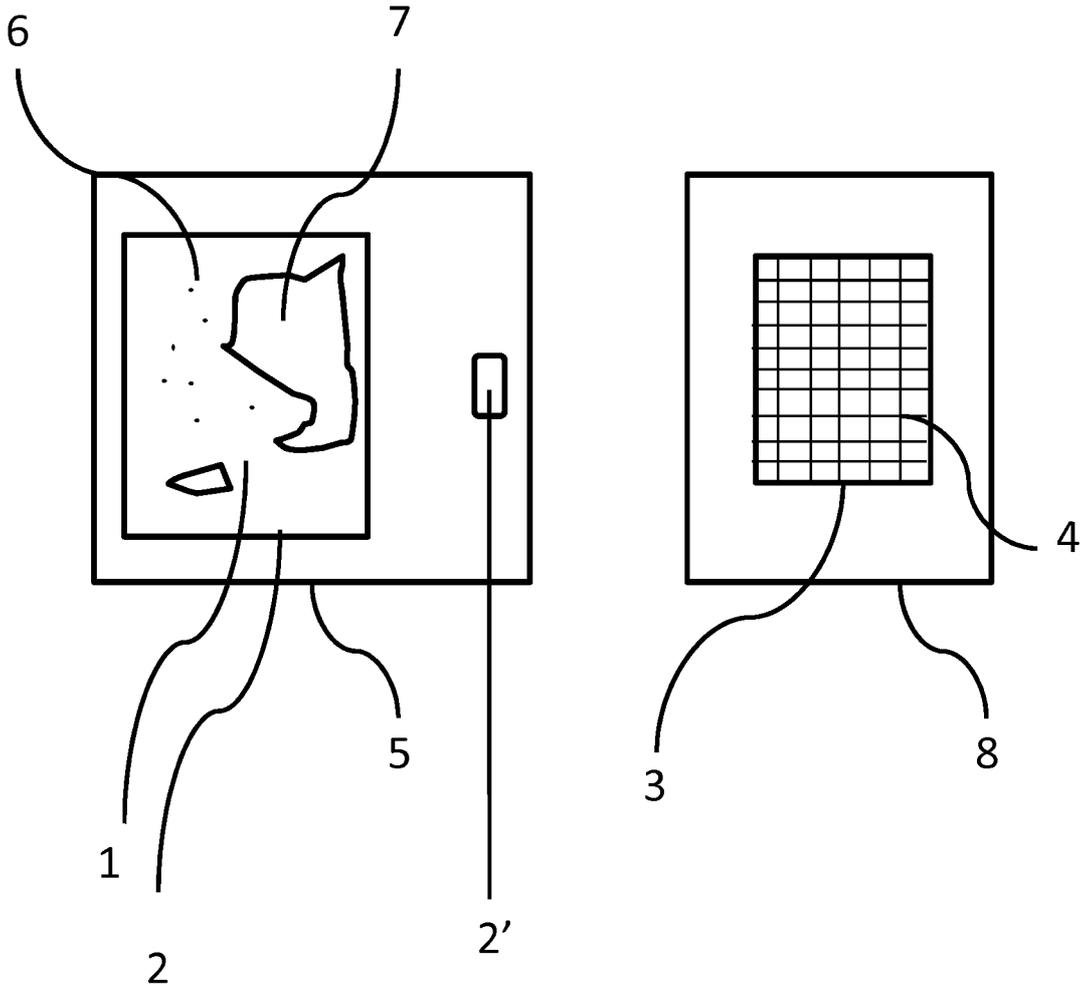


Fig. 1

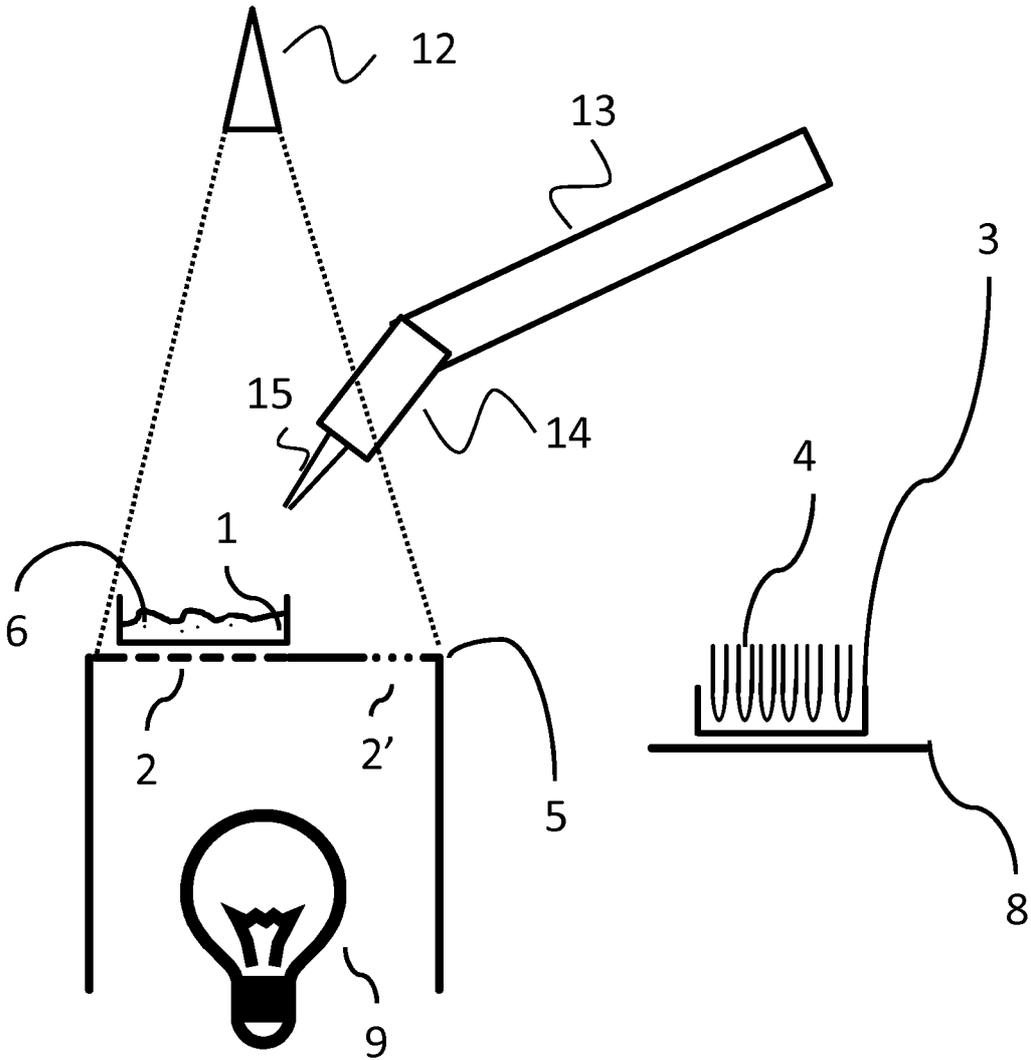


Fig. 2

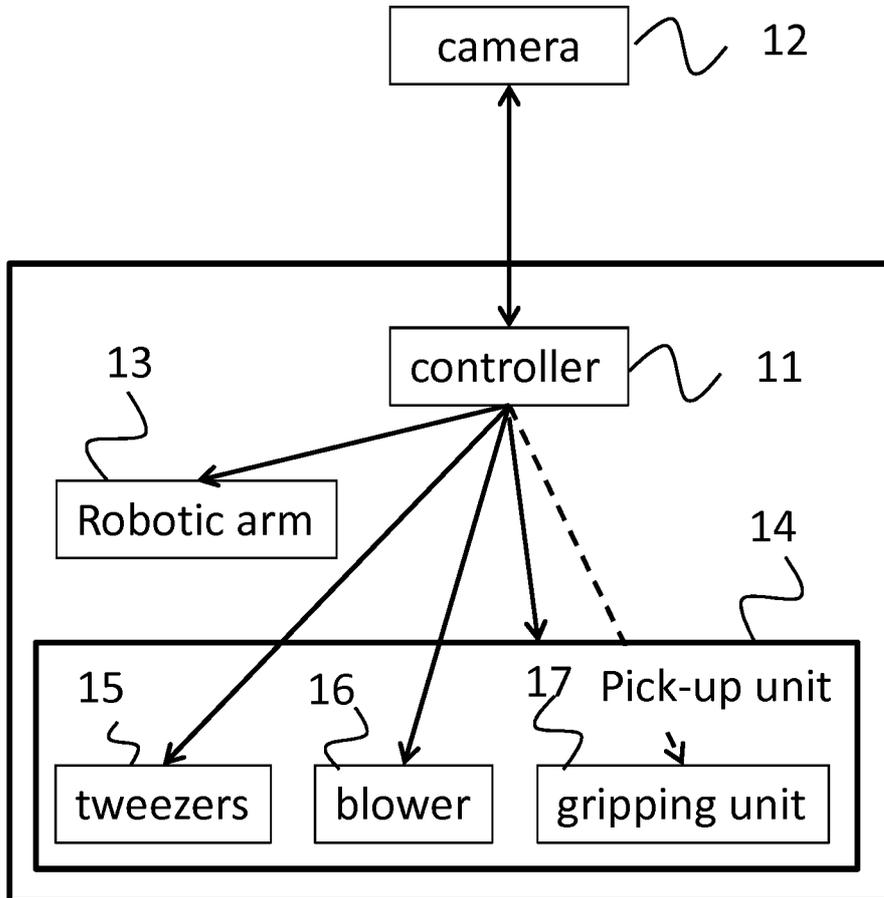


Fig. 3

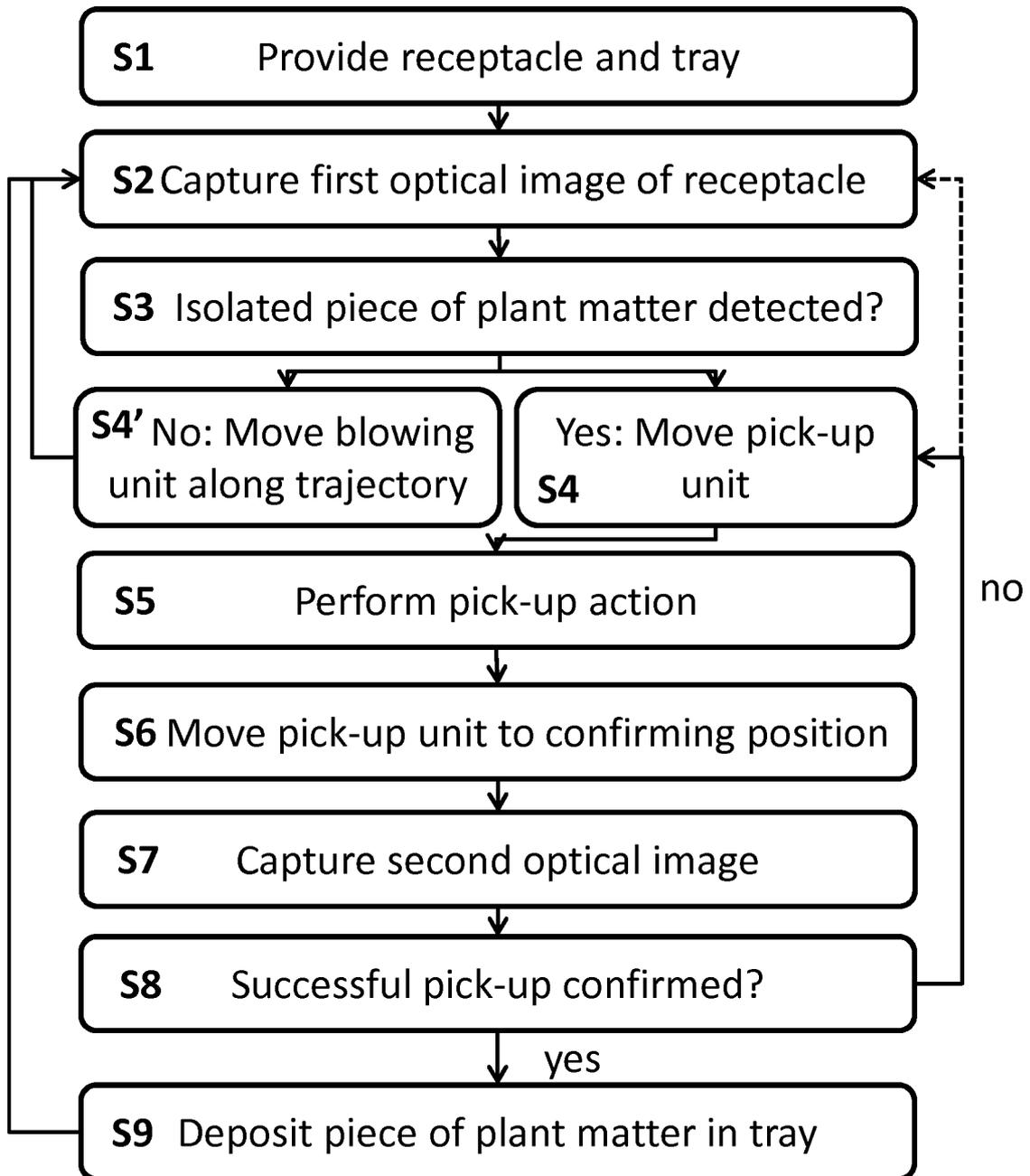


Fig. 4

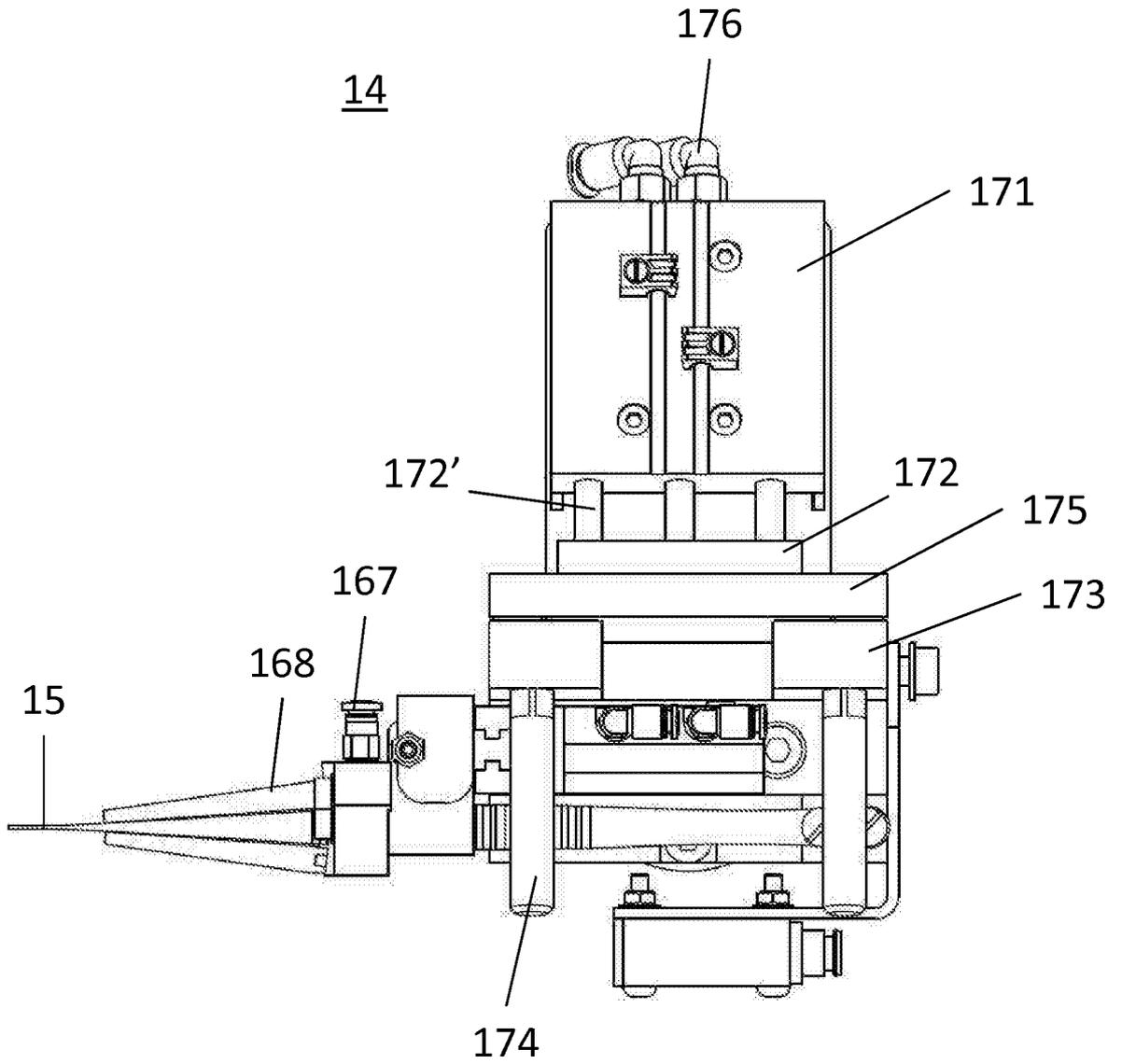


Fig. 5

Fig. 6A

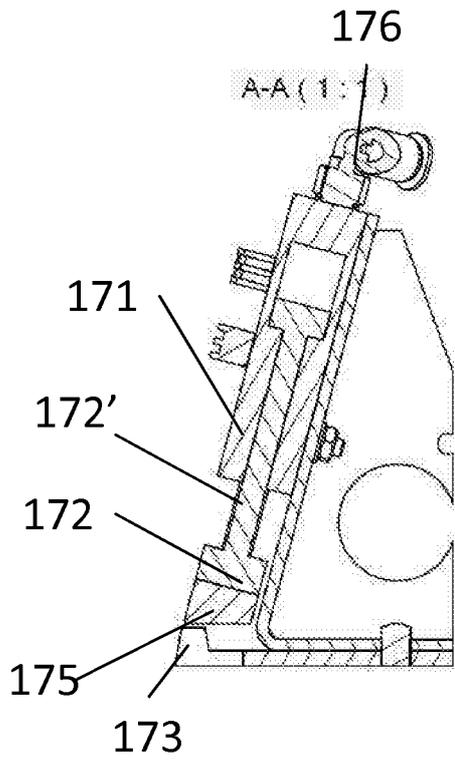
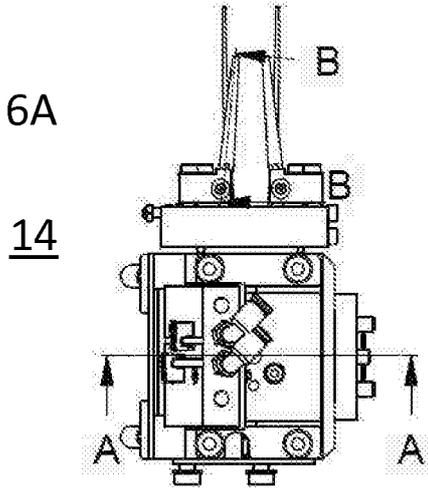


Fig. 6B

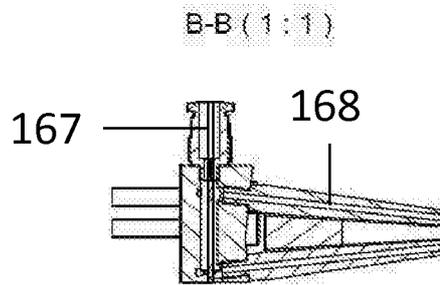


Fig. 6C

Fig. 6D

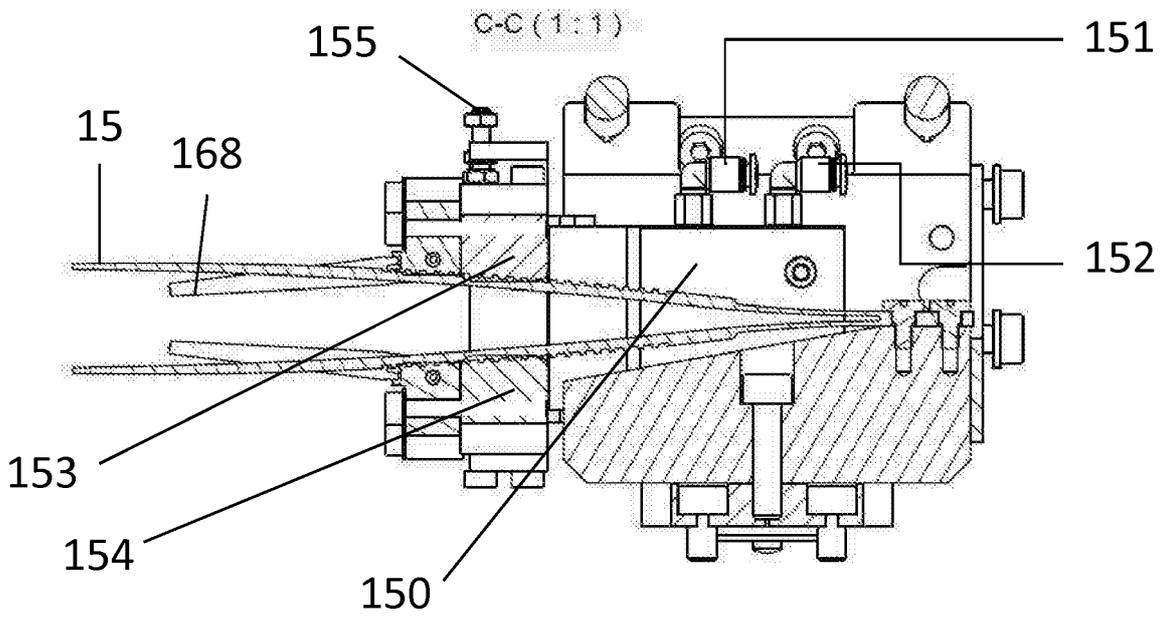
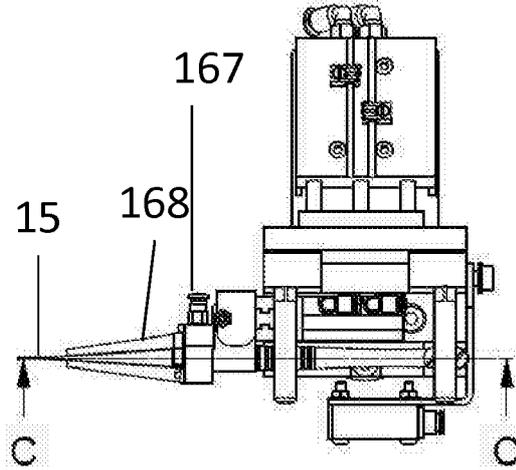


Fig. 6E

Abstract

The invention relates to a method and system for picking up and collecting plant matter, in particular plant embryos. To pick up the plant matter, a pick-up unit is used that is mounted to a robotic arm.

According to the invention, two separate imaging steps are performed at two different positions of the pick-up unit. The first imaging step is performed to identify an isolated piece of plant matter. The second imaging step is performed when the pick-up unit is at a confirming position and enables a verification of whether a piece of plant matter has been picked up or not.

The confirming position is in between the position of the pick-up unit for picking up plant matter and the position for depositing plant matter in suitable receptacles.

15

SAMENWERKINGSVERDRAG (PCT)

RAPPORT BETREFFENDE NIEUWHEIDSONDERZOEK VAN INTERNATIONAAL TYPE

IDENTIFICATIE VAN DE NATIONALE AANVRAGE	KENMERK VAN DE AANVRAGER OF VAN DE GEMACHTIGDE
	3B/2TS21/BD/464
Nederlands aanvraag nr.	Indieningsdatum
2017599	10-10-2016
	Ingeroepen voorrangsdatum
Aanvrager (Naam)	
Rijk Zwaan Zaadteelt en Zaadhandel B.V.	
Datum van het verzoek voor een onderzoek van internationaal type	Door de Instantie voor Internationaal Onderzoek aan het verzoek voor een onderzoek van internationaal type toegekend nr.
21-01-2017	SN68210
I. CLASSIFICATIE VAN HET ONDERWERP (bij toepassing van verschillende classificaties, alle classificatiesymbolen opgeven)	
Volgens de internationale classificatie (IPC)	
G01N1/00;C12M1/36;G01N15/14	
II. ONDERZOCHE GEBIEDEN VAN DE TECHNIEK	
Onderzochte minimumdocumentatie	
Classificatiesysteem	Classificatiesymbolen
IPC	G01N;C12M;G05B
Onderzochte andere documentatie dan de minimum documentatie, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen	
III.	GEEN ONDERZOEK MOGELIJK VOOR BEPAALDE CONCLUSIES (opmerkingen op aanvullingsblad)
IV.	GEBREK AAN EENHEID VAN UITVINDING (opmerkingen op aanvullingsblad)

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2017599

A. CLASSIFICATIE VAN HET ONDERWERP
INV. G01N1/00 C12M1/36 G01N15/14
ADD.

Volgens de Internationale Classificatie van octrooien (IPC) of zowel volgens de nationale classificatie als volgens de IPC.

B. ONDERZOCHETE GEBIEDEN VAN DE TECHNIEK

Onderzochte minimum documentatie (classificatie gevolgd door classificatiesymbolen)

G01N C12M G05B

Onderzochte andere documentatie dan de minimum documentatie, voor dergelijke documenten, voor zover dergelijke documenten in de onderzochte gebieden zijn opgenomen

Tijdens het onderzoek geraadpleegde elektronische gegevensbestanden (naam van de gegevensbestanden en, waar uitvoerbaar, gebruikte trefwoorden)

EPO-Internal, WPI Data, BIOSIS, CHEM ABS Data, EMBASE

C. VAN BELANG GEACHTE DOCUMENTEN

Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
Y,D	US 2005/114918 A1 (HIRAHARA EDWIN [US] ET AL) 26 mei 2005 (2005-05-26) in de aanvraag genoemd * alinea's [0006], [0026] - [0041]; conclusies; figuren *	1-29
Y,D	EP 1 498 025 A2 (WEYERHAEUSER CO [US]) 19 januari 2005 (2005-01-19) in de aanvraag genoemd * alinea's [0009] - [0012], [0037] - [0044]; conclusies; figuren *	1-29
Y	WO 01/13702 A2 (WEYERHAEUSER CO [US]) 1 maart 2001 (2001-03-01) * bladzijde 3, regel 7 - bladzijde 4, regel 2 * * bladzijde 5, regel 5 - bladzijde 10, regel 24; conclusies; figuren *	1-29
	-/--	

Verdere documenten worden vermeld in het vervolg van vak C.

Leden van dezelfde octrooifamilie zijn vermeld in een bijlage

* Speciale categorieën van aangehaalde documenten

"A" niet tot de categorie X of Y behorende literatuur die de stand van de techniek beschrijft

"D" in de octrooiaanvraag vermeld

"E" eerdere octrooi(aanvraag), gepubliceerd op of na de indieningsdatum, waarin dezelfde uitvinding wordt beschreven

"L" om andere redenen vermelde literatuur

"O" niet-schriftelijke stand van de techniek

"P" tussen de voorrangsdatum en de indieningsdatum gepubliceerde literatuur

"T" na de indieningsdatum of de voorrangsdatum gepubliceerde literatuur die niet bezwaarnd is voor de octrooiaanvraag, maar wordt vermeld ter verheldering van de theorie of het principe dat ten grondslag ligt aan de uitvinding

"X" de conclusie wordt als niet nieuw of niet inventief beschouwd ten opzichte van deze literatuur

"Y" de conclusie wordt als niet inventief beschouwd ten opzichte van de combinatie van deze literatuur met andere geciteerde literatuur van dezelfde categorie, waarbij de combinatie voor de vakman voor de hand liggend wordt geacht

"&" lid van dezelfde octrooifamilie of overeenkomstige octrooipublicatie

Datum waarop het onderzoek naar de stand van de techniek van internationaal type werd voltooid

17 mei 2017

Verzenddatum van het rapport van het onderzoek naar de stand van de techniek van internationaal type

Naam en adres van de instantie

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040
Fax: (+31-70) 340-3016

De bevoegde ambtenaar

Burkhardt, Peter

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Nummer van het verzoek om een onderzoek naar
de stand van de techniek
NL 2017599

C.(Vervolg). VAN BELANG GEACHTE DOCUMENTEN		
Categorie *	Geciteerde documenten, eventueel met aanduiding van speciaal van belang zijnde passages	Van belang voor conclusie nr.
Y	<p>LEE E. WEISS ET AL: "Dynamic Sensor-Based Control of Robots with Visual Feedback", IEEE JOURNAL ON ROBOTICS AND AUTOMATION, 5 oktober 1987 (1987-10-05), bladzijden 404-417, XP055361747, USA ISSN: 0882-4967 * bladzijde 404, kolom 2, alinea 3 - bladzijde 407, kolom 2, alinea 3 * * bladzijde 416, kolom 1, alinea 1; figuren *</p>	1-29
Y	<p>Peter I. Corke: "Visual Control of Robot Manipulators- A Review", Visual Servoing, 1 januari 1993 (1993-01-01), XP055042324, http://reference.kfupm.edu.sa/ Gevonden op het Internet: URL:http://reference.kfupm.edu.sa/content/v/i/visual_control_of_robot_manipulators_569323.pdf [gevonden op 2012-10-26] * bladzijde 2, alinea 2 - bladzijde 4, alinea 2 * * bladzijde 11, laatste alinea - bladzijde 16, alinea 1 * * bladzijde 21, alinea 2 - laatste alinea *</p>	1-29
Y	<p>EP 2 543 482 A1 (CANON KK [JP]) 9 januari 2013 (2013-01-09) * alinea [0009] - [0011] * * alinea [0016] - alinea [0030]; conclusies; figuren *</p>	1-29

**ONDERZOEKSRAPPORT BETREFFENDE HET
RESULTAAT VAN HET ONDERZOEK NAAR DE STAND
VAN DE TECHNIEK VAN HET INTERNATIONALE TYPE**

Informatie over leden van dezelfde octrooifamilie

Nummer van het verzoek om een onderzoek naar
de stand van de techniek

NL 2017599

In het rapport genoemd octrooigescrift	Datum van publicatie	Overeenkomst(e) geschrift(en)	Datum van publicatie
US 2005114918	A1	26-05-2005	CA 2484533 A1 25-05-2005
			FI 20041483 A 26-05-2005
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			CL 2004001619 A1 03-06-2005
			CN 1618277 A 25-05-2005
			CN 1860859 A 15-11-2006
			EP 1498025 A2 19-01-2005
			JP 4342388 B2 14-10-2009
			JP 2005040131 A 17-02-2005
			MX PA04006474 A 08-06-2005
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			NZ 533676 A 27-01-2006
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			CA 2381905 A1 01-03-2001
			FI 20020339 A 20-02-2002
			NZ 517137 A 29-08-2003
			US 6684564 B1 03-02-2004
			WO 0113702 A2 01-03-2001

EP 2543482	A1	09-01-2013	CN 102914293 A 06-02-2013
			EP 2543482 A1 09-01-2013
			JP 2013036987 A 21-02-2013
			US 2013010070 A1 10-01-2013

WRITTEN OPINION

File No. SN68210	Filing date (day/month/year) 10.10.2016	Priority date (day/month/year)	Application No. NL2017599
International Patent Classification (IPC) INV. G01N1/00 C12M1/36 G01N15/14			
Applicant Rijk Zwaan Zaaďteelt en Zaadhandel B.V.			

This opinion contains indications relating to the following items:

- Box No. I Basis of the opinion
- Box No. II Priority
- Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- Box No. IV Lack of unity of invention
- Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- Box No. VI Certain documents cited
- Box No. VII Certain defects in the application
- Box No. VIII Certain observations on the application

Examiner Burkhardt, Peter

WRITTEN OPINION

Application number
NL2017599

Box No. I Basis of this opinion

1. This opinion has been established on the basis of the latest set of claims filed before the start of the search.
2. With regard to any **nucleotide and/or amino acid sequence** disclosed in the application and necessary to the claimed invention, this opinion has been established on the basis of:
 - a. type of material:
 - a sequence listing
 - table(s) related to the sequence listing
 - b. format of material:
 - on paper
 - in electronic form
 - c. time of filing/furnishing:
 - contained in the application as filed.
 - filed together with the application in electronic form.
 - furnished subsequently for the purposes of search.
3. In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
4. Additional comments:

Box No. V Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty	Yes: Claims	1-29
	No: Claims	
Inventive step	Yes: Claims	
	No: Claims	1-29
Industrial applicability	Yes: Claims	1-29
	No: Claims	
2. Citations and explanations
see separate sheet

WRITTEN OPINION

Application number
NL2017599

Box No. VIII Certain observations on the application

see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

- 1 The following documents (D) are listed in this written opinion. The numbering follows the order of the Search Report.
 - D1 US 2005/0114918 (Weyerhaeuser Company)
 - D2 EP 1498025 (Weyerhaeuser Company)
 - D3 WO 01/13702 (Weyerhaeuser Company)
 - D4 Weiss *et al.*, 1987. IEE J. Robot. Autom. 3:404-417
 - D5 Corke, 1993. In: Visual Servoing, K. Hashimoto, Ed. pp. 1-31
 - D6 EP2543482 (Canon)
- 2 Claim 1 is directed to a method for picking and depositing plant matter into a compartment with a robotic arm. The movement of the robotic arm during collection and depositing of the plant matter is controlled by optical imaging.
- 3 The closest prior art to the subject-matter of claim 1 is any of documents D1 (paragraphs 6, 26 - 41; claims; Figures), D2 (paragraphs 9 - 12, 37 - 44; claims; Figures) or D3 (page 3, line 7 - page 4, line 2; page 5, line 5 - page 10, line 24; claims; Figures).
- 4 All documents disclose methods for picking plant embryos and depositing them into compartments with a robotic arm under optical control of digital imaging cameras. The disclosures of D1 - D3 differ from the method of claim 1 in that the movement of the robotic arm is controlled by comparing two images at different time points in the picking and depositing process for the presence of the plant material.
- 5 The objective technical problem could thus be formulated as the provision of an alternative method for picking and depositing plant matter with a robotic arm. The method of claim 1 solves that problem but the solution does not involve an inventive step for the following reasons.
- 6 Image-based visual servo control employing the location of features on the image plane of consecutive images directly for feedback on robotic arms is well known from the prior art.
- 7 The disclosures of D4 (page 404, second column, third paragraph - page 407, second column, third paragraph; page 416, first column, first paragraph; Figures), D5 (page 2, second paragraph - page 4, second paragraph; page

11, last paragraph - page 16, first paragraph; page 21, second paragraph - last paragraph) or D6 (paragraphs 9 - 11; paragraph 16 - 30; claims; Figures) may serve as examples for that.

- 8 No inventive activity can be acknowledged for combining this well know means of image-based visual servo control with the methods of D1, D2 or D3. A man skilled in the art in need of an alternative image control system would simply apply the knowledge of D4 - D6 to the methods of D1, D2 or D3 and arrive at the subject-matter of claim 1 without any inventive effort.
- 9 The same holds true for the system of claim 19. Dependent claims 2 - 18 and 19 - 29 do not contain any features beyond a trivial level that would merit an inventive step.

Re Item VIII

Certain observations on the application

- 1 The subject-matter of claims 1 and 19 encompasses an extremely broad scope, namely collecting and picking any plant matter with robotic arms under under optical control.
- 2 The application as filed does not disclose such a wide scope in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art. It would amount to an undue burden or require inventive activity to carry out the claimed invention over its entire broad scope.